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A CHEMIST'S RETROSPECTS AND PERSPECTIVES[1]

By Dr. RICHARD WILLSTÄTTER

MUNICH

Mr. Chairman, Members of the Chicago Section of the American Chemical Society, Ladies and Gentlemen: Allow me to express my heartiest gratitude for the great honor you have conferred upon me by the award of the Willard Gibbs Medal. At the same time, let me express my deep appreciation to the entire American Chemical Society for having elected me their honorary member at the occasion of my last visit to your country six years ago. With a feeling of deep emotion, I accept the medal which carries the image of that upright and profound character, your great J. Willard Gibbs.

It is the third time that this high distinction has been conferred by your jury on a foreign chemist. I am facing, thus, a great and distinguished assembly to most of whom I am rather a stranger. Not to all of you, however, as there are a certain number of American chemists, who have gone forth from my laboratory and some of whom occupy leading positions in American universities—for instance, at Urbana and in your industry, for example, with the du Pont Company. However, I do not feel like a total stranger; for it is a privilege of the scientist to find friends in every country of the globe, wherever he sets his foot. This is my feeling in your midst.

At any rate, as I do not want to remain a stranger to you, I think I may best introduce myself by presenting some of my scientific memories and ideas. I have been studying chemistry for the last forty-three years; thus, I can look back on two generations of organic chemistry, the development of which is reflected on a small scale in my life.

In my younger days, chemistry was dominated by

[1] Address on the occasion of the presentation of the Willard Gibbs Medal of the Chicago Section of the American Chemical Society for distinguished achievement in science, Chicago, September 13.

two formulas: the formula of methane, representing the idea of the tetravalence of the carbon atom, and the formula of benzene, which expresses the stability, the symmetry and the isomerisms of the aromatic nucleus. These two formulas were the stars which—during my youth—safely guided explorers of the organic system in their navigations. Nowadays, chemical research travels far beyond the limits of this system, chiefly in the realm of substances, which occur in minimal traces, act in high dilutions and are endowed with high and specific reactivity. I refer to the hormones, the vitamins and enzymes, and the immuno-active substances. My mentor, Adolf Baeyer, was asked in his doctor's examination seventy-five years ago, "What is the most important hydrocarbon?" All of you know that the examiner, Professor Mitscherlich, meant benzene. If a student at Harvard were asked to-day, "What is the most important nucleus?," Professor Conant would expect no answer but "Pyrrol."

I was born during the short interval between the enunciation of the periodic system of the elements and the discovery of the asymmetry of the carbon atom, the foundation of stereochemistry. This was the time when Liebig's life was drawing to a close and when his successor Baeyer discovered the phthalein dyes, elucidated the structure of indigo, and when his pupils synthesized alizarine. I learned the three R's when Willard Gibbs enunciated the phase rule upon which his everlasting fame is founded.

As a student, I entered the laboratory of Professor Baeyer, whose successor I was to become twenty-five years later. It was my greatest experience to gain Baeyer's friendship while still a student. The influence of this master, who had and still has a number of distinguished pupils in this country, was unique, due to his strict and pure positivism and his unprejudiced experimental profundity. He loved passionately the experimental method as a child of eight and as a patriarch of eighty. When his parents took him on a trip as a boy of eight, he wrote to his governess at home to take good care of eight date pits, which he had planted in as many flower pots.

He wrote her to pour water over one of them, milk on another, wine on a third, ink on a fourth, and so forth, in order that he might observe upon his return the differences in his palm trees. To a scientist and teacher of his type we owe confidence in the experimental method and liberty in the adaptation of hypothesis to experiment and experiment to hypothesis. His example taught us not to try to direct nature, but to heed her. A young student is fortunate if he can follow a commanding personality as an example in devotion to great tasks without petty regards and intentions. However, the greater the teacher, the more difficult for the pupil to overcome his influence and to develop his own personality in the choice of problems and methods. One should not remain a pupil too long.

Shortly after I received my doctor's degree, I became "privat-docent." In those years, revolutionary discoveries, such as x-rays, the inert gases and the radioactive substances, inaugurated a new era of physics and chemistry. The classical period of organic chemistry enjoyed two last triumphs—the tetravalent oxygen of Collie and the trivalent carbon of Gomberg. My own research problems in those days were of their time, for instance, problems of constitution and synthesis of atropine and cocaine, which contain a peculiar nucleus of seven carbon atoms. The occupation with alkaloids, those natural pharmaceuticals, led me to the life-long hobby of finding means for the alleviation of pain. Thus, I participated in the discovery of a few hypnotics and narcotics, the last number of this series being avertin. Service for the welfare of humanity is not the immediate task of chemistry, but the noblest goal for the chemist. Every one of us invents a narcotic and conceives a benzene theory.

Aromatic compounds are of greater usefulness for the training of pupils. Investigations into the relationship between color and constitution led to studies on the hitherto unknown ortho-benzoquinone and quinonimines, parent substances of various classes of dyes. Prototypes for aniline dyes were found in the so-called meri-quinoid compounds. Most captivating were problems, which entailed hardly surmountable experimental difficulties, the study of the most unstable, most reactive organic molecules. The detached joy in the "performance" is not confined to physical sports. In scientific endeavor, likewise, the experience, that is, the experiment itself, is sometimes more important for the experimenter than the effect as measured in terms of practical consequences. To delve into nature's secrets is something beautiful beyond description; it is an enviable privilege of the scientist to conquer obstacles, when all known devices were deemed inadequate for their circumvention, and to penetrate far enough to lift nature's veil a little more and more from her hidden treasures. This sensation of felicity in the struggle for knowledge is not dimmed by age. To-day, in a study of ferments in blood cells, I live through similar suspense and equal fascination as a beginner forty years ago. According to an aphorism of Lessing, it is not the possession of truth, but the successful struggle for it which constitutes the happiness of the scientist.

Simple plant alkaloids, simple synthetic dyes prepared me for a greater undertaking—the study of the natural pigments. Here, in a certain respect, I digressed from the tradition of my time. Professor Baeyer and Professor Emil Fischer used commercial preparations as starting materials in their studies of natural products. I preferred to provide plants and animal-organs and to work them up myself. I remember well the time of my first experiments on chlorophyll. I told my assistant to prepare a solution from grass under specified conditions. When he asked, "Shall I order the grass from Merck's?," I took him to the window and showed him the view on our old botanic garden. At our feet lay a meadow, which perhaps was much greener than meadows appear to me nowadays. But I seemed to disregard my own teachings; when I started the study of anthocyanins seven years later in Zurich, I actually bought flowers from Merck, dried powdered corn-flowers. A rose from my own garden had served for preliminary experiments, but it was already November. The powdered material contained but one half per cent. cyanin, but the difficulties of isolation, crystallization and analysis could be overcome. Later on, the experimental field near my house in Berlin-Dahlem bore purple cornflowers, dahlias, asters and chrysanthemums which contained 14 to 30 per cent. pigment and which would have facilitated those first steps.

There is a special thrill and enticement in those first steps which create from an entirely unknown and obscure natural product a well-defined preparation revealing the essential features of its chemical character, but the initial study has to forego the revelation of ultimate details and much is left for pupils and successors. The productive period of man's life is so short and it is nice to gather the roses as well as the grass, besides many other things. Much which we sow will be reaped by others.

Chlorophyll was the main subject of my work during the seven years that I was professor in Zurich. The most surprising result of these studies was the presence of magnesium in complex form in chlorophyll. The oxidative processes, prevailing in the animal organism, are catalyzed by iron derivatives of the haemin group. Plant life, on the other hand, is based essentially on a reduction process. The reduction of atmospheric carbon dioxide to carbohydrate is catalyzed by magnesium. Furthermore, the alcohol phytol, with a skeleton consisting of twenty carbon atoms, was found. It constitutes one third of the chlorophyll molecule and it is the most wide-spread alcohol in nature. The pigment proper was recognized as a system of four pyrrol rings. When you contemplate the green in nature, light and dark leaves, bushes and trees, terrestrial and aquatic plants, the question comes to your mind, Is there one chlorophyll only or are there several or even innumerable? It is always the same chlorophyll, composed of two closely related components, differing slightly in oxygen content.

Is nature as simple in its synthesis of the ornamental colors in flowers and fruits, colors which vary from bright scarlet to dark purple? These dyes are salts of bases with tetravalent oxygen benzo-pyryllium derivatives. There are three main types—pelargonidin, cyanidin and delphinidin—differing from each other by one atom of oxygen. Here, too, nature follows a simple pattern. These alluring problems had been attacked in my laboratory when the great war broke out. Soon, the laboratory was half depopulated, but fortunately my American assistants, Mr. E. K. Bolton and Mr. C. L. Burdick, continued their work on pelargonium, aster, sage and chrysanthemum pigments and attained great success.

These studies of well-defined chemical substances served as a training in biochemical research. Increasing specialization usually forces the chemist very early to choose a special field in physical or inorganic, organic or biological chemistry, but biochemical problems are frequently of a highly involved nature. Is it not advantageous, therefore, to devote years—not necessarily decades—of preparation to the study of chemical methods and of pure substances? Ferments or enzymes as well as problems of platinum catalysis and inorganic investigation on alumina and silici were my problems in recent years.

All chemical processes in the organic world, in each animal or vegetable cell, are ruled and guided by organic catalysts—enzymes. Their nature was veiled until recently in impenetrable darkness. We had no conception as to whether enzymes were at all definite substances. Are the vital chemical reactions catalyzed by definite organic compounds of puzzling structure, as, for example, by chlorophyll, a true enzyme; or are they catalyzed by a haphazard array of well-known substances in a specific physical arrangement and degree of dispersion? I shall have the honor to-morrow to say a few words on the development of our conceptions in this respect. Enzymes are the most delicate and the most efficacious reagents in chemistry. They occur naturally in mixtures which can be compared to systematic collections of various precision instruments. If one destroys the living tissue or cell, then these mixtures can still be found, but no longer in an orderly and protected condition. We open a lock with a single key, not with a whole key-ring, and we turn a screw with a screw-driver, not with a tool-kit. This emphasizes the necessity of separating natural mixtures of these precision instruments into their individual members. Our chemical technique and manufacturing processes are usually drastic and crude, resembling forces of the inorganic rather than of the organic world. It is our task to approximate more and more the delicate methods of the living cell, where reactions proceed at normal temperatures and pressures, with mild reagents and with the most subtle catalysts. When we dare to tackle greater problems in spite of the shortness of human life, the work carries us further and it grows beyond us. In that case we do not create, but unveil.

From this bird's-eye view of my memories and ideas, I return to this assembly and to the great country whose hospitality I am enjoying. A few days in this center of magnificent activity, a few hours in the overwhelming exposition of the Century of Progress have deeply impressed me with the ingenious expressions of the technical spirit of America. In twentieth-century Chicago, in the Century of Progress, we recognize better than anywhere else the significant dualism of scientific endeavor. Has mankind really progressed through the centuries in art, philosophy, morals, ethics, tolerance, humanity, in one word, in religion? It seems to me that each generation and each individual must start anew and develop in certain aspects its own ideas, its own standards and its own faith. Thus the contrast between human and technical development is steadily increasing. I agree with Sarton, the historian of the exact sciences, when he writes: "The acquisition and systematization of positive knowledge is the only human activity which is truly cumulative and progressive." Constant and permanent progress is only achieved in science and its applications, industry and medicine. Isaac Newton's saying: "If I saw further, it was because I stood on giant shoulders," holds for every one of us. We all have thousands of great teachers and we, ourselves, contribute to the growth of the structure of fundamental and applied science to greater height. Oftentimes we may ask ourselves with severe scruples: Is mankind really becoming wiser, better and nobler? Has the power of religion grown, to render impossible hate and strife between races and nations? Let us wish that religion attains the goal of blessing mankind with love and peace. The ever-increasing beauty and power of science are manifest. While I hinted at the contrast between the spiritual and the scientific, I strongly sense that which is common to both religion and science. Both are truly international, both serve in the end the common weal of men.

WELCOME TO THE INTERNATIONAL GEOLOGICAL CONGRESS[1]

By Dr. HENRY FAIRFIELD OSBORN
AMERICAN MUSEUM OF NATURAL HISTORY

ON behalf of President Davison, the trustees and the scientific staff of the American Museum of Natural History I have the honor to extend a cordial and open-hearted welcome to the delegates and members of the International Geological Congress in its sixteenth session.

We feel honored by the presence of representatives from China, Japan, South Africa, Argentina, Cuba, Canada, Norway, Denmark, the Netherlands, Poland, Belgium, Germany, Austria, Hungary, Czechoslovakia, Rumania, Italy, France, Scotland and England.

As guests of the American Museum you are invited to enjoy our exhibition halls; to study our preparation laboratories; to examine our reserve collections; to note our peculiar methods of research; to observe our independent printing and publication; to visit the library and study its methods of distribution and exchange with over 900 of the leading scientific institutions of the world; to note the special building devoted to public and scientific education, which touches the school, college, university and research life of the entire country. Then, after your journey to Washington and through America, you are especially invited to return to our museum and take advantage of our warm hospitality to investigators from all parts of the world, selecting your own material for research. You will see much that is entirely novel and, at first thought, even foreign to a natural history museum—for instance, that anthropology is under the same roof as zoology and geology, also that astronomy is embraced in our scheme of the sciences; still more surprising, that there is a very live department of experimental biology and that in the building section to be devoted entirely to bird life there will be special provision for experimental ornithology.

You may wonder how these many branches are financed and how during the past twenty-five years it has been possible to expend no less than $38,000,000 on the development of all these branches. People who do not know imagine that we Americans have the golden tree of the Chinese and that all that is necessary is to shake the tree for a shower of millions of money; this is very far from the truth—in fact, we have to work extremely hard for every appropriation and for every gift. I will tell you our secret:

So far as public funds from the state and municipality are concerned, we must demonstrate practically that we are a living and active force in the education of the vast scientifically ignorant population that surrounds us. Accordingly, first, we touch 32,000,-

[1] Address at the luncheon at the American Museum of Natural History, July 21, 1933.