OPINION

Antoine-Laurent de Lavoisier (1743–1794) and the birth of respiratory physiology

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ABSTRACT

Background For more than 1500 years, the status of knowledge concerning the physiology of human respiration has remained almost unchanged. In the 18th century, the French chemist Antoine-Laurent de Lavoisier conducted breathing experiments on human and animal respiration.

Methods The main bibliographic sources concerning Lavoisier's life and work on respiration have been investigated and analysed.

Results Using an ice-calorimeter, Lavoisier proved that combustion and respiration were one and the same. He also measured the oxygen consumed during respiration and concluded that the amount changes depending on human activities: exercise, eating, fasting, and sitting in a warm or cold room. Moreover, he found variations in pulse and breathing rate.

Conclusions Lavoisier's work on respiration is of great historical significance as it represents the first effort to measure human respiratory gas metabolism contributing significantly to the development of respiratory physiology.

Key messages

What is the key question?
- How did Lavoisier's experiments impact our knowledge on respiratory physiology?

What is the bottom line?
- Lavoisier's work boosted respiratory and metabolic physiology into a new era.

Why read on?
- To realise the evolution in the study of respiratory physiology and the significant progress that was achieved during the 18th century.

Antoine Lavoisier was born in Paris on 26 August 1743 into a family of wealthy merchants. He received an excellent basic education at the prestigious Collège Mazarin and then he studied Law.[1] In addition, he took voluntary classes in many scientific subjects. However, two distinguished scientists initiated Lavoisier in natural sciences: Guillaume-François Rouelle (1703–1770) in chemistry and Jean-Etienne Guettard (1715–1786) in geology, contributing in 1765 to Lavoisier's first paper in the Royal Academy of Sciences, on gypsum.[2] In 1769, he was elected member of the French Academy of Sciences for his essay on the best means to illuminate the streets of Paris at night and in recognition of his earlier research.[2] At that time, he became a member and invested his fortune in Farmers General (tax farm), a private corporation of financiers commissioned by the French government to collect tolls and taxes. His income allowed him to pursue his experiments. In 1771, Lavoisier married Marie-Anne Pierrette Paulze (1758–1830) who became his collaborator, translating for him the works of British scientists and depicting illustrations of his experiments for his books.[1]

Among his achievements, he published a new nomenclature for chemistry; gave oxygen its name; discovered the composition of water; clarified oxygen's role in combustion and oxidation; explored the mechanisms of acid formation and water decomposition; and established a metric system of weights and measures.[1]

From the early 1780s Lavoisier had been concerned with the process of respiration. His hypothesis was that combustion and respiration were one and the same and combustion occurs with every instance of respiration. In 1784, with his friend Pierre-Simon Laplace (1749–1827), he designed an ingenious ice-calorimeter to measure the amount of emitted heat during combustion and respiration.[3] This apparatus consisted of three chambers: the inside chamber held the source of heat, a live guinea pig or a piece of burning charcoal; the middle one held a specific amount of ice for the heat source to melt; and the outside chamber held packed snow for insulation. Moreover, they connected a sleeve in a separate container to collect the 'fixed air' that was given off during combustion or respiration. They measured the quantifiable and specific amount of caloric and 'fixed air' produced during respiration and concluded that respiration is combustion (*la respiration est une combustion*) that occurs in the lungs and enables the living animal to maintain its body temperature above that of its surroundings.[3]

But a question arose. Could the consumed oxygen during respiration be measured? To answer it, Lavoisier turned to a volunteer, the young chemist Armand Séguin (1764–1835). During the experiment, Séguin breathed oxygen through a tube in an air-proof mask and Lavoisier was measuring the amount of gas Séguin used, the speed of his breathing and his pulse over the course of an hour. The level of the consumed oxygen varied

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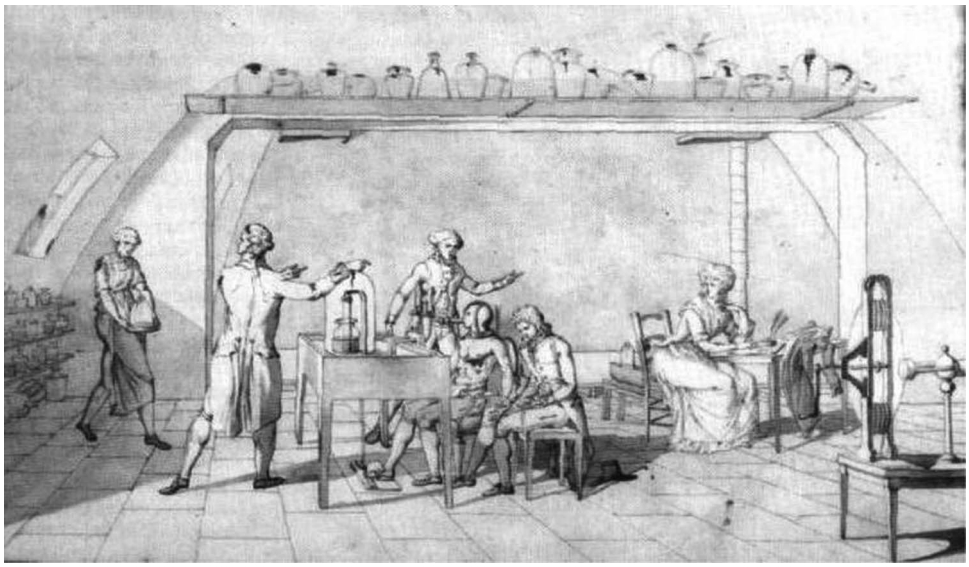

Figure 1 Drawing of Madame Lavoisier depicting the experiment on respiration. Source: http://www.iupui.edu/~histwhs/H374.dir/H374.webslides/chemrev/exp_respiration2.jpg.

depending on his activities: he needed more oxygen when exercising than when resting, more when eating than fasting, and more when sitting in a cold room than in a warm one. His pulse and breathing rate varied too[2 3] (figure 1).

Lavoisier's experiments on respiration constituted a fundamental pillar for the development of respiratory physiology. However, his research would abruptly pause in the wake of the Reign of Terror, a period of violence that occurred after the onset of the French Revolution. Lavoisier was linked to the Old Regime through the tax farm and was executed on the guillotine on the afternoon of 8 May 1794 after a trial by the Revolutionary Tribune which lasted a few hours.[1] Shortly afterwards, his friend, the mathematician Joseph-Louis Lagrange (1716–1813), paid tribute to Lavoisier by stating: "It took them only an instant to cut off that head, and a 100 years may not produce another like it".[4]

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