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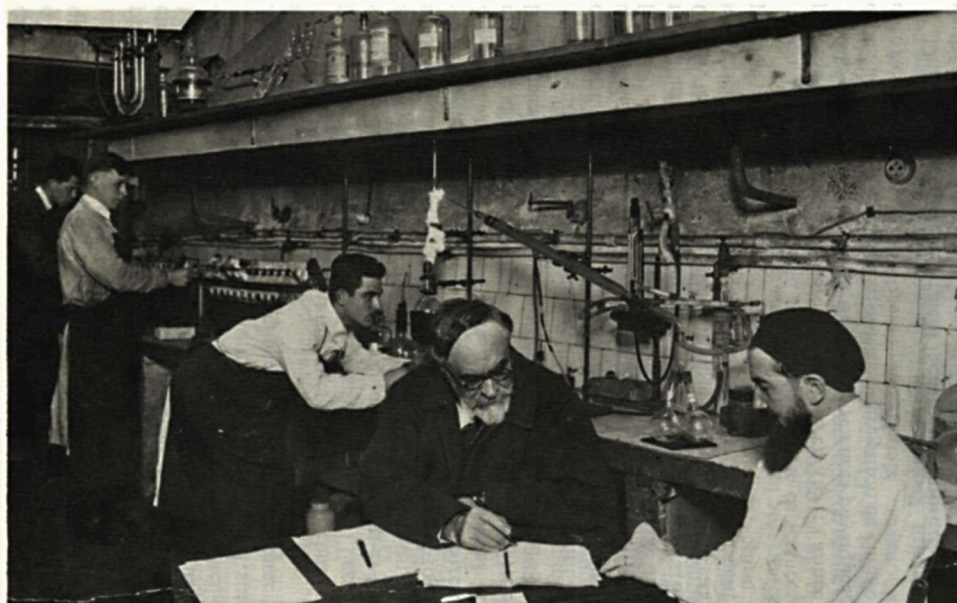
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Charles Moureu: From the Collège de France to poison gases

Marc Fontecave

- 1 As a professor of chemistry at the Collège de France, it is with much emotion and respect that I recall Charles Moureu's name, even though it is associated with the production of chemical weapons and poison gases during the First World War. It is important to bear in mind the violence of the historical conditions in which French intellectuals worked at the time.



- 2 Patriotic and nationalistic feelings were exacerbated and played a crucial role in their professional and political choices. What makes me turn to Charles Moureu is that he was the only professor appointed at the Collège de France during the four years of the conflict.

- 3 This was in 1917, when he was 54. He was appointed to the prestigious Chair of Organic Chemistry, succeeding Émile Jungfleisch, who was Marcelin Berthelot's successor. He deserved it. As an organic synthesis chemist elected to the French Academy of Sciences in 1911, he was renowned for his work not only on acrylic acid and its derivatives, but also on acetylenic compounds, phenolic compounds, especially natural products derived from plant essences, and rare gases (these gases are not toxic).
- 4 During those war years, Moureu and his student Charles Dufraisse worked on acrolein, a precursor of acrylic acid that he knew well. This is a compound with highly irritating and lacrymatory vapours. He had known it since 1893, when he used this aldehyde to prepare acrylic acid. Acrolein was to be used as a poison gas. At the end of 1916, French artillery shells contained benzyl iodide as well, which Moureu and Dufraisse also studied at the École Supérieure de Pharmacie where Moureu was appointed in 1907.
- 5 This research, which the war justified and which can now be considered unacceptable, led Moureu to a major discovery on a fundamental level that later resulted in applications of great importance for the well-being of humanity. This work, published in 1922 only, seven years before his death, had started in the midst of the war. Acrolein, developed by Moureu for chemical warfare, is an unstable compound which tends to polymerize when it comes into contact with air, and thus to lose its toxic properties. After the war, in his laboratory at the Collège de France, Moureu studied these processes and showed their very general nature. Most organic products degrade spontaneously, though at widely varying speeds, when they come into contact with air, following oxidation reactions due to the presence of oxygen in the air. Most of the time catalysts activate these reactions. This is the phenomenon called autoxidation.
- 6 In a way everything around us autoxidizes. For example, it is now accepted that humans' ageing is partly due to processes of autoxidation of biological molecules. In the life sciences and medicine, the expression "oxidative stress" is used to describe this set of natural processes to which all organisms living in an oxygenated atmosphere are subject. Moureu understood this process's origin and mechanisms, and identified catalysts triggering it. Above all, he found that some compounds, particularly phenolic compounds such as hydroquinone, which he studied extensively during that period, had the capacity to slow down or inhibit these reactions. In so doing he made a major discovery in the history of science, no doubt his most striking discovery: antioxidants, the current name for what Moureu called "antioxygens" at the time.
- 7 This discovery would surely have deserved the Nobel Prize, had Moureu's work, as I have already pointed out, not been tainted with the blood of soldiers asphyxiated by his molecules developed during wartime. These antioxidants are now used on a large scale as preservatives and to slow down the ageing, in other words the oxidation, of molecules and materials in the chemical, food and cosmetic industries. Many medicines are used for their antioxidant properties.
- 8 Living organisms themselves have elaborated complex antioxidant regulatory mechanisms allowing them to live in the Earth's oxygenated atmosphere, and specifically antioxidant molecules such as Vitamin C and Vitamin E or ubiquinone, a membrane antioxidant on which we are currently working in my laboratory. From chemical weapons to antioxidants, the paradox between science and what humans make of it is once again fully apparent.

Excerpts from the paper delivered by Prof. Marc FONTECAVE

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The full paper is available at www.college-de-france.fr/site/colloque-2014/symposium-2014-10-16-14h00.htm

Programme

Opening Address

Serge Haroche, Collège de France

Vienna before 1914 and after 1918:

Continuities and Breaks

Anton Zeilinger, University of Vienna

Berlin after 1918: A problematic modernity

Céline Trautmann-Waller, Sorbonne Nouvelle University - Paris 3

The Consequences of the War for University Life in Europe

Jürgen von Ungern-Sternberg, University of Basel

Orientalists: Adventurers, experts and diplomats

Henry Laurens, Collège de France

Charles Moureu: From the Collège de France to poison gases

Marc Fontecave, Collège de France

A Turning Point in Relations between Mathematics and Physics

Françoise Balibar, Paris Diderot University - Paris 7

War, Literature and Democracy

Antoine Compagnon, Collège de France

Language, Logic and Philosophy

Jacques Bouveresse, Collège de France

French Philosophers Faced with the War: Politics, morality and philosophy

Claudine Tiercelin, Collège de France

Picasso, Duchamp, Kandinsky: The 20th-century workshop

Roland Recht, Collège de France

War and Cinema under the Weimar Republic

Olivier Agard, Paris Sorbonne University - Paris 4

Superficial and Profound Breaks in Music

Makis Solomos, University Paris 8 Vincennes

The Emergence of Psychoanalysis: A fact of civilization?

Roland Gori, University of Aix-Marseille

A Great-War Effect on French Psychiatry?

Isabelle von Buelzingsloewen, Université Lumière Lyon 2

Wars and the Construction of the State: The example of education

Philippe Aghion, Harvard University

The Leader: Transnational study of a shared object

Yves Cohen, EHESS

The War Transformed Love

Michelle Perrot, Paris Diderot University - Paris 7

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Chemistry of Biological Processes