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THE TEACHING OF CHEMISTRY IN AMERICAN AGRICULTURAL COLLEGES[1]

THE collection of statistics is very difficult. One special difficulty in connection with the subject which I have selected is due to the number and kinds of courses in the American agricultural college. This paper will be confined to two phases of chemistry in the agricultural college, viz., (1) the chemical instruction which is given to those who are preparing for agriculture, and (2) the opportunities afforded in these institutions for the preparation of students for careers in agricultural chemistry. With this purpose in mind we must omit all consideration of the various engineering courses in these institutions. We must omit from consideration also the various short agricultural courses and the courses in the agricultural colleges for negroes, as the chemical work in both cases is generally below the usual college grade and the consideration of either would of itself furnish sufficient material for a paper. These exclusions leave us the agricultural and the chemical courses. We shall first consider the four-year agricultural course. There are complications even here on account of the large number of electives which in effect give us several courses, such as in general agriculture, agronomy, horticulture, forestry, dairying, veterinary science, domestic economy, botany, etc. As we can not discuss all of these, the matter which we have collected is from one four-year course in each agri-

[1] Presidential address before the Association of Official Agricultural Chemists. Read at the twenty-seventh annual meeting in Washington, D. C., November 11, 1910.

cultural college, and this is the course in general agriculture, or agronomy. The chemistry which we consider in these is the minimum requirement. In the second part of the paper we shall consider the maximum chemical instruction which it is possible for one to receive in these colleges.

Another difficulty which confronts us is the great variety in the different institutions in the method of expressing requirements. In some cases there are given separately the requirements for the class room and for the laboratory in actual hours a week. In some cases the laboratory work is calculated to an equivalent of class-room work and in other cases the class work is calculated to an equivalent of laboratory work, and the two are expressed jointly. Even in this case there is no uniformity, as two hours, two and a half hours and three hours, in different institutions, are taken as the equivalent of one class-room hour. In some cases the actual number of hours is given, not as for the week, but as the total actual hours for the term, the term being the third, or the half year. The unit system is followed in many institutions, and is not uniform, referring in some cases to the third, the half or the whole year and varying in its representation from one to five hours a week. To make a comparison it is necessary to reduce these requirements to a single standard. The one selected is total class-room hours a week for the year, laboratory work being calculated to class-room work, and two hours of laboratory work being taken as the equivalent of one hour of class-room work.

The requirements for admission vary very much, and thus make great differences in the grade of work. For example, in some cases mathematical study begins in the freshman year with algebra, in others with plane or solid geometry, in others with trigonometry and in others all the mathematical study is required for entrance. Expressed by the Carnegie Foundation scale, the variation is from two or three points to about fourteen. The classification of states followed is that used by the Bureau of Education and other governmental departments.

GENERAL CHEMISTRY

In all the North Atlantic states (nine) general chemistry begins in the freshman year and in one state it continues two years. The number of hours a week given to the subject ranges from $2\frac{1}{2}$ to $5\frac{3}{4}$, the average being 4.

In the South Atlantic states (eight), four begin the subject in the freshman year, four in the sophomore year and in one the subject continues through the second year. The number of hours a week varies from 3 to $7\frac{1}{3}$, the average being 4.7.

In the north central states (twelve) all but two begin the subject in the freshman year and in one state it continues through the second year. The number of hours a week varies from 2 to $5\frac{1}{2}$, the average being 3.6.

In the south central states (eight) all but two begin the work in the sophomore year and in two it continues through the second year. The number of hours a week varies from $1\frac{1}{2}$ to 6, the average being 4.6.

In the far western states (eleven), excepting one, the information in regard to which is not available, one requires chemistry for admission, in seven the subject is begun in the freshman year, and in two in the sophomore year. In one it is continued the second year. The number of hours a week varies from $2\frac{1}{2}$ to 8, the average being 4.2.

By groups the hours a week vary from 3.6 in the north central states to 4.7 in the south Atlantic states, the average for the United States being 4.2. In one state gen-

eral chemistry is required for admission, in 32 the study of it begins during the freshman year, and in 14 during the sophomore year, and in 6 it continues through the second year. Without a single exception laboratory work accompanies class-room instruction.

ORGANIC CHEMISTRY

Organic chemistry is the branch of the subject which seems to be the least appreciated by those who have fixed the requirements of the course. Of the north Atlantic states three require the subject, in the south Atlantic states five, in the north central states four, in the south central states three and in the far western three, making a total of eighteen, or only a little more than a third of the states. Where given the number of hours a week varies from $1\frac{1}{3}$ to 5, the average, including those in which it is not given, being one. It is quite likely that in addition to this a little time is given to the subject in connection with the introductory courses.

Agricultural chemistry, the first of the agricultural sciences, in point of time, may be said to date from 1840 if any definite date can be assigned. The work which brought it into existence was prepared at the request of the chemical section of the British Association for the Advancement of Science. In the 1852 revision of Liebig's work by Lyon Playfair, the editor says, "the former edition of this work was prepared in the form of a report on the present state of organic chemistry." The title was "Organic Chemistry in its Application to Vegetable Physiology and Agriculture." When the second part of his report—that relating to animal physiology and pathology—appeared in 1852, Liebig said, "The connection between chemistry and physiology is the same [*i. e.*, 'so fused'—W. A. W.] and in another half century it will be found impossible to separate them." How could he know that about 1902 our knowledge of the carbohydrates and proteids and their cleavage products would have advanced so much! Will the agricultural colleges, while so highly honoring the memory of Liebig, at the same time minimize the subject, the knowledge of which made Liebig's work possible.

ANALYTICAL CHEMISTRY

Qualitative analysis is required in all the north Atlantic states but three, in all the south Atlantic states, in all the north central states but two, in all the south central states but two, and in all the far western states but one, making a total of only eight states in which it is not required. Quantitative analysis is required in two north Atlantic states, four south Atlantic states, four north central states, two south central states and four far western states, making a total of sixteen states or about one third in which quantitative analysis is required.

The average number of hours a week given to qualitative and quantitative analysis together is 1.5 for the north Atlantic states, 2.3 for the south Atlantic states and north central states, 1.4 for the south central states and 2.7 for the far western states, with an average of 2 for the entire United States.

AGRICULTURAL CHEMISTRY

As taught to agricultural students, agricultural chemistry appears upon examination of the college catalogues to have three different meanings, viz: (1) general chemistry, with such omissions and additions as will better fit the subject to the needs of agricultural students; (2) quantitative analysis, with its scope similarly modified, and (3) the consideration of plant and

animal nutrition, the substances involved in these processes and their products—useful and waste. The time spent along the lines mentioned first and second is included in this paper under the heads of general chemistry and quantitative analysis, which have already been discussed. The time spent upon what is generally called agricultural chemistry averages 1.6 hours a week for a year in the north Atlantic states, 1.7 in the south Atlantic states, 1.6 in the north central, 0.8 in the south central and 2.0 in the far western states, with an average of 1.5 for the whole United States. This average includes those institutions in which it is not required of agricultural students. The subject is not given at all, or is not required, in five north Atlantic states, in one south Atlantic state, in four north central, three south central, and four far western states, making a total of seventeen states in which it is either not taught at all or not required. This is probably due to the fact that the matter which was formerly included under the term agricultural chemistry and taught by the chemistry department is now, in many cases, taught by other departments under the names soils, fertilizers, plant nutrition, animal feeding, etc. The lines, representing the division of this work between the husbandry departments, do not seem to be very clearly drawn. For example, we find that a certain well-known text-book is used in some institutions in the chemistry department for agricultural chemistry and in others by the agronomy department for soils. This condition of things will in time probably adjust itself in the best way.

A summary of these findings is included in the following table:

NUMBER OF INSTITUTIONS REQUIRING CHEMISTRY IN THEIR AGRICULTURAL COURSES

Groups	Inorganic	Organic	Analytical	Agricultural
North Atlantic...	9	3	6	4
South Atlantic...	8	5	8	7
North central.....	12	4	10	8
South central.....	8	3	6	4
Far western.....	10	3	9	7
Total.....	47	18	39	30

CHEMICAL REQUIREMENTS IN AGRICULTURAL COURSES EXPRESSED IN HOURS A WEEK FOR A YEAR

	Inorganic	Organic	Analytical	Agricultural	Total
North Atlantic...	4.0	0.5	1.5	1.6	7.6
South Atlantic...	4.7	1.7	2.3	1.7	10.2
North central....	3.6	0.9	2.3	1.6	8.4
South central.....	4.6	0.6	1.4	0.8	7.4
Far western.....	4.2	1.0	2.7	2.0	9.9
Average.....	4.2	1.0	2.0	1.5	8.7

In 1897 the Committee on Methods of Teaching Agriculture reported to the Association of American Agricultural Colleges suggestions regarding a four-year course in agriculture. The matter relating to chemistry is as follows:

	Hours
Chemistry (class-room work)	75
Chemistry (laboratory work)	75
Agricultural chemistry, in addition to general requirement	180

Taking, as we have done, two hours of laboratory work as the equivalent of one hour of class-room work, and 36 weeks as the length of the college year, the recommendations of the committee of the college association would amount to the equivalent of 8.1 hours a week for a year, while the figures compiled by us show that an average of 8.7 hours is actually given.

The estimates by the committee of agriculturists as to what should be done and the average of what is actually done agree very closely indeed, and the truth must be somewhere near these two figures. The close agreement is all the more remarkable when we consider the great variation which we have in the different colleges. As time goes by we shall probably find the different

colleges conforming more closely to these averages.

UNDERGRADUATE WORK FOR CHEMISTS

The second portion of this paper relates to the opportunities offered by the agricultural colleges for training for chemical careers. Practically every agricultural college makes provision for such work, (1) by offering electives in the agricultural or scientific courses; (2) by grouping these electives so that beginning with the junior or senior year of the agricultural course a student may devote a large part of his time to chemistry, and (3) by offering four-year courses in chemistry or chemical engineering. The different catalogues show an ample number of electives, but unless there are fully organized four-year courses it is impossible to tell how many students avail themselves of their opportunities, and further consideration of them must be omitted.

The report of the Bureau of Education shows the following students enrolled in chemical engineering and chemistry in the various agricultural colleges for the year 1908–9.

State	Chemical Engineering	Chemistry
Maine	12	28
New Hampshire	19	
Vermont		33
Rhode Island	7	
New Jersey		12
Pennsylvania	11	65
North Atlantic states	49	138
Maryland		15
Virginia		34
North Carolina		17
South Carolina	9	
South Atlantic states	9	66
Ohio	34	
Indiana	51	19
Illinois	59	48
Wisconsin	23	41
Minnesota	15	46
Missouri	16	
North Dakota		4
North central states	198	158
Kentucky		25
Alabama		22
Louisiana	64	64
Texas	1	
Arkansas	55	55
South central states	120	166
Montana		4
Washington		18
California	51	
Far western states	51	22
Total for the United States	427	550

Total students in chemical engineering and chemistry in the agricultural colleges, 977.

This list does not show fully the undergraduate work for training chemists, but for the reasons stated above the data for fuller information were not available.

GRADUATE WORK IN CHEMISTRY

Practically every agricultural college has a few graduate students doing work in chemistry for the master's degree. This is a secondary feature in some of the colleges, and others have well-digested schemes for work. A very valuable paper showing the scope and extent of graduate work in America appeared in SCIENCE for August 19, 1910, entitled "Doctorates Conferred by American Universities." From that paper we learn that 178 doctorates were conferred for work in science in 1910, about one third of them by the universities of which the agricultural colleges are a part, and about two thirds by other institutions. Of this number 44 were in chemistry and about the same relation existed between the two classes of institutions. 15 doctorates for work in chemistry were conferred by Cornell, Illinois and Wisconsin. A table made from the paper referred to is inserted here, which shows among other things the very rapid development in the graduate departments of the universities of which the agricultural colleges are a part.

DOCTORATES CONFERRED IN THE SCIENCES [2]

	Average for 10 Years, 1898–1907	1908	1909	1910	Total for 13 Years, 1898–1910	In Chemistry, 1910
Cornell	10.4	15	24	27	170	4
Wisconsin	2.8	6	4	13	51	5
California	2.4	2	6	4	36	—
Nebraska	1.3	1	2	1	17	—
Illinois	0.3	0	2	9	14	6
Minnesota	0.7	1	2	1	11	—
Missouri	0.3	2	0	2	7	—
	18.2	27	40	57	306	15
Other universities	105.1	157	152	121	1,481	29
Total in America	123.3	184	192	178	1,787	44

AGRICULTURAL CHEMISTRY TEACHERS

Bulletin No. 224, of the Office of Experiment Stations, shows the organization of the different agricultural colleges in December, 1909. From this publication we find that there are 228 teachers of chemistry in these institutions who come in contact with the students in agriculture. This list does not include all the chemistry teachers, therefore. These are distributed approximately equally in the different sections except that the south Atlantic group has about half of her proportion, the deficiency being made up by the north central group. Of the 228, 51, or about one fourth have published enough research work to find a place in the "Directory of American Men of Science," 1906 edition. This publication, as is well known, contains brief biographical sketches of those who by research work have contributed somewhat to our store of knowledge. This is an average of a little more than one for each college. In number of teaching agricultural college chemists named in the Directory the north Atlantic and north central divisions lead, are about equal in numbers and together make about three fifths of the total number. The other groups are about equal and each has about half as many as each of the two groups first named. The larger proportion of names comes from the chemists in the south Atlantic division, it, out of a total of 24 chemists, having 9 names in the directory.

In the 1910–11 edition of "Who's Who in America" 31 find a place, or about one out of every 7 of the 228. This publication, now issued for the sixth time, contains the names of those who on account of their achievements in some directions have become subjects of more or less national interest. The greater number of agricultural college chemists, as in the case of the directory, comes from the north central division which is followed closely by the north Atlantic division. These two together make up three fourths of the names, the other groups of states falling very far behind.

There is still another standard for comparison. The editor of the directory referred to has prefixed a star in his valuable publication to the names of about a thousand of those whose work is supposed to be the most important. Of the 228 chemistry teachers in the agricultural colleges whose names appear in the organization list prepared by the office of experiment stations, nine appear in the directory with a star. Five of these are in the north Atlantic and four in the north central groups. There are no starred names in the south Atlantic, south central or western divisions. These figures are shown in detail in the following table.

It may be interesting to see how the chemist in the agricultural college compares with his fellow chemist, when judged by the same standard. Information is lacking as to the exact number of chemists in America. There are 4,653 resident members of the American Chemical Society, and since many are not members of that society we know that there are more chemists than that number in America. If from this number we subtract 228, the number

[2] Compiled from SCIENCE, August 19, 1910.

CHEMISTS IN AGRICULTURAL COLLEGES, TEACHING AGRICULTURAL STUDENTS, WHOSE NAMES APPEAR IN

	Bull. 224 O. E. S.	American Men of Science	Who's Who in America	Starred Names in American Men of Science
North Atlantic states...	49	14	10	5
South Atlantic states ...	24	9	2	—
North central states	73	15	13	4
South central states.....	41	7	4	—
Far western states.....	41	6	2	—
Total in United States..	228	51	31	9

of agricultural college chemists, we shall have left 4,425. The non-agricultural college chemists furnish 168 starred names, or one name out of more than 31, while the agricultural college chemists furnish one starred name out of 25. This relative standing would be considerably increased were we to make correction for the number of chemists not members of the American Chemical Society. While it is doubtless a matter of pride that the agricultural chemist is assigned such high rank among American chemists by those who are considered by the editor of "American Men of Science" as the most capable judges, this fact should serve as a stimulus to greater effort.

W. A. WITHERS

ADDENDA.—Since the reading of the above address the second edition of American Men of Science has appeared. It shows that the Agricultural College Chemists have made a net gain of 38 names in the directory and 5 starred names. They have therefore not only maintained the relative rank previously assigned them, but have improved it. The distribution is shown by the revised table.

AGRICULTURAL COLLEGE CHEMISTS

	Bulletin 224. O.E.S.	American Men of Science	Who's Who 1910–11	Amer. Men of Science. Starred. 1910
North Atlantic states...	49	19	10	6
South Atlantic states ..	24	12	2	—
North central states....	73	28	13	8
South central states....	41	13	4	—
Far western states.....	41	16	2	—
	228	88	31	14

W. A. W.

BIOLOGICAL SURVEY OF THE PANAMA CANAL ZONE

A BIOLOGICAL survey of the Panama Canal Zone is about to be undertaken under the direction of the Smithsonian Institution. In connection with all of the preliminary government surveys for transcontinental railway routes, provision was made for biological studies, and at the time of the building of the Suez Canal a scientific commission was appointed to report on the facts pertaining to the natural history of that region. When the building of the Panama Canal was undertaken by the United States appeals were made by naturalists for the organization of a similar survey of the Canal Zone. It was found, however, that the officials in charge of that work felt that the actual labor involved was so great and the cost so enormous that it was unwise to divert time or money in any way from the single purpose of constructing the canal.

Under these circumstances, Professor C. H. Eigenmann, of the University of Indiana, induced various scientific bodies, including the International Zoological Congress and the American Association for the Advancement of Science, to address memorials to the Secretary of the Smithsonian Institution urging that the work be undertaken by the great scientific institution under his direction.

Secretary Walcott considered these appeals and under his direction a meeting of representatives of the National Museum, the Bureau of Fisheries, and the Biological Survey, the Bureau of Entomology, and the Bureau of Plant Industry of the Department of Agriculture was held. Their decisions confirmed the desirability of such a survey and in consequence of their opinions he prepared the following memorandum which was submitted to President Taft: