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THE CHANDLER LECTURE

1914

beyond one hundred and odd years. They became distinctly evident during the first French Republic, increased under Napoleon, gradually spread to neighboring countries, and then reaching out farther, their influence is now obvious throughout the whole world.

Beginnings of chemical industries

France, during the revolution, scattered to the winds old traditions and conventionalities, in culture as well as in politics. Until then, she had mainly impressed the world by the barbaric, wasteful splendor of her opulent kings, at whose courts the devotees of science received scant attention in comparison to the more ornamental artists and belles-lettrists, who were petted and rewarded alongside of the all-important men of the sword.

The French Republic and Napoleon

The kings of France neglected science in favor of arts and literature

In fact, as far as the culture of science was concerned, the Netherlands, Germany and Italy, and more particularly, England, were head and shoulders above the France of "le Roi Soleil."

The struggles of the new régime put France in the awkward position of the legendary beaver which "had to climb a tree."

If for no other reason, she needed scientists to help her in her wars against the rulers of other European nations. She needed them just as much for repairing her crippled finances and her badly disturbed industries which were dependent upon natural products imported until then, but of which the supply had suddenly been cut off by the so-called Continental Blockade. Money-prizes and other inducements had been offered for stimulating the development of chemical processes, and—what is more significant—patent laws were promulgated so as to foster invention.

Creation of French patent system

Nicolas Leblanc's method for the manufacture of soda

to replace the imported alkalis, Berthollet's method for bleaching with chlorine, the beet-sugar industry to replace cane sugar imported from the colonies, and several other processes, were proposed.

All these chemical processes found themselves soon lifted from the hands of the secretive alchemist or the timid pharmacist to the rank of real manufacturing methods: Industrial chemistry had begun its lusty career.

First successes stimulated new endeavors and small wonder is it that France, with these favorable conditions at hand, for a while at least, entered into the most glorious period of that part of her history which relates to the development of chemistry, and the arts dependent thereon.

Backward position of Germany

It is difficult to imagine that, at that time, Germany, which now occupies such an enviable position in chemistry, was so far behind that even in 1822, when Liebig wanted to study chemistry at the best schools, he had to leave his own country, and turn to Gay-Lussac, Thénard and Dulong in Paris.

Development of British chemical industry

But the British were not slow to avail themselves of the new opportunities in chemical manufacturing so clearly indicated by the first successes of the French. Their linen bleacheries in Scotland and England soon used an improved method for bleaching with chloride of lime, developed by Tennant, which brought along the manufacture of other chemicals relating thereto, like sulphuric acid and soda.

The chemical reactions involved in all these processes are relatively simple, and after they were once well understood, it required mainly resourceful engineering and good commercial abilities to build up successfully the industries based thereon.

From this epoch on dates the beginning of the development of that important industry of heavy chemicals in which the British led the world for almost a century.

In the same way, England had become the leader in another important branch of chemical industry—the manufacture of coal-gas.

Liebig's influence in Germany

The Germans were soon to make up for lost time. Those same German universities, which when Liebig was a young man were so poorly equipped for the study of chemistry, were now enthusiastically at work on research along the newer developments of the physical sciences, and, before long, the former pupils of France, in their turn, became teachers of the world.

Liebig had inaugurated for the chemical students working under him his system of research laboratories; however modest these laboratories may have been at that time, they carried bodily the study of chemistry from pedagogic boresomeness into a captivating cross-examination of nature.

And it seemed as if nature had been waiting impatiently to impart some of her secrets to the children of men, who for so many generations had tried to settle Truth and Knowledge by words and oratory and by brilliant displays of metaphysical controversies.

Indeed, at that time, a few kitchen tables, some clumsy glass-ware, a charcoal furnace or two, some pots and pans, and a modest balance were all that was needed to make nature give her answers.

Development of organic chemistry in Germany

These modest paraphernalia, eloquent by their very simplicity, brought forth rapidly succeeding discoveries. One of them was truly sensational: Liebig and Wöhler succeeded in accomplishing the direct synthesis of urea; thinking men began to realize the far-reaching import of this revolutionary discovery whereby a purely organic substance had been created in the laboratory by starting exclusively from inorganic materials. This result upset all respected doc-

trines that organic substances are of a special enigmatic constitution, altogether different from inorganic or mineral compounds, and that they only could be built up by the agency of the so-called "vital force"—whatever that might mean.

Research in organic chemistry became more and more fascinating; all available organic substances were being investigated one after another by restless experimentalists.

The influence of Kékulé's theory

Coal-tar, heretofore a troublesome by-product of gas manufacture, notwithstanding its uninviting, ill-smelling, black sticky appearance, did not escape the general inquisitive tendency; some of its constituents, like benzol or others, were isolated and studied.

Under the brilliant leadership of Kékulé, a successful attempt was made to correlate the rapidly increasing new experimental observations in organic chemistry into a new theory which would try to explain all the numerous facts; a theory which became the sign-post to the roads of further achievements.

Discovery of artificial dyes

The discovery of quickly succeeding processes for making from coal-tar derivatives numerous artificial dyes, rivaling, if not surpassing, the most brilliant colors of nature, made the group of bold investigators still bolder. Research in organic chemistry began to find rapid rewards; entirely new and successful industries based on purely scientific data were springing up in England and France, as well as in Germany.

Stimulating influences of the dye industry on organic chemistry

Some wide-awake leaders of these new enterprises, more particularly in Germany, soon learned that they were never hampered by too much knowledge, but that, on the contrary, they were almost continuously handicapped in their impatient onward march by insufficient know-

ledge, or by misleading conceptions, if not by incorrect published facts.

This is precisely where the study of organic chemistry received its greatest stimulating influence and soon put Germany, in this branch of science, ahead of all other nations.

Money and effort had to be spent freely for further research. The best scholars in chemistry were called into action. Some men, who were preparing themselves to become professors, were induced to take a leading part as directors in one or another of the new chemical enterprises. Others, who refused to forsake their teachers' career, were retained as advisers or guides, and, in several instances, the honor of being the discoverers of new processes, or a new dye, was made more substantial by financial rewards. The modest German university professor, who heretofore had lived within a rather narrow academic sphere, went through a process of evolution, where the rapidly growing chemical industry made him realize his latent powers and greater importance, and broadened his influence way beyond the confines of his lecture-room. Even if he were altruistic enough to remain indifferent to fame or money, he felt stimulated by the very thought that he was helping, in a direct manner, to build up the nation and the world through the immediate application of the principles of science.

Industrial research laboratories

In the beginning, science did all the giving and chemical industry got most of the rewards; but soon the rôles began to change to the point where frequently they became entirely inverted. The universities did not furnish knowledge fast enough to keep pace with the requirements of the rapidly developing new industries. Modern research laboratories were organized by some large chemical factories on a scale never conceived before, with a lavishness which made the best equipped