be effectively used on various species of *Aspidiotus*, *Pulvinaria*, *Icerya*, *Lecaneum* and other coccids. In the control of these scale-insects, wetting power is not so much needed as the large size of the globules found in *Castrol AA*. Several of the large size globules completely cover up the scale, causing death through suffocation. Besides, the emulsion from lubricating oil is not penetrating and not so dangerous to foliage as the kerosene oil emulsion. Lubricating oil is also not likely to cause canker of stems, branches and twigs and the future prospects of its use as sprays against scale-insects in India appear to be great. Detailed results on these will be published elsewhere.

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[1] Moore, *Univ. Minn. Tech. Bull.*, 1921, **2.**
[2] Richardson, Griffen and Burdette, *Jour. Agric. Res.*, 1927, **34.**
[3] English, *Illinois*, 1928, **17.**
[4] De Ong, *Jour. Eco., Ent.*, 1926, **19.**
[5] Stellwaag, *Zeit. Angew. Ent.*, 1924, **10.**
[6] Moore and Graham, *Jour. Agric. Res.*, 1918, **13.**

Biochemistry in Relation to Agriculture.

By Sir John Russell, D.SC., F.R.S.

"YOU, at the Indian Institute of Science, are engaged in a field which offers great opportunities to add to the richness of life, to alleviate human sufferings and to improve the lot of the millions of agriculturists in India; and I hope that the triumphs and achievements of biochemistry will further be improved by the work that you are doing at the Institute"—so declared Sir John Russell, Director of the Rothamsted Experimental Station, in concluding an interesting address on "Biochemistry in Relation to Agriculture" which he delivered under the auspices of the *Society of Biological Chemists* at Bangalore on December 15th, last.

Biochemistry, said Sir John, was the chemistry of substances concerned with life. In the early days of biochemistry that subject had been a distinct branch of chemistry and people had thought of life as entirely distinct from non-living things. That was the origin of the distinction between organic and inorganic chemistry, a distinction which still survived and caused confusion among students. In the second period of the study of biochemistry it was shown that substances with life could also be synthesised in the laboratories and that there was no fundamental difference between organic and inorganic substances.

Later still the difference became one purely of convenience in study. In reality the realm of nature was one and indivisible but they classified their studies into different groups because one could not study every field.

Agriculture.—Referring to agriculture, Sir John said, that one Professor had defined it "as something to keep away from". In his young days, he had been warned that there was no career to be made out of agriculture. He, however, held that there was a great deal in agriculture and that there was a close connection between agriculture and biochemistry. As a result of recent studies in biochemistry they had found it possible to define quality in relation to crops. In England, for example, quality problems in connection with crops were first studied in relation to barley which was used in the production of beer. Later, the studies in quality extended to wheat and it was found that there were three different kinds of wheat—one which was best adapted for loaves, another which was good for biscuits, and another which was good for macaroni. What was good for one purpose was not necessarily good for the other two. Biochemical study had been able to relate the composition of wheat in a general way with the question of its suitability to any purpose, but the details were still obscure.

In India they had a particularly important set of problems concerned with the food of the people, especially of the Indian ryot, who as they all knew, was the basic foundation on which the whole of this country was built. In order to arrive at the normal daily food available for consumption by the average ryot, Sir John had collected figures referring to the total crop production in India and found that the average consumption of grain by the Indian ryot worked out at about one pound per head per day. In the Punjab and in Bengal it was slightly over a pound, while it was slightly under a pound in Madras. Curiously enough, these figures tallied closely with those for consumption furnished by the ryots themselves whom Sir John had interrogated. The normal food of the ryot in the Punjab consisted of fifty per cent. wheat, thirty per cent. gram and the rest of cereals. That would furnish a diet very rich in protein. In Bengal the diet was very poor in protein, as it was almost wholly composed of rice. In Madras they had an intermediate sort of diet, rice accounting for 70 per cent. and the rest being made up of protein foods.

Protein Content of Grain.—There is great need for the determination of the nature and amount of proteins present in the common grains in use in India. They knew the protein contents of wheat and barley but they wanted more information than was available now, about the proteins of Indian grains. Till that study was completed they could not say how the daily diet of the Indian ryot could be improved. Agriculturists could not be expected to know what foods to grow from a dietary point of view.

What was the source of vitamins for the Indian ryot and agriculturist? In an Indian village, he had met an old man who could not say how old he was, but was obviously above 70 years. If one could accept his own account of his diet, he would have had very little of the vitamins A, B, C, or D. That would constitute a biochemical mystery making one wonder whether by some physiological process the Indian ryot had evolved the secret of protecting himself, against deficiencies of vitamins in his food. Scientists, perhaps, in an effort to explain it away, would fall back upon the abundance of brilliant sunshine

which they had in India. Sir John felt that there was a great deal in it and that the abundant sunshine might somehow or other make it unnecessary for the Indian ryot to have as much vitamin supply as was needed in less sunny countries.

That did not, however, mean that there was no room for improving the diet of the Indian ryot. That could and should be improved. That problem could be solved only after they had solved the biochemical problems relating to Indian food products.

Livestock Problems.—Sir John then referred to the conditions of animal stock in India and said that everywhere in India, poor stalks of grain crops, and poor grazing fields provided the main food for cattle. That was an inadequate diet for animals. There was a great need to radically improve the dietary of animals both in quality and in quantity. He was glad to note that at the Animal Husbandry Conference held in Madras, they had on the previous day (December 14) emphasised that point. The bullock was the greatest source of power for agriculturists in India and they had to remember that power could not be produced out of nothing. The problem of milk supply was also one which required their immediate attention. In most villages milk could be got only in very small quantities by the children and sometimes not at all.

Nitrogen Fixation in Soils.—Referring to the need for a scientific study of soils, Sir John said that they had not yet fully understood the remarkable cycle in Nature with reference to nitrogen production. Though that subject had been fairly fully studied in connection with the temperate climates, yet in the tropics it still remained to be studied adequately. Particularly, with reference to soil study, they had to conduct large-scale field experiments to ascertain facts and to work out processes. Some work in that direction had been done in U. S. A. But the results obtained there did not agree with those obtained in temperate climates, such as in England. In England they had established that the source of nitrogen in the soil was leguminous plants. But in the arid regions of U. S. A., they failed to get clear evidence of fixation by leguminous plants. What they should know was whether or not, in a country like India, fixation by free living organisms played an important part as a source of nitrogen. That was a problem of fundamental importance in soil study. In England they could not determine whether nitrogen fixation proceeded independently of leguminous plants. That could only be done in a tropical climate. Even in regard to experiments connected with composts and farm manures they found that the results varied as between England and America. Therefore if they wanted to obtain satisfactory solutions for their problems connected with agriculture, biochemists in India would have to solve them.

Water-logged Soils.—The chemistry of water-logged fields was another direction in which experimental work by biochemists would prove of great value to the Indian ryot. The conditions relating to water-logged areas in India differed very much from those in England, where water-logged areas were merely swamps where the water was stagnant. On the other hand, in India the water was being constantly renewed in water-logged areas owing to evaporation and replacement by fresh water. At present not enough was known about the micro-biological conditions of paddy soils. Sir John felt sure that there was great scope for the application of modern biochemical knowledge towards the improvement of paddy cultivation, especially by way of extension of the pioneering work carried out by Harrison and Iyer in that direction.

Utilisation of Wastes.—The use of waste products was another direction in which the biochemist could help a great deal. The possibilities of utilising on a commercial scale, plants and plant products which were not edible deserved study.

The biochemist could also contribute a great deal by studying problems connected with the utilisation of sewage. Sir John was glad to note that Dr. Gilbert Fowler, who had done a great deal of successful work in that direction, was present at the meeting. In the West as in England they had succeeded in disposing of the sewage in a healthy manner, though in a wasteful way. Dr. Fowler's method, however, enabled the Western method of sewage disposal to be adopted without losing the manurial value, especially in regard to nitrogen and phosphates. Phosphates formed an important fertilizer material whose supplies were almost monopolised by France and America. Thanks to the activated sludge method it had become possible to recover a considerable portion of the phosphates from sewage. The only problem in that connection which remained to be solved was that of drying the truculent colloids. The retention of moisture by colloids was a problem for the man of physics to solve.

Concluding, Sir John referred to the rapid growth of the sugar industry in India and the possibility of putting the by-product, *viz.*, molasses, to much better use than was being done now.