

## PRESIDENT GILMAN'S ADDRESS.

### The Relation of the Sheffield Scientific School and its Work to the Times and to the Progress of Science in the Last Fifty Years.

[Being the full text of the address as delivered at the semi-centennial celebration of the Scientific School, the slips being revised by President Gilman.]

This is the hour for congratulation and reminiscence. It is our privilege to look backward over the path of half a century and to trace the steps, often slow but never devious, by which the penniless, nameless and homeless offspring of an ancient and vigorous stock has attained commanding influence, rich in possessions, beloved by thousands of followers, honored wherever known, and still with the fresh enthusiasm of youth, aiming at lofty ideals, attractive as the face of nature, varied and comprehensive as the laws by which this world is governed.

It would be easy, and it might be profitable, to engage in an exclusive commemoration of those who have made this institution, and to bring forward reminiscences of incidents and events—some of them truly romantic—which illustrate the progress of its remarkable life; yet the dignity of this assembly, the presence of so many persons from a distance, and the relation of the Sheffield School to higher education in the United States forbid such limitations. You must therefore permit me to give a subordinate place to those sentiments which are uppermost in our hearts—congratulations mingled with affection and gratitude, and with vivid memories of those who have departed—while I try to do justice to their wise and assiduous labors by showing their relation to the times and to the progress of science in the latter half of the nineteenth century.

If the Antiquary should now appear, you would be sure to remember that his task had already been well performed; and if I should assume the garb and chisel of Old Mortality, you might remind me that the moss has not yet gathered upon the inscriptions in yonder cemetery. While Argus and Briareus, the one for the University and the other for the School of Science, are on the alert, it requires some assurance to traverse the annals which they have collated; and yet this discourse must be historical. So in face of difficulties, enhanced by the distance which has separated the speaker from these once familiar scenes, from muniments and archives, I enter upon the duty of the hour, conscious of the honor received from your courtesy and grateful for an opportunity to stand once more among former colleagues, pupils and friends. It is a delight to see this favored university renewing its youth at the approach of its second centennial anniversary—more comprehensive, more useful, more liberal and more worthy than ever before of loyal affection and support.

#### A PRE-NATAL EXISTENCE.

Eighteen hundred and forty-seven is the year of our nativity. But there was a pre-natal existence worth remembering, and there was a reincarnation, if not a regeneration, when the school was christened by the name of Sheffield. Yale College has always stood for Science, and it therefore is no wonder that those who initiated the department of Philosophy and the Arts, just after President Woolsey assumed the chair, had faint notions of the importance of their proceedings. They were quite unconscious of developing new forces. Mr. Bryce, in his sketch of the Holy Roman Empire, remarks that the year A.D. 476, which school-boys are taught as one of the most important dates in everybody's chronology—the downfall of the Roman Empire—was no such date to those then living as it has since become, nor was any impression made on men's minds commensurate with the real significance of the event. So it is in our academic chronology. As conclusive evidence, recur to this modest announcement originally made in the Catalogue of 1847.

"It has long been felt at Yale College to be important to furnish resident graduates and others with the opportunity of devoting themselves to special branches of study, either not provided for at present, or not pursued as far as individual students may desire." Accordingly the department of Philosophy and Arts is established. By this simple decree the system of graduate studies now in vogue throughout the land was formally inaugurated. Moreover an inconspicuous postscript states that "Professors Silliman and Norton have opened a laboratory on the College grounds for the purpose of practical instruction in the applications of science to the arts and agriculture."

#### A BIRTH, WITH IDEALS AND AN EMPTY PURSE.

Thus was born the Sheffield School, with the inheritance of an opportunity, a desire, a hope and a belief, supported by an empty purse and slight expectations.

"That primal age which did as gold excel  
Seasoned its acorns with keen appetite  
And thirst to nectar turned each spring well."

To illustrate the evolution of this idea, then first proclaimed among us, to show what ingredients it included, what unexpected nurture it received, what storm and stress it survived; especially to show that this idea was planted in fertile soil by the spirit of our age, the *Zeitgeist*, believing and delighting in the study of nature and her laws, we must consider the state of mankind in the middle of the nineteenth century, and the conditions of liberal education then prevalent in the United States and England. No milestone marks the transition from the old to the new, yet the older men in this assembly are conscious that this is a very different state of society from that of 1847. The education, the creeds, the industries, the commence, and of course the science and the arts of civilized countries are changed. This is a freer, busier, wealthier, more complex, and indeed a wiser and happier world than that of our fathers—before the gold of California and Australia and the diamonds of South Africa had been discovered, or the magic spark, flashing over land and sea, had transformed the usages of domestic life and the processes of international intercourse; or the life-giving agencies, the heaven-sent blessings of anaesthesia and antiseptics, had removed from the bed of pain, apprehension and distress.

#### EPOCH-MAKING PAPERS.

It was the middle of this century when the doctrine of evolution, which has pervaded every branch of natural history, and extended its influence to medicine, anthropology, sociology and history, was publicly set forth, a period, as a recent historian has shown, in which a doctrine that may be traced to Empedocles, Heraclitus and Aristotle, found "its perfect expression" in the writings of Charles Darwin. On the evening of July 1, 1858, a day almost as memorable as that when the island of Guanahani was revealed to Columbus, the epoch-making papers of Darwin and Wallace were read to the Linnean Society of London; but it should not be forgotten that, sixteen years before, Darwin had written out a sketch of the Origin of Species, and with wonderful self-control had kept it in his portfolio while he gave eight patient years to the study of barnacles. We have the authority of Sir Archibald Geikie for saying that the two geological chapters in the Origin of Species produced the greatest revolution in geological thought which has occurred in our time. It was in 1860, when Herbert Spencer announced the programme of his philosophical system; but nine years earlier he had printed a volume entitled "Social Statics, or the conditions essential to human happiness specified and the first of them developed." Lyell had been for a long while the leading authority of England in the science of Palaeontology, but the startling book in which he demonstrated the antiquity of man did not appear until five years after the publication of the Origin of Species. This is not the place to discuss the far-reaching and all-pervading influences which proceeded from these writings, nor to dwell on the controversies they evoked, such as those with which we are familiar between Agassiz and Gray, but I

bring these instances forward as indications of the extraordinary intellectual vitality of the middle of the nineteenth century and of the changes in human thought of which this school has been the watchful observer.

I have the authority of an eminent naturalist for saying that "the most significant aspect of this movement is the general recognition, by all thoughtful men, of the proof which was afforded by the progress of discovery, of the truth that the unity of nature is orderly, and discoverable by scientific methods."

#### IN PHYSICS.

In the domain of physics, changes have occurred almost as remarkable. The doctrine of the conservation and correlation of forces, beginning with a determination of the mechanical equivalent of heat, was suggested and developed between the years 1842 and 1862 by Mayer, Grove and Joule. Faraday was then at the zenith of his powers, Helmholtz and Kelvin at the outset of their illustrious careers. But it was as far back as 1830 when Joseph Henry, then a schoolmaster in a country town, reached those discoveries in electromagnetism which made the telegraph a proximate certainty and brought into the intercourse of mankind a revolution almost as great as the primitive invention attributed to Cadmus. Spectrum analysis, that powerful agency which reveals the constituents of every burning body, even the chemical and physical nature of the remotest stars, was then unknown. At any rate it did not go beyond a beautiful exhibition of the colors of the prism.

#### MATHEMATICS AND ASTRONOMY.

Likewise glance at mathematics and astronomy fifty years ago. Laplace had been dead for over twenty years; Gauss was living in an advanced age; Sir Wm. Rowan Hamilton had announced but had not published the new calculus—Quaternions—which was to give him rank with the greatest mathematicians; Abel, Cayley, Sylvester, and Hermite were at the portal of those investigations which have made their names illustrious in the science "which never takes a backward step." The abstract reasonings of such men are beyond the apprehension and appreciation of minds non-mathematical; but this is not true of astronomy, for every human being, the wayfarer and the shepherd, as truly as the philosopher, is interested in the progress of celestial science. No purely scientific discovery within our memory has made such an impression on the popular mind as that of the planet Neptune, whose existence, foretold by Adams and Leverrier, was demonstrated on the night of September 23, 1846. Then the fortunate astronomer of Berlin turned his lens, by request, to the predicted place, and recognized as a planet that vast orb which had been circling in solemn silence for countless ages thousands of million miles from the sun. This superb achievement, like the torch bearers of Aurora's car, was the precursor of a long series of splendid additions to astronomical science, as well as of great improvements in the telescope and of great endowments for astronomical research. But most unexpectedly a new astronomy has supplemented the old, and celestial physics is standing side by side with celestial mechanics as the interpreter of the mysteries of the universe. Surprising as was the revelation of Neptune, wonderful as are the maps of the heavens, and the calling of the stars by their names, it is more remarkable that astronomy can now tell us the constituents of every heavenly body. This is the triumph of spectrum analysis, already mentioned, the contribution of chemistry and physics to astronomy, an inevitable evolution from the researches of Kirchhoff and Bunsen, in 1859.

#### A HOST OF OTHERS.

I am in danger of multiplying these fascinating allusions, and of trying to give in a single page an abstract of a cyclopaedia, which would be the task of Icarus, predestined to fall; but mention must be made, if it be only with a word, of recent advances in some other

departments of science. Think of geology, including palaeontology on one side and petrography on the other; of chemistry, with its revelation of new elements, leading up to the Neptune-like discovery of Argon; and with its innumerable contributions to agriculture, metallurgy and pharmacy, to color, food, and flavor; of engineering and mechanics with their acquired control of force and matter, in ordnance, ships, dynamos, engines, bridges, air ships and tunnels; of the sciences of metallurgy, meteorology, geodesy, exploration, navigation and aerostatics. It is truly a half century of marvels proceeding from the patient, unrequited, unscen pursuit of science by men of extraordinary ability and of absolute concentration to the advancement of knowledge. By common consent, it is known as the age of electricity, and the history of that single branch of science verifies a saying of Faraday's, which was early adopted in this school, "There is nothing so prolific in utilities as abstractions." But every science has made its contributions to the advancement of the race, and every advance has made more obvious the mystery of existence and increased the humility of man as he thinks of that which transcends his reason.

As "knowledge grows from more to more,"  
So "more of reverence with us dwells."

Different minds will place different estimates on the intellectual accomplishments of these recent years. In ordinary conversation the men of the mart will point to an Atlantic cable, an Eiffel tower, a suspension bridge, a continental express train, a man-of-war, a Kaiser Wilhelm der Grosse, or a great exhibition. On the other hand, scholars of the lamp, like Freeman, will give precedence to the comparative method of study now employed in history, language, politics, economics and religion. But before this assembly I venture to claim that the greatest triumphs of the intellect during the last half-century are these five contributions to human knowledge: The establishment of the principles of evolution; the establishment of the principles of the conservation of energy; the development of mathematical science and its applications to physics, mechanics, electricity and astronomy; the development of spectrum analysis and the consequent discoveries respecting light and electricity; and the discovery of the nature and functions of bacteria, and of their influence, for weal or woe, upon living organisms.

To these may be added, perhaps, the birth of experimental psychology, a child so young that though it seems to belong to the family of Hercules, its strength has not been fairly tested.

#### EDUCATIONAL QUESTIONS.

It is time to turn from the aspects of science to those of education. Prior to the days of Faraday, Darwin and Huxley, of Agassiz, Dana and Whitney, the classics held their sway and controlled with almost absolute supremacy the liberal education of England and the United States. The benefits of instruction in Latin and Greek, enormous as they were, received exaggerated praise, in spite of the dictum of Sir Wm. Hamilton, which was often quoted, that nothing brought the classics into such disrepute as requiring them of every student. To enforce this statement it is not necessary to appeal to the opponents of classical culture. The words of a renowned scholar, distinguished for his knowledge of antiquity and his love of the ancient landmarks, tell the story well. The classical revival, says Freeman, "in all its forms and stages, fostered the idea that the languages, the arts, the history of Greece and Rome at certain stages of their being, were the only forms of language, art and history which deserved the study of cultivated men. It led to the belief, not perhaps fully put forth in words, but none the less practically acted on, that those two languages, and all that belonged to them, had some special privilege above all others—that the studies which were honored by the ambiguous name of 'classical' were fenced off from all others by some mysterious barrier—that they formed a sacred precinct which the initiated alone might enter and from which the profane were to be jealously shut out. Such a state of feeling, a feeling which has even now far from died out, could not fail to lead to mere contempt, and thereby to mere