You will do the greatest service to the state, if you shall raise not the roofs of the houses, but the souls of the citizens; for it is better that great souls should dwell in small houses than for mean slaves to lurk in great houses.

After all, it is the development of genius that is most important for the progress of the world. The lives of such men as Faraday, Liebig, Pasteur, Williard Gibbs, are of inestimable value to mankind. Though these men themselves have lived their little day and passed on, their work is immortal; and it is certain that many of the investigations carried out in the laboratories of this splendidly equipped university will still shine with undimmed luster long after these noble buildings have crumbled in decay.

The pyramids that cleave heaven's jewelled portal;
Elean-Jove's star-spangled dome; the tomb
Where rich Mausolus sleeps—are not immortal,
Nor shall escape inevitable doom.
Devouring fire and rains will mar their splendor;
The weight of years will drag the marble down;
Genius alone a name can deathless render,
And round the forehead wreathe the unfading crown.

Marston Taylor Bogert
Columbia University

THE TEACHING OF THE HISTORY OF SCIENCE

ITS PRESENT STATUS IN OUR UNIVERSITIES, COLLEGES AND TECHNICAL SCHOOLS

The significance and merit of the present investigation, while of great interest to the author, remains for those actively engaged in the work of teaching to determine. It is only recently that any great indication of a change in method in science teaching in our higher institutions has been manifested. They have found that "science," as a means of education, assumes a broader aspect in courses upon the history of scientific progress—such as those originated by Harvard University and the Massachusetts Institute of Technology. Proof of the coming change can be seen in the character and number of critical reports and articles appearing in the various scientific and educational journals. For those who seek further enlightenment, a short bibliography will be found appended.

This paper is divided into two parts, namely, the arguments regarding the intrinsic value of the history of science as a study and as a factor in educational efficiency. These arguments are supported by citations from erudite men, active in the promotion of scientific training. The second division contains facts, tables and other material necessary to show the present condition and trend of the subject, and if possible to validate the arguments upon the value of a course in history of science as a whole, over courses in the more specific fields—as the history of chemistry, or astronomy, etc.

I

The discussion centering about a course which should give some idea of the history of science as a whole is of comparatively recent date, at least in this country. It arose in the demand of a small body of progressive scientific men for a study that would give our students (scientific and technical) something more than mere facts, theory and technic, in solving problems. We have heard too much of the orthodoxy of science, its over-specialization, and (as one of our foremost philosophers has put it) a certain amount of crudeness and pettiness in our methods and opinions concerning problems in science—at least in comparison with European scholars.

During the last decade of our scientific progress there has come about a development and reaction from the extreme and powerful method of specialization, both in methods of research and in teaching, whereby stress is laid upon the cultural and broadening effects in scientific study—the learning of principles and not mere facts. One factor in this development, though not seemingly important in the past, is now demanding its full recognition, the *teaching* of science from the *historical* point of view, not entirely from the economic or problem-solving reasons—the historical development of the principles, the evolution of science itself, showing correlation and interrelation between the most simple and the most

complex concepts. This then may be assumed to be the purpose and intent of the study of the history of science, or as Dr. H. C. Brown, of the philosophy department (Stanford University), states it, it shows a growing recognition of the value of mind. Intelligence was a plaything for the ancients, a consolation for the medievals, but an instrument for the modern.

In the words of Dr. C. R. Mann, of the University of Chicago:[1]

> One immediate consequence of this sort of historical study would be the much-desired humanizing of science, for we should be compelled to recognize the various ways in which science has cooperated with the other phases of human activities in bringing us into our present condition.

The theory of Dr. Wilhelm Ostwald[2] is that "the history of the sciences offers the best and most authoritative material for the study of law in the evolution of mankind." Further, as Professor Ostwald sees it, the history of science is not merely history for its own sake, but a new method of study, a new way of getting at the results of research.

From John Fiske in his study of evolution as a method of study,[3] we find these precepts:

> Study the present in the light of the past. The easy work of science is mostly done. Those who would continue work must study, not living objects, but laws that govern them. Whether planets or mountains or molluscs or subjunctive modes, or tribal confederacies, be the things studied, the scholars who have studied them most fruitfully were those who have studied them as phases of development. Their work has directed the currents of thought.

Ostwald[4] emphasizes the importance of historical study as an interpreter of the interrelationship of science and life:

> The nineteenth century was too full of creative work in the various fields of science to give historical studies their full play. The new century, on the other hand, though it has achieved already some very remarkable results in the way of positive additions to our knowledge of the forces of nature, will offer a larger field for historical studies, for the reason that the practical value of such studies will be more clearly demonstrated. The author deprecates the idea that pure science can have no connection with life. The great investigators, he says, "were almost without exception in their younger days passionately enthusiastic over some concrete, practical aim, and it was in the course of the further and higher development of these problems (which indeed followed rapidly upon one another) that they themselves attained a wider and higher point of view. The tree of knowledge raises its crown high in the ether of pure science, but it is rooted in the firm ground of human needs and activities.

Pres. Henry S. Pritchett,[5] after discoursing upon the progress of science in past ages, and especially upon the larger aspect of science from the middle of the nineteenth century to the beginning of the twentieth, brings out the fundamental contrasts which stand out most prominently:

> First, the last fifty years have seen a greater betterment of the theoretical basis of physical science. Second, this development has been marked by a notable stimulation of scientific research, a differentiation of scientific effort, and the creation thereby of a great number of special sciences or departments of science. Third, the possession of a secured theoretical basis and the intellectual quickening which has followed it have resulted in the application of science to the arts and to the industries in such measure as the world has never before known. These applications have to do with the comfort, health, pleasure and happiness of the human race, and affect vitally all the conditions of modern life. Fourth, perhaps in many respects the most significant of all, is the effect which has been produced upon the religious faith and the philosophy of life of the civilized world by the widespread introduction of what may be called the modern scientific spirit.

Lastly, here we may add perhaps the most fundamental principle, which should also be vital indeed in the purpose of the study of the

[1] "The History of Science, an Interpretation," *Pop. Sci. Mo.*, April, 1906, Vol. 76.

[2] See introduction to his book, "Die Entwicklung der Electrochemie."

[3] Quoted from excerpts in Dr. D. S. Jordan's "Syllabus on Evolution," 1895, pp. 4–5.

[4] Quoted from a review of his book, "Die Entwicklung der Electrochemie" (Leipzig, J. A. Barth), in *The Nation*, Vol. 90, p. 637, June 23, 1910.

[5] *Atlantic Monthly*, November, 1907, p. 614.

history of science—namely the development of the scientific concepts or ideas (see Ostwald's "Naturphilosophie") and the methods evolving such.

Up to the present time the range and domain of science includes all that is of nature, and from her the four great interrelating principles have been evolved. Manifestly, they are well known, but for contemporary testimony they will be restated. Dr. W J McGee[6] has termed them "the four cardinal principles of science—namely, the indestructibility of matter, the persistence of motion, the development of species, and the uniformity of nature." The philosophy of each of these accepted doctrines is the history of science.

It is interesting at this point to note the following ideas from a powerful article by Dr. J. F. Woodhull:[7]

> Culture courses, or information courses, are often spoken of scornfully as a smattering of all the 'ologies.
>
> Science culture differs in its methods from the old classical culture, but it has the same spirit and same object.
>
> The weakest thing about our research to-day is that our men are not widely informed.
>
> Davy, Faraday, Tyndall, Pasteur, Humboldt, Huxley, Maxwell, Agassiz, Cooke, Shaler, Newcomb, all preached the doctrine that science is good for culture and should be given to all.
>
> Value scientific courses—not simply because they cultivate the perception and reasoning faculties, but because they fill the mind with lofty ideals, elevated conceptions and noble thoughts; indeed there is no better school in which to train the esthetic faculties of the mind—taste and imagination—than the study of natural science.
>
> The history of science tells of a multitude who have worked in faith for the love of knowledge, and made themselves and their fellows more noble men.

The history of science is referred to here as including all the divisions of pure science, not emphasizing one over another, nor one apart from another (as, for instance, physical and biological). No matter what particular specialty he chooses, the whole field of science is to the student of science vital and important. In this manner its history will comprehend what relations exist between the development of the various subjects in various periods, the correlation of these divisions and their advances, the problems of science, and lastly, the evolution of the sciences, all will be to him an intellectual pleasure and a noteworthy part of his training and education.

[6] Washington Academy of Science *Proceedings*, Vol. II., pp. 1–12, 1900.

[7] "Science for Culture," *School Review*, Vol. 15, p. 123, February, 1907.

II

The problem this paper is attempting to consider is twofold: First, to show somewhat the historical development of these courses in the history of science; second, to argue that although a course in the history of a specific subject may be desirable, it does not possess the value and merit in education that a strong and well-developed general history of science has. It will be also shown that such a course is the most economical in regard to time, service to the university authorities, and service to the student. Various single courses can be combined and correlated, to make one course (general) for 3 or 4 hours throughout the year.

In America the early history of the development of the science instruction in our higher schools is one certainly important, and possessing interesting characteristics; and the history of the courses upon the history of science—general and specific—has had almost a parallel treatment.

The early development of this movement can be traced from the crude materialism of the older physicists in Europe, to about 1880. In the following few years the period of overspecialization was coming to a climax, and with this, an undercurrent of idealistic and critical tendencies in scientific thoughts was being manifested. Probably the first conscious indication of interest in the history of science dates back to 1883, when "Die Mechanik in ihrer Entwickelung, historisch-kritisch dargestellt," by Dr. Ernst Mach, first made its appearance, followed by Karl Pearson's "The Grammar of Science" (1892) and in Germany by Dr. Wilhelm Ostwald's "Naturphilosophie." In France Henri Poincaré's work

has its influence and bearing, and in Italy Anton Favaro.

Out of this critical-idealistic tendency to react from the materialism of science grew the idealistic-historical movement. This is sometimes thought of as the synthetical and generalizing phase in scientific learning. The effect of that movement in this country was slight at best, but a beginning had been made in Harvard University by Dr. Richard in 1890, and in the Massachusetts Institute of Technology by Dr. Sedgwick and Dr. Cross, somewhat earlier. Dr. Richard's course was a series of voluntary lectures upon chemical philosophy, but it was virtually a course upon the history of chemistry. Later, receiving official recognition, it changed to its present title—historical development of chemical theory and elementary physical chemistry. From this grew out (1911) the present courses in the history of the physical and biological sciences given by Dr. L. J. Henderson.

The development of the courses by Dr. Sedgwick had somewhat similar progress. In 1887 he offered a course of twelve popular evening lectures upon the history of biology; later this was transferred to the regular institute curriculum, and became known as the history of the natural sciences. Also in the same year Professor Cross gave to the seniors a reading course on the history of the physical sciences, requiring French and German as well as elementary physics and laboratory work as prerequisites. It was not until 1905 that these courses were combined and given as a regular course called history of science—offered by Professors Sedgwick and Tyler.

In 1879–80 at Johns Hopkins University a course of twelve lectures upon the history of chemistry was given, but in such a manner that it has never been considered a regular and definite course.

An interesting fact, again manifested here, is that most of our pioneering in intellectual activities inevitably has its origin in the older New England institutions. To Harvard University belongs the credit of first establishing a definite and systematic course in the history of a special field in science, and to Massachusetts Institute of Technology, the recognition of the more general field in the historical work in science. That the authorities of Harvard have fully recognized the value and purpose of this new advancement in science teaching, is revealed, not alone by the establishment of the history of science as an independent "group" in their curriculum, but in doing something of a missionary character, as well. This is a very notable instance in educational progress. Dr. L. J. Henderson was, during the past semester, the exchange professor to five middle-Western colleges—Beloit, Carleton, Colorado, Grinnell and Knox. At each of these institutions he gave a course of twelve lectures upon the history of science. The order and sequence in which they were established and given are excellent, and therefore a copy of the lecture-series is here added:

1. What is Science?
2. Ancient Astronomy and Its Importance.
3. Ancient Physics.
4. Ancient and Modern Science.
5. Harvey and the Renaissance of Biology.
6. Galileo to Newton, and the Renaissance of Mechanics.
7. The Seventeenth Century.
8. The Eighteenth Century.

9–10. The Great Synthesis of the Nineteenth Century.

11. The Industrial Revolution and the Scientific Revolution.
12. The Value of Science.

Having now shown in brief what the beginnings of this movement were, it will be of further interest to trace it through the few other schools to the present. We are still to bear in mind that the specific courses *only* are being considered; the general history of science courses are of late origin, and exist only in a few schools. The response to this new phase of science instruction was slow, in many cases irregular, and in some cases indifferently considered. This fluctuation is only apparent in the older schools in the early period—as, for instance, when the history of astronomy was once given, it is now discontinued, and *vice versa*. In 1892–93 Yale University first offered a course in the history of mathematics

and in astronomy; both were discontinued, and to-day there is established a course in the history of biology. The University of Chicago likewise in the same year announced courses in the history of astronomy and of chemistry, but several years later these were discontinued.

The effort to keep up this work at the University of Chicago has never ceased, however; we find the history of physics and of geology offered, as well as a course in the history of geography (which of course is not a pure science subject). At the same university the scientific faculty attempt to institute a very unique and ambitious plan for the fostering and development of the historical courses in science. A letter from Dr. F. R. Moulton explains it:

> The department of philosophy was to initiate the system by giving an introductory course in Ancient Science, developing it to about Galileo's time. From here the following departments (mathematics, physics, chemistry, astronomy, biology and geology) were to carry over the modern period of science in their particular fields.

These courses were to be correlated, and so given as to form a large and orderly sequence in the history of science. The one difficulty in the scheme, Dr. Moulton writes, is that it was impossible to get the same students to continue throughout the year; and worse still, the methods of the different professors were so diverse that there was really no continuity in the discussion. The plan has now been abandoned. But for a substitute there has been developed an excellent series of courses by Dr. G. H. Mead in the philosophy department, on a closely allied subject—the history of the ancient and modern scientific concepts.

In time a number of other schools followed —Universities of Pennsylvania, Cornell, Illinois, Michigan, Northwestern, Stanford and California. This response was felt to be necessary in the west as well as in the east, and California and Stanford have maintained it consistently. From 1895 to date a course in the history of chemistry has been offered at the University of California, with slight and varying degree of success. In the department of astronomy from 1896 to date, the historical course has been found to be in greater demand, whereas the history of mathematics was given only for a period of three years. Stanford University has, from the time of its foundation (1891), offered a course in the history of chemistry almost continuously, except that of late it has been given in alternate years. The course in the history of physics has been abandoned. Instead, however, a "Journal" course is given with the same idea, *i. e.*, discussing certain epoch-making problems in physics, from the historical point of view.

A further study of the individual colleges and universities will reveal a like condition regarding the changeable character of historical studies in the science departments, and the reasons for this are many, apparent to the individual schools themselves; namely, lack of students, lack of interest, improper correlation and requirements, and no ideals of what constitutes true breadth of culture and efficiency in scientific training. A very noticeable and astonishing neglect exists in a number of our larger schools, in which one naturally would expect greater efficiency and continuity. They omit entirely the historical treatment of some of their strongest scientific departments. A historical course should certainly be given in the departments where some degree of strength and prominence has been attained. California and Michigan in astronomy, Harvard in chemistry, Chicago in physics and mathematics, have carried this idea out partly.

A study of the conditions in smaller schools is naturally not very different from the larger, except in the total number of courses offered, as well as the types, which center around the physical sciences.

In order to obtain a scientific account of the present trend of the historical courses given, a statistical study was first undertaken, which was divided into three parts by grouping the universities, colleges and technical schools.[8] There are about 600 higher institutions of learning in the country, and it was found impractical and unwise to use the entire number for this particular study. It is also untrust-

[8] Selected from the Report of U. S. Commissioner of Education, 1913, Vol. II., pp. 193–209.

worthy, for comparative study, to segregate universities from colleges. Therefore some means of standardizing was resorted to, in order to eliminate schools having no concern in the discussion, such as theological seminaries, trade schools and preparatory schools. The problem was very much simplified by rating the efficiency and high educational qualities of a school, not by numbers in registration, but by the quality and type of instruction, the work given, and by library facilities and accessions. The first element was easily determined by using the accepted list of schools, as passed by the Association of American Universities for the Prussian Kulturministerium.[9] These schools will be known as the association group. The second group is the library standard group, containing colleges whose library accessions are over 10,000 volumes. The reason for making this limit was that equipment and not large student body was to determine the strength of the school. A school of from 300 to 500 students and library of 5,000 volumes did not compare with a school of from 200 to 400 students and 10,000 volumes. The third division will be called the technical group, composed of about 50 of the technical, agricultural and mechanical arts colleges.

At best, these three groups are arbitrary divisions, but they will serve the purpose of this study.

Of this list of over 600 schools, more than 500 catalogues and college curricula were examined thoroughly, and the information desired was found in some 350 catalogues, of schools conforming with the above restrictions. In all cases the information was taken from the latest catalogues—either 1914–15 or 1915–16—except in a few instances. The facts searched for are as follows:

(*a*) Type of historical courses—general, physics, chemistry, etc.

(*b*) Hours of lectures, whether given in one semester or both; or alternate years.

(*c*) Graduate study and requirements for "majors" in departments.

[9] See *Educational Review*, December, 1913, p. 510–518.

(*d*) Other facts bearing upon this discussion.

The arrangement of the statistics gathered together in this paper is for the purpose of showing what each institution is doing. One can, for example, see at a glance what work is offered at Chicago or Harvard, and compare it with courses in other institutions. While this study is as scientific as it was possible for the writer to secure reliable data, it must be taken with some consideration of the probable errors existing. It was found in at least four to six cases, through special correspondence, that a number of courses were offered in the catalogues, but not actually given for various reasons. Another interesting fact regarding these figures, which on first assumption might indicate a definite policy of the colleges concerned, and one which parallels with the attempts of the University of Chicago plan, is that there appears to be a continuity in some of these courses, which in reality does not exist. For example, a college may offer a series of three or four history courses in the specific sciences; these are not correlated, and they are not completed by courses of the same type in the remaining sciences. The schools having this apparent arrangement of continuity of courses (see Table III.) are Alleghany, Carleton, Columbia, Iowa State, Mt. Holyoke, California, Illinois, Michigan, Pennsylvania and Pittsburgh. The criticisms of such a continuity are well sustained by Professor F. R. Moulton. However, a small college may succeed in this where it is better adapted to alternate its courses. If this could be accomplished, no doubt there are educational factors of merit in such a system, that are not to be had in a single general history course—namely, a more comprehensive treatment of the special subject, and a study of the development of its theories and technic.

Table I. is an analysis of the data gathered from the principal or association group. The subject-matter is arranged for a comparative study of courses, hours of lectures, and class enrollment. Column one contains the list of nine subjects comprising pure science, technically speaking; column two, the total num-

ber of courses in each subject in this particular group; in three and four are the number of half and full courses offered (column two is the sum of both); column five contains the total number of hours devoted to lecturing or instruction, and in six and seven are the average number of hours per course and average number of students per course.

TABLE I

Group Ia (Association Standard)—113 Schools

Subjects	Total No. Courses	½ Semester Courses	Full Yr. Courses	Total No. Hrs. of Instruction.	Average No. Hrs. per Course per Wk.	Average No Students per Course
Math.....	47	27	20	113	2.4	14
Physics..	19	10	9	31	1.6	7
Chem....	38	17	21	74	1.9	13
Astron...	13	11	2	33	2.5	9
Geology..	4	4	—	12	3.0	3
Biology..	14[10]	6	8	28	2.0	8
Botany..	4	2	2	12	3.0	2
Zoology..	17[10]	17	—	36	2.1	—
Psychol..	6	6	—	16	2.6	—
	162[11]	100	62	355	2.3	8.0
General history of science	14[12]	9	5	30	3.0	51.0

In the total number of courses offered in the 113 schools, two subjects stand out more prominently than all others—mathematics and chemistry. The explanation of this condition is to be found by a study of the catalogues of courses themselves and of the answers to questionnaires sent out. The subjects reveal two differing points of view, though both are, apparently, desired by students.

In the case of mathematics, the large number of courses offered is due to the fact that the teaching methods (especially those for the elementary teacher) are taught in combination with the history of the subject. The largest class enrollment in the history of mathematics is found to be at Teachers' College, Columbia University; it is given by Dr. David Eugene Smith. The average for four years (1910–14) was 54 students. In consideration of the average large class attendance (14—the range being 2 to 54) it is to be inferred that the course is primarily adapted for teachers or those preparing to teach.

In the case of chemistry the conditions differ decidedly. The total number of courses is 38, and from the general expression of opinion regarding its place in the curriculum, the history of chemistry is given solely for its intrinsic value. This value is expressed in educational terms as culture, breadth of chemical learning; it is also given with a great deal of philosophic interest by the instructors concerned. And in only one case is it offered and not given. Here again the class enrollment is high, 13 being the average attendance, and the range, from 1 to 85. This largest class in the history of chemistry for the five years, 1910–15, was composed of 85 students under Dr. Theodore W. Richards, at Harvard. The value and interest of such a course tend also to increase, judging from the answers received to the questionnaire, the larger class attendance, and the fact that a number of half-year and alternate-year courses are breaking down to a regular full-year course. These give credit for two hours each semester, which seems to be the average time for a lecture course.

There are probably only two reasons to be advanced for this state of affairs in chemistry. In the history of chemistry, beside its broad philosophic interest, the subject itself involves more of the fundamentals of other sciences, and consequently approaches the realm of the more general history of science, thereby appealing to the interest of the scientific students. Before passing, it might be well to mention a one-hour course given in the University of Pennsylvania on the history of chemistry in America, by Provost Smith. This course was instituted in 1908; it is primarily for graduates. A course in the general history of chemistry is also given; it had its beginning in 1896.

Taking up our next largest subject from the point of view of numbers, we find physics offered in 19 schools in this group. Here the study reveals a decided and strong reversal of

[10] Courses in *Evolution* included.

[11] Almost 15 per cent. of these are given in alternate years.

[12] Five of this number are Harvard Exchange lectures.

conditions from those found in the preceding two subjects; in fact, the remaining subjects—astronomy, geology and the biological sciences, though not so large in numbers of schools represented, and class attendance—do not show indifference to the teaching, value and purpose of the course—that is, in the majority of cases. In the teaching of the history of physics this condition is marked; and for such a subject, known to be one of the fundamental sciences, this attitude is not to be expected; the study should approach chemistry in its higher educational value.

As it is, 19 courses are offered in this group of 113 schools; of these, six courses have been dropped, or are to be discontinued, and in addition, in two cases they are represented in the catalogue, but not given. The average class attendance is small (7; the range being 1–12), being half of the first two subjects mentioned.

The next study of special interest is astronomy. Here we have a subject involving other features not included in the first three fundamental sciences. In considering the small total number of schools offering astronomy (15) we must bear in mind that this is a highly technical and specialized subject, requiring expensive instrumental equipment, and that it is therefore not to be found in many curricula. If at all, it is usually represented only by a single course—a general descriptive course, and going beyond the observatory visits only in the larger schools.

This number (15) is reduced to 13, for in two schools it was discovered that instead of a history of astronomy, the history of nautical astronomy and the history of geodesy were given. The average class was found to be 9 students, with a range from 2 to 43. The relation this large class attendance of 43 (five years' average) has to the prominence of the department (University of California astronomical department, with Lick Observatory) is probably well explained by the cases already cited (mathematics in Columbia and chemistry in Harvard). As to the strength of the cultural value astronomy and its history has, all scholars agree.

Combining the study of botany and zoology with biology, we have here again a very interesting situation. The actual number of history courses in these subjects is small in comparison with the other courses, but in the number of students they are fair. Over 75 per cent. of these courses are represented by a course in evolution, history and theory. The reason for this inclusion is probably one personal to the writer; but, from his experience, it is a just reason. At two different times he has taken a course upon the theory of evolution from the biological and philosophical departments, and in each case the historical method was strongly emphasized. Probably in all the history of thought no greater principle has been discovered and developed than the doctrine and theory of evolution. One can not study evolution unless the principal factors of biology are considered, and these have a historical antecedence or sequence; and *vice versa,* one can not study biology unless he constantly bears in mind the evolutionary principles involved.

In the matter of the interest and theories of those teaching, there is a firm desire to advance this subject. From the small percentage of returned answers the figures do not represent actual conditions, but as a whole no doubt, they are fairly good. At Northwestern University a course is being given which, according to the title[13] and other information regarding methods of conducting the course, bears evidence of decided value. The class (1913–14) had a total of 13 students, with a good percentage of graduates. According to another letter, from Whitman College (Walla Walla, Wash.), Professor H. S. Brode offers a series of well-selected and comprehensive lectures on the history of biology, in conjunction with the general course—the attendance in class being on the average, 30. The reason for mentioning these special courses is to show recognition of their value, and the spirit of interest found alike in different types of schools—large and small. In Yale University in the department of zoology, we find again a valuable

[13] "Source of Biological Ideas, from the Revival of Learning to the Present," by Dr. W. A. Locy.

course on the history of biology given by Dr. L. L. Woodruff as a graduate course. From 1908 to 1915 it has been offered five times, with an average of 6 graduate students, out of a department list of approximately 12 graduate students. Advanced students in biology from the college are admitted by the consent of the instructor. Bryn Mawr College offers an interesting course entitled historical biology. It is partly lecture and laboratory work, including a critical analysis of the theory of evolution.

The courses in evolution by itself, its history, theory and relation to other fields of thought through the historical development, will not be discussed here. Their importance to this field of the history of thought has a larger bearing than is at first inferred, and therefore these courses were included in this study as possessing merit.

The study of the history of botany is offered in four schools—University of Chicago (a 5-hours' quarterly course). Johns Hopkins University (3 hours), Mt. Holyoke (3), and Smith College (2). In the University of Chicago, the course is given as a seminar by Dr. John Coulter. He sounds the keynote of all historical courses, in desiring to give the students a historical background in their field of study. Johns Hopkins has a course of a type distinct from others in that it takes up special topics and discusses their historical sequence. At Smith College Dr. W. F. Ganong has offered a course for five years, which was not actually given because not enough students elected it. However, he is convinced that the historical basis of science is very desirable, and in view of such, he writes that one of his teachers was assigned to study the history of botany as a specialty, and at the same time was to collect the botanical classics.

Concerning the remaining two topics—geology and psychology—nothing of any great value was found, except in the case of geology. Two courses were offered and not given—not from lack of teaching interest, but from lack of students. University of Chicago's plan is a seminar. At Princeton University, though no formal lectures are offered, the graduate student is required to read before graduation a selected number of books, of which two are historical.[14] In the University of Michigan, the course is a small seminar for advanced students, given only once (to 3 students), but offered again this coming year—1915–16. Professor W. H. Hobbs writes, however, in a very optimistic tone; he says that the subject is susceptible of presentation to large classes along broad lines, with great profit.

Some geologists believe that the historical phase of their subject is better taken up as outside, independent reading—that teaching of the technic is of greater value (as regards the instructor's time) than lecturing upon history. The author is inclined to differ from this opinion. The average student would rather listen to lectures and spend the spare outside time upon the non-essentials of life.

In this investigation, psychology was included too late to send out questionnaires and make such further study as was necessary. The history of psychology is comparatively a new study; in fact, the subject itself has only recently been established as a science. Heretofore its destiny has been controlled by the philosophy department, and to a great extent it is even yet. But the importance of the subject is gradually attaining the dignity of an independent science, in the same degree as mathematics, physics, etc. Therefore, although the research in the records of this subject is not as wide as in some of the others, a brief survey of a few courses will be given.

Six schools of group I., and one school of group II., offer this subject with its historical significance—Harvard, Chicago, Clark, Mt. Holyoke, Illinois and Michigan. The course offered at Harvard is practically an advanced one, and open only to students who have taken four other courses in the department. It lays special emphasis on those portions of the history which are of great importance to the understanding of psychology's concepts and problems. Chicago apparently places great stress upon this subject; in the annual catalogue for 1913–14 are listed three separate

[14] Geikie, "Founders of Geology," Merrill, "History of American Geology."

courses—the "History of British Psychology," the "History of German Psychology," and "American and French Psychologists" (for graduate students). Michigan has a course entitled the "History of Modern Psychology," primarily for graduates.

In summing up the results of this study in the specific historical courses (as given in group I. *a*, Table I.) and comparing them with the study of the general historical courses, and also with the study of the other two groups (I. *b* and I. *c*) the figures themselves seem to be arguments that establish the validity and the greater merits of the general history of science course for all groups of schools. This statement is made, notwithstanding the fact that the percentage of successfully conducted courses in the specific group is probably large.

We have in the total number of courses offered in group I. *a*, 162 courses (not including seven unrelated courses previously noted). Of this number, 100 are half-year courses, and 62 full-year courses, with a total of 355 hours of instruction, thus giving an average of 2.3 hours per course, with 8.0 students as average class enrollment. Also we find, of the 162 courses and 113 schools, an average of 1.4 courses per school.

Considering now, briefly, what the figures are concerning the history of science in general, we have some telling facts. The comparison may not seem to be exactly fair, because the more general subjects are only found in the larger institutions (not including the Harvard Exchange lectures), as against the large number of smaller schools offering special courses. However, for a general study of the trend of the movement, we must look to the larger schools, and therefore this comparison may answer our purpose. In this group there are 14 general history courses, and from these 5 constitute the Harvard Exchange lectureship, which, according to the terms of exchange, is only temporary; the subject-matter changes with professor and department. The course at Throop College of Technology (a third group school) was discontinued or crowded out. Reed College presents a different type of historical course, which is not to be considered a complete course, the historical treatment being combined with a general science course. Lehigh University has a course which is a combination of the biographies and the progress of science—1 hour, 1 semester. Pennsylvania's course is given by the philosophy department, and is known as "The Philosophy of Nature." Chicago and Columbia both offer courses for the quarterly and half-year terms, in the history of the physical sciences; at Chicago Dr. Mann attempts to consider something of the history of science in America. The remaining four larger schools —Harvard, Princeton, Carnegie Institute of Technology and Massachusetts Institute of Technology offer complete courses in the history of the physical and biological sciences. In the last few years the Carnegie Institute of Technology has manifested a great activity in the general aspect of this study. Last year a course on the philosophy of science was offered, and a new, more general course upon the history of science is being planned.

The number of the smaller schools interested is encouraging, and indicates progress: Hamline University, Hunter College, Simmons College, Massachusetts Agricultural College and University of Cincinnati.

TABLE II

	General Courses (Groups I *a*, I *b*, I *c*)	Specific Courses (Group I *a*)
Total numbers of courses	20	162
Total numbers of hours	42	355
Av. numbers of hours per course.	2.2	2.3
Av. nos. of students per course.	39	8.0
Av. nos. of courses per school.	1.0	1.4

On further analysis of the subjects, represented in group I. *a*, *b*, *c*, it can be shown (by dividing these courses into physical and biological groups—exclusive of mathematics) that the average number of hours for instruction throughout the year of each, is 2.2 hours and 2.4 hours. The average number of students for the physical group is larger than the biological group. Comparing the figures of the two divisions given in Table II., we find the

relative proportion is about the same as far as the number of hours per course is concerned; but the attendance per class in the general history of science figures is decidedly in the advance. The "specific" class enrollment of 8 students shows that the course is limited, that it is for those *prepared* to take it; whereas the "general" class enrollment is 39 students. This is, of course, the average of 8 schools; it was not possible to get figures for the balance, and therefore it would be unfair to assume that this was the average for 20 schools. It is probable, however, that this average could not alter very greatly were the entire list of figures to be had. It shows, too, that the value of the subject appeals to a large number of students, providing the question arises, "Does the size of the class indicate the general approval of such a course?"

Taking also the average hours per course from the first 8—or the largest schools—we have 3 hours, which is approximately the proper number of hours for a course of this type. Of course, all of these courses represented are not full history of science courses, as later discussion will show; but they approach the type of course advocated, namely the Harvard plan. And as far as it is possible to show by this study, the Harvard type fulfils the ideal requirements, both in treatment, number of hours for lectures, size of class, and requirements. With an advanced course in the nature of a seminar, the study would be practically complete, for those who wished to follow the subject further.

Having mentioned the subject of continuity of courses, the following table, containing schools, courses and hours of lectures, is given for further discussion.

In Table III. are listed those schools having three or more subjects bearing upon a number of particular historical courses in science. The reason for selecting these is that it takes at least that number to constitute a well-balanced continuous course in the history of the physical sciences—those three to be, preferably, mathematics, physics and chemistry. The grouping given in the table is composed of all possible arrangements of subject-matter, including the biological sciences.

TABLE III

(Group Studies, Good Substitutes for a General Course: Mathematics, Physics, Biology—Zoology and Botany—Included.)

Schools	No. of Courses	Subjects	Total Hrs.	Av. Hrs. per Course.
Allegheny....	4	Astr. Phys. Chem. Biol.	6	1.5
Bryn Mawr...	3	Math. Phys. Biol.	5	1.6
Columbia.....	3	Math. Astr. Chem.	7	2.3
Indiana.....	4	Math. Phys. Biol. Bot.	13	3.1
Iowa State ...	3	Math. Phys. Chem.	6	2.0
Mt. Holyoke .	5	Math. Astr. Phys. Chem. Bot.	11	2.2
Univ. of Calif.	4	Math. Astr. Phys. Chem.	9	2.2
Illinois.....	3	Math. Phys. Chem.	5	1.6
Michigan.....	4	Math. Astr. Chem. Geology (4)	10	2.5
Pennsylvania .	4	Math. Astr. Phys. Chem.	8	2.0
Pittsburgh....	3	Math. Chem. Astr.	7	2.3
Wisconsin....	3	Math. Chem. Zool.	5	1.6
		Average.....	...	2.7

Assuming that continuity and system were established in these courses, we should have no further argument as to their worth. But as a matter of fact, as far as it was possible to ascertain, no such condition existed in any case.

The class attendance in every case was not obtained, so that this phase of the problem is omitted. However, from the point of view of hours of instruction, the average was found to be little more than two hours (2.7). In all cases we are referring to the regular periods of instruction, namely, weekly recitations, etc. It is evident that the figure given does not satisfy the average requirement for standard (3 hours a week, general course) and can not in this sense be substituted as equal.

Probably better results would have been obtained had the investigation gone further into the question regarding the percentage of students in the scientific department of each school who took the historical course, and those who did not take the course. It was planned to work this problem along such lines,

but it was found that too many questions in the circular letter would be discouraging to those asked to fill them out, especially at a time shortly before the commencement period.

Having considered the study only in one group of schools, let us for a moment give a brief summary of the subject and its status in other groups (I. *b* and I. *c*) and compare with the first (I. *a*). Though no great results are to be expected in this comparison, sufficient interest is there to warrant setting off this table into three parts.

In regard to the total number of specific courses, we have this proportion: 27 per cent. of the courses are in the history of mathematics; 22 per cent. in the history of chemistry; approximately 9 per cent. in the history of physics; 5 per cent. in that of astronomy; 2 per cent. in history of geology; 7 per cent. in history of biology; 6 per cent. in history of zoology, and 2 per cent. in history of botany; 20 per cent. in the history of science, philosophy of science and psychology.

Restated, we have the figures: 65 per cent.

TABLE IV

Schools	No. Schools	Gen. Hist.	Math.	Phys.	Chem.	Astr.	Geol.	Biol.	Bot.	Zool.	Psych.	Phil. of S.	Total No. Courses	Miscel. Hist. Courses
Group I. *a*—Association	113	14	47	19	38	13	4	14	4	17	6	27	202	Hist. of geodesy Hist. of naut. astr. 3 courses hist. of forestry.
Group I. *b*—Library.....	189	3	42	11	26	4	3	9	2	5	1	6	112	2 courses hist. of geogr.
Group I. *c*—Technical.....	50	3	3	2	10	0	0	1	0	1	0	1	22	Hist. of engineering Hist. of mech. engineering Hist. of heat engineering.
Total.....	352	20	92	32	74	17	7	24	6	23	7	34	336	

From the best source,[15] the number of universities, colleges and technical schools in the United States is 598; of this number we have listed 352. The balance (246) came within the restrictions placed upon them. Of the 352 schools having courses in almost all of the sciences, 224 schools offer courses treating of the history of science (both general and specific subjects); 128 schools do not. In other words, approximately 63 per cent. of the schools listed have 336 courses—or, 37 per cent. of all the schools (598) have 336 courses. However, the basis of our calculation will be the schools given in Table IV.—352 schools and 336 courses.

Group I., 113 schools, has 60 per cent. of the courses.

Group II., 189 schools, has 33 per cent. of the courses.

Group III., 50 schools, has 7 per cent. of the courses.

[15] U. S. Commission Report, 1913.

of the courses in the physical sciences, and 15 per cent. in the biological group (including the history of evolution). The question is, then, is there more emphasis placed upon the physical group than on the biological? One is impressed, after studying Table III. and the notes following, and Table IV., with the idea that there seems to be a tendency in that direction.

This study can not properly close without at least indicating the general methods of presenting these courses in the classroom. There is no one method predominating, but in general the two prevailing methods show a natural and progressive tendency in academic instruction.

Whenever a text-book is published upon a special history of physics, mathematics, etc., it was noted that its topics are presented by the text-book with the aid of lectures and papers. When the subject is for advanced students, the seminar, reports, and references to

classical memoirs, etc., are resorted to. With few exceptions, all of the combined continuous courses just discussed are being carried out in this way.

At Harvard, Dr. Richard's method in "Historical Development of Chemistry" has decided merit, for its unique treatment. To quote from him:

> The course is conducted by a series of lectures, in which the main topics are written upon the board, somewhat after the manner of a syllabus. The students are forced to do some reading by a system of extempore theses, according to a plan outlined in a paper entitled "A Partial Substitute for Examination"—see *Educational Review*, November, 1908.

Attention was called in a former paper[16] to the bibliographical material in the field of the history of science. It was chiefly foreign publications, of a periodical nature. Here, attention should be directed to a special bibliography which every man, in science especially, should have in his library—namely, the "John Crerar Library List of Books in the History of Science," by A. G. S. Josephson, cataloguer (Chicago, 1911). To this a supplement is being prepared, and as a companion volume there is soon to appear a "List of Books on the History of Industry and Industrial Art." Such a volume upon the desk of any scholar in science, after he has perused its contents, can not fail to reveal to him the vast importance of his own and allied subjects—not merely as a specialist, but as a student of human affairs.

CONCLUSION

Notwithstanding the present status of the greater number of courses upon the history of science in a special field (as was shown in Table IV.), it remains to note the tendencies of progress. In so doing, this paper will conclude with a brief summary of a few replies received from men prominent in science, philosophy and education, upon the question of the intrinsic value and the future of the history course in science.

From the facts as they have been deduced in the discussion of Table I. and Table IV., there is strong evidence of the probability that the specific courses are losing favor (with the exception of chemistry and mathematics, for reasons already given, and of isolated cases in the other subjects) and that the general course is coming to be the accepted standard for history in science. The slight significance of the history of the several sciences is probably the best argument for the more general history course.

Therefore, as the figures now stand, it would seem that it is far more advantageous to offer a course of three hours throughout the year with a larger class enrollment in the general subject, than to have so many scattering courses offered with an average of two hours, and a very small class attendance. From the point of view of efficiency in educational administration, and educational values, both in the instructors' and students' interest, the general course is far more desirable.

The salient points of the value and importance of a course, such as its use for culture, general depth, breadth of scientific knowledge, and training, were all brought out on the introduction of this paper. And as far as further study of the subject is concerned, a list of short articles will be found appended as a bibliography of the subject.

It is evident from the inherent nature of the specific history course in science (such as physics, chemistry, etc.) that it has value only for a limited number of students. Whereas the course of the more general history of science, treated broadly and thoroughly, has a far greater application and merit—and affects a larger number of students. The methods of treatment in both cases vary only in the degree of application, and not essentially in subject-matter, except in the amount considered vital to a well-developed course. For example, take the history of chemistry. In such a course the instructor can with proper allowance (for the confines of all specific courses are restricted more or less) dwell upon the history of chemical theories in a far larger sense than it is possible or practical to do in the more general history of science course. He can also en-

[16] See Science, N. S., Vol. XLI., pp. 358–360 (1915).

large upon the technic of its methods, give a more minute examination to the development of chemical concepts (historically), and finally, move with greater intimacy in the study of the lives of eminent chemists.

On the other hand, in the study of the history of science as a whole, we come to the chronological order, and principles, as well as the relationship and parallel progress of all sciences, their order of logical sequence, and application of science to the progress of civilization, and a conception of what the world owes to science. Also it allows a wider selection and interest in the vital part of all historical study—the biographical study. Lastly, in seeking for a greater analysis of the problems of the future in science, the history of science furnishes the background for all future investigations and progress.

The question is not, do we need more courses in our over-developed curricula, but a larger degree of intensive and correlated courses in order to bring out the better human faculties for greater service and deeper insight into the problems of nature. The failure of universities, colleges or technical schools, to make the necessary provisions for courses in either specific or general history of science, decreases their general efficiency, especially in their scientific curricula. From the point of view of economy in academic administration, and taking into consideration the merits of each case, as they have been set forth, the choice should certainly be with a general history of science course.

As Professor A. O. Lovejoy, of Johns Hopkins, writes:

> One hesitates to suggest further increase in the already too-diversified supply of mental pabulum urged upon undergraduates; but I should think an introductory course in the history of science would be a valuable addition to the curriculum of any college.

Further, he says that the history of science is assuredly important enough to be recognized as a distinct branch of teaching and of research. Professor Josiah Royce writes also; he points out how

> a deadening influence of a too exclusive absorption in the technique of one's own specialty could be prevented by the study of the history of science. Such a study is at once humanizing and an important auxiliary training towards acquiring a good method in technical work.

It is interesting to note that a number of years back some of our prominent men in science pointed out the present trend of this study as it is brought out in this investigation. Dr. R. F. Moulton, of the University of Chicago, was of the opinion that "it is worthy of a much better place than it now (1909) has"; Dr. Henry Crew, of Northwestern University, expressed a hope that as time went on the history of science should become a separate topic of study for advanced students; Dr. Florian Cajori, of the University of Colorado, inclined to the opinion that the stronger universities of the country would pay more and more attention to the history of science as the years went on.

Having now seen what the "expert opinion" has been regarding the future interest in the history of science, especially in our more prominent universities, within the last five or six years, it may be confidently expected that in the next few years very rapid progress will be made. No doubt many conditions have prevailed which retarded this progress, and probably the strongest one is that no well-adapted text- or source-book, or selected reading, is available. This is evident, and scientific men are aware of this deficiency. At the present time, two series of volumes are being prepared to aid the methods of teaching this subject. At the Massachusetts Institute of Technology, Professor W. T. Sedgwick and Professor H. W. Tyler are preparing a two-volume text entitled "Outlines of the History of Science," designed expressly for the use of their own classes. Volume I. is to deal with the rise and progress of science and scientific spirit to the fall of the Roman empire. Volume II. treats of the development of science in medieval and modern times.

Dr. Walter Libby, of the Carnegie Institute of Technology, with the collaboration of Dr. Locy and Dr. Crew, of Northwestern University, is preparing a series of short volumes: the History of the Biological Sciences, the History

of the Physical Sciences, an Introduction to the History of Science, and a probable fourth volume on the Applications of Science.

It has often been emphasized that the history of science can not be taught because of its encyclopedic extent. This objection can be overruled. It is true that we can not all be a Leibnitz, or possess minds of the type of his; however, in our modern methods of training or in specialized education, we may at least obtain the broadest viewpoint possible—through historical methods and their perspective, and withal, historical inspiration.[17] The principles of history have a criterion based upon scientific methods, just like any other subject of study intended for philosophical interpretation. This must be recognized by the future historian of science.

And when the historian of science is fully imbued with the "Geist und Leitmotiv of human learning," then, and only then, can the history of science be of value, and be possessed of a future. The final message of the history of science is to show the high plane of science—that which has given life, stability, truth and wealth—in its universal activities and its established international character as the arbiter of the future of man and of peace.

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[17] See "Outlines of the Principles of History," by Johann G. Droysen (1897), trans. by E. B. Andrews, pp. 9–58.

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THE COMMITTEE ON POLICY OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

The committee met at 5 P.M., on November 15, in the room of the New York Academy of Sciences, American Museum of Natural History, New York City (continued later at the Hotel Majestic), with Messrs. Pickering, Paton, Woodward, Noyes, Fairchild, Cattell and Howard present.

The preliminary announcement and arrangements for the Columbus meeting were considered. It was recommended that public addresses be worded so as not to allude to the present war in a way which might give offense. Dr. W. W. Campbell, president of the association, was appointed as delegate and Dr. L. O. Howard, permanent secretary, as alternate to the Second Pan-American Scientific Congress. The question of the relation of the association to the congress was referred to a special committee consisting of Messrs. Woodward, Howard and Humphreys.

Mr. Pickering submitted a report of progress for the committee on expert testimony.

Mr. Woodward submitted a report on the Coburn bequest.

Other matters considered by the committee and its recommendations will be submitted to the council at the Columbus meeting of the association.

At 9.30 P.M. the committee adjourned.

L. O. Howard,
Secretary

SCIENTIFIC NOTES AND NEWS

As was stated in Science last week, the Nobel prize in chemistry for 1914 has been awarded to Professor Theodore William Richards, of Harvard University, and the prize in physics to Professor Max von Laue, of Frankfort-on-Main, for his work on the diffraction of rays in crystals. The prize in medicine has been awarded to Dr. Robert Barany, of