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, NOVEMBER 23, 1906.

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 UNIVERSITY AND THE WORLD'S GREAT WORKSHOP.[1]

President Drinker, Trustees, Alumni, Faculty, Students and Friends of Old Lehigh:

IT was with a feeling of diffidence that I consented to address you on this the fortieth anniversary of the founding of your university—knowing the difficult task I should have in following the splendid men who have addressed you on former occasions, but your president, aided by some of his good friends from the great body of your alumni in western Pennsylvania, so adroitly laid the trap for me that escape was well-nigh impossible.

However, I must say that I am not at all reluctant to be found among my friends at Lehigh. For many years I have been more or less intimately associated with the men who have been telling factors in making Lehigh what she is to-day, men who have not only helped to push outward the borders of human knowledge, but have *done* things that count in the workshops of the world. The Founder's Day you celebrate must be one of very happy memory to many who are here. Could Judge Packer look upon this scene that we are permitted to witness to-day (and who can say that he does not)—could he see these splendid buildings you have completed, dedicated and used for the higher education, others that are being constructed for

[1] An address by John A. Brashear, D.Sc., LL.D., of Pittsburg, Pa., at Lehigh University, South Bethlehem, Pa., October 11, 1906.

the same purpose—surely he would rejoice with you in the rounding out of the grand scheme so long hoped for by your presidents, your board of trustees, your alumni and the many friends of old Lehigh.

I come to assure you that the good people of the western end of our state have more than a passing interest in the new life that has come to you. Of the 1,500 alumni you have sent out to do the work of the world, we have captured no less than 175 good strong men who are to-day potent factors in the great industries of western Pennsylvania; indeed, we have many of Lehigh's very best men scattered among our 5,000 manufacturing establishments where are employed more than a quarter million workmen turning out a yearly product valued at $450,000,000.

These men—your alumni—occupy no menial positions, but are holding places of honor, trust and responsibility; indeed, I know what I am saying when I tell you that many of them are at the very head of some of the most important industries of our great city of Pittsburg and its environments. Between forty and fifty of your alumni are associated in the works of the Carnegie Steel Company. Many of them —more than a score—are associated with the Westinghouse Electric Company, others with the Crucible Steel Company of America and the American Bridge Works; in fact, your graduates may be found in every important industry in western Pennsylvania.

It seems to me that you should be proud of the record of your alumni in the part they have taken in the development of the various ramifications of the great steel interests of our country, for no less than six hundred of your men have been intimately associated with it; the fact is, right here in your own Bethlehem Steel Company you have a goodly number of Lehigh men who have made their influence felt and their labors count for the very best.

But Lehigh's record is not confined by bonds of iron and steel—her men have gone into many of the varied avocations of life and have been most successful in their calling. I have in my own library some splendid volumes that have come from your astronomical observatory—records of work of the very highest type in measurements of precision—volumes which have been criticized most favorably by astronomers all over the world, and I say it with much pride that you have turned out some of the best young men from this department that now grace the astronomical departments of universities in both hemispheres. So it has been with your departments of mechanical, civil and mining engineering, chemistry and physics; and you have also graduated men who have brought honor to their alma mater as statesmen, educators, authors, editors, scientists, lawmakers, manufacturers—indeed, covering very many phases of the world's great work. Surely Lehigh may well be proud of the record of her alumni.

It may be a hobby of your speaker, but he has been of the opinion for many years that not only is it of paramount importance that every student of technology should have enough of the so-called 'humanities' in his curriculum to develop the higher manhood, and thus broaden out his vision; but, conversely, every student who may choose the humanities should get in touch with at least enough of science, of technics, to enable him to comprehend the marvelous advances in every line of human thought and industry that will surely come to pass during his day and generation.

Will not some knowledge of the starry heavens be of use to the man who is to stand in the pulpit and proclaim the mighty works of the Creator's hand? How

about the microcosm and the macrocosm in the make-up of the universe of God? Will it add to or subtract from him who is to proclaim the Word of God who has a knowledge of and can talk about these noble subjects, or shall he be content to say:

> A primrose by a river's brim
> A yellow primrose was to him
> And it was nothing more.

Did not the Master say with an eloquence that has lived through the centuries:

> Consider the lilies of the field, how they grow; they toil not, neither do they spin, and yet I say unto you that even Solomon in all his glory was not arrayed like one of these.

I firmly believe that every student whose purpose is to follow some one of the professions will have a more successful and a happier life by absorbing at least enough of science, of technics if you please, to broaden out his views, as a knowledge of the humanities will surely do for the technically-trained student.

In an address to the students of the Sheffield Scientific School my friend, Col. H. G. Prout, made this remark, "Scientific study may in itself be a great expander of the imagination and I venture the assertion that the study of chemistry and biology, machine design, or analytical geometry, geology or astronomy, is as quickening to the imagination as the study of Greek or Latin grammar, moral philosophy or rhetoric, as any formal study of English literature."

Some Founder's Day I think you could not do better than to have read before you the splendid address of that splendid man, Eckley B. Coxe, which was delivered at the Montreal meeting of the American Association of Mechanical Engineers, of which he was then president. I had the great pleasure to hear that address on 'Technical Education,' and to you who knew the man I need not say that it made a deep and lasting impression upon my mind. It was a mighty sermon from its opening to its closing sentence, showing a most profound knowledge of the whole subject. Surely Lehigh was honored by the association of Eckley B. Coxe as a member of its board, and as a noble patron who had your best interests at heart.

Other names have graced your roll of honor, some of whom have passed over to the 'summer land of song'; yet we can rejoice to-day that some of the old guard are still with you, lending a helping hand to lift Lehigh to a still loftier plane in the domain of higher education.

As a citizen of Pittsburg I am here to-day to rejoice with you that *my* friend of a quarter of a century, and *your* friend of to-day, Andrew Carnegie, will from this time on have his name inscribed in your annals, in the hearts of your undergraduates and alumni and all that have the interest of your university at heart, as a friend and patron.

It was a joy to me to learn that he had made it possible to build the dormitories you have needed so long, and I must congratulate your president and also one of his co-workers in our end of this good old commonwealth in having secured the friendship and patronage of this friend of science; no one knows better than he who addresses you what the friendship of Andrew Carnegie means.

We Pittsburgers also have a Founder's Day, and our next one will commemorate his grandest and, we think, one of his greatest gifts to the world, namely, the splendid institute in which the arts, the sciences, music and literature will find a home and be fostered, and with this we shall also commemorate the founding of the great technical school, which has already nearly fifteen hundred students within its

walls, with thousands more begging for admittance, which we expect some day to take care of through Mr. Carnegie's munificence. Surely Lehigh can rejoice with us on our Founder's Day, for we hope to keep in close touch with your university. You need us. We can not do without you. We have already captured some of your good men for our technical school, perhaps we can reciprocate in the future, for as yet we are but a year old.

And now, lest I weary you, let me hasten to discuss the theme I have chosen for my address, namely, 'The University and the World's Great Workshop.' Of course, I shall speak only of the modern university, totally dissociating it from the scholasticism of the middle ages.

In a recent and very excellent article by Professor Edward Sisson, of the University of Washington, on Francis Bacon and the modern university, full credit is given to this learned man, as being the founder of the universities of to-day.

I quote one or two paragraphs from the article referred to that are apropos to my theme:

Bacon says: "I may lament that no fit men have been engaged to forward those sciences which yet remain in an unfinished state." Professor Sisson, commenting on this remark of Bacon, says:

> The sciences which Bacon knew have been advanced to a plane far beyond the highest imaginations of even his great mind and new regions of knowledge have been opened of which he could not dream.
>
> Even more significant is the fact that we have given up believing in the possibility of a *finished* science! All sciences are unfinished and it therefore becomes the duty of every devotee to labor for their advancement. The universities, after centuries of inertia, have at last waked up, or rather, vigorously aroused to their duty to be creators as well as conservators of the store of knowledge.
>
> The use of Latin as an exclusive means of communication and the worship of Aristotle as the source of final authority upon all questions were the two great prerogatives of the medieval universities. All this has been changed, and we live in the dawn—yea, in the broad light of a better day.

There was a time when a university education did not stand for what it does now; indeed, I am sure that there are those in this audience who can remember when the graduates of our universities, particularly those who received a technical education, were looked upon with doubt or even suspicion when they applied for a position in any of our manufactories or workshops. Perhaps it was in some instances in the earlier days a well-founded suspicion that the applicant had surfeited himself with book learning and had no knowledge whatever of the practical side of the position he sought. Happily that day has passed and the time has come when our mills, factories and workshops, in fact every important industry, appeal to our universities and technical schools to furnish them with men who have not only been taught to think, but to *do* things.

Setting aside for the moment the purely professional schools, where would the great industries of our land be to-day without the men who have come from our universities and technical schools?

I know I lay myself open to criticism by those who will say that many of our great industries have been originated and developed by self-made men, men who had only the most meager education to start with. Certainly we must grant all this, but let us take as an illustration that Nestor of the steel industry in America—your honored citizen—my friend John Fritz, a man loved by everybody on earth and in heaven. Did he not go through mighty struggles, struggles that no man will ever know but himself; did he not have to master the very problems which is the province of the university to teach your students? True, you

can never give them that which comes only with the experience this splendid man has passed through, but you can and do train them so as to eliminate the empiricism that handicaps the man who does not possess what you give to your graduates.

I know I can say without fear of contradiction that no man knows better the value of the higher education than just the kind of man I have spoken of; I need not dilate upon this subject, the witnesses are all with me. Let it be said to the honor of these self-made men, these men who have made a commercial success in their business career, that you will find their names on record as the very best friends of education; they are the men who have given millions to build up and foster the universities and technical schools of this good land of ours. Not only has your patron, Mr. Carnegie, contributed many millions to higher education, but he has gone farther by endowing original research and also providing a fund to care for the men who have borne the heat and burden of the day as teachers in our educational institutions. What a splendid work for one self-made, self-educated man to do. Other names I could mention who have done nobly for the cause of education, and when the book of God is written Ben Adhem's name will not be the only one recorded of those who loved his fellow men.

It is a great pleasure to me to be honored to-day with the presence of my long-time friend, Mr. Charles M. Schwab, who has done so splendidly for technical education in our great manufacturing town of Homestead; nor did his interest cease with this good work, for I know what he has done for State College, for the Western University of Pennsylvania in Pittsburg and kindred institutions. He knows and appreciates what there is in the hearts of his workmen and how they love to learn of the good and beautiful things in this life that they can and should have a share in enjoying. All honor to such men.

Every industry, every scientific pursuit, every calling of to-day demands the best education that can be given by the best men in the best schools, and the magnificent results that have crowded in upon us in the last half century are largely due to the masterly work done in our institutions of higher learning.

Let us examine for a little while some of the results coming to us from university men. In the great field of astronomy and astronomical physics we have been brought almost to the borderland of the infinite. In the last quarter of a century, discovery after discovery has been made and so many new facts brought to light that no one mind is capable of comprehending them all.

In the domain of solar physics we have thrust our spectrobolometers into the very depths of the sun's photosphere. With our spectrographs we have taken hourly records of the terrific storms that rage upon our great luminary. That record can be made to tell us the very elements that go to make up the solar disturbance. The sun's energy has been measured and its source discovered—not in the old-time meteoric theory of accretion, but we now know that the shrinkage of the solar envelope is all sufficient to keep up its temperature for at least ten millions of years to come, should no new source of its energy be discovered.

The university man has also shown us that in all probability our sun is a variable star, with a variation of perhaps ten per cent. in its radiant energy. Some day he will tell us its period of variability as we now know with absolute certainty the period of many variable stars in the heavens. The university man has also measured the radiant energy coming to us

from our sun, and while we receive only about one twenty-two hundred millionth of that which is sent out from our great luminary, we know that it has conserved, and this old earth has stored up untold billions of 'units of energy' that we are now utilizing to do the work of the world. Some day this storage battery will run down and we must either renew it or go to the original source for our energy. The university man has been on the alert and already he has tapped the wires of the great solar dynamo by harnessing old Niagara's waters as they tumble over the mighty rocks—lifted there by the sun's potent forces.

We have also learned that the earth's atmosphere is so constituted that it conserves the long waves of energy coming from the sun, which if it did not do, organic life, as we know it, would be impossible on our globe.

Our medieval astronomers taught us the stars were all fixed, immovable in the heavens. The doubting student came along in later years, and with his instruments of precision soon discovered there were *no* fixed stars. He could readily measure their movements across the line of sight, but when moving away from or toward us, his instrumental equipment utterly failed him. Then came the university man Doppler to his help, with the principle of variable wave motion now known as Doppler's principle; then came the telespectroscope, by the use of which this principle could be applied; and now our astronomers are rapidly gaining a knowledge of the motion of all the more important stars in the heavens. With this knowledge has come to us the interesting fact that our own solar system, our sun, our earth and our sister planets are all moving through the universe at the rate of about one million and eighty thousand miles in twenty-four hours, or twelve and one half miles a second, in the direction of the constellation of Hercules.

But the end is not yet. Your university men could not reconcile certain minute displacements of the stars that were of a rhythmic character and they began to suspect that this old globe was not stable, that it had a wobble, if you please, like a top after it had passed its 'sleep.' Here you will pardon me when I tell you that one of your best men, with a big brain, but rather inadequate equipment, was one of the pioneers who undertook to solve this abstruse and difficult problem, and be it said to the honor of Lehigh, the continuation of this work by this man has settled the question to a degree of precision never dreamed of when he commenced his work. Another difficult problem has been attacked by your astronomers at Lehigh, namely, the constant of aberration, the solution of which speaks for itself. I should like to tell you more about it; indeed, I should like to mention the names of some of your men who have made epochs in the world's work, but I dare not, lest I overlook some who should be on the roll of honor. Suffice it to say that the published results of these long, difficult and patient researches have already become classic in the annals of astronomical literature.

Patience, patience is the watchword of a sage,
Not to-day, nor yet to-morrow, can complete a perfect age.

Other volumes on double and binary stars have recently been given to the astronomical world by one of your alumni and have found immediate recognition as works of the highest value. I am informed by your president that still another volume is ready for publication, the results of observations made at your observatory, the gift of one of your oldest and most honored trustees. Surely you have a right to be

proud of your record in this the most exact and perhaps the most fascinating of all the sciences.

I am sure, however, that you as university men are all interested in the great progress made in this noble science by your colleagues all over the world. American astronomers coming from American universities are gathering, constantly gathering, new sheaves from the stellar fields, fields that seem to be perpetually ripening for the harvest.

It was but yesterday we heard of a new star whose brilliant light burst forth in the heavens, not when we first caught a glimpse of it, but may be a hundred years ago, and it is so far distant that its light, flashing across the stellar depths at the rate of 186,000 miles per second, has taken all these years to reach us.

Placing the slit of our telespectroscope upon the new star, we observe the awe-inspiring phenomenon 'of a sun in flames.' Our inference is that there has been a collision between two stellar worlds somewhere in the universe, and now we witness the elements 'melting with fervent heat' perhaps a hundred years after the awful cataclysm has taken place. A year later the light of that brilliant star had faded from mortal vision, but the astronomical camera, penetrating far deeper into stellar depths than the human eye, even when aided by the telescope, reveals to us the story of a disintegrated world, now a mass of nebula, ready to go through its long evolution, possibly in countless millions of years to become a star again.

'Tis a fascinating theme upon which I could dwell for all the time at my command, but "I must come back to this good old world again, where the birds still sing and the fields yet are green, surely the place of all we have found, the best suited for our dwelling place."

For more than a quarter century your speaker has had the privilege of knowing and associating with the men who have been wresting the secrets of the heavens from their hiding places. The 'new astronomy' has taken the place of the old, and marvelous have been the discoveries made by these men, university men, in this beautiful science.

But with astronomy as with all other sciences there are as yet many problems unsolved, it is an *unfinished* science and the storehouse of heaven is still full of treasures for the searcher after truth.

Ye quenchless stars; so eloquently bright,
Untroubled sentries of the shadowy night,
While half the world is lapped in downy dreams,
And round the lattice creep your midnight beams.
How sweet to gaze upon your placid eyes
In lambent beauty looking from the skies.

There are some problems in astronomy that invite the cooperation of the physicist and the engineer. I have already mentioned the fact that the physicist has utilized the solar energy very nearly at headquarters, but that source, namely, of the great waterfalls, has its limits.

For many years I had the honor to be associated with the late Professor Langley in his studies of the radiant energy from the sun. Many attempts were made to conserve this energy direct without the use of concentrating lenses or mirrors, one of which gave great promise of success. Some day it will be done. Perhaps there will come a time when our fuel supply will be exhausted, then why not capture the original source of energy and make it do our bidding. Professor Langley calculated that it would require all the coal of all the coal fields of Pennsylvania to keep up the energy of the sun one thousandth of a second.

When we learn that the solar energy, if conserved, would approximately equal a horse power for each square meter of

the earth's surface for every twenty-four hours, we may surely consider it a problem worthy of profound study by our scientific investigators.

But I dare not go farther in this interesting subject. I shall only add, if ever the desert is 'to blossom as the rose,' utilization of the direct energy of the sun on the desert wastes will bring to us a realization of the prophetic vision.

What has the university done for us in the domain of the physical sciences? Here we open up another field of unlimited acreage, rich in revealed and yet undiscovered treasures.

Eighteen years ago I was the guest of Professor Dewar at the Royal Institution in London. Among the treasures of that historic laboratory I was shown the first safety lamp made by Sir Humphry Davy and after I had examined it to my heart's content, my friend placed in my hand the first induction coil made by Michael Faraday in 1841. Professor Dewar remarked as I examined the precious, though crude piece of apparatus, 'That is the father of all the dynamos and motors of the present day.' This was eighteen years ago. What marvels in electrical science have been developed in this short interval. One has only to walk through the great Westinghouse works at Pittsburg, or the General Electric, at Schenectady, to see the magnificent dynamos and motors that are the direct evolution of the Faraday induction coil.

Follow these finished machines to Niagara or the great power plants driving electric cars over a vast network of lines that already cover thousands of miles, both urban and suburban, and the end is not yet. I dare not undertake to predict what surely will be done in the very near future by the aid of this powerful ally of man, but I do know that for more than a double decade the university men have been all-important factors in this wonderful development of electric machinery. Go with me through the Westinghouse Electric and Manufacturing Works at East Pittsburg—and what do you find?

I can say from personal knowledge and contact with the men that are doing things in that great center for the output of electric machinery that a very large proportion of those connected with the testing laboratories, the experimental shops, in short, all scientific departments of this typical American workshop, are dominated by graduates of universities.

I am sure it would delight any of your men of Lehigh to spend an evening with the Westinghouse Club. I do not know of any place on earth among men where I have felt a greater inspiration than in talking to these young college graduates, saturated as they are with a love for their chosen pursuit. Here are gathered from four to five hundred men from the colleges and universities all over the land. They are here not only to hear lectures on the purely scientific side of their work, but to learn of men, of methods and other topics so necessary in modern institutions, and I am glad to say that the ethical relations of this splendid body of men are of immense value in their life work.

While writing the last paragraph I thought to call by telephone my friend, Charles F. Scott, who for a long period of years has been the chief electrician of the Westinghouse interests. In my conversation with him I was informed that when he came to the Westinghouse works eighteen years ago there were only four or five college men besides himself in the entire establishment. You will be surprised when I tell you that of the young men who graduated from colleges and universities last

June, two hundred and twenty-five secured positions in this great establishment.

I do not argue here nor do I wish it to be understood that as soon as a graduate has secured his diploma he is ready to take a position as a full-fledged astronomer, electrician, engineer, chemist or other position for which the university has prepared him, but I do say and believe that the earnest student will in his three or four years become so well grounded in the fundamental principles taught him that a very few years of practical work will place him as far along as the self-made man after half a lifetime of hard, hard struggle to gain such knowledge. There are noble exceptions to this statement, but they are all too rare.

A number of years ago I was invited to a luncheon given by the friends of Rose Polytechnic Institute, of Terre Haute, to a body of scientific men. Richard Thompson, so well known as 'Old Dick' Thompson, who was Secretary of the Navy under President Hayes, was an honored guest, and when called upon for a speech, gave us this interesting experience that happened when he was a member of congress from that district in 1844.

He with his colleague from the state decided that year to go to New York before going to Washington. At the hotel he found several congressmen from the east. The day after his arrival he was asked by a member from Massachusetts if he would not go across the way and see a machine invented by a man by the name of Morse, by which, it was claimed, he could send a message from Washington to Baltimore in less than a second of time. You may be sure we were all deeply interested in the old man's story as he stood before us with his flowing white hair. "I saw the machine," he said, "and after Mr. Morse described it to me, he very kindly said, 'If you will ask me a question I will answer it through the ten miles of wire I have placed through this house.'

"I asked him," said Mr. Thompson, "who would be the next President of the United States. Immediately there came the message on a little paper ribbon, and the answer was *Henry Clay!*"

Mr. Thompson replied that 'he knew nothing about the machine, but he liked its politics,' and promised to vote for a subsidy to put a telegraph line between Baltimore and Washington. He then told us that he voted for the $25,000 asked for by Mr. Morse, as did also his colleague. At the next election he was elected by 'the skin of his teeth,' but his colleague was defeated because he had *wasted the public money.* I need not enlarge on how Morse lost his signals by laying his wires underground, how Ezra Cornell, the founder of Cornell University, came to his rescue and enabled him to place his wires upon poles, and that one of the first messages that came over the wires was the announcement of the result of the election of the President—but it was *not* Henry Clay.

This story is recorded here solely for the purpose of showing how great have been the results brought about in telegraphy, largely due to the work of college men who have evolved it to such a degree of perfection that it now answers almost every demand made upon it, exacting as they are.

I was a guest at the laboratory of my friend Professor Rowland some years ago when he was developing his system of quadruple telegraphy, sending four messages both ways over one wire and printing the messages in letters of the alphabet. Your restless scientific investigators, not satisfied, have taken another step forward and are now sending electric waves across old ocean without the conventional wire. Some day they may girdle the earth in this

way—who can say it will not come to pass?

Again, your physicists, unsatisfied with the worlds of knowledge they have already conquered, earnestly seeking for others to vanquish, have brought to light a new form of energy, which they call radioactivity. They seem to have well nigh demolished the Daltonian atom as the ultimate particle of matter, and now they talk to us of ions, of electrons which we laymen are permitted to call corpuscles.

We learn from these men of the university that an atom of hydrogen can be broken up into nearly a thousand corpuscles, an atom of mercury into 200,000 corpuscles, that the atom of radium has stored within it an energy of which our older science did not dream.

Furthermore, our advanced physicists, or at least some of them, have relegated matter to a new field, and they tell us that negative electricity is matter, *i. e.*, that electrons and matter are intercontravertible terms!

Taking these wonderfully interesting theories, combining them with Arrhenius's theory of the pressure of waves of radiant energy from the sun, a new, a beautiful solution comes to us of the origin of the sun's corona, of the zodiacal light, of comets' tails—of the aurora and all correlated phenomena. Surely we appear to be bordering on Kantian transcendentalism when our physicists have reached such dizzy heights.

Lord Kelvin says of the atom: "If we raise a drop of water to the size of the earth and raise the atom in the same proportion, then will it be some place between the size of a marble and a cricket ball."

If you fill a tiny vessel one centimeter cube with hydrogen corpuscles you can place therein, in round numbers, five hundred and twenty-five octillions of them. If these corpuscles are allowed to run out of the vessel at the rate of one thousand per second it will require seventeen quintillions of years to empty it. Such a computation seems almost like trifling with science, indeed apparently trifling with the human intellect, but it is with these subtle theories that our physicists are wrestling, delving into the innermost chamber of the infinitely minute, to build for us, upon the most stable foundation, the macrocosm of a universe.

Lehigh has not been slow in its department of physical science, and her alumni can well be proud of the splendid set of text-books on physics that have come from within her walls.

But I dare not dwell longer on this fascinating theme, or I shall lead you into a maze from which there is no egress.

I have now taken so much time that it is impossible to give more than a brief review of other fields of work which have been so well cultivated by the university men of the past quarter century.

Chemistry, that all-important science—so closely related to every industry—be it of the farm, the workshop, the sanitation and water supply of cities, aye a thousand and one things in which the comfort and conveniences of life are concerned, the university man has taken hold of and developed to an astonishing degree. In one of these phases of the chemist's work your own past president Drown took a great and abiding interest, namely, that of the water supply of towns and cities. At the New Orleans meeting of the American Association for the Advancement of Science, held in January of this year, Professor Kinnicut, of the Worcester Polytechnic Institute, paid a high tribute to the great value of President Drown's labor in this field of research.

Read over the list of famous chemists of later years, such men as Hoffman, Perkin,

Raoult, Draper, Barker, Dewar, Prescott, Ramsay, Remsen, Morley, Atwater, Clarke, Drown, Baskerville, Cooke, Mallet, Gibbs, Moissan, Mendeléeff, Meyer, Oswald and a host of others. In quoting these names I take no glory from the older chemists—Lavoisier, Berzelius, Dalton, Dana and their colleagues.

Nearly all of this honored list who have passed away were university men. Those who are still with us are university men. You chemists know what they have done for the world's work; indeed, it would seem to me an easier task to write of what they have not accomplished rather than what they have done. We need only look at the marvelous achievements of Raoult and Dalton in molecular and atomic chemistry, of Morley in the same field, of Hoffman and Perkin in the coal-tar derivatives, of Ramsay's researches on the new gases in the atmosphere, of Dewar and his assistant, Travers, in the liquefaction of gases and other most valuable and interesting investigations made by them.

Chemistry and the university are to-day inseparable and it is beyond the ken of man to prophesy what discoveries these men of your schools will bring to us in the years to come.

In the domain of mechanical engineering, structural design and kindred studies, Old Lehigh stands as the peer of any institution in the land. This you may consider as flattery or unjust praise from your speaker, but the facts I have quoted in the beginning of this address are surely evidence enough to prove what I now say, and in giving you this meed of praise I do not wish to detract from the good work done by your sister colleges east and west of the Alleghanies. All are doing a noble share in the engineering work of this busy era of steel bridges, steel buildings, steel structural work of every conceivable shape and form; surely in this age of steel there is a call for the university man such as there never has been before and he has not been found wanting.

Text-books on engineering coming from within the walls of Old Lehigh are works of the highest standard, and your sister colleges have not been slow to adopt them.

Engineering is now so closely related to all sciences that the astronomer, the physicist, the chemist, the geologist, all must come to him for help in their time of trouble and he has not failed them. The electrically driven locomotive, the wonderful turbine engine, are coming to stay; they are the results of his handiwork—what shall we look for next?

Mathematics as the handmaiden of all the studies I have enumerated, has a firm foundation in our American institutions of learning. Bartlett has well said that 'the man endowed with the priceless boon of a mathematical knowledge possesses the key to the external universe.' I need add nothing further. Bartlett's saying may be adopted as a maxim rather than a postulate.

I have but few words to say of architecture, geology, biology and kindred studies, for I have lingered too long in this fairy land, in these workshops of the world, to tell you what the university man has done in and for them, but while geology has long been taught in our schools of higher learning, it is only of late years that architecture has been taken up in this country and made a study of the importance it should be, and that newest of all studies, biology, is now making deserved inroads into the curricula of the best colleges of the land. While it is the newest of sciences, it seems to me that it opens up one of the most important and valuable lines of research in the whole realm of scientific investigation because it is so inti-

mately associated with all that pertains to organic life on this old round world of ours.

The immortal Darwin gave it a mighty impetus when he presented to the world his doctrine of natural selection, and the researches of Brooks in our own country place us on a high plane in this beautiful study. Some day the world will be startled by the results of biological research.

Perhaps the most remarkable discovery recently made in embryology, a branch of biology, is that we can trace the evolution of a species through its development in the embryo, that is to say, the very beginning of the embryo is identical with the most ancient form; throughout its development we see its evolution to its present condition. Koch's discovery of the bacillus of tuberculosis made another epoch in the science of biology.

Brooks has said: "It may be some day we shall be able to construct a living organism by the combination of the proper elements." Atwater has trodden upon almost forbidden ground in his remarkable investigations of the calorific value of foods in the human subject—indeed, has gone so far in this splendid research that we may dare hope some day to measure the food value of a thought.

I am aware, as already remarked, this is treacherous ground upon which to build a solid foundation, but the better day has come when the earnest seeker for truth is no longer hindered in his onward course by that ancient barrier 'hitherto shalt thou come and no further.'

In the broad light of the twentieth century the investigator, the university man, untrammeled by fear, save the fear of error, will rise to heights of knowledge never dreamed of in our philosophy.

I verily believe that the storehouse of God's truth is like unto the 'widow's cruse,' take from it as we may, it will never be emptied of its rich, its priceless treasures.

To-day we are but learning single notes. To-morrow we shall blend them into chords. The hour will chime when all humanity shall know the law of harmony—when every note in every chord shall find its part in the sublime oratorio of universal life.

John A. Brashear.

Scientific Books.

Outline of the Evolution of Weights and Measures and the Metric System. By William Hallock and Herbert T. Wade. The Macmillan Company. Price, $2.25.

The science of metrology in its evolution has been regarded by many as furnishing the best means of tracing the history of the exact sciences. If this be true, we should welcome this carefully prepared treatise by Hallock and Wade—men fitted by taste, training and experience to write upon this topic.

We have here presented a systematic general history of weights and measures, the scientific methods by which units and standards have been determined, the correct standards by which the units are represented, and the present aspect of modern systems of weights and measures together with the difficulties and advantages involved in any proposed change.

A work of this sort is especially opportune just now when a determined effort is being made to introduce the metric system in this country. It will give much useful information to help those in doubt to decide whether a change in our metrology is advisable or not. Whatever the personal views of the authors are on this subject, they have wisely refrained from giving them undue prominence.

The work contains chapters on the beginnings and development of the science of metrology, origin and development of the metric system, extension of the metric system throughout Europe and elsewhere, weights and measures in the United States, the metric system in the various arts and trades, electrical units, standards and tables of useful constants and equivalents.