# SCIENCE NEWS

## NOTES ON THE CENTENARY OF THE FRANKLIN INSTITUTE

*(By Edwin E. Slosson, Director of Science Service)*

Six Nobel prize men on a single program is the unique achievement of the Franklin Institute for its centenary celebration, at Philadelphia, September 17 to 19. The annual prizes of $40,000 for the greatest discoveries in chemistry and physics are awarded by the Nobel Foundation in Stockholm without distinction of nationality and these six scientists represent four countries. Sir William Bragg, of London, is the leading authority of the world on the structure of crystals and his son, Professor William L. Bragg, of Manchester, shares his father's field and fame. Their compatriot, Sir Ernest Rutherford, of Cambridge, startled the scientific world in 1903 by the theory that atoms are not immutable but that radium breaks up into other elements. Professor Pieter Zeeman, of Amsterdam, has put his name permanently into all languages as the discoverer of the "Zeeman effect," the doubling of spectral lines in a magnetic field. Professor Fritz Haber, of Berlin, is the inventor of the Haber process for converting the nitrogen of the air into ammonia and nitric acid. The only American of the group is Professor A. A. Michelson, of Chicago, and he was born in Germany. He has made the most accurate determinations of the wave lengths and velocity of light. His latest determination of this constant made this summer at Mount Wilson gives 186,330 miles per second for the velocity of light.

It will be noticed that these various researches made by independent investigators in different countries are yet coordinated and all contribute toward the solution of the greatest physical problem of the present, the structure of the atom and its relation to light. As Sir William Bragg said the last few years have given us more knowledge of atomic and molecular structure than had been gained in ten thousand years preceding. The new tool which has enabled Sir William to see how the atoms are put together in mineral or metal is the X-ray which has waves ten thousand times shorter than light and so can penetrate opaque solids and reveal the bones in the human body. The X-rays that are reflected from the interior of solids disclose their crystalline structure and the connections of their atoms. It is the annual custom of a professor of chemistry to astonish his freshmen insofar as modern freshmen can be astonished by telling them that the clear crystalline diamond and the black greasy graphite are composed of the same element, carbon. He could prove it to his class but he could not explain it if any student were so rude as to ask him. But when Sir William Bragg held up in one hand a model of the diamond molecule and in the other a model of the graphite molecule we could all see that the difference was merely one of structure. The models were made of wooden balls stuck together by wires. Any boy could make one for himself out of peas and toothpicks. Four toothpicks are to be stuck into each pea so as to be as far apart as possible and equally distant, or to put it in mathematical language so they form a regular tetrahedron. When enough of the balls are so stuck together it will be seen that the structure takes the shape of a diamond crystal, that it shows the natural cleavage planes along which the diamond is cut for jewelry, that the carbon atoms represented by the balls form zigzag chains and also hexagonal rings. Now such long carbon chains and six-membered rings are the very forms which chemists invented years ago to picture for books and blackboards the molecules of organic compounds but without supposing that they were anything more than mere symbols. In the graphite molecule the carbon atoms are laid in layers and it is the sliding of these layers over one another that makes graphite a good lubricant. It is a similar structure as the speaker said "that makes grease greasy." He has examined various fats by reflected X-rays and finds that they consist of thirty or more carbon atoms in a snaky series with an acid head containing two oxygen atoms. Now when a drop of grease is squeezed thin between two glass plates all the fat molecules arrange themselves perpendicularly in double layers half of them upright and the other half head down. One molecule layer sticks to the surface of the solid and the other slides easily over it.

In his public address in the evening Sir Ernest Rutherford analyzed the structure of the atom as Sir William Bragg had analyzed the structure of the molecule. He showed us how he has been able to smash up the atoms of many elements by bombarding them with powerful particles projected from radium atoms as these break up spontaneously. The projectiles are known as alpha particles and weigh about four times as much as an atom of hydrogen, the lightest of elements. They carry a double charge of positive electricity, but whenever they can steal two negative electrons from the atoms that they drive through in their swift flight they settle down into inert atoms of helium gas, a very different element from the heavy metal radium which gave them birth. By means of a new and more delicate apparatus Professor Rutherford has succeeded in disintegrating the atoms of many of the natural elements, namely nitrogen, aluminum, sodium, potassium, boron, phosphorus, fluorine, magnesium, silicon, sulphur, chlorine and argon. But some of the elements, notably oxygen, have so far stubbornly resisted his best efforts to break into the nucleus of their atoms. This exceptional stability may account for the fact that oxygen forms half of the substance of the rocks, air and water taken together. When the elements are arranged in the order of their atomic weights and numbered from hydrogen the lightest to uranium the heaviest it is found that the even numbered elements form eighty-six per cent. of the earth's crust as we know it. Oxygen is one of the even numbered elements and its nucleus is supposed to contain four alpha particles each made up of four hydrogen nuclei, forming a strong and stable structure.

Who is the greatest man of science that America has produced in the last hundred years? You may have ten guesses and more if you like for you may need them. But if you asked any of the three hundred distinguished scientists assembled to celebrate the centenary of the Franklin Institute you would be apt to get the same reply—"Willard Gibbs." The genius of the quiet unassuming Yale professor of mathematics was recognized in Europe before it was in his own country and two of the overseas speakers, Professor Fritz Haber, of Berlin, and Professor F. G. Donnan, of London, have cited him as a pioneer in their fields.

Professor Donnan in his address quoted Henry Adams, the historian, in saying that, after Benjamin Franklin, Gibbs was the greatest man of science that America has produced and he added "that in the history of the physical science of the seventeenth, eighteenth and nineteenth centuries Gibbs ranks with men like Newton, Lagrange and Hamilton who, by sheer force of power of their minds, have produced those generalized statements of scientific law which mark epochs in the advance of science. So faithfully and wisely did he use the splendid gifts which nature bestowed on him that after a half century of time his work remains a potent and living force."

Professor Donnan told how during the war when it was necessary to make ammonium nitrate in enormous quantities for the British high explosive amatol the munition chemist solved the problem by the use of Gibbs's thermodynamic formula. Professor Donnan generously gave credit to Gibbs for the prior discovery of what is known as the "Donnan equilibrium formula" which the late Jacques Loeb made the basis of his theory of colloid chemistry.

Professor W. D. Bancroft, of Cornell, in his address on colloid chemistry also called Gibbs an epoch-maker in this new and fertile field. He defined colloid chemistry as "the science of bubbles, drops, grains, filaments and films," and showed its practical importance in all the industries dealing with such forms. Bubbles are employed by the makers of carbonated drinks, fluffed ice cream and floating soaps and in the flotation process of ore purification. Drops are the controlling factor in mayonnaise, margarine and milk, as well as in the formation of rain clouds. A knowledge of grains is essential in the manufacture of glass, pottery, brick, cement, starch, crayons and photography. Filaments include all the textiles, rubber, asbestos, coke and soap. The science of films covers paints, varnishes, glue, printing, filters, lubrication and oiled roads. The bare list shows what a large part the colloid chemist must play in our daily life.

One of the most difficult and dangerous branches of colloid chemistry is that which deals with the manufacture of high explosives as Dr. Charles L. Reese, of Wilmington, explained. By dissolving the solid nitrocellulose in the liquid nitroglycerine a colloid called blasting gelatin is obtained that is safer than the latter and stronger than the former ingredient. In the search for new and better explosives during the war and after a large number of raw materials were nitrated. Among them were starch, sugar and lactic acid. Glycerine was formerly extracted from fats but can now be formed by the fermentation of molasses. So it seems that our most innocuous and nutritious foods, such as milk and molasses, sugar and starch, may be made into explosive material to destroy our enemies or exploit our mines. For the peace time employment of high explosives amounts in the long run to more than the war time. Last year the production of explosives in the United States amounted to five hundred and thirty million pounds and this involved the preparation of a hundred million pounds of nitroglycerine. At the conclusion of the war the government had left on its hands nearly four hundred million pounds of explosive material and it proposed to throw it into the ocean to get rid of it. But much of the picric acid and TNT has since been used by the government in road building and distribution to the farmers and the smokeless powder is being reground under water to make dynamite for such purposes as ditch digging and stump blasting.

Power in more continuous form has been discussed at the sessions by two men responsible for the two most modern methods of generating power from fuel. The famous English engineer who fathered the steam turbine, Sir Charles Algernon Parsons, predicted a bright future for this type of engine which has become dominant on sea and land because of its high efficiency and the simplicity of its rotary motion. Sir Charles told of the continual progress toward higher pressures resulting in greater economy of coal. High speed turbines operating at 1,500 pounds per square inch are now under construction whereas the usual steam plant operates at 200 pounds steam.

Mercury is the life blood of a new kind of power producer described by William LeRoy Emmet, consulting engineer of the General Electric Company, inventor of the mercury boiler. A half million dollars has already been spent in perfecting this invention and by vaporizing mercury instead of water a gain in efficiency of nearly 50 per cent. is obtained since mercury boils at a temperature some three times that of water and can utilize the heat from the fuel more effectively. Already an initial installation has been so successful that a large mercury boiler and turbine unit is being made to supply electricity for Hartford, Conn. Like the steam turbine, the mercury boiler is going to sea and Mr. Emmet expects his invention to make marine transportation cheaper.

The appearance of a German scientist among the honored guests and leading speakers at the hundredth anniversary of the founding of the Franklin Institute may be considered an indication that the war is over and that the internationalism of science may again be restored. Certainly the institute in extending such an invitation to a representative of the German Chemical Society was acting in the spirit of its patriotic patron saint who held that "there never was a good war or a bad peace" and who negotiated the treaty with Prussia which held till 1917.

No man contributed more to the military power and endurance of Germany than her delegate to the centenary, Professor F. Haber, director of the Institute for Physical

Chemistry and Electrochemistry at Berlin, for it was the Haber process for the fixation of atmospheric nitrogen that supplied that country with high explosives and fertilizers when cut off from Chilean nitrates.

In his address he showed how such practical applications of chemistry followed the development of fundamental scientific theories each of which opens a new epoch. In the first period chemists were absorbed in the study of the structure of molecules and how the atoms were connected. In the second period chemistry became dynamic and ideas of energy took the place of the static conceptions previously prevailing. The third period we are now entering when the chemist has to consider particles smaller than atoms, the electrons, and has come to deal with atoms of energy, the quanta. The chemist can now enter the domain of life since he is learning the laws of cell membranes and the colloid contents which form the substance of living beings. Man begins by imitating nature but may learn to surpass her in food products as he has already done in the manufacture of dyes and drugs and the fixation of nitrogen.

Dr. Haber then dipped into the future and prophesied that "now we may expect the exploration of those paths by which nature brings forth her living things. The most urgent chemical need is providing for our sustenance and our health. Nutrition and cure are the tasks of natural science opening new fields to industry and new prospects of a happier state of man. We are far enough advanced in science to know the minute difference between the structure of starch and cellulose. But we are not yet far enough advanced to be able to live in stalks of corn instead of the grain of wheat."

None of the papers read at the institute would have interested old Ben Franklin more than that which told about his lightning rod and how to improve its protective power. The electrician of the twentieth century is not confined to drawing sparks from the thunderclouds by means of a kite and a key. He sets up and charges a thunder cloud of his own and produces lightning to order in his laboratory. F. W. Peek, Jr., of the General Electric Company, described his artificial lightning plant at Pittsfield, Mass., that supplies a charge of two million volts at a rate equal to several million horsepower. In the path of such a discharge wood is blown to pieces and wires are converted into vapor. Besides such laboratory experiments a field party has been studying natural lightning as it runs wild in the mountains of Colorado. It is found that lightning has a voltage of about a hundred million which is a million times more than the ordinary household lighting circuit. The most striking characteristic of lightning is its proverbial quickness. A current of eighty thousand amperes may pass from the cloud to the ground in a few millionths of a second. On its way through the air it performs all sorts of pranks, knocking off electrons from atoms as a wind blows off hats in a street. The atoms thus deprived of their natural companions hook up with any other atoms that are handy. So it happens after a thunderstorm that some oxygen atoms instead of pairing off in their usual way get connected in a triple group called by the chemist "ozone" and by the ignorant "a sulphurous smell." Sometimes the oxygen connects with nitrogen and then the soil is enriched with nitric acid as good as any Haber could make though not so cheap. We may even assume that the nitrogen atoms that get hit the hardest may be smashed quite to pieces and that other elements, helium or hydrogen, may be formed from the fragments.

THE secret of the cause of color and why dyes dye is to be found, according to Professor Julius Stieglitz, of the University of Chicago, in the dance of two tethered electrons attached to a carbon atom. This original theory was explained and illustrated in one of the sectional sessions of the Franklin Institute Centenary. The table of the lecture room was set with a series of wine glasses such as might serve for a pre-war banquet but which turned out to be intended for purely chemical purposes. In one of them Professor Stieglitz dissolved a white powder and by adding to the solution liquids equally colorless the contents of the glass changed successively to yellow, to red, to brown and to black while the lantern projected on the screen the carbon chains and rings of the structural symbols of the dyes produced. What he was doing, it appeared, was loosening up a pair of electrons belonging to one of the carbon atoms so they could vibrate in tune with the light waves received by the substance. The little waves at the violet end of the rainbow spectrum were easiest to absorb and the light that was left to be perceived by the eye belonged to the red and yellow end of the spectrum. By giving the electrons a little greater freedom of movement they were able finally to respond to all the wavelengths and so to absorb all the light leaving the liquid black and opaque. For the color that we attribute to an object is not the color that it catches out of the light and holds but the color that it rejects and returns to our eyes.

Now, according to the Stieglitz theory, all dyes and pigments are so constructed as to have a positive atom which is short of electrons closely adjacent to a negative atom possessing a surplus of planetary electrons and the pull of the positive atom on these electrons sufficiently detaches them from their allegiance to the negative atom that they are able to dance to the tunes that the passing light waves may bring to them just as the strings of a piano echo the sound waves of the air.

All the thousands of coal tar dyes have one common characteristic structure. They all contain two antagonistic combinations of carbon atoms which were called in the days before we learned about electrons, "oxidizing" and "reducing groups." Every dye can be reduced to a colorless form, a white powder, by reduction, which as we now know consists in adding electrons to certain carbon atoms that needed them. The effort to get back lost electrons is what the early chemists called the "elective affinity" of the elements until Goethe gave the term a bad reputation by applying it to human affairs. If Goethe were living to-day he might carry his analogy farther for it seems that a period of increasing agitation and excitation of the electrons precedes the union or separation of two atoms, and this is what gives color to the world.