# Address of the President.

## A Century of Progress in Scientific Thought.

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The Centennial thought is uppermost in the minds of the people of the great commonwealth of Indiana. In every hamlet and village, in every town and city, the history of our beloved state has been represented on canvas and on the streets, in parks, in church, auditorium, and hall. The praises of Indiana have been sung by bard and proclaimed by the minister and statesman, by the children and the teacher until the entire state is filled with thoughts of the wonderful progress and the marvelous resources and possibilities of this commonwealth.

It has seemed to me to be eminently fitting, in this centennial year, that the address of this hour should be devoted to a resume of scientific thought during the past century covering the period of the statehood of Indiana No state has a corner on scientific thought. It is the work of the world, hence national boundaries vanish when we consider such thoughts.

In order to most fully appreciate this century of progress in scientific thought, it is necessary to take ourselves back one hundred years to 1816 when our state was born, and look about us so that we may view our subject from the best standpoint. The Battle of Waterloo had just been fought. The conquered hero had been banished to the Island of St. Helena. George III was still living. It was three years before the birth of Queen Victoria. Abraham Lincoln was a lad of eight years. James Monroe was President of the United States. There were only nineteen states in the Union. The territory west of the Missippi was practically unknown. It was sixteen years before the first railway, thirty-one years before the electric telegraph, sixty-one years before the telephone and ninety-one years before the wireless telegraph. No steamship had crossed the Atlantic. No airship had been thought of.

The world was truly in the pioneer stage of scientific thought. Little by little new thoughts began to dawn upon the minds of some who began to express themselves in a public way and occasionally in the way of some invention like the railway or electric telegraph so that the people began to see that there was a real value in such thought. The public was very slow to appreciate the intrusion of modern inventions and even the inventors themselves were very cautious. It is interesting to note how careful the early railroad companies were concerning their trains. One time-card read as follows: "The —— Railroad Company will run a train daily leaving —— station at 10 a. m. provided it does not rain."

Within my own memory, when the mowing machine was first introduced, the men who had been mowing the grass with the scythe, feeling that their work was gone, arose in some places as one man against this intrusion and demolished this new machine. The same was true with the introduction of the self-binder to replace the cradle, also the replacing of the horse street cars in the cities with the cable and electric cars. The resistance to modern scientific thought has been powerful not only in the orient, but also in our own country. To overcome that resistance has required tact and great perseverance. Like all reforms the greatest gain has been made by teaching these new things to the youth in the public schools, colleges and universities.

Even in the schools the progress has been slow, at least until recent years. Dr. J. P. D. John said he taught Chemistry in Moores Hill College in 1875 and did not perform a single experiment, and he was one of the most advanced teachers of that day. Who today would think of teaching in that way?

I think it is generally conceded that the greatest stimulus to scientific thought in this century was the injection into the thinking world of Darwin's Origin of Species in 1859. Not that everybody accepts his views but it has served as a stimulus to thinking men, and has caused them to direct their efforts in a way that has resulted in the most rapid development of scientific thought in the history of the world. Man must know how to learn new truths. It has required the centuries past to teach him the experimental method of investigation.

Another event likewise has had a tremendous influence on scientific thought, and this was the first marine laboratory established on the island of Penikese in Buzzards Bay in the summer of 1873 by the greatest naturalist of his time, Louis Agassiz. This Summer School gave the greatest impetus to the correct method of teaching the biological sciences and in an indirect way to the other natural sciences. The students, fifty in number, were largely teachers from the eastern states. Agassiz's purpose was to train these fifty teachers in the right methods of work. They would carry into their schools his views of scientific teaching. Then each of these schools would become a center in its time to help others, until the influence toward real work in science would extend throughout the educational system. This purpose has been realized in a remarkable degree. Among the men who were in this school were David Starr Jordan, William K. Brooks, Charles O. Whitman and Charles S. Minot. Dr. Jordan is known throughout the world not only as a great scientist but also as a most inspiring teacher. The students of Indiana University and Leland Stanford University know how to sing his praises. Only three years after this Summer School closed, Dr. Brooks began his career at the Johns Hopkins University, this being the first year of that great University. Every student of the school from 1876 to the day of his death in 1908 felt the influence of his life and teaching. Dr. Whitman had a similar but not such a long career at Chicago University as a center of influence, and Dr. Minot at Harvard. Who can measure the scientific influence that has gone out from these four men at Leland Stanford, Johns Hopkins, Chicago and Harvard. The stamp of the method and spirit of Louis Agassiz is upon every one of them and upon their followers.

When the methods of Darwin and Agassiz became throughly established in the schools, the progress of scientific thought became rapid. Every line of science felt the impress of this method of study. The response was quick and certain. To show what progress has really been made it will be necessary to consider some of the leading subjects.

## I. Astronomy.

At the beginning of the century under consideration the greatest activity was in Germany. There was not an observatory in the southern hemisphere, neither were there any in the United States. Sir William Herschel was just closing his remarkable career as an astronomer. He made for himself the first large telescopes and with them searched the heavens so thoroughly and with such keen vision that a new and clearer conception of the stellar universe was given to the world. Herschel with LaPlace laid such a foundation for astronomical observation and research that the future study went forward with rapid strides. Uranus had been discovered in 1781 and the asteroids were being discovered. Before very much more could be done it was necessary to establish observatories, in order that greater accuracy might be secured.

In 1821, the first one in the Southern Hemisphere was established at Parramatta in New South Wales. In 1829 one was built at Cape of Good Hope, in 1868 one at Cordova in Spain and the Harvard Observatory in 1881 at Arequipa in Peru for studying the spectra of the southern stars. It seems that the American Observatories began with the Cincinnati Observatory under Professor Mitchell about 1845. Since then numerous and well equipped observatories have been established in the leading centers of Europe, such as Potsdam, Kensington, Paris, Berlin and Greenwich, and in the United States at Washington, the Lick, Yerkes, Mt. Wilson and Harvard. The United States at present holds about the position that Germany did at the beginning of the century.

In 1816 no refracting telescopes with the object glass larger than six inches had ever been made. Herschel had, however, made a reflecting telescope with a mirror four feet in diameter as early as 1801.

In 1824 Fraunhofer made an object glass 9.9 inches for the Dorpat Observatory in Russia. This was regarded as a "giant." In 1833, one fifteen inches in diameter was made for the Pulkowa Observatory in Russia and about 1843 one was supplied to Harvard College. In 1865, Thomas Cooke of York, England, completed one twenty-five inches in diameter, then Alvan Clarke of Cambridge, U. S. commenced one twenty-six inches in diameter for the Washington observatory, and in 1877 one thirty-six inches for the Lick Observatory and in 1892 one forty inches for the Yerkes Observatory.

The branch of Astronomy that was practically unknown at the beginning of the century—that of spectrum analysis—has during the century assumed the most far-reaching proportions. The discovery in 1814 of the many dark lines in the light of the sun and also in the stars marked the beginning of spectroscopic astronomy.

The chemistry of the sun began to be known and now thirty-nine of the elements found on the earth have been found in the sun. Helium was found in the sun before it was discovered on the earth. Exhaustive studies of the spectra of the stars, nebulae and comets have been made, so that we know much about the composition of the various heavenly bodies. With the spectroscope, the approach or the recession of a star can be determined together with the velocity of the same.

Another method of astronomical study that has become exceedingly valuable is that of celestial photography. It must be borne in mind that the art of photography was not known until 1830 when Niepce and Daguerre founded this art. Its marvelous development is well known. The astronomer soon recognized how this art might be made use of in celestial study. The first celestial ob ect to be photographed was the moon in 1840 by Dr. J. W. Draper, and the sun in 1845 by Foucault and Fizeau. The first photograph of a star was that of Vega in 1850 at Harvard. The total eclipse of the sun of 1860 was photographed. The first photograph of the spectrum of a star was made in 1872 by Henry Draper. Long exposures have become an important feature, the time occasionally reaching forty hours. Time will not permit me to more than mention the great advances made in cataloguing the stars, finding out the distances of the heavenly bodies, determining much concerning stellar evolution as a result of spectroscopic investigation, and the science of thermo-dynamics, the discovery of some close relationship between the solar and terrestrial weather, and the really marvelous achievements in the realm of higher mathematics by such men as Adams, LeVerrier, and Newcomb.

## II. Chemistry.

A century ago, our knowledge of Chemistry was indeed very primitive. The studies in this line were shrouded with the mysterious and hence were lost in the thoughts of alchemy. The beginning of real Chemistry, however, had been made. Oxygen, hydrogen, and chlorine had been discovered. The bleaching power of chlorine had been demonstrated and applied in the manufacture of cloth. A few of the organic compounds such as lactic, citric, malic, oxalic, and gallic acids had been discovered. Most of this work had been done by Scheele. Then came the work of the founder of modern chemistry, that of Lavoisier. His greatest work, probably was the overthrow of the phlogiston theory, which paved the way for the true conception of combustion. With this settled there was a chance for the development of true chemical relations.

In 1807, a most important discovery was made by Sir Humphrey Davy. He applied his galvanic battery to the decomposition of caustic soda and caustic potash. This lead to decomposing calcium chloride and other related compounds, and finally to the preparation of the metal aluminum by Wohler in 1827 from certain compounds of potassium and clay. Davy also proved that oxygen is not a necessary constituent of an acid, but that hydrogen is. A number of theories and laws soon followed. Dalton established the laws of definite and multiple proportions and the atomic theory. Gay-Lussac's law of combining gases and Avogadro's law were important discoveries.

The work of Berzelius followed in determining the atomic weights which developed most of our analytic methods. He closed his work in 1848.

The law of specific heat was discovered by Dulong and Petit in 1819. The work of these men lead to a much clearer knowledge of the molecule and the atom with its electrons and the nature and composition of gases, together with the powers of combination. In organic chemistry especially the study of the structure of chemical compounds has resulted in great progress in the industrial world, for it was discovered that new compounds could be made by uniting the elements composing them, such as urea, uric acid, caffeine, alizarine, indigo and some alkaloids. This method of building compounds has led to the manufacture of gun-cotton, dynamite, and similar explosives, the development of the candle industry, to the improvement of tanning and brewing and the preparation of gases and oils and many other lines of industry.

The periodic system or the arrangement of the elements according to their atomic weights is one of the greatest generalizations of the century. This has been developed by Newland beginning in 1864, and Meyer, followed by Mendeleef in 1869 and others continuing the study.

Thus chemical thought has continually advanced through the century and the result has been the marvelous application to almost everything: agriculture, manufacturing, mining, in the home, in business, in medicines and in the arts.

## III. Physics.

The advances made in physics are as surprising as in other lines of scientific thought. The century opened with conceptions that could not stand the test of modern methods of thinking and experimenting.

For instance, the caloric theory of heat that held that heat was a subtile fluid had just been exploded by Count Rumford who showed that heat is the result of molecular motion. Newton's corpuscular theory of light was still generally accepted. Even in the eighth edition of the encyclopedia Brittannica published in 1856, heat was defined as a material agent of a peculiar nature, highly attenuated.

Fourier demonstrated the laws of conduction by mathematical as well as by physical research which also covers electrical conduction and this is the real basis of Ohm's Law.

Another experimenter of great renown was Regnault. His most noted work was in improving the thermometer and determining the laws of the expansion of gases, vapor pressure, specific heat of water, and the elastic force of steam. These studies led to one of the most important accomplishments of the century, the liquefaction of all gases. This was first done in 1877 by Pictet and Cailetet when they reduced oxygen, nitrogen, hydrogen and air to the liquid state.

Carnot created the science of thermo-dynamics or the dynamics of heat. Lord Kelvin and others were contributors to this science.

The mechanical theory of heat naturally led to the doctrine of the conservation of energy. This doctrine was first stated by Robert Mayer, a German physician in 1842, but the heat equivalent of mechanical energy was first determined by Joule in 1847 and further proved by Lord Kelvin, Helmholtz and Tyndall.

The establishment of the undulatory or wave theory of light is one of the great achievements of the century. This was due to Thomas Young, an Englishman, and Fresnel, a Frenchman. As a result of this conception, other discoveries followed, such as spectrum analysis, polarization of light and the determination of the velocity of light.

The most marvelous achievements of the century in physics have been in electricity and magnetism. We are tracing the scientific thought and not primarily the application to the needs of man.

Just before the opening of the century the discovery of the Galvanic battery by Galvani and Volta made possible the future developments. The next discovery was by the Danish physicist Oersted which showed the close relationship of electricty and magnetism. The electro-magnet was the result. This paved the way for the electric telegraph which Joseph Henry first made in 1832 but was made practical by Morse in 1844.

The conversion of electricity into mechanical energy was made possible by Oersted, Arago, Ampere, Sturgeon and Henry. This gave rise to motors. Another discovery was necessary; how to convert mechanical energy into electricity. This was accomplished by Michael Faraday. This gave us the dynamo, but it was nearly half a century before it came into practical use. In 1831, Faraday also discovered the principle of induction. This greatly improved the telegraph and made possible the telephone. To Graham Bell is due the honor of having made the first telephone for practical use.

The past twenty-five years has been marked by continuous and persistent research and many new discoveries are being made. Maxwell's theory of electric waves and its verification in 1888 by the German physicist Hertz laid the foundation for the wireless telegraph of Marconi in 1907.

The wonderful experiments of Sir William Crookes in passing an electric current through a high vacuum and experiments in radiant matter were preliminary to the discovery of the X-rays by Roentgen of Germany in 1895. The radio-activity of matter now is attracting much attention. Research continues in the most perfectly equipped laboratories that man can devise and the world is confidently expecting the report of other great discoveries in electricity.

Many physicists have been studying acoustics and the laws of harmony have been revealed. The photographing of sound waves has been accomplished by Prof. Foley and others. The invention of the phonograph by Edison was the result of the study of the principles of acoustics.

Other physicists have been interested in finding the nature of matter itself.

## IV. Geology.

Geology is a young science. Many facts have been described since the dawn of history. Many volumes had been written on the subject, but it was not a science as that term is understood today. It is really a present century science. Not until the last century had nearly closed had any one thought of the earth as having been evolved through the ages. The most learned thought the earth had been formed instantly about 6,000 years ago. It, however, dawned upon James Hutton near the close of the last century that the earth really had had a history. How to read and interpret this history was the next question to settle. Some inductive method needed to be found. The basis was laid by Hutton as early as 1795 but Charles Lyell in 1830 clearly set forth the method. He showed that the earth structures had been formed by the processes now in operation. With this method it was easy to explain most of the varied formations.

About the beginning of the century, two fundamental geological truths were outlined. One, that of stratigraphy, by William Smith in 1815, and the other palaeontology by Cuvier in 1808. With such foundations, they were now ready to make some progress in interpreting the history of the earth.

The advances made in the geological interpretation of the history of the earth during the present century may be conveniently considered under three divisions, viz, catastrophism, uniformitarianism and evolutionism.

In the early part of the century, the dominant thought was that the great changes in the earth as an inorganic body and in the organic part were due to great catastrophes in which the ocean bottom would rise and cause the waters to flood the lands thus destroying all life. Things would then quiet down, new organisms would be created by special act of God and a new geological regime would be started. The catastrophe was supposed to be supernatural and the quiet period natural. Species of animals and plants were regarded as immutable. When these ran their courses they were destroyed and new ones formed.

Lyell opposed this view and insisted that the processes now in operation must be considered in action in the same way in the past and that there was thus a uniform and gradual advance from the earliest times to the present geological conditions. This was the doctrine of uniformitarianism.

A new thought, however, was in process of formation which was destined to attract much attention and arouse the thinkers of the world and that was the theory of evolution.

Darwin's Origin of Species set the world in a whirl of thought. For half a century this thought has been advanced by one school of thinkers and hotly contested by another. Battle after battle has been waged and compromise after compromise has been made, and now at the close of the century has this thought come to be recognized as of inestimable value in the interpretation of the great book of nature.

James Dana took up this new thought and made use of it in his geological studies. He thought of the development of the earth as a unit. Geology was not simply a record of geological events but a study of causes and effects—a real philosophic study. Under his skillful research and thinking Geology was rapidly organized into a real science. Explanation of the origin of ocean basins and continents, the mountains and valleys, the stratified and unstratified rocks, the water and the heat, the great variety of organic forms and the origin of the earth, now could be more satisfactorily interpreted. The age of the earth, the mineral resources, and their uses to man, the evolution of the various forms of life, and the origin of man have received the most thorough attention on the part of the greatest geological thinkers of the world.

## V. Biology.

The last line of scientific thought that will engage our attention is biological. This is the most important for it deals with life problems and these concern us most acutely. This science was also born in this century. While many facts were known concerning plants and animals yet the principles underlying the life of these organisms was little understood.

The first valuable work of the century was in the realm of embryology. The greatest work was done by VonBaer. He began his investigations in 1819 after reading the works of Pander. After many years of study he established the truth of the three germ layers, and the development of the various tissues and organs from these layers. This gave a new direction to the study of embryology. Balfour, Huxley, Remak, Hertwig, and others continued these studies and brought the subject to its present stage. In these investigations a new line of thought has been evolved, that of cell-lineage. Boveri, Conklin, Wilson, Whitman, Lillie, and others have shown that there are certain areas in the protoplasm of the egg that give rise to definite parts of the adult animal.

The next great truth to be discovered was that set forth in the cell theory, that all plants and animals are made of cells. In 1665, Robert Hooke of England observed the cellular structure of cork and spoke of the little boxes composing it, but he did not realize the full purpose and nature of these. It was left to the present century to fully establish and announce this theory to the world. This honor belongs to Schleiden and Schwann principally to the latter and was made known in 1838. In 1835 Dujardin had seen living matter in the lower animals and called it sarcode. Schleiden had seen it and called it gum. In 1846, Hugo von Mohl observed a jelly-like substance in plants and called it protoplasma. It soon dawned upon the scientists that the sarcode of the animals and the protoplasma of plants were one and the same thing. In 1861, Max Schultze fully set forth the protoplasmic doctrine. With this new thought the modern conception of the cell theory would include four things—the cell as a unit of structure, the cell as a unit of physiological activity, the cell as embracing all hereditary qualities within its substance, and the cell in the historical development of the organism.

The study of the cell is the great field of the biologist. Staining the protoplasm began in 1868. The centrosome was discovered in 1876, and the chromosomes in 1883. The chromosomes are now regarded as the structural parts which carry the hereditary characteristics. Another problem came up for settlement and that was the origin of the living things. From the earliest times it had been considered that living things were generated spontaneously. In 1836, Franz Schultze performed the first experiments to overthrow the theory of spontaneous generation. The death blow to this theory was given by Pasteur in 1864 and Tyndall in 1876. It was clearly demonstrated that all life must come from previously existing life.

The next great advance in biologic thought was the discovery of the germtheory of disease. As early as 1687 when Leeuwenhoek discovered bacteria, some medical men suggested that contagious diseases were due to microscopic organisms that passed from the sick to the well. This suggestion was soon dropped and was not revived until 1837 when the Italian Bassi demonstrated that the diseases of silkworms were due to the transmission of minute particles from the sick to the healthy. Upon these experiments Henle in 1840 announced the germ-theory of disease. Experimental proof was not found until 1877 when Pasteur and Koch showed that splenic fever of cattle was caused by anthrax germs.

In 1867, Sir Joseph Lister added another important discovery that of the use of antiseptics in surgery. Carbolic acid was first used. This has revolutionized surgery.

In 1859, as already stated, Darwin's Origin of Species started on its mission. New interest in evolution was now kindled. Gregor Mendel, in 1866 and 1867 announced a great truth—the purity of germ-cells. This, however, attracted little attention on account of Darwin's new thoughts about organic evolution. The truth of Mendel was re-discovered in 1900 by the botanist DeVries and others. The names of Galton, Weissmann, Castle and Davenport must be added as important in developing Mendelism as a theory of heredity. The doctrine of evolution is too extensive to review in a brief paper. In its establishment as a scientific truth four names should be honored by being mentioned—those of Lamarck, Darwin, Wallace and

Weismann. A host of others have done much by way of demonstration and interpretation.

In developing scientific thought so much depends upon the method. The experimental method of investigation of the truths of biology as used today is worthy of special mention. In the further use of this method, we may expect much in the fields of heredity and evolution, changes in the environment of organisms, studies in fertilization, and on animal behavior.

If the discovery of these truths meant simply intellectual achievements, I am sure they would not impress the world very much, but most of them have a practical application for the benefit of mankind. Man must more and more be considered the most important creature.

He can and must be developed as a symmetrical being. Through biological study, disease is being checked, lives are being spared, eugenics is playing a part in the evolution of the race, temperance and sanitation are being placed on a sure foundation, and even peace ethics and religion can be advanced in their beneficial influence upon the race.

In conclusion, may I pay a word of tribute to the scientists of the world who, quietly in laboratory and library, unassuming for the most part, not anxious to have their names heralded abroad but diligent in their search for truth and when found to gladly and unselfishly give the benefits to the world usually "without money and without price," sometimes to an ungrateful world, but usually due honor comes in time. I am also glad to record that the scientific men and women of Indiana and especially of the Indiana Academy of Science have contributed no small part in the advancement of the scientific thought of the world.

The mission of science may be expressed in the words of the sacred writer: "Man bindeth the floods from overflowing and the thing that is hid bringeth he forth to light."