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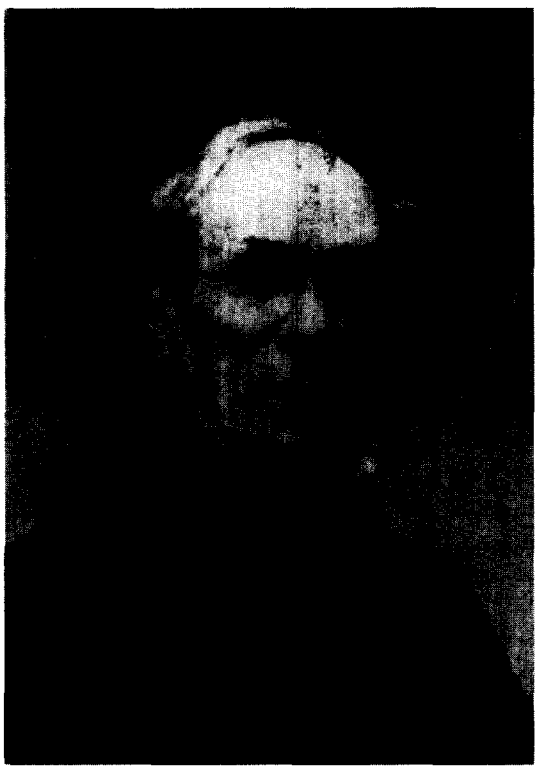
Augustin Pierre Dubrunfaut



On the occasion of the first Dubrunfaut Award given by the International Society for Biological Calorimetry, it is only appropriate to present a short account of the life and work of the French scientist who, in 1856, determined for the first time the heat of alcoholic fermentation [1]. No drawing exists of his calorimeter, which he described as a large, oak fermentation vat in the shape of a truncated cone, 3m deep and also having an average diameter of 3m, the wood of which had a volume of 1.4m^3 and a weight of 1120kg. In the single experiment that was performed, the culture medium consisted of 21400l of a molasses solution containing 2559kg of crystallizable sugar, to which was added enough yeast inoculum (the exact quantity was not specified, but it must have been large!) so that the fermentation could be completed in four days. During this time, the temperature of the vat rose from 23.7 to 33.7C, an average of which was considerably above the ambient temperature, which varied from 12 to 16C. Dubrunfaut calculated the loss of heat due to radiation and convection by measuring the rate at which the vat cooled after fermentation had ceased and applying Newton's Law of Cooling. He also corrected for the following: the heat absorbed by the wood in the vat, the negative heat of solution of CO_2(aq) passing into the gas phase, the heat equivalent of the mechanical work done by the expansion of evolved CO_2(g) against the atmosphere, and the evaporation of water from the vat. The result was 94.91kJ/mol of glucose equivalent fermented, which was considerably lower than the 138.57kJ/mol to be expected on the basis of the complete fermentation

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of glucose to ethanol and CO_2, as predicted by the Gay-Lussac equation. It has been suggested by Battley [2] that this was at least partly due to the storage and utilization of the sugar by the yeast cells in the processes of fermentative assimilation and growth. The reason why Dubrunfaut carried out such a massive experiment is made evident by the nature of his scientific career.

Augustin-Pierre Dubrunfaut (there is some confusion in the literature as to the order of Dubrunfaut's given names, in that he is identified variously as Pierre August (photograph), Auguste-Pierre [5,6,10], and Augustin-Pierre [7–9]) was born in Lille, France, on September 1, 1797. He received a classical education, and studied chemistry and physics at the Collège de Lille under Drappiez and Delezenne [8]. He continued his education at the Collège Stanislaus [6] (but also stated as the Savouré institution [10]), which was completed at the Faculté des Sciènces in Paris, where he worked under such well-known chemists as Dulong, Gay-Lussac, Pouillet, and Thénard, after which he returned to Lille [9]. He was initially employed in a bank. However, his aptitude was minimally attuned to financial matters, and after a trip to Holland and Belgium during the course of which he visited several distilleries, he became attached to a sugar refinery [8] and, thereafter, devoted himself to a career in science and industrial chemistry. In 1819, aged 22, he introduced into industry a simple device for lifting and conveying liquids by air pressure, the "air lift", which became at that time one of the fundamental operations of chemical engineering, and in 1823 he was awarded the Olivier de Serres Gold Medal for his paper on the "Saccharification des fécules" [8]. With respect to applied chemistry, his two most important works, in 1824–1825, related to a comprehensive survey of the practice of distillation [3] and the manufacture of beet sugar [4], and it is from this time and as a result of these publications that the rapid development of the French sugar-beet industry is said to have begun, with considerable effect on the economy of France. He held a professorship in applied chemistry and physics from 1824 to 1830 at l'Ecole Special de Commerce, in Paris [5] (Ref. [10] places this school in Lille), and, in 1827, founded at Bercy, a suburb of Paris, a school for beet-sugar manufacturing. This latter appears to have been his favorite location and, possibly, is the place where he carried out his calorimetric experiment. The reason he used such a large calorimeter vessel was probably because these were the sort of containers he used in the fermentation industry. Whether or not the vat he used for his calorimeter was initially constructed for that purpose, it most probably was intended to be used routinely for the production of alcohol. These large vats also offered a smaller surface/volume ratio that was favorable to reducing heat loss.

Although of historical importance in the field of biological calorimetry, Dubrunfaut's single experiment in 1856 was only a small part of what he did throughout his career in pure and applied chemistry, the scope of which is far too great to cover in detail here. Apart from the effect two of his publications [3,4] had in stimulating the development of the French sugar-beet industry, he made many other contributions to science. While engaged primarily in industrial problems, his scientific abilities led him to pursue several important researches in sugar chemistry. In 1830, he became the first to recognize that a clear extract of malt contained an active principal that liquefied starch paste, that lost its activity on heating above 70C, and that was completely killed at 87C (i.e. an enzyme *in solution*). Three years later this enzyme was separated by Payen and Persoz as a dry powder and called "diastase". In the same year, he also made the important discovery that yeast inverts cane sugar before fermenting it. In 1846, he described mutarotation and, in 1847, discovered levulose and maltose. Together with many other papers on the action of yeast on sugars and on sugar chemistry, he also published on such diverse subjects as suspersaturation, superfusion, the expansion of gases, the spectral analysis of gases, the nature of ozone, the isolation of fatty acids by distillation and osmotic analysis. He was a collaborative editor of two journals, two encyclopedias, and for several years published the monthly journal *Agriculteur manufacturier*. He established an industrial school in the beet-sugar factory at La Varenne-Saint-Mauer (1830), managed an agricultural distillery at the Ménagerie de Versailles (1831), and established others at Douai (1834), at Valenciennes (1837), and at Bercy (1837), all distilling fermented sugar-beet molasses to produce alcohol. By 1850, he owned four sugar-beet factories: Tournus, Valenciennes, La Villette, and Courrieres, and in 1852 developed a method of directly fermenting sugar beets to produce

alcohol, without having to pass through the molasses stage. This latter was used in a large distillery constructed at Chalon-sur-Saône in 1858. In 1854, he developed an osmotic method of extracting sugar from sugar-beet molasses. His activity was immense. His contributions were well recognized during his lifetime by the receipt of several medals and by being named "Chevalier de la Légion d'Honneur". However, although he applied, to his chagrin he was never made a member of the French Academy.

Little is known about Dubrunfaut's personal life. He was considered a modest, kind, and well-liked man of definite opinions who, apparently, never married and who was generous at many levels with the considerable money he made as an industrial sugar chemist. He died on October 7, 1881, at Bercy, before his retirement, as a result of poisoning from a gas leak in a room in which he was sleeping. In his time, he was an extremely important industrial chemist who seems, over the years, to have become a forgotten man. We remember Pasteur. We do not remember Dubrunfaut. It is fitting that he now has an award named after him in recognition of his work.

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