SCIENCE

A WEEKLY JOURNAL DEVOTED TO THE ADVANCEMENT OF SCIENCE, PUBLISHING THE OFFICIAL NOTICES AND PROCEEDINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

FRIDAY, APRIL 22, 1904.

CONTENTS:

MSS. intended for publication and books, etc., intended for review should be sent to the Editor of SCIENCE, Garrison-on-Hudson, N. Y.

*THE GROWTH AND FUNCTION OF THE MODERN LABORATORY.**

IT is opportune, upon an occasion such as this, when we are assembled at the dedication of the newest of scientific laboratories, to consider for a moment the process of development by which they arrived at the state of efficiency of which this building is so striking an example. Then, too, it is of vital interest to those of us whose work lies in laboratories, and of much more than passing interest to every individual in the community, to have a clear idea as to what good purpose this and other similar institutions may be expected to serve, and how best they may accomplish that purpose.

The marvelous advances of the past seventy-five years are well enough known to us all, and never fail to fill us with astonishment when we stop to think about them. Discoveries and applications of discoveries have followed each other with such rapidity that our sense of appreciation is in a measure blunted, and we fail to realize adequately what they mean to each one of us, in comfort and convenience. No sooner did we become accustomed to the fact that we could telegraph across the ocean, than we were occupied in wondering at our ability to telephone to any one within a radius of several miles, and the great present extension of this radius, and the high probability that we shall be able to talk across the Atlantic in a very few years, does not meet appreciation to correspond

* An address read at the dedication exercises of Palmer Hall, Colorado College, February 22, 1904.

to the difficulties which have been overcome. Gas lighting was not universally introduced before electric lighting reached such a high degree of development that many belated country towns skipped a cog and put in dynamos. If this possibility had been suggested fifteen or twenty years ago, it would have been greeted with incredulous smiles. Only an insignificant minority of us had actually looked through a fluoroscope and seen the bones of our own hands by means of Roentgen's rays, when Becquerel rays and all the various rays from radium intervened to confuse us with the very multitude of wonders. All these great advances have been made possible and have had their origin in laboratories and laboratory methods, so that it is but natural that laboratories themselves should have undergone equally rapid and radical changes.

Eighty years ago there was not, in any country, a single laboratory for the purpose of teaching chemistry. To be sure, the subject had been taught for many years, both abroad and here, by lectures which formed a recognized part of a medical education. At Harvard, Dr. Aaron Dexter was installed as professor of chemistry and materia medica in 1783. In 1791, Major William Erving died, and in his will declared that, "Being unwilling to pass through existence without profiting the community, it is my will and pleasure that a sum of money, not less than one thousand pounds, be paid, as soon as it conveniently can be after my decease, into the hands of the overseers and corporation of Harvard College, for the sole use and purpose of enlarging the salary of the professor of chemistry, who is to receive the annual interest of it." If this quotation adorns my tale, it also points a moral by no means out of date. The Erving professor of chemistry and materia medica, in the year 1811, was drawing the munificent salary of $700 annually.

We get a realistic picture of the facilities for teaching chemistry at that time, from the early history of Columbia, in the first volume of 'Universities and their Sons.' It appears that in 1792 a committee of the trustees of that institution concluded that they needed 'a professor of natural history, chemistry, agriculture and other arts depending thereon.' They further defined his duties in this wise: "The schedule or sketch of this professorship to comprehend the philosophical doctrines of chemistry and natural history under the following heads: (1) geology, or the natural and chemical history of the earth; (2) meteorology, or the natural and chemical history of the atmosphere; (3) hydrology, or the natural and chemical history of waters; (4) mineralogy, or the natural and chemical history of fossil substances; (5) botany, or the natural and chemical history of plants; (6) zoology, or the natural and chemical history of animals."

This program would be sufficient to stagger most of us, and so it is with some relief that we learn a little farther on that the college had facilities for the work, which they described as 'a handsome chemical apparatus * * * and a considerable collection of fossils.' But any growing confidence in the desirability of the position is shattered when we learn that in 1814 the trustees memorialized the legislature, and amongst numerous complaints detailed, the following is not the least grievous. They say, 'they have found it due to the state of science and to public opinion to institute a professorship of chemistry as a part of the academic course, and have appointed a professor without being able to give him any compensation'!

While all teaching was done by means of lectures alone, laboratories did of course exist, though we might well hesitate before granting them the dignity of that title. They were private affairs, belonging either to rich individuals with a taste for natural philosophy, or to apothecaries, or to some of these lecturers, who provided themselves somehow or other, in spite of obstacles nearly insurmountable, at their own cost, with the means of experimenting. There is a minute description of a laboratory, evidently just such as it should be, in Dr. Ure's 'Dictionary of Chemistry,' the American edition of which appeared in 1821. A few sentences will suffice to give us a picture of the laboratory of that day. Dr. Ure tells us that, 'Many people think that a laboratory level with the ground is most convenient * * * but it is subject to very great inconvenience from moisture.' "In such a place, the inscriptions fall off or are effaced; the bellows rot; the metals rust; the furnaces molder, and everything almost spoils." "In the laboratory a chimney ought to be constructed, so high that a person may easily stand under it, and as extensive as is possible; that is, from one wall to another." "As charcoal only is burnt under this chimney, no soot is collected in it; and, therefore, it need not be so wide as to allow a chimney-sweeper to pass up into it." "Under the chimney, at a convenient height, must be a row of hooks driven into the back and side walls; upon which are to be hung small shovels; iron pans; tongs; straight, crooked and circular pincers; pokers; iron rods, and other utensils for disposing the fuel and managing the crucibles." "To the walls of the laboratory ought to be fastened shelves of different breadths and heights; or these shelves may be suspended by hooks." "The shelves are to contain glass vessels, and the products of operations, and ought to be in as great a number as is possible." "In a laboratory where many experiments are made there can not be too many shelves." The detailed description which he gives as to the necessary equipment, not forgetting even 'a glue pot, with its little brush,' and 'a good steel for striking fire,' is both amusing and interesting, but these quotations are enough to produce a fairly precise picture of a 'modern' chemical laboratory of 1820.

We have another, and much more interesting and historically valuable description of one of these old laboratories, as it was just before the marvelous rush forward began. You will remember that Wöhler, forever famous as the first to break down the apparently impenetrable barrier between inorganic substances and those formed through processes of life and growth, by making urea in the laboratory, went, in 1823, to study and work with the yet more famous Berzelius. He has left us a description of the laboratory, which was in Berzelius's own house. He says the laboratory was 'close to the living rooms and consisted of two ordinary rooms, most simply fitted up; they contained no furnace nor draft, no water nor gas pipes.' "In one of the rooms stood two common pine wood-working tables; Berzelius had his working place at one, I mine, at the other." "On the walls were some cupboards containing reagents, of which there was no excessive variety, for I had to send to Lübeck for some potassium ferrocyanide when I needed it in my experiments." "The arrangement for washing apparatus consisted of a stone water jar, with a stopcock and slop jar beneath it." "The balances and other instruments were in the second room, and near by there was also a little workshop with a turning lathe." "In the kitchen, where the austere old Anna, cook and factotum to the northern master who was then a bachelor, prepared the meals, there stood a little furnace and the sand-bath which was always kept hot." And yet in these surroundings and with these appliances Berzelius discovered several elements, isolated others for the first time, determined a great number of atomic (or, as we prefer to call them, combining) weights, worked out numerous new analytical methods, and did much of great importance in organic chemistry. You probably recollect that Sir John Herschel, while at the university in 1819, for lack of a better place, converted his sleeping room into a laboratory, discovered the solvent action of sodium thiosulphate, so important in photographic processes, and had endless trouble with the chambermaid and his landlady because of the mess he made.

The leading scientific men of those days were as well aware of the necessity of laboratory teaching to convey a proper knowledge of the subject as we are ourselves, and repeated efforts were made to induce college and university authorities to recognize this need. But insuperable difficulties were met, and not the least of these was the opposition of those engaged in teaching the classics. These ultra conservatives, to use no harsher term, were not even willing to grant that chemistry ranked as a science, and vigorously resisted attempts to introduce it as a regular study. To Liebig, at Giessen, belongs the credit of making the first successful breach through these prejudices, and establishing the first chemical laboratory ever opened to students in a university. This was soon after 1824, the year in which he began his work at Giessen. This famous laboratory of his was small and had a precarious existence at first. Ten years after its opening Liebig, in a bitter letter to the chancellor of the university who controlled the funds, complained that he had been given nothing but four bare walls, and no money whatever for equipment or running expenses. Every piece of apparatus, and every chemical in it, he had bought and paid for out of his small salary. His patience was exhausted and he threatened to resign, and to make known the treatment he had received in justification of his resignation. In response to this, and stirred by the fear of the scandal that exposure would cause, the chancellor provided the minimum amount of money necessary to appease and retain Liebig. But students had flocked to Giessen from every civilized country, and returned inspired and eager to follow Liebig's example in their own homes. Laboratories, and courses in chemistry, modeled on Liebig's, sprang up in too rapid succession to follow. We may, however, describe one or two of the beginnings in our own country.

Chemistry was taught in the laboratory in the medical department of Harvard, in the city of Boston, at an early date, and in 1846 a new medical school was built, the basement of which was devoted to a chemical laboratory capable of accommodating 138 students. In the academic department recognition of the subject was slower. Professor Josiah P. Cook, Erving professor of chemistry, who died only a few years ago, succeeded in getting a small laboratory fitted up in the basement of the main university building in 1851, and President Eliot was the first student to take advantage of the opportunity offered.

At Yale Professor Benjamin Silliman and his son established a laboratory of analytical chemistry and mineralogy, as a private venture, and it became of sufficient importance to be incorporated as part of the university in 1847. This proved to be the nucleus from which sprang the present Sheffield Scientific School.

The University of Michigan is generally recognized as having always set the pace for other state universities, and maintained its leadership in this department also, by being the first of them to introduce the laboratory method in teaching. Three years after Professor Cooke had begun educating President Eliot, Dr. Douglas, of the University of Michigan, was instructing a class in qualitative analysis, in a small room of the medical building, now utilized as a preparation room for lectures. A building exclusively for the teaching of chemistry was finished at a cost of $6,000, including the equipment, and was in use in 1856, or a year before Boylston Hall was opened at Harvard. In one of his reports, written as this laboratory was nearing completion, President Tappan says that it 'will unquestionably be unsurpassed by anything of the kind in our country.' Every few years the demands for more space became so urgent and so obvious that an ell was added, or a cellar was excavated, until, in that huge labyrinth, whose very floors are worn through by constant use, as it stands to-day, one may study the development of laboratories, as the geologist studies the development of the earth, by an inspection of the strata. It is worthy of remark that we have the promise of our board of regents that the next large building which they undertake shall be a new chemical laboratory.

Turning now from this review of by-gone times to the present, we may well marvel that such a complete revolution of conditions could occur in fifty years. It would be harder to find a university without moderately good laboratories to-day than it was to find one with them in 1850. And they are increasing in numbers and size, through the munificence of individuals and of legislatures and governments, at a surprising rate. These modern laboratories need no description, for we have the actual model here before us.

At no other period in the history of the world has so much money been available for the teaching and the advancement of science. The great endowments and bequests of recent years, as represented by the Carnegie Institution, Leland Stanford University and the University of Chicago, to mention only three, are as well known to you as to me. I had the curiosity to look through Science, for the year 1903, and to add together all the sums recorded there as actually given during that year to colleges and universities, excluding items that might be simply newspaper rumors. It was surprising to find that they footed up to $15,241,533. Add to this Carnegie's ten millions to the Scottish universities, and the McKay fortune, variously estimated at from four to twenty millions, which is to go to Harvard eventually, and the total is truly princely.

Such figures lead very naturally to the question: Have the universities deserved such sums, from the point of view of what they have accomplished in the past, and can they possibly require more than they now have? Any one who has had to do with a university can answer in the affirmative to each of these questions without hesitation and without qualification. It is my intention to prove that all the money ever given to the cause of education and science does not equal a fraction of one per cent. of the returns made by them, and at the same time to prove that no better, nor more surely profitable investment for money is to be found, than in increasing these endowments and bequests many fold. In the first place, we should realize that most of these gifts are principal sums, and the interest only is available, which puts a different aspect on the question at once. Furthermore, we must also realize that most of the bequests are for specific purposes, and very generally are so hampered with restrictions that they can not be applied where they will do the most good. An illustration of the way in which such conditions may work out in the course of time is the bequest of a well-meaning clergyman made more than a century ago to Harvard, the interest of which was to support a preacher among the Indians.

He evidently intended to protect home industries, but the bursar's checks have to travel a long way now. It is not in the least essential to my argument to diminish the total amount to be accounted for, rather let it be imagined that all the money now invested in the buildings and equipments of our universities has completely vanished, and still we shall be able to find hundreds of dollars' worth for every dollar expended on laboratories or scientific work.

The duties or functions of laboratories have always been, and properly are, twofold, to teach and to advance knowledge, Some have been devoted exclusively to teaching and others exclusively to research, but the best balanced are undoubtedly those which take up the full burden and do both. The results along either line are ample to justify my contention. Consider what some of the discoveries made in laboratories have been, and what they have meant to civilization. It is not my intention to weary you with a list of several hundred valuable discoveries, but rather to call your attention to certain characteristics possessed by them, not often enough emphasized. First and foremost among these characteristics must stand the fact that, with scarcely an exception, those discoveries which have been of the greatest material benefit to society have been the results of disinterested research in pure science, complete and unconditional gifts to the whole world. Brandt received nothing for his discovery of phosphorus in 1669, but after the lapse of a century and a half it gave us those simple but indispensable conveniences, matches. Valerius Cordus, when he first made ether in 1540, and Guthrie and Liebig, when they discovered chloroform in 1831, got no rewards for those godsends they were giving to suffering humanity. Such examples might be multiplied, and they would all have that characteristic—they have been free gifts to mankind.

To my mind, at least, another class of results is even more important than such as these. I refer to the great and fundamental laws, principles and theories of our sciences. For while the chance of financial reward to the discoverer is practically eliminated, they alone make possible the far-reaching applications of science, and assure us of a continuation of our advance, by furnishing the firm working bases. Who can estimate the value of Dalton's atomic theory, and all the patient and painstaking work involved in the determination of the atomic weights, for the manifold chemical and allied industries, and through them for us all? How much was Faraday's discovery and study of the phenomena of electrical induction worth, bearing in mind that it made possible our dynamos and motors? Scarcely an electrical measurement is made but what Ohm's law is used in the calculation, yet how many of us have stopped to think what an immense saving of time and money is effected daily by that simple formulation of his? But once more there is danger of becoming prolix with such a vista of apt examples opened out before me.

The reproach is sometimes made by those who know little of science, that much of the research work done is useless from the practical point of view, and results only in scientific curiosities. Such curiosities were cerium and thorium at one time, but now we have the Welsbach gas mantle. The scientific curiosity of to-day is very apt to become the household necessity of to-morrow. A friend once watched Faraday in his laboratory for a while, and then asked him of what use such work could be. Faraday immediately replied with the question, 'Of what use is a baby?'

It is not impossible that the objection might be raised that many of the newest inventions at least are patented, and that then tribute is levied in the shape of royalties. This is true, and it is somewhat unfortunate, also, that in the majority of instances the wrong man gets the royalty. A law of nature is not patentable, but the application is, and so it comes about that the real discoverer, retiring and absorbed in his science as he must be to produce his intellectual marvels, is overlooked by the public, overshadowed by some one who happens to find a patentable application of a discovery in which he took no part. It is worth pondering a moment that practical and patentable are not synonymous terms. It is far from my intention to imply that the patentee does not deserve his royalties; he unquestionably does, and fills an important and necessary function in the social economy.

In any case, such tribute as is levied in this way is but a small fraction of the worth of the invention, and the public always gets a good bargain. The actual value, in dollars and cents, of that portion of the fruits of scientific labor which is given for nothing is hard to estimate, but perhaps we may get a notion of it by analyzing one specific case. Suppose some one unprincipled individual obtained an absolute and unquestioned monopoly of all telephones to-morrow. Suppose him to be under no legal restraint, and that he proceeded to squeeze every user of a telephone as hard as possible. It is safe to predict that single business firms would pay him thousands of dollars, rather than lose that indispensable adjunct to their facilities for carrying on their work. Add together all that he could possibly get in this way from all over the world, and subtract from this total the amount now being paid, and we shall get the value of one little gift of science to mankind. Is it extravagant to estimate this one item, as exceeding the total cost of all educational institutions since the dawn of civilization?

Let me put the question in another form: What is the total value of all the time saved by telegrams and by our present means of transportation? And again, how much would you pay for enough antitoxin to save your child from death by diphtheria? These things are inestimable, and my original statement stands proved.

Professor Dewar drew a particularly illuminating comparison about a year ago. He wished 'to find out exactly what some definite quantity of scientific achievement has cost in hard cash.' He found that 'the total cost of a century of scientific work in the laboratories of the Royal Institution, together with public demonstrations,' was £119,800. This is the price which was paid for all the achievements of Young, Davy, Faraday, Tyndall and Dewar himself. No wonder that Dewar reaches the conclusion 'that the exceptional man is about the cheapest of natural products.' We may sum all this up by saying that it is impossible to fix the value of the results obtained by research workers in laboratories, for the simple reason that they have been the *creators of nearly everything that makes money worth having.*

And so far we have touched upon only one of the two functions of our universities and laboratories. The laboratory of yesterday taught the engineer and the doctor of to-day, and the laboratory of to-day is training the discoverer and inventor of tomorrow. The value of the educational work done is so generally recognized and attested by the donations of private citizens, and the constantly increasing grants made by far-sighted legislative bodies, that it requires no elaboration. It admits of no argument that the total knowledge of the human race is worth more than all the money in the world. Our constant strides to higher and higher planes of enlightenment which were never so rapid as now, and which seem to be subject to a law of acceleration similiar to that of gravitation, are due, we are all of us ready to acknowledge, more than to any other influence, to the constantly increasing numbers who obtain the advantage of superior, of college and of university educations. Statistics taken from biographical dictionaries for a definite period show that one out of every 250 of those with college training do something worth recording in such a book, while of those without this training the proportion is about one in 10,000.

We are too apt to fix our attention exclusively upon the exceptions, upon those brilliant individuals who make their marks in the world, and to withhold deserved appreciation from that much larger number of what we may call the average, the mediocre. Yet these latter do the most of the world's work, and in the aggregate their output is in excess of that of the exceptional individuals. Upon their ability to appreciate and to utilize the discoveries and the methods, found and described by the leaders, depends our advance as a race. The most useful and effective of machines is practically useless and ineffective, if only one man in the world has the knowledge and ability to run it. In this scientific and mechanical age of ours, where specialization has been carried so far in every branch of industry and every occupation in life, there is an ever-increasing necessity for more and better preliminary training, before a man is competent to control and govern the more and more complicated conditions. Upon our laboratories devolves the task of disseminating a general knowledge, broad enough and widely enough distributed, to ensure the recognition and immediate utilization of the great improvements made possible by scientific methods, and also of turning out ever larger numbers of men, thoroughly equipped to cope with the industrial processes as they stand to-day, and with the intelligence to adopt improvements as they appear.

Our manufacturers are rapidly waking to the fact that it is sound business sense, and brings big returns, to fit up private laboratories of their own and employ well-trained scientists to study and to improve their processes. It is strange that, leaders as we are in so many particulars, we should be so far behind the Germans in this respect. They learned this lesson years ago, and to it owe their leadership of the world in nearly all branches of chemistry. A forcible comparison between German and British chemical industries is drawn by Professor Dewar in his address to which I have already had occasion to refer. You are doubtless familiar with it, but a few sample statistics will certainly bear repetition. From details regarding 633 German and 500 British works-chemists, he finds that 69 per cent. of the Germans hold the degree of doctor of philosophy, and 84 per cent. have received thorough systematic training, while 31 per cent. is the outside figure for the thoroughly trained among the British works-chemists. He next finds that the German chemical industries do a business of over $250,000,000 yearly, and that they are largely based on English discoveries which were not appreciated nor developed, in spite of the abundance and cheapness of raw material close at hand. We sometimes forget, in the multiplicity of his accomplishments, that Faraday discovered benzene. He gives figures to show the progress of one of the German firms, that of Friedrich Bayer & Co., which employed one hundred and nineteen workmen in 1875. He says: "The number has more than doubled itself every five years, and in May, 1902, the firm employed five thousand workmen, one hundred and sixty chemists, two hundred and sixty engineers and mechanics, and six hundred and eighty clerks.'' ''For many years past it has regularly paid eighteen per cent. on the ordinary shares, which in 1902 rose to 20 per cent.; and in addition, in common with other and even larger concerns in the same industry, has paid out of profits for immense extensions usually charged to capital account.'' ''There is one of these factories, the works and plant of which stand in the books at $7,500,000, while the money actually sunk in them approaches $25,000,000.'' Such statistics are producing their inevitable effect, and the demand from our industries for graduates capable, not merely of carrying out qualitative and quantitative analyses, but with a training fitting them to study and improve processes, and develop new ones to meet new wants, is already much in excess of the supply, and will grow larger and more imperative. Only a short time ago a recent graduate was offered a position in our university at $1,500, whereupon his employer raised his salary to $3,000, and wrote to the university jocularly suggesting that it increase its bid to that amount, and he would raise it again.

To meet these demands, as well as the just expectation of society, that laboratories and scientific workers shall continue their free gifts to all, means that our laboratories must not merely keep abreast of the times, they must keep ahead of them. To do this they must have apparatus and equipments which grow more elaborate and more costly each year.

Thinking of the astonishing results obtained by the pioneers of chemistry and of physics, as compared with the extreme simplicity and the paucity of their instruments, it is natural that the first impulse should be to conclude that our modern laboratories are extravagant in their demands. But there is more sound truth than there is generally conceded to be in that time-honored jest about the young aspirant for scientific laurels who, after a long search through the archives of science, came back to his professor with the bitter complaint that 'all the easy things had been discovered already.' The domain of science is not exempt from the general law that the simplest and easiest is done first, and saying this should not be construed as detracting in the least from the fame of a Columbus of science who launched forth in the courage of his convictions, and after much hardship discovered a new world. The first comer had but to pick the plant nearest at hand to obtain a new specimen, and the roughest sketch of the coast line was a great contribution to knowledge. But think of the years of skilled labor, the reams of calculations, and the thousands of exquisitely made instruments that had to be employed before the government could issue those perfect charts of the waters surrounding our country. It was not so very many years ago that gold and silver could be found on and near the surface hereabouts, but that is not now the case. It is said, and it is no doubt true, that the treasures of the Rocky Mountains have been no more than scratched as yet. These scratches are on the surface, and the easiest ones to make, and you must dig more mines and deeper each year. Once a pan and a stream of water were the essentials to wash out a fortune; now gold-bearing quartz is crushed in the stamp mills, and is treated by the cyanide process. Your modern gold mine requires an initial expenditure of one or two hundred thousand dollars before it begins to pay dividends. The analogy is perfect. The prospector's pan of yesterday is to the installation of to-day as the laboratory needs of yesterday are to the laboratory needs of to-day.

Please notice it pays well to dig deeper, to crush the ore, to concentrate it and to send it to a smelter. The processes are longer and more expensive, but the investment is still returned with high interest. The problems to be met have been growing more difficult, but they have been met, and successfully solved, by those with laboratory training, or by those who have profited by the knowledge of the facts dug out in the laboratory. More problems, and more difficult ones, will arise, and they in their turn will be solved, if laboratories and their equipments are maintained at their highest degree of efficiency by liberal endowments and grants. But it would be as absurd to expect our men of science to cope with the complex questions of the present and the immediate future with antiquated utensils, as it would be to send our sailors off in the wooden ships of the war of 1812 to grapple with the Japanese navy.

The idea that a given sum will build and equip a laboratory, and that once set going it will run itself and require nothing more than occasional small sums to replace loss by breakage and the like is a pernicious fallacy. New methods, requiring new or improved instruments, appear each year, and these instruments must be had, if there is to be any pushing forward into the unknown in the branch to which they are adapted. It is a noteworthy fact that, crude as the materials of the early experimenters were, they were the best for their purpose to be had in the world of that time. Faraday insulated his wires with bits of string and old calico, but no one had better insulated wire. Davy obtained sodium and potassium by electrolysis, but he had the biggest and best galvanic battery in existence at the time. It would have been practically impossible to discover Hertzian waves, or Röntgen rays, or wireless telegraphy, without the best of induction coils. And so we might continue *ad infinitum*. It is clearly impossible for one laboratory to have the best of everything, but it is equally clear that each laboratory should have a fairly representative equipment on all general lines, primarily for teaching purposes, and should have an outfit equal to the very best for one or two topics. These topics should be different in different places, and may often be adapted to special localities; they should be chosen by the members of the instructing staff according to their individual aptitudes and interests.

Our laboratories have overwhelmingly justified their cost by their past history, and are justified in making greater demands than ever, by the importance of the functions which they fulfil.

It is to be hoped that philanthropists will be still more liberal than they have been, and that the people will tax themselves more than they ever have, through their legislatures, to give to all schools, colleges and universities. Such money is the fire insurance and the life insurance of society as a whole, guaranteeing the maintenance of law and order, and the ability of the next generation to support the burden of advancing civilization, when its turn comes.

S. Lawrence Bigelow.
University of Michigan.

*IS THE COURSE FOR COLLEGE ENTRANCE REQUIREMENTS BEST FOR THOSE WHO GO NO FURTHER?**

The question is an old one. Is there conflict or harmony of interests between secondary and higher education? Should the high-school student be laying foundations for future study, or should he be doing work that is complete in itself, so far as it goes; or may he not secure a maximum of present utility while laying satisfactory foundations for future studies? I should prefer to discuss the question the other

* Address delivered before the Biological Section of the Central Association of Science and Mathematics Teachers in Chicago. General subject of the meeting: 'Essentials of a High-school Course in Biology.'