SCIENCE

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THE ESPECIAL VALUE OF RESEARCH IN PURE CHEMISTRY[1]

MY colleague, Dr. Cattell, having considered the broad topic of the value to a democracy of research in pure science, I welcome the opportunity to take up for a few moments one of the subdivisions of his field, in order to point out somewhat more fully the especial importance of research in chemistry.

Let us, therefore, first pass rapidly in review a few of the contributions which chemistry has made or is now making to the health, happiness and material prosperity of our country, that we may be able more accurately to assess its value to the community, gain a better appreciation of the debt we owe it, and accord to it that position of high honor and dignity which is its just due.

In the reports of the Twelfth Census of the United States it is written that

> Probably no science has done so much as chemistry in revealing the hidden possibilities of the wastes and by-products of manufacturers. This science has been the most fruitful agent in the conversion of the refuse of manufacturing operations into products of industrial value. Her fairy wand has only to touch the most noisome substances, and the most ethereal essences, the most heavenly hues, the most delicious flavors and odors instantly rise as if by magic.

Whether this is a wholly overdrawn picture or not will appear in what follows.

Dealing with the ultimate constituents of our material universe, their combinations and transformations, it is chemistry that

[1] Address delivered on the occasion of the establishment of the Willard Gibbs Chair of Research in Pure Chemistry at the University of Pittsburgh, October 26, 1915.

has determined the composition of those substances which make up our own bodies, the earth upon which we live, the air we breathe, and the heavenly worlds beyond. Every particle of matter animate or inanimate acknowledges its sovereignty, for its laws govern alike the smelting of an ore, the manufacture of a complex dyestuff, or the mysterious vital processes of the living organism; and upon these laws our physical and our industrial life depend.

The transformation of the raw material into the finished product consists usually either in changing its external form, as in metal or wood working, weaving, and the like; or there is involved a chemical change, as in metallurgy, fermentation industries, the manufacture of cement, glass, soap, chemicals, etc. Our manufacturing processes are thus either mechanical or chemical, or a combination of the two.

Let us consider briefly the part chemistry plays in connection with some of the more important of these industries.

Turning first to the mineral world, it should be borne in mind that metallurgy is but one of the branches of engineering chemistry, whether it concerns the initial smelting operations or the production of new alloys for special purposes. The chemist is busily at work here, discovering ways of obtaining cheaply metals previously rare or expensive, thus inaugurating entirely new industries, as witness that of the manufacture of aluminium goods and alloys; analyzing raw materials (ore, coke, limestone, etc.), intermediate products (for many industrial operations are under chemical control at all points), and final products, such as the furnace gases, slags, and the like; improving old processes; devising new ones, particularly those which will render available low-grade or refractory ores; showing how wastes and by-products may be made valuable, the waste heat to raise steam or pre-heat the blast, and the slags for the production of cement and concrete, as fireproof packing for steam pipes, as ballast for railroad tracks, for macadamizing highways, for building purposes (as slag brick, slag blocks, etc.), or when rich in phosphorus (as those from the Thomas-Gilchrist process) for fertilizers. His success has been such in the iron industry, for example, as to lead Mr. James Douglas to remark that

> When all the volatile products of the blast furnace . . . are deprived of their heat-giving properties and their chemical constituents, and when the slags, as well as the metal, have returned their heat to man instead of to the atmosphere, and the slag itself has been turned into cement or some other useful article, it will be a question as to whether the pig iron is the principal object of manufacture or one of the by-products

It was the pioneer investigations of Bunsen and DeFaur which pointed the way for the use of furnace gases in many of the directions in which they are now so extensively employed. Another chemist, Sir Humphry Davy, by his invention of the safety lamp, has done more than any one else to protect the miner from accident and injury and, as you are well aware, the chemists of our government are now conducting experiments in this city to further reduce the loss of life and property incident to fires and explosions in mines.

Without the powerful explosives of the chemist, modern mining, modern warfare, and such great engineering projects as the Panama Canal, would all alike be impossible. After the precious metals have been extracted from their ores, it is the powder of the chemist which stands guard over them, as it does over all the accumulated wealth and property of this and other nations.

The chief source of our light, heat and power still remains the chemical combustion of some form of carbon, be it coal, petroleum or natural gas; and chemistry again has shown how wastes may be avoided and by-products utilized. The great losses formerly permitted in the coking of coal are now being checked and the volatile products recovered, with the result that we shall soon be supplying all the benzole needed for our own home market. In the great illuminating gas industry, the by-products—ammonia water, tar and coke—are all made available by the chemist. The ammonia water is a leading source of ammonium compounds; and, as for the tar, the way in which this black, sticky, evil-smelling mass has been made to minister to the comfort and general prosperity of mankind constitutes one of the most brilliant chapters in the volume of modern scientific achievement. In the hands of the chemist, it has been transformed, as by magic, into a veritable Pandora's Box, from which may be produced healing drugs or the deadliest of poisons, delicious perfumes or the most disgusting of odors, dyestuffs of every hue of the rainbow or explosives powerful enough to annihilate this building in an instant—pleasure or pain, life or death, lie dormant there, awaiting the summons of the chemist. Then, too, chemistry has contributed the necessary mantles and filaments for modern incandescent lighting, whether by gas or by the electric current; and the calcium carbide from which acetylene gas is obtained.

A good example of the economy often accomplished by chemical research and discovery is afforded by the history of ultramarine. Many years ago when this pigment was made by powdering the mineral lapis lazuli, it sold for more than its weight in gold. Since the chemist has found how to make it from such cheap substances as kaolin, sodium sulfate and carbonate, charcoal, sulfur and rosin, the price is only a few cents per pound.

The value of our specie, upon which every commercial transaction rests, is decided by the chemist, while the green ink used in printing our banknotes, and to which they owe their name of "greenbacks," was invented by a former president of the American Chemical Society, Dr. T. Sterry Hunt.

The chemist lets nothing escape unsearched. The sweepings from the mints and from the shops and factories of workers in precious metals, as well as the water in which the workmen wash their hands, are all made to give up the gold or silver they contain. Even waste photographic solutions must disgorge their silver before they are permitted to escape.

Through the labors of the chemist, the pollution of our atmosphere by smoke, fumes, flue dust and noxious gases is being rapidly reduced; and the University of Pittsburgh is playing a prominent part in this campaign. Hundreds of thousands of tons of sulphur dioxide, formerly wasted in various quarters of the globe in polluting the atmosphere, are now, thanks to the discovery of the "contact process," annually converted into sulphuric acid, to be used for the manufacture of fertilizers, indigo and other valuable substances.

The purity of our water supply is a matter of serious concern to all of us, whether it is to be used for drinking purposes or for the industries, and both the chemist and the bacteriologist must pass upon it. The chief industrial use of water is for the generation of steam, and for this purpose the water must be free from large amounts of mineral salts, or the formation of boiler scale will proceed rapidly. So that, even in such a fundamental engineering operation as steam-power generation, the engineer must first consult the chemist as to the quality of the fuel and water he expects to use. The loss due to locomotive boiler scale alone in the United States has been estimated as equivalent to fifteen million tons of coal per annum. Chemistry has also rendered yeoman service in reducing the pollution of our streams and coastal waters, by showing how many of these wastes may be converted into valuable commercial products, and more money be made in this way than by dumping them into the streams.

In those operations in which pure water is indispensable, the cost of impure water is the cost of purification, and it is to the chemist that the manufacturer must turn for instructions as to how this purification may be accomplished best. Impure water means additional cost of production, not only to the steam-power plant, as just mentioned, but also in paper-making, strawboard mills, brewing, distilling, ice manufacture, bleacheries, dye works, canning and pickle factories, creameries, abattoirs, packing-houses, factories for explosives, sugar, starch, glue, or soap, woolen mills, tanneries and chemical works, as well as in many other lines of industry.

Agriculture still remains the world's most important industry, as nearly 36 per cent. of our people are engaged in it, and all the rest depend upon it. Mr. James J. Hill has said that

> In the last analysis, commerce, manufactures, our home market, every form of activity runs back to the bounty of the earth by which every worker, skilled or unskilled, must be fed and by which his wages are ultimately paid.

And Liebig, in the preface to his great work on "Chemistry in Its Applications to Agriculture and Physiology" calls attention to the fact that

> a rational system of agriculture can not be formed without the application of scientific principles, for such a system must be based on an exact acquaintance with the means of nutrition of vegetables, and with the influence of soils and actions of manure upon them. This knowledge we must seek from chemistry, which teaches the mode of investigating the composition and of studying the character of the different substances from which plants derive their nourishment.

In this great domain, the services of chemistry include the fixation of atmospheric nitrogen, the elucidation of some of the ways in which atmospheric nitrogen enters into organic combination and of the methods whereby organic nitrogen is prepared for plant food, the analysis of soils and the determination of their relation to plant growth, the analysis of plants and agricultural products and a study of the influence of environment upon their composition, the manufacture of fertilizers and their adaptation to the needs of different soils and crops, the protection of the farmer from fraud when he purchases the same, methods of utilizing plant food and of conserving it for future use, the establishing of the general principles of plant growth and the chemical changes involved, the replacing of natural dyes and drugs by synthetic articles, the manufacture of artificial silk and the saving of the natural silk industry from threatened obliteration, the production of other artificial fibers and fabrics, the mercerization of cotton, the manufacture of substances to take the place of resins and shellac, the rescue of crops from impending destruction by providing effective insecticides and fungicides, the production of valuable substances from former wastes (cottonseed oil, corn oil, gluten from starch factories, cream of tartar from wine lees, and the like), and of industrial alcohol from crop refuse. Dr. H. W. Wiley has expressed the opinion that

> The application of the principles of chemical technology to the elaboration of raw agricultural products has added a new value to the fruits of the farm, opened up new avenues of prosperity, and developed new staple crops.

The introduction and enactment of our Pure Food and Drug laws, as every one is aware, were due primarily to the tireless activity of this same chemist.

It probably has not occurred to the layman that the chemist might appear also in the rôle of a land reclaimer, and yet the discovery of commercially profitable methods of manufacturing alizarin and indigo from coal tar has set free for other crops hundreds of thousands of acres formerly devoted to the raising of madder and indigo.

In the realm of animal industry, the chemist has elucidated the laws of animal nutrition and taught the farmer how to adapt his feeding-stuffs to the needs of his stock, so as to secure the maximum return in work, meat, fat or milk, and by analytical control again protects him from fraud when he buys his cattle feed. When diseases attack the herd, chemistry supplies antiseptics and powerful remedies of all kinds. Not so many years back, it was the custom to build slaughter houses on the banks of streams into which all the refuse was turned. But chemistry has revolutionized all this, and the old joke about the Chicago packing-houses using every part of the pig, including the squeal, is now not far from the truth. In modern abattoirs and packing-houses, the hides are used for leather; the grease is converted into soap, candles, oleo and glycerol (for nitroglycerin manufacture); the blood and scrap into blood albumen, fertilizers and potassium cyanide (for gold extraction, among other uses); the horns and hoofs into jelly, buttons, knife handles, etc.; the feet, bones and heads, into glue, bone oil and bone-black. The skim-milk formerly wasted, now surrenders its casein, from which so many interesting and useful articles are manufactured. Chemistry has also provided a number of satisfactory leather substitutes, while the waste from real leather is converted into fertilizer or glue.

It is chemistry again which has put into the hands of the builder non-combustible building materials, such as iron and steel, cement, brick, plaster, terra-cotta, tiles of all kinds, porcelain, pottery, stoneware and earthenware, and all kinds of metallic furnishings and fittings; fireproofing solutions for the safeguarding of combustible materials; paints and varnishes, to protect from weathering and decay; preservatives to prolong the life of the timber and ward it from the attacks of marine borers, molds and fungi.

Formerly all the alkali required for soap manufacture was derived from wood ashes; but the chemist has shown how it can be secured much more economically by the electrolysis of common salt.

In addition to all this, and much more which could be cited, it is chemistry that provides a majority of our most potent anesthetics, antiseptics and remedies of various kinds. In his fight with disease and death, the physician has no more powerful or resourceful ally than the chemist. Finally, the processes of the living organism, plant or animal, are primarily chemical, and instead of the formation of organic compounds in the living organism being longer referred to a mysterious "vis vitalis," the question has lately been raised seriously as to whether life itself is not merely one of the products, or the resultant, of a definite series of chemical reactions. Dr. Schaefer, in his presidential address before the Dundee meeting of the British Association for the Advancement of Science, after calling attention to the comparatively few elements and simple compounds of which living matter is composed, said "The combination of these elements into a colloidal compound represents the chemical basis of life; and when the chemist succeeds in building up this compound, it will without doubt be found to exhibit the phenomena which we are in the habit of associating with the term 'life'"; and he further suggests "that heredity also is one of the questions the eventual solution of which we must look to the chemist to provide."

I like the old familiar concept of the human organism, not as an individual but as a community, a humming, bustling hive of industry, where each separate cell has its own special kind of work to perform; some splitting up the raw material as it is received into simpler substances and classifying these for transmission to other cells, where they are built up into materials necessary for the life and development of the organism; some cells carrying on a process of benevolent assimilation, others "doing an illicit still business"; with the great central pumping station driving life and energy to the remotest corners of the establishment. That is not only the most fascinating organic chemical laboratory in the world, and its most important chemical industry; but it is also the one which concerns us most intimately. Whether we live or die within the next five minutes, depends absolutely upon whether the reactions now going on in all the minute organic laboratories of our bodies continue in their normal healthy course or suddenly go wrong.

Chemistry has been well characterized as "the intelligence department of industry." It does not skim the cream of other men's labor, but is itself so great a creator of national wealth that the actual money value of its services is beyond computation.

In this brief and very superficial fashion, I have endeavored to give you some idea as to what chemistry means to our present-day civilization. All of these remarkable achievements are but the outcome of patient and painstaking research in the field of pure chemistry. Investigations in pure science laid those broad and deep foundations upon which applied science has erected the wonderful structure of modern industrial operations. Small wonder, then, that the establishment of a chair of research in pure chemistry is a cause for gratification and encouragement.

No one can tell at what instant some observation recorded in the course of a research may suddenly become of immense importance. When Cavendish, 130 years ago, read a paper before the Royal Society describing the formation of nitric acid by the passing of an electric spark through air, it certainly never occurred to any one present that the question of the fixation of atmospheric nitrogen might one day prove the means of saving the human race from starvation, and yet such may turn out to be the case in the years to come. Perkin had no intimation that the experiments conducted during the Easter vacation of 1856, in the effort to obtain quinine synthetically, would result in a billion dollar world industry in coal tar dyestuffs; nor could Bessemer have foreseen that his process would one day save the world over two billion dollars annually.

The nineteenth century has been described as the Age of Physics and Engineering, since it witnessed such triumphs as the development of steam and gas engines, and the utilization of electricity as a source of light, heat and power, and as a means of communication. The twentieth century will quite certainly be an Age of Chemistry. Germany realized this some years ago, with results that are now evident to all.

If we would not be left far behind in the race, we must pursue a similar course, and that at once. We have yet to convince many of the nations of the earth that the form of government in which we believe, and to establish which our ancestors died, is the best not only for the freedom and happiness of the individual, and the development of the noblest intellectual and moral standards, but also for the growth of the country in physical strength and resourcefulness, and that in the hour of need it will not be found wanting in the vital matter of industrial efficiency and solidarity which is the corner-stone of all military power.

In the terrible world war now raging, the law of the survival of the fittest will be found as inescapable, immutable and inexorable in the case of nations as it is with individuals. It listens to no explanations, accepts no excuses, and knows absolutely no pity. Our own country is beginning to awaken to the fact that civilization unarmed by science is at a terrible disadvantage in the event of a struggle for existence, and that this arming can not be done at short notice. The result is a loud and urgent call upon the universities, colleges and technical schools of the land for help.

Conspicuous among those answering this call most effectively are the University of Pittsburgh and its Mellon Institute. Conducting an energetic campaign for the education of the community to a better appreciation of science, pointing out to the manufacturers wherein the chemist can aid them, and winning their support for chemical research, prosecuting skilful investigations directed to the immediate public needs, and turning out highly-trained scientists, this university has already made an enviable record of service, and has placed under a lasting debt of gratitude not only the city of Pittsburgh, the chemical profession and the nation, but the entire world of humanity as well; for its activities minister in the highest degree to the progress of civilization, and its achievements ultimately become the property of all mankind.

Robinson has defined education as "the process of fitting the individual to take his place and do his part in the life of his age and nation," and no educational institution at the present time can discharge this responsibility faithfully unless it accords, in its equipment and in its curricula, adequate recognition to so comprehensive a science as chemistry which, in its wide sweep, touches almost every phase of human life and endeavor.

Two years ago, in an address which I had occasion to deliver in England, I ventured the opinion that the most pressing need of the day was the proper endowment of chemical research, by the founding of great research institutes and the creation of research professorships. That opinion I have not altered.

The establishment in this university of the Willard Gibbs Professorship of Research in Pure Chemistry is an occasion for warmest congratulations: to the chancellor and trustees of the university on the momentous step they have taken in the direction of building up a great new school of graduate and research work in pure chemistry; to the distinguished director of the Mellon Institute, Dr. Raymond F. Bacon, for his wise foresight in securing such a department as a powerful means of advancing progress in industrial research; to the university and its Mellon Institute, on securing as the first incumbent of the new chair a most talented teacher and investigator, Dr. Martin A. Rosanoff, whose researches have already won for him an international reputation; and to Professor Rosanoff himself, on being selected for this high honor.

That this new chair should bear the illustrious name of Josiah Willard Gibbs is peculiarly appropriate, for, as an investigator in the field of pure chemistry, Ostwald has called him "by far the greatest scientist America has yet produced," and Le Chatelier has said that his work marks an epoch as important as that of Lavoisier. Abstruse and recondite as those researches were, their fundamental bearing upon the development of our science is daily becoming clearer.

In felicitating the chancellor and trustees, it is not necessary to point out that a university's greatness is not determined by the magnificence of its plant, its athletic prowess, or the size of its student body, but by the number and importance of its graduate schools; and that the standing of a graduate school, in the judgment of those whose opinion is really worth having, is measured by the amount and quality of its output of genuinely original investigation. The extent of the assistance which a university secures from its surrounding community in the creation of such splendid graduate schools as we see here, is not infrequently the reflection of the attitude of the university authorities themselves toward such work; and the city of Pittsburgh is indeed fortunate to have at the head of its famous university a chancellor and trustees who know how to prize original scientific investigation at its real worth, and under whose fostering care and guidance it is certain to have full opportunity for development.

To the staff of noted teachers and investigators already connected with this university, Dr. Rosanoff has been called, and I bring to him the congratulations of our chemical department at Columbia and our best wishes for a long, happy and useful career.

He is an unusually gifted man—chemist, physicist, mathematician, linguist—and intends to devote his versatile talents to the difficult, but very important field of physico-organic chemistry. He should be a very happy man to-night, for I know that it has been his ambition to be permitted to devote his life to research in pure chemistry, and happiness has been defined as the quotient obtained by dividing our ambition by our achievements. There is no doubt that he will do all in his power to widen the boundaries of knowledge in his chosen field, and that he will succeed, through his own labors and those of his junior colleagues, research associates and students, in bringing honor and prestige to the chair.

I would gladly explain to you the importance of the numerous discoveries he has already made, but time does not permit, and much of it, I fear, would be about as fascinating to the uninitiated as an attempt to expound the fine points of Sanskrit syntax.

Accordingly, I will limit myself to a few of his more notable contributions.

Fractional distillation is an ancient process, but it has remained largely an empirical one. True, its practical applications have developed and experience has shown the particular value of various forms of distilling apparatus, but the underlying theory has continued more or less in dispute and it has been impossible to calculate accurately in advance the correct arrangement of the distilling heads necessary to realize a maximum separation of the components of a liquid mixture; the only way to find out having been to assemble an outfit and make a trial run. Professor Rosanoff's studies of the problem have convinced him that the conclusion arrived at by previous investigators to the effect that a single regulated still-head sufficed to separate completely binary mixtures was not in accord with the facts. By an application of the theory of partial vapor pressures he has corrected this error and shown that not one, but a series of still-heads is necessary, the temperature of each of which bears a definite mathematical relation to that of every other one. This has been experimentally confirmed very many times during the past three or four years, and it would appear that research in pure chemistry has at last placed this age-old process upon a firm scientific basis. The American Chemical Society recognized the fine quality of the work by awarding Professor Rosanoff its Nichols Medal for the year 1910. As distillation plays a very prominent part in many of our leading industries, the importance of the investigation requires no comment.

Other valuable researches conducted by Professor Rosanoff had to do with such well-known generalizations as the theory of electrolytic dissociation and the law of mass action. In the case of the hydrolysis of sucrose, and the decomposition of tertiary amyl esters, other investigators have reported results which were at variance with one or both of these hypotheses, and the consequence has been increasing confusion and perplexity. By long-continued study of these problems, on the part of his co-laborers and himself, Dr. Rosanoff has proved both mathematically and experimentally that the observations primarily responsible for this troublesome condition of affairs were inaccurate and misleading, and that the theories of electrolytic dissociation and of mass action are beautifully confirmed in these particular cases also. To bring order out of chaos is indeed a welcome service. The "hydrolysis of sucrose" probably sounds highly technical to the layman, but it is a chemical reaction upon which depends the evaluation of the entire sugar output of the world. As our country has something like three hundred million dollars invested in the sugar business, the problem obviously has its practical side as well.

All of his work has been characterized by the refinement and precision of the physico-chemical measurements made, the painstaking and laborious efforts to eliminate all possible sources of error, and the immense number of experiments carried out before any conclusions are drawn.

In the coming years, I can wish for him no higher reward than that he may succeed in communicating to his students some of his own contagious and enthusiastic love of the subject, since this is the greatest been in the gift of any teacher and the one which brings most happiness to the donor. With that compelling inspiration, the student will get the dry facts of the science in due time; without it, knowledge alone can never make him a really great man.

For his comfort, I would remind my colleagues of the words of Epictetus:

> Remember that such was, and is, and will be the nature of the universe, and that it is not possible that the things which came into being can come into being otherwise than they do now; and that not only men have participated in this change and transmutation, and all other living things which are on the earth, but also the things which are divine. And indeed the very four elements are changed and transmuted up and down, and earth becomes water and water becomes air, and the air again is transmuted into other things, and the same manner of transmutation takes place from above to below. If a man attempts to turn his mind toward these thoughts, and to persuade himself to accept with willingness that which is necessary, he will pass through life with complete moderation and harmony.

I am confident that he will never become so deeply engrossed in his researches as to lose sight of the main purpose of all education, which is to make better men and more useful citizens; and that his efforts will always be directed to training men to be not only great scientists, but also great Americans, and that in so doing he will not fail to impress upon each student that the individual is but one of the players in the mighty drama of human life and endeavor, and that he should therefore play his part worthily, as owing a debt both to his profession and to the community in which he lives. "What art do you teach, Protagoras?" asked Socrates. "I teach the art of citizenship," replied the sophist. "Then, indeed," said Socrates, "you teach the noblest and best of all arts, for it includes all others." And Epictetus writes:

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