HOW THE PUBLIC WILL SOLVE OUR PROBLEMS OF SCIENCE TEACHING.

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In this prognostication I have thought it necessary to reinforce my views with the testimony of a score of witnesses. I beg leave therefore to act as the editor rather than the sole author of this paper. Its composite authorship will be found duly set forth in the various footnotes.

In this country we need not fear a revolution in matters of education both because democracies are proverbially conservative and because educational administration is now well organized. Changes are therefore sure to be a matter of development and growth and he who would work most effectively may prepare for what is before him by studying the history of the past and the trend of the present.

A very casual survey of history reveals the fact that education in this country has always been an exponent of the times.

When one considers the changes that have come over all educational institutions in the past generation, it is impossible to escape the conclusion that the public determines what shall be the nature of education. And this seems to be equally true whether we consider the so-called private or public institutions, and whether we consider elementary, high school or university education. All must be largely conventional and partake of the character of the times. This fact has been often recognized and commented upon both by those who regret it and by those who take satisfaction in it.

It should be noted that the college community is a part of the public and not apart from it.

I. THE PUBLIC WILL TAKE GREATER CONTROL OF EDUCATIONAL INSTITUTIONS AND THE NUMBER OF PUPILS WILL GREATLY INCREASE.

Fifty years ago there were only forty high schools in the United States. Now there are about twelve thousand. Ten years ago there were about half a million high school pupils and now there are about twice that number. The rate of increase in the number of pupils naturally is much greater than that of

buildings or of teachers. A similar state of affairs exists in the colleges, universities and technical schools. All this has occurred in spite of the attempts of some of the colleges to "put up the bars" and deny education to all but a relatively few. The methods of selecting those upon whom the fruits of education may fall are likely to be revised by the public who feel that the money spent upon education should make better citizens rather than a proletariat.

It has been shown that the academic methods do not select the most efficient candidates.

It has also been shown that of those who enter the high school two thirds drop out chiefly because the instruction is not adapted to their needs¹.

"The real difficulty lies in the lack of adaptation of the instruction in the high schools to the need and opportunities of the pupils." * * * "The instruction should be made as far as possible to serve the needs of the great mass of the pupils." * * * "The high school (as now administered) is essentially a 'select' school * * * the real and imperative needs of the many are sacrificed to the doubtful satisfaction of the needs of the few * * * what the whole system requires is the skillful provision for the real good of the greatest number."²

Dr. Edward J. Goodwin, president of Packer Institute and recently Assistant Commissioner of Education of the State of New York, as quoted in the *New York Times* for October 25, 1908, says: "We are gradually coming to recognize the injustice of organizing our high schools in the interests of the few alone. Our high schools contribute in New York State for example less than two per cent of the men who yearly enter the so-called 'unlearned' professions."

It is inevitable that all educational institutions will become much more crowded in the near future for the public is moving toward a greater control of the schools and colleges; and a still further increase of attendance upon our schools and colleges will forthwith compel us to make some modifications in our methods of instruction, so as to deal with larger numbers of pupils. For instance, it will make it difficult to seriously talk of "laboratory divisions limited to twelve."

¹Professor E. L. Thorndike, Columbia. The future of the College Entrance Board. Ed. Rev., May 1906. Also, The elimination of pupils from school. Bulletin of the Bureau of Inf.

²The *New York Times* in a recent editorial.

"The real voice of the voters who have lately so multiplied high schools has not yet been clearly heard, and their unformulated purpose has not yet been accomplished. * * * The evils of college dominance are now so great and manifest that they must be transient."³

"The people know what they mean by education after all really quite as accurately as we do, whose peculiar business it is to define the term."⁴

The conditions of our modern life are driving everyone to the study of science. Evening classes, extension classes, correspondence classes are multiplying. Books and periodicals give increasing space to scientific subjects. The development of machinery has made the study of physics not only a matter of interest but a necessity to all persons.

The automobile, the motor boat and the like are not only rivals of the schools in the teaching of physics but they are at the same time the most potent cause for the reform in that teaching.

From Sir Humphrey Davy, whose inaugural address at the Royal Institution sets forth the services of science to humanity and science as an agent in the improvement of society, through the long line of masters down to the present, there comes a complete and overwhelming condemnation of Cavendish exclusiveness in science.

"The subject matter of physics is far more closely connected than that of any other science with daily life * * * the things we need to know most are the physical things * * * there is no other science except chemistry which touches common life at so many points."⁵

II. THE PUBLIC WILL NO DOUBT REQUIRE THAT SCIENCE INSTRUCTION SHALL BE PRACTICAL, OR AS PROFESSOR BAILEY PUTS IT—APPLICABLE.

Unless it is applicable it can neither be scientific nor humanistic.

The high schools of the future will without doubt be more closely allied to schools of applied science than to those of pure science. There will be more of the study of processes than of principles; more of physiology than of anatomy; more of agri-

³President G. Stanley Hall, Clark. *Adolescence*, Vol. 11, p. 515.

⁴State Supt. Henry C. Morrison, New Hampshire. *Educational Review*, October 1908 p. 247.

⁵Professor William F. Magie, Princeton. Boyle and Townley or Observation and Reflection. *Proc. Physics Club of New York*, January 29, 1904.

culture, nature study, natural philosophy as Faraday understood it, than of physics and chemistry, as the terms are now sometimes understood.

Faraday thought that physical science was a most appropriate study for children and mentioned *light* as a particularly good subject for that purpose. He who thinks that it requires a "heaven-sent gift" to study physics probably thinks of a very pure science."⁶

Professor William Conger Morgan of the University of California has an article in *SCHOOL SCIENCE AND MATHEMATICS* for November, 1908, on the "Relation of the Technical World to School Chemistry," in which he shows admirably how the high school course in chemistry might be enriched and he completely justifies the substitution of "practical" illustrations for the usual academic treatment when he says "the best reason for introducing experiments from the industrial world is to illustrate the general principles of chemistry."

This is not materializing or commercializing; it is the most effective way of teaching science for its own sake.

But let us put special emphasis upon the next division of our subject.

III. SCIENCE TEACHING WILL BE MORE HUMANIZED.

"Nothing is of real worth unless it can be directly connected with some result of conspicuous benefit to mankind.

"This attitude has profoundly influenced educational theory. This is a change of attitude of the world at large.

"Society wants the things of practical moment taught and it is the task of education to do it.

"Science has the confidence of the people before whose court it must justify itself. Science teaching has every natural advantage in its favor, including the keen interest of the pupil and no excuse will be accepted for its failure.

"Science teaching has its mission in general education. It may be taught so that it throws light on almost every phase of human interest.

"The lives of the great scientists are just as significant for education as the things which they stand for. The more students learn about personality the larger men they become."⁷

⁶Professor Perkins, Trinity. The Present Status of Physics Teaching in Secondary Schools. Proc. Eastern Assn. of Physics Teachers, 1905.

⁷Dr. A. S. Dewing, Harvard. School Science, Oct. and Nov. 1908.

"It is gradually becoming clear that for purposes of teaching, science must be treated as a part of human experience. It must be so closely linked with the interests and problems of the daily life as to become part of it. It must be shown to have arisen for the purpose of meeting human needs and to have played a very important part in the development of our present social life."⁸

"The call to life, and to life in this world is the first and fundamental call of the scientific age, it is a call to sacrifice and to service and the call to service has been the deepening undertone of the call to humanism."⁹

IV. THE STATUS OF THE HIGH SCHOOL TEACHER WILL BE GREATLY IMPROVED AND WE MAY HOPE THAT GREAT TEACHERS WILL ARISE AS OF YORE.

If we are to meet the needs of the public we must again have great teachers.

"The great teacher is the man of great personality, in whom nobility means more than attainments, and therefore the man whose personal touch upon the student is sure to be quickening and ennobling. He must know surely and clearly the subject he is teaching, but he must know even more profoundly and sympathetically the object he is teaching, namely, the other human beings, his pupils for whom he is guide and leader.

"The greatest students of this world have been formed one by one by great masters.

"Give me a good teacher, of noble nature, and I am comparatively indifferent to his or her scholarly attainments. The attainments will follow. Of what use for educating our boys and girls would it be to have the most gifted if that teacher is himself a small-natured, mean-natured, close-natured, little-natured soul?"¹⁰

"The educational process is not the mechanical impact of textbook or even of ideas upon the intellect, but the impact between living beings; and in the interaction of these vastly more is given and received than is ever formulated. What the teacher expresses itself; and always the teacher's personality is the greatest educational influence."¹¹

The high school age is the most important for education, and

⁸Professor G. R. Mann, Chicago. Ed. Rev. June 1907.

⁹Professor W. T. Sedgwick, Mass. Institute of Science of Teach. Science, Aug. 14, 1908

¹⁰Professor Andrew F. West, Princeton. Ed. Rev. Sept. 1908.

¹¹Educational Review, October 1908, p. 295.

the public will there place its greatest teachers. They cannot be specialists for as intelligence increases in one direction ignorance becomes more dense in other directions. The specialist seldom measures up to the average intelligence of his own pupils.

The greatest teachers of the future like the great teachers of the past will teach not one but many sciences and these with reference to their applications.

"A generation ago * * * the work was usually in the hands of one of those admirable all-round pedagogues who were capable of teaching with equal facility every subject in the curriculum and it may be said in homage to their talent that the best of them taught every subject as well perhaps as some of the specialists of to-day teach the one subject to which all their time is given."¹²

"And we all praise famous men—
Ancients of the College;
For they taught us common sense—
Tried to teach us common sense
Truth and God's Own Common Sense
Which is more than knowledge."¹³

"A well rounded mind rather than the mind of one idea is the general purpose of teaching."¹⁴

Teaching is a "high and sacred calling" and we might expect it to react upon the personality of the teacher.

An Englishman writing of his visits to American schools says, "I have found teachers the most attractive class in the nation, because more than any other class, not excepting the clergy, they are free from sordid aims."¹⁵

We may expect that such teachers will maintain sympathetic relations with their pupils.

At present teachers appear to be divided into two camps with reference to their mode of treating the pupils. One party feels that there can be no education without coercion, the other feels that it is possible to win students to voluntary efforts which shall count for more. The first party accuses the second of using "kindergarten methods" and of entertaining and interesting pupils until they lose the capacity for work. Work, they claim, is their watchword, and play, they claim, is the watchword of the

¹²Professor Nichols, Cornell. Proc. Eastern Association Physics Teachers. Dec. 1905.

¹³Stalky and Co., Kipling.

¹⁴Dr. Dewing. School Science, November 1908.

¹⁵Educational Review, October 1908, p. 295.

second party. But the second party has never agreed to this claim. On the other hand it says to the first party, you boast of work but you really administer sedatives. Your quantitative laboratory exercises and your mathematical treatment of physics is not hard, it is stupid. Its only justification is that it is the easiest thing for an overworked teacher to administer, particularly if he be a teacher who lacks the power to hold the attention of a class and therefore dreads qualitative experiments. Furthermore the second party claims that it secures a *compelling* interest in the subject which insures voluntary effort not only in school but out of school, and through life. These two parties have never been able to get together by argument and I take it that it is a hopeless case of lack of affinity. Unless I am greatly mistaken, these two parties in education would also be found to be two opposite sects in religion and for similar reasons. The first requisite of a great teacher is that he retain a vivid recollection of himself as a child, that he may be able to fully appreciate the pupil's point of view.

V. AS THE HIGH SCHOOL TEACHER INCREASES IN DIGNITY THE DOMINATION OF THE COLLEGE WILL CEASE AND THE EVILS OF UNIFORMITY WILL DISAPPEAR.

"High school physics has problems all its own to which its representatives should address themselves with courage, resolution and above all with independence or else the present decadent tendencies due to college control will continue.

"College entrance requirements as now enforced are almost an unmitigated curse to the high schools, exploiting them against their normal interests and the purpose of the people who support them.

"The high school should be master not servant.

"Perhaps no institution in modern times needs inspection, visitation and scrutiny so much as the private endowed American colleges themselves."¹⁸

We can never have a truly educational treatment of any subject so long as it is studied solely with college entrance examinations in view.

In England and on the continent entrance examinations have been abolished on the ground that they are no test for power.

¹⁸ President Hall, *Adolescence*, Vol. II, pp. 157, 510, 520 and 527.

"The function of secondary schools is distinct in itself and will one day establish its independent right when it has rid itself of the vicious term and still more vicious idea of college preparation."¹⁷

The high school teachers of this country have their subject matter and method of treatment minutely prescribed for them by those who understand neither the subject nor the pupils as well as they do.

Some persons unconscious that physics is a living subject, that every man, woman and child has his own physical world to study, varying with persons and with localities, demand that these high school pupils shall be fitted to the Procrustean bed.

They assert that physics is a quantitative subject; that it presents the greatest difficulty to all except those few who have special gifts. They say that this is predetermined in the nature of the subject. All this, however, has been explicitly denied by some of the greatest natural philosophers and the greatest educational philosophers. In the hands of great teachers few subjects are difficult; in the hands of some teachers all subjects are not only difficult but utterly incomprehensible.

"Any of the sciences can be made impressive if taught by a full mind which alone can elementarize,"¹⁸ and the ability to simplify is one of the marks of true greatness.

"We must distinguish between the teaching function and the research function. It is our business as teachers to open the minds of the young to the facts of science. * * * Nature study is not a new subject, it is a new mode of teaching and is just as applicable to the college as to the common school."¹⁹

"The craze for uniformity more than any other one thing has led to the great success of our schools in the development of mediocrity."²⁰

"Even more harmful than overcrowding is the oversystematizing which characterizes our present day methods. The tendency nearly everywhere is to reduce teaching to a routine and thus to deprive both teacher and pupil of the chance to do and think for themselves. A committee is appointed to draw up a syllabus and to outline the physics teaching for a whole state

¹⁷ F. Whitton, *School Review*, 1900, p. 261.

¹⁸ Hall's *Adolescence*, Vol. II, p. 202.

¹⁹ Professor L. H. Bailey, Cornell. *Proc. N. Y. Science Teachers Association*, Albany, 1907.

²⁰ Professor Stanley Coulter, Purdue University. *Nature Study Review*, January 1908.

or for the entire country. Every school equips itself to follow this program and every physics teacher goes through the prescribed course in the prescribed manner with section after section, day after day and year after year, until physics to him, instead of being the world-wide glorious science that it really is, is comprised within the scanty pages of the syllabus. Some spirits there are that refuse to be thus confined, but the tendency to uniformity levels down as well as up and the hilltops from which one may look out and view the true beauties of sciences are cut down in order that we may have a plain, easily traversed and easily cultivated."²¹

"The interests and needs of the pupils should be the determining factor in the arrangement of courses and the choice of methods.

"It follows that a high degree of uniformity in teaching physics is neither practicable nor desirable.

"Physics should be taught not as a preparation for college but as preparation for life."²²

The Physics Club of New York, before whom Mr. Spaulding's paper was read on March 7, 1908, adopted the following recommendations:

"College entrance examinations as now conducted upon the broad and indefinite subject, physics, compel high school teachers to give their entire energies to cramming and drilling. In this matter experienced and efficient teachers have no advantage over inferior ones.

"It is manifest that a very definite and complete topical syllabus upon which examinations should be based would be one step toward the alleviation of this situation, but nevertheless such an instrument would constitute a galling yoke, forcing well equipped teachers to keep step with their inexperienced fellows.

"It seems probable that a very definite but incomplete syllabus by securing a certain amount of freedom in teaching, would enable the best teachers to do their best. Inexperienced teachers may be helped and guided by a Teachers' Manual, which should be much richer in suggestion than any syllabus can be.

Therefore, resolved that a uniform course in physics for all schools is both undesirable and unattainable. We recommend:

1. That syllabuses should deal with the barest outline of general

²¹ Professor E. L. Nichols, Cornell. Proc. Eastern Assn. Physics Teachers, Boston, 1905

²² Mr. F. B. Spaulding, Boys' High School, Brooklyn. School Science, 1908, p. 674.

principles, leaving each teacher free to fill up the course according to his best judgment.

2. That examinations for College Entrance should be confined to the general principles specified in the syllabus and that a teacher's certificate should be accepted for other material—this might well take the form of a rather full statement of the work done."

It has been asserted that what the colleges want for preparation in science is very definite and perfectly well understood but this may be doubted when so many divergent opinions are expressed in print by college men.

In spite of the fact that the best high school teachers of to-day have become experts in their profession, the latest commission charged by the college entrance board to plan the work for high school physics contains not a single person actively engaged in teaching high school physics. A situation which would be impossible in any other country in the world now exists, temporarily I believe, in representative America.

VI. AS ATTENDANCE UPON THE HIGH SCHOOL CLASSES IN SCIENCE INCREASES, INDIVIDUAL LABORATORY WORK WILL OF NECESSITY BE SOMEWHAT CURTAILED AND MORE IMPORTANCE WILL BE ATTACHED TO THE LECTURE.

To begin with, the so-called inductive work will be eliminated from the laboratory.

High school pupils are sometimes taught to "test" and to "verify," in short, to learn things "first hand" when they have neither capacity for nor ground upon which to draw conclusions.

"I am an enemy of the inductive method in the school course. It is utterly absurd to expect an immature boy of fifteen or sixteen to perform that intellectual feat of generalization that is considered the most mature effort of the human mind. * * * It is supposing a mental endowment that only comes late in life to most of us and often never at all. * * * Bad as this method is in the hands of an experienced teacher it is confusion worse confounded when a novice attempts it."²²

The laboratory at best is a very artificial means of supplying experiences upon which to build physical concepts. While it is useful and needful it cannot take the place of an appeal to life's experiences and the phenomena of nature. The charge that pupils may read about nature in books and not recognize her

²² Professor Perkins, Trinity. Proc. Eastern Association. Physics Teachers, December 1905, p. 25.

out of doors is quite as applicable to laboratory work. In physics it is too unreal; too much devoted to statics—too many things are presented which are never found outside of a laboratory and which are not parallel to or explanatory of anything found in ordinary human experience.

Professor Mann, Chicago, says that "for the general student college laboratory work is neither essential nor desirable."²⁴

"Too much time is given to so-called laboratory work with elaborate and expensive apparatus. Too little attention is paid to simple and effective illustrations of physical phenomena and simple applications of fundamental principles to be found in every school room and its immediate environments."²⁵

Professor W. S. Franklin, Lehigh, "My experience is most emphatically, that a student may measure a thing and know nothing at all about it, and I believe that the present high school courses in elementary physics in which quantitative laboratory work is so strongly emphasized, are altogether bad." * * *

"I believe that the physical sciences should be taught in the secondary schools with reference to their practical applications. I cannot endure a so-called knowledge of elementary science which does not relate to some actual physical condition or thing, and I believe that the only physical things that are sufficiently prominent in a young man's mind to be brought into the field of his science study are the things which have been impressed upon him in everyday life. Say what you will, you must do one of two things to be able to teach physics in any school; either you must create an actual world of the unusual phenomena of nature by purchasing an elaborate and expensive equipment of scientific apparatus or you must make use of the boy's everyday world of actual conditions and things."²⁶

The public has expended lavishly for laboratory equipment in physics, doubtless in the expectation that their children will be better instructed thereby to cope with the new conditions of modern life. There is no department of education which the people have more at heart and there are abundant signs that they will not long permit their purposes to be thwarted.

Education is not wholly a process of training; It is in considerable measure a matter of acquiring the mass of information which it is conventional to have at any particular age.

²⁴ Education, December 1906.

²⁵ Mr. J. W. MacDonald, Agent Massachusetts State Board, Report for 1907.

²⁶ Professor W. S. Franklin, Lehigh. Proc. 12th Annual Meeting N. Y. State Science Teachers' Association, Albany, 1907.

The lecture is the only means by which we may bring in all the good things that we feel moved to introduce. The great teachers of the future will be able to instruct large classes by "talks, which is the method of the real teacher."

This is to-day the method of the German teachers who are notoriously the best teachers in the world.

Large portions of science should be merely touched upon; made understandable for a brief moment and then forgotten, not even retained for recitation, much less for examination.

"Curiosity and interest are generally the first outcrop of intellectual ability. Youth is normally greedy for knowledge and that, not in one but in many directions.

"Never is the power to appreciate so far ahead of the power to express and never does understanding so outstrip ability to explain. Overaccuracy is atrophy. Mental acquisition sinks too deep to be reproduced by examination. With pedagogic tact we can teach about everything we know that is really worth knowing, but if we amplify and morselize instead of giving great wholes—if we wait before each methodic step till the pupil has reproduced all the last we starve and retard the soul.

"The nature of youth demands that science should be taught in a large all-comprehensive way. We must have an introduction to science that touches rather lightly on nearly all the great hypotheses over the whole field.

"The boy in his teens needs great wholes, facts in profusion, but few formulæ. He has a native gravity toward those frontier questions where even the great masters know as little as he.

"The college should stand for extensive more than for intensive study.

"It should stand with doors hospitably open to those who have time to pause for it on the road to a profession, or to spend a period of culture and acquire an avocation before entering a career. It should let teaching have its perfect work.

"The teacher should forage widely and incessantly, and bring everything within reach in his field to his class. The lecture method should be made the most of, being conversational and designed to provoke reactions. He should teach every topic broadly and comprehensively, and instead of disparaging mere information, it should ooze from his every pore.

"Every great expert should feel it his duty to put the best that is in him in a form most interesting and profitable to a cultured lay audience." ²⁷

²⁷ Hall's *Adolescence*, Vol. II, pp. 85, 453, 151, 156, 528, 548.

The lecture room is the place for presenting the history of science and the biography of scientists; the story of inventions and how they have transformed society; the rise and development of modern scientific theories, e. g., the slow progress of thought concerning combustion through the phlogistic up to the oxidation theory; the linking of the history of science with general history showing how the evolution of science was both helped and handicapped; the contributions of science to our comfort, our health and our general happiness.

Mr. B. M. Jaquish of Erasmus Hall High School, Brooklyn, N. Y., in an unpublished paper has very effectively shown that countless references in all our literature require for their interpretation a general knowledge of science and this is rapidly becoming a *sine qua non* for current literature.

The lecture should show the application of science in the occupations of the particular community in which the school happens to be located.

Hence no syllabus can be made to fit the whole country. If the school is in a large city and is located in one of our most modernly equipped buildings the lecture in physics will often be devoted to an explanation of that equipment which will be found to illustrate every chapter in physics far better than any laboratory can.

VII. WE MAY UNDERTAKE TO FRAME A PLATFORM FOR FUTURE SCIENCE TEACHING AS FOLLOWS:

1. Science for high schools consists of a well organized mass of useful information.

2. In order that the amount of information may be considerable it is given for the most part "second hand."

3. The three means for giving this information, stating the more important first, are: (a) Illustrated lectures. (b) Study of text-book with recitations, and reading many references in books and magazines with written and oral reports. (c) Laboratory work—a small portion of which consists of exact measurements.

4. This mass of useful information being acquired at the hand of a competent teacher involves discipline and training.

5. While the science teacher has a peculiar part to perform in the processes of education which the teacher of no other subject can do so well, his task is not absolutely unique and the

methods of instruction which are best in the treatment of other subjects are for the most part best for science.

6.. A quantitative treatment with whole numbers, so to speak, runs through much of the instruction in lectures, recitations and laboratory work—giving concreteness and therefore interest to the subject—but this is only incidental and of minor importance.

7. Science is not presented as a catalogue of principles, but rather as history, biography and the evolution of changing ideas. The topics for study are phenomena rather than laws, and principles are presented only for the purpose of explaining some definite problems in life.

8. Since all this applies equally to all general or first courses whether given in high schools or colleges, it follows that college admission tests are the same as high school graduation tests.²⁸

The foregoing paper was presented before the Science Conference of the Wisconsin State Teachers' Association at its meeting in Milwaukee on November 12. After the reading of the paper there was a spirited discussion of it, resulting in the appointment of a committee of five to draw up resolutions expressing the sentiment of the meeting. The following are the resolutions, which were unanimously passed by the conference the next day:

WHEREAS: The present methods of teaching physics in secondary schools do not yield as satisfactory results as we desire to get; and,

WHEREAS: We believe this to be due to the fact that far too great emphasis is now placed on accurate quantitative work; and,

WHEREAS: This overemphasis of the importance of quantitative work is due to the fact that some colleges take the position that physics is by nature a quantitative science, that it is the only such subject in the high school curriculum, and that it must therefore be so taught, irrespective of the needs and abilities of the pupils; and

WHEREAS: We believe that physics for high schools should consist of a study of the processes and principles of phenomena of the daily life of the student; therefore be it

RESOLVED: That we, members of the Science Conference of the Wisconsin State Teachers' Association, in convention assembled, do hereby agree to change the methods of teaching physics by abandoning as far as may be found desirable the exact quantitative work, and by substituting therefor a more living treatment of the subject based on the daily experiences of the pupils.

²⁸I have discussed rather fully this platform in four papers already published as follows: 1. "The Enrichment of the High School Course in Physics." *Proc. Eastern Assn. Physics Teachers*, Boston, November 5, 1904. 2. "Modern Trend of Physics and Chemistry Teaching." *Educational Review*, March 1906. 3. "The Intensive Method in Chemistry." *School Science*, Vol. VI, p. 585. 4. "Science for Culture." *School Review*, Vol. XV, p. 123.