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CHANGING IMAGES OF CHEMISTRY

INTRODUCTION

The tensions between chemistry and medicine (or life science) are as old as chemistry itself. They were caused by enthusiastic alchemists who vied with nature or were accused of doing so. The promise of creating a living creature through laboratory operations survived the collapse of the alchemical tradition and profoundly shaped the public image of chemistry. The dichotomy between the laboratory and Nature as the creator of life was still at the center of literary images of chemists in the early nineteenth century. In her popular 1817 novel *Frankenstein*, Mary Shelley revived the Promethean image of an all-powerful chemist. This image, which has created an association of chemistry with witchcraft, magic and charlatanism has persisted through the centuries in spite of the many successful and useful products that have issued from the chemist's laboratory. As early as the eighteenth century, chemists began to substitute artificial, man-made products such as ammonia, oil of vitriol (sulphuric acid), and what they called "facticious" (that is, *artificial*) soda (sodium carbonate) for products formerly extracted from vegetable- or animal-matter. By the end of the eighteenth century chemistry was, therefore, celebrated as a useful science, contributing to public welfare and the wealth of nations. Chemists were no longer perceived as dangerous people. Rather they had become respectable professionals enjoying social recognition and, often, political responsibilities.

In the mid-nineteenth century, however, the development of synthetic chemistry revived the competition between chemistry and life. One purpose of this paper is to contribute to an understanding of how and why the term "synthetic" became a synonym of "chemical" and the antonym of "natural" or "organic" in popular language. I will also discuss to what extent this common view has changed because of the most recent developments of chemistry.

CREATING LIFE

The public view of synthesis rests on a legend created and propagated by chemists such as Hermann Kolbe, Wilhelm August Hofmann and Marcellin Berthelot.¹ They

pointed to Friedrich Wöhler's synthesis of urea, an organic compound, from inorganic material in 1828 as the death sentence of vital forces. The metaphysical belief in a vital force was supposedly destroyed by this experiment bridging the chasm between the inorganic and organic realms. Wöhler's synthesis was presented as an epoch-making discovery, the dawn of a new era, when chemists would be able to create organisms.

In reality, vital forces were not swept away by the synthesis of urea. As John Hedley Brooke has argued, this is a biased interpretation of this synthesis.² Urea is an organic substance but not an organism; it is a product of life but it was not synthesized through the same process as it is in the organism. It was thus easy for Claude Bernard to state that chemists could certainly imitate the products of life but could not imitate the ways of nature.³ Thus the anti-metaphysical claim rests on a confusion between "organic" and "organized" and between product and process.

The claim is also unacceptable because Wöhler's synthesis was not a direct synthesis from elements, but rather a partial synthesis from a cyanate. This cyanate was itself not synthesized from its elements but by oxidation from a cyanide extracted from horns and hooves of animals. Therefore Wöhler's synthesis did not affect the belief of chemists such as Jöns Jakob Berzelius and Justus Liebig in the existence of a vital force, active in the formation of organized bodies.

The synthesis of urea as a crucial experiment overthrowing a metaphysical dogma is thus a myth, intended to exalt the power of chemical synthesis. If Wöhler's synthesis was an epoch-making discovery it was so not because it killed vital forces but because it revealed a strange phenomenon, later called "isomerism." Urea was obtained from the same components as potassium cyanate, although it did not present the same properties. Consequently, the belief that the properties of a compound were exclusively determined by the nature and proportion of its constituent elements was challenged. Wöhler's synthesis was thus a landmark because it drew the attention of chemists to the arrangement of atoms within the molecule. In the 1860s, the understanding of the structure of the benzene molecule by August Kekulé allowed the synthesis of many aromatic compounds, synthetic dyes, by the substitution of atoms within benzene's hexagonal structure.

Substitution of atoms or groups of atoms in a molecular edifice was the real practice of synthesis in the second half of the nineteenth century. However, the popular connection between "synthetic" and "artificial" does not rest on this practice. Rather it was rooted in Berthelot's view of synthesis as a creation. "Chemistry," he wrote, "creates its own object." This creative faculty, like that of art itself, distinguishes it fundamentally from the natural and historical sciences.⁴ For Berthelot, who opposed all atomistic views, synthesis was like the construction of an edifice, starting from the ultimate elements – carbon, hydrogen, oxygen and nitrogen. Berthelot claimed he could build up carbohydrates, "which are so to speak the building blocks of the scientific edifice;" and he would then proceed to the synthesis of ternary compounds made of carbon, hydrogen and oxygen, such as alcohols; the next step would start from the alcohols and build up ethers, alkaloids or organic acids, which in turn would lead to amides such as ureas, at the threshold of living matter. Through progressive syntheses, chemistry could create anything. This ambitious program is described at length in Berthelot's popular book *La Synthèse chimique*.



Figure 1. Marcellin Berthelot. Reprinted with permission of the Agence Bridgeman Giraudon, Paris.

However, it remained a paper program. In fifty years, Berthelot realized only a small, insignificant part of his grand design. He synthesized wine alcohol from ethylene (not from the elements); formic acid by combining carbon and soda; and acetylene by directly combining carbon and hydrogen in an instrument named “the electric egg”, a name presumably reminiscent of alchemical instruments. The view of synthesis as an artificial creation, therefore, rests on no effective practice. Rather it was a fantasy, forged with the help of rhetoric and reminiscences.

Today the image of the chemist as a creator is in competition with another heroic image of the synthetic chemist put forward by the Nobel Laureate Roald Hoffmann in the 1980s. In contrast to the nineteenth century image of an all-powerful creator, manipulating the elements of nature, the modern synthetic chemist is portrayed as an

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