Princeton, N. J.; Columbia College, New York City; Cornell University, Ithaca, N. Y.; Johns Hopkins University, Baltimore, Md.; Lake Forest University, Lake Forest, Ill.; Leland Stanford, Jr., University, California; Northwestern University, Evanston, Ill.; University of Colorado, Boulder, Colo.; University of Chicago, Chicago, Ill.; University of Indiana, Bloomington, Ind.; University of Kansas, Lawrence, Kan.; University of Michigan, Ann Arbor, Mich.; University of Minnesota, Minneapolis, Minn.; University of Virginia, Charlottesville, Va., University of Wisconsin, Madison, Wis.; Vanderbilt University, Nashville, Tenn.; Western Reserve University, Cleveland, Ohio.

Allow me to call attention, in this connection, to the desirability of forming a complete collection of all printed dissertations of American universities, and to suggest that the Smithsonian Institution is the proper place of deposit for such a collection. The Institution already receives those issued by the John Hopkins University and is willing to give others a place. When the magnificent new Library of Congress is completed, a collection of American university dissertations could be well housed, and would make a really valuable addition to the treasury of books; eventually a catalogue of these works could be published, as has recently been done in France. (Catalogue des Thèses de Sciences, 1810-1890, Albert Maire, Paris, 1892; Catalogue des Thèses de Pharmacie à l' Ecole de Pharmacie de Paris, 1815-1889, Paul Dorveaux, Paris, 1891; Catalogue des Thèses de Pharmacie soutenues en Province, 1803-1894, Paul Dorveaux, Paris, 1895). It may be proper to state that I am attempting to catalogue all the printed chemical dissertations of American colleges for the *Supplement* to my 'Select Bibliography of Chemistry,' and I appeal to the members of the Chemical Section for assistance.

Finally, could bibliographical researches be introduced into the chemical curriculum of American colleges several advantages would ensue beyond the mere collection of indexes; such a procedure would train students to accuracy in making citations; it would encourage in them a disposition to give credit to earlier workers in the same field of research as their own; it would tend to enlarge their views as to the immense domain of chemical literature; it would lay foundations upon which the post-graduates might build more substantially in after years, and it would develop an appreciation of the historical aspects of chemistry, which busy workers in the laboratory too rarely have opportunities of cultivating.

H. CARRINGTON BOLTON.

AGRICULTURAL CHEMISTRY.*

AGRICULTURAL chemistry is a cosmopolitan science. It was founded by Liebig, of immortal memory. Its early apostle in France was Boussingault; in England, Gilbert; in America, Johnson. It is presumably that science most nearly allied to the sustenance of human life, and thus lies nearer than any other to the heart, or perhaps the stomach, of humanity. Its home is wherever a plant grows. Its devotees are found wherever a plowshare turns the soil. Its base lies in the study of the composition of the soil and the constitution of plants. Its superstructure rises high enough to touch the most abstruse questions of mineral and vegetable physiology and metabolism. Turning from philosophy to facts, we find this science linked indissolubly with the greatest industry of the world. There is scarcely a field or a forest which has not felt the impress of its power. From the field its domain has extended to the factory and the guidance and advice of the

* Read before Section of Chemistry of the American Association for the Advancement of Science, September 3, 1895.

chemist are sought for the further preparation of foods and fabrics for the use of man. It has also secured a place in the domain of public and advanced instruction, and even the conservatism of the great universities has yielded to agricultural chemistry a prominent place in the curriculum of studies. Both in this country and in Europe hundreds of special schools and experiment stations are found devoted largely to the service of agricultural chemistry and its coördinate branches of science.

The art of fertilizing the fields, at first purely empirical, has become an exact science. The methods of saving and recovering waste fertilizing products, at the present time, renders many great industries possible which otherwise would have to yield to the fierce competition which every human endeavor has to meet at this end of the century. Further than this the paternal efforts of agricultural chemistry extend and seek to recover from the mine and from the sea the elements of fertility apparently forever lost during the centuries that have passed.

The science of agricultural chemistry acknowledges, without stint, its indebtedness to the other fields of chemical work. In its very beginning it was the simple use of the principles of mineral analysis, applied to the soil and its products. By this means the parts of the plants which were derived directly from the soil were determined, and the surprising fact was thus developed that nearly the whole of the vast product of vegetable growth is a free gift of Heaven and not chargeable to the soil. This was the point of union between agricultural chemistry and meteorology, and the basis of the science of meteorology applied to agriculture. The supply of carbon dioxid and water to the growing plant becomes thus a problem of the profoundest interest to agriculture, and the chemist and physicist have thus been led to study the great problems of precipitation, drainage and irrigation as affecting the products of the field. The best methods of disposing of an excess of rainfall, with the minimum loss of plant food due to percolation of water through the soil, are of no less importance. In connection with this, that treatment of the soil by chemical and physical means which will best prepare it to distribute the supply of moisture available to the advantage of the growing plant has been carefully studied.

Agricultural science has also drawn freely on the resources of organic chemistry. In agricultural products are presented to the students some of the most complicated as well as interesting organic compounds. In the growth of the plant are seen the wonderful resources of the vegetable cell in the way of chemical activity. The most renowned achievements of modern synthetic chemistry have consisted in the reproduction of some of the simpler forms of vegetable organic compounds. It will be admitted, without doubt, that the simple sugars are the least complicated of organic vegetable products, and these have been at last successfully made in the laboratory. The step from a hexose to a hexobiose seems indeed a short one, and yet it has not been taken. Only step by step must we expect the onward progress of synthesis until, for instance, a starch is reached. Yet in the progress of organic synthetic chemistry already accomplished, great good has come. The exact chemical relations of the sugars to the aldehyds, ketones and polyatomic alcohols have been established and the bonds which unite the organic chemistry of man to that of Nature clearly distinguished. On a former occasion, in an address to the Chemical Society, I have pointed out the futility of the expectation that synthetic organic chemistry will ever be able to take the place of agriculture, but the debt agriculture owes it is one of great and constantly increasing magnitude.

Not of less practical importance to agriculture has been the recent progress in our knowledge of that indefinite complex which has so long passed under the misnomer of 'nitrogen-free extract.' With the exception of the facts that it is not nitrogen-free and that it is not an extract, the name may do well enough. At least some agricultural chemists have an idea of what the term signifies, and to others it serves the purpose of the physician's malaria, permitting them to designate, in a fairly mysterious way, a something of which nothing is known. The constitution of the greater part of this complex body is now known, and the proportions of cellulose and of pentosans which it contains can be determined with a fair degree of definiteness. We should deem it a matter for congratulation to be assured that the day is fast approaching when the agricultural chemist will no longer be called on to determine forty per cent. or more of a cattle food 'by difference.'

In late years not only has organic chemistry helped us in the way of a better understanding of the composition of the carbohydrates, but it has also pointed out to us some of the main points in the constitution of those most valuable products, the vegetable proteids. We are far behind our digestive organs in our understanding of these bodies and have been accustomed in practical work to place all proteid matter together in a single class. But there is no doubt of the fact that the vegetable proteids differ as much among themselves as those of animal origin, and at last the chemist is able to distinguish between them. Even if it should prove that there is little difference in their food value, yet it must be conceded that a knowledge of their structural differences, together with the several contents of nitrogen found therein, will prove in the end of the greatest advantage to the agricultural chemist.

The relations of agriculture to pedagogic chemistry have already been mentioned. In many of our public schools it is thought to be quite as important to teach the child something about the life of the field and the orchard as to drill him in the geography of Johore. How plants and animals grow is a theme which will one day be developed in every school in the land. Naturally, in agricultural colleges, the pedagogic side of agricultural chemistry receives due consideration, but alas ! with these institutions it is sometimes *nomen et prœterea nihil.* In these cases agricultural chemistry must often give place to a heterochronistic psychology. But, on other hand, many of our universities have recognized the need of such instruction and have provided properly therefor. Merely material considerations should induce all our higher institutions of learning to provide for advanced instruction in agricultural chemistry, for just now there is, and for years to come there will be, a large demand for young men well trained in this direction. It will not be many years before it will be required of every well-equipped university to provide liberally for the professional education of the young men who are to take charge of the agricultural colleges and experiment stations of the country.

In its relations to bacteriology, agricultural chemistry is also a debtor. In the life history of those minute vegetable organisms which exert so profound a chemical action on many bodies has been found the solution of the problem of those fermentations which prepare for use the nitrogenous foods of plants. The successive conversion of organized nitrogen into ammonia, nitrous and nitric acids is a process of the most vital importance to plant life. It is true that these activities were exerted for several millions of years without our knowing anything about them, and they would doubtless go on until the end of time if our knowledge of them should entirely cease and determine. Nevertheless, the value of what little knowledge we now possess seems almost the groundwork of scientific agriculture. The micro-organisms which nitrify organic nitrogenous compounds, as well as those which act in the opposite direction, viz., in reducing nitrates to a lower form of oxidation, are of the utmost importance to agricultural chemistry. It is not beyond the range of possibility that a barren field may be rendered fertile by securing conditions favorable to nitrification and then seeding the soil with a few active nitrifying ferments.

Quite true it is, already, that any scheme for an analysis of a soil which leaves out of consideration the determination of nitrifying activity is far from complete. The action of bacteria on the ripening of cream and of cheese is a matter of but little less importance. The fermentation of cream and of cheese is already as much of an art as the fermentation of malt in the manufacture of beer. In the curing of tobacco the same activity is discovered and the day is not far distant when commerce in high bred tobacco bacteria will be an established fact. In short, we may look forward to the day when the bacteria active in agriculture will be carefully cultivated and the bacterial herd book will be found along with those of the Jersey cow and the Norman horse. Agricultural chemistry makes demands on every science which can aid it in the production of food and in the advancement of rational agriculture.

But we may go still a step further and follow the crude food into the factory and the kitchen. From the knowledge of the action of ferments mentioned above the great art of food preservation has been created. The sterilization of food products and their preservation from the further action of destructive ferments is one of the practical developments of rational agricultural chemistry. This method of food preservation is infinitely preferable to that other simpler process which consists in adding to the food a substance which paralyzes the further action of micro-organisms. Happily, agricultural and analytical chemistry have provided a certain method of detecting chemicals thus used for food preservation.

The conversion of foods into appropriate digestive forms and the study of their nutritive power mark the final step in agricultural chemistry in its control of food products. In this relation it comes into intimate contact with hygiene and animal physiology, thus almost completing the circle of intimate union with nearly all the leading sciences. Intimately associated with this branch of the subject is the control of the purity of the food itself and the detection of the adulterations to which it may be subjected.

The thoughts suggested in the foregoing pages are those that have come to me amid a multitude of distractions as those suited, at least in part, to meet the views of your presiding officer in asking me to introduce the theme of agricultural chemistry for discussion before the Section. I now yield the floor for a more particular treatment of some of the branches of the subject.

H. W. WILEY.

PROCEEDINGS OF THE BOTANICAL CLUB, A. A. A. S., SPRINGFIELD MEETING, AUGUST 29th TO SEPTEMBER 2d, 1895.

THE meetings were held in the room assigned to Section 'G,' in the State Street Baptist Church.

THURSDAY MORNING, AUGUST 29.

In the absence of the President, Prof. D. H. Campbell, and of the Secretary, Prof. F. C. Newcombe, the meetings of the Club were placed in organization by Prof. Geo. F. Atkinson. Hon. David F. Day was made Chairman *pro tem.*, and Prof. H. L. Bolley, Secretary.