

## Marcello Malpighi (1628–1694) The Revolution in Medicine

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**M**arcello Malpighi (1628–1694) is considered the father of modern pathology and physiopathology. He correlated diseases to specific gross and microscopic anatomic changes, laying the basis of modern physiology and embryology (Figure 1).

Malpighi was born in a small village near Bologna and received a degree in Medicine and Philosophy in 1653, under the tutorage of Bartolomeo Massari.<sup>1–3</sup>

### Cultural Environment in Bologna

Bologna was the most important city, after Rome, of the papal state.<sup>3–6</sup> The city of Bologna, thanks to its geographic position, was an important commercial center, with the possibility of cultural exchanges with Northern and Eastern Europe.

The University of Bologna was founded in 1088. Teachers and students organized confraternities (so-called *nationes*) that controlled the policy of the university. The confraternities represented a family with rigid rules. All swore loyalty to tradition, with complete acceptance of Galen medicine.

New theories and ideas were reported in secret meetings, to avoid conflict with the confraternities and with the establishment.

Marcello Malpighi assisted his tutor, Bartolomeo Massari, in the public, conventional lectures. Bartolomeo Massari organized at home the *Accademia del Coro Anatomico*; he performed anatomic dissections and experiments on animals. In these meetings, new ideas were discussed, based on a rigorous analysis. The concept that diseases were related to specific organ alterations, as well as the new theories about blood circulation, was developed and accepted, contrasting in secret the traditional theories.

The traditional theories by Galen considered diseases an altered balance of the humors.

### Contrasts at the University and New Opportunities

Marcello Malpighi practiced as a surgeon at the University Hospital. He tried to perform anatomic dissections on all patients who died in the hospital, correlating symptoms to the gross pathological changes in the organs. During this time, he was appointed lecturer in theoretical medicine at the university. His intellectual honesty, and his willingness to talk directly and frankly, compelled him to openly discuss the new theories: diseases were not an altered balance of the humors,

as traditional Galen medicine described, but they were correlated to organ alterations. He exposed the new concepts about the cardiovascular system, contrasting the ideas by Galen, in which the blood formed in the liver and was consumed in the periphery. In Galen theories, the venous and arterial circulation were connected by microscopic pores in the heart septa. The public lectures by Malpighi generated conflict with the other faculty members; conflicts that became physical attacks. The solution to these conflicts came unexpectedly a few months later, when Ferdinand II, Grand Duke of Tuscany, summoned Malpighi to Pisa, where he took the chair of theoretical medicine. In Pisa, Galileo Galilei (1564–1642), Professor of Mathematics, had underlined the importance and need for a close relationship between mathematics and theoretical and experimental physics. He perfected a telescope with a  $\times 30$  magnification to observe the sky. Malpighi collaborated with Giovanni Alfonso Borrelli, a talented mathematician, and he had in his hands a microscope, virtually an untried tool. He understood the importance of moving from gross to microscopic observation, founding the basis of modern ultrastructural pathology. Malpighi added microscopic observation to all his studies on humans, animals, and plants. He opened a new world of ideas, leading to modern physiology.

In 1659, Malpighi had to go back to Bologna for family reasons. Malpighi published his most famous work, “*De pulmonibus observationes anatomicae*” (1661), in which he described the microscopic details of the capillaries in the lungs (Figure 2A and 2B). According to the classic theories by Galen, the lungs were solid structures full of blood. Malpighi demonstrated, first on animals and later in humans, that the lungs were structures similar to honeycomb of bees, full of air. He observed the pulmonary alveoli, in which arteries and veins connected themselves through a network of capillaries, opening the possibility that these capillaries, in contact with bronchial terminations, were implicated in the oxygenation of the venous blood. The venous blood returned to the heart, thanks to these connections. Malpighi completed the work by William Harvey “*Exercitatio anatomica de motu cordis et sanguinis in animalibus*” (1628).

The publication of “*De pulmonibus*” brought new conflicts with other faculty members. Malpighi experienced several assassination attempts. He accepted an offer to move to Sicily, at the University of Messina. In this period, he wrote several

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**Figure 1. Portrait of Marcello Malpighi in the office of the Rector of the University of Bologna.** Marcello Malpighi has represented a continuous example for the students and teachers of the University of Bologna. He has been considered a friendly mentor and tutor (oil on canvas, author not known).

essays, describing in detail the gross and microscopic characteristics of the brain, of all sensory organs, of the liver, and kidney. The reaction by the other faculty members in Messina was even worse than in Bologna.

Malpighi decided to go back to Bologna, shifting his attention to his private practice (quite significant) rather than to public teaching. Despite this, he was again at the center of continuous scientific and physical attacks. His house, including the library and all scientific notes, was destroyed by a fire.

## Revolutionary Theories

### *Cardiovascular and Respiratory System*

Malpighi completed the theories by William Harvey, demonstrating the pulmonary capillaries, which connect the venous and arterial circulation (*De pulmonibus observationes anatomicae*, 1661; *De pulmonibus epistula altera*, 1661).<sup>7</sup> He observed the close adherence of these capillaries to the terminal bronchi.

### *Nervous System*

He identified the cerebral white and gray matter, from where the nerves originate to go to the periphery, secreting a nervous juice (*De Cerebro*, 1665; *De Cerebri Cortice*, 1666; *De Externo Tactu Organo*, 1665; *De Lingua*, 1665). He discovered the tactile terminations in the skin and the taste buds in the tongue, determining their sensory function and their connection with the brain.

### *Renal System*

Malpighi described the microscopic structure of the kidney and proposed a new, modern theory about the physiology of excretion (*De viscerum structura*, 1665; *De renibus*, 1666).

### *Liver Function*

Malpighi noted in animals and humans the lobular structure of the liver, distinguishing the venous and biliary system (*De hepate*, 1666). The bile was produced by the liver and not by gallbladder as thought previously. Malpighi hypothesized for the liver a filter for toxic substances and a secretive function. He contrasted the previous theories that identified the liver as the central organ for blood production and perfusion.

### *Spleen Function*

For Malpighi, the spleen had a filter for toxic substances function (*De liene*, 1666). He identified white little bodies that were correlated to infection (lymphoid nodules, later named Malpighian corpuscles).

### *Red Blood Cells*

Malpighi identified the red blood cells, initially defined as adipose cells, later as coagulated blood cells (*De polipo cordis*, 1666). He considered the blood formed by 2 portions: the serous and the dense part. The dense part was involved in the blood coagulation.

### *Embryology*

Malpighi's investigations of the lifecycle of plants and animals led him into the topic of reproduction (*De formatione pulli*, 1667; *Opera Omnia*, 1675). He made detailed drawings of his studies of chick embryo development, seed development in plants, and the transformation of caterpillars into insects. His discoveries helped to illuminate topics of epigenesis and metamorphosis.

### *Botany*

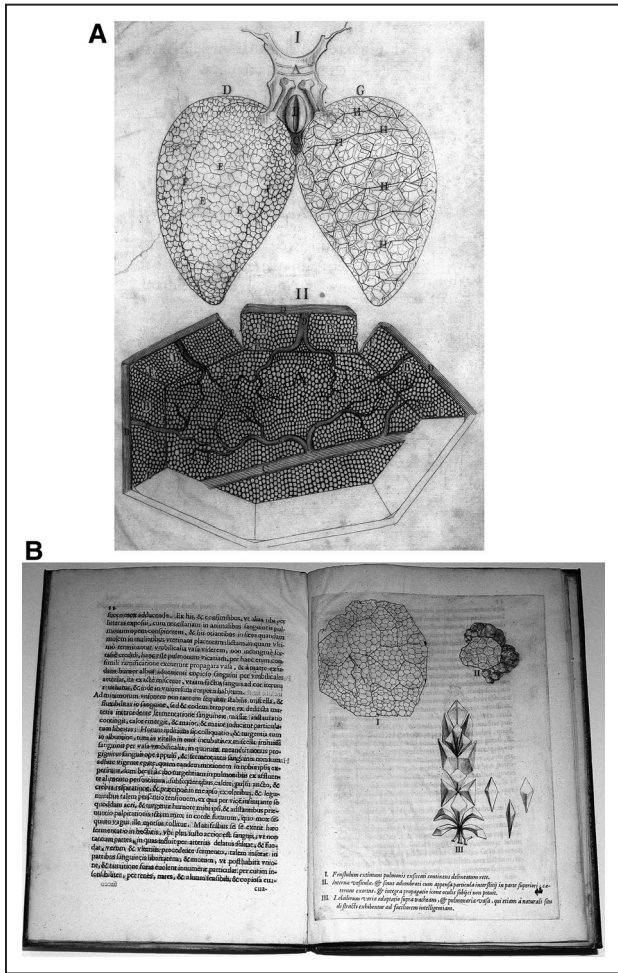
Malpighi made fundamental discoveries in this field (*Anatome Plantarum*, 1675). He disagreed with the view of his contemporaries that the galls of trees and herbs gave birth to insects. He conjectured that the creatures in question arose from eggs previously laid in the plant tissue.

## Recognition of Malpighi's Work

In the second half of the 1600s, there was a significant change in the general attitude toward scientific progress. The establishment understood that scientific progress could be an additional power in its hands.

Much attention was paid to the scientific method as described by Bacon, Galileo Galilei, Locke, Newton, and David Hume. Their theories influenced the general and philosophical thinking and the birth of the Enlightenment in England and later in France.

Malpighi—a very religious and honest man—was always supported in the most difficult situations by the Church, in particular by 2 Jesuit high prelates, Antonio Pignatelli and Cardinal Farnese. In 1691, Antonio Pignatelli went up the papal throne as Innocenzo XII. He named Marcello Malpighi as Archiiatra (a position similar to that of Surgeon General or Minister of Health).



**Figure 2.** Discovery of the connections between venous and arterial circulation. **A**, Microscopic structure of the frog lungs. **AI**, On the left, the external appearance of the lung; on the right, the alveoli, perfused by pulmonary arteries and veins. **AII**, Connections between venous and arterial capillaries inside an opened alveolus. These drawings were made by Malpighi who was an excellent illustrator (*De pulmonibus observationes anatomicae*, 1661). **B**, Microscopic structure of the frog lungs. **BI**, Appearance of the lung, composed by many lobules. **BII**, Appearance of the alveoli. **BIII**, The structure of the bronchial system (Malpighi, *De pulmonibus observationes anatomicae*, 1661).

In those days, in England, a group of physicians and natural philosophers under the leadership of John Evelyn and Robert Boyle founded the London Royal Society. The members of the society were members of secret sects like the invisible college or the invisible philosophical society who decided that it was time to come out from the dark.<sup>8</sup> Probably, these efforts were supported by King James II.

The London Royal Society named Malpighi as honorary member and published all his work. In a short time, Malpighi and his discoveries were well known all over.

**Malpighi: a Gentleman**

Despite his success and public recognition, Malpighi did not take revenge toward the many colleagues who had criticized him. Today, the Hospital of the University of Bologna—one of the leading medical centers in Italy—is named Ospedale Sant’Orsola-Malpighi.

In classic Italian anatomy, >50 structures are named after Malpighi.

**Disclosures**

None.

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