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## Two hundred years of the *Anatomia universa* of Paolo Mascagni (1755-1815): a milestone in the history of medicine and an innovative and modern approach to medical education

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**Abstract.** Two hundred years ago, the first of the nine volumes of Paolo Mascagni's *Anatomia universa* was published posthumously. This work was the fruit of a project that had occupied Mascagni for most of his life: an Atlas of anatomy that was the perfect replica on paper of dissection, a fundamental part of the teaching of this discipline. Through a short journey that traces some of the most important passages in the life of the great anatomist, the authors commemorate the *Anatomia universa*, an extraordinary work in the history and teaching of medicine. To do so, they draw on information and recover evocative *Anatomical plates* that are still conserved intact today in the prestigious Museum of Siena. The plates are organized to reveal the body from the superficial muscle layer down to the skeleton, as in the process of dissection. For the first time in the history of anatomy, the plates were life-size. Furthermore, in an original manner, and again for the first time, these plates showed the network of lymphatic vessels that Mascagni had brought to light a few years earlier. The beauty and perfection of these drawings are the result of Mascagni's knowledge and his ability to recruit the most expert artists and engravers of the time. Mascagni's treatises testify to the modernity of his approach to medical education, and his deep conviction that the main objective was to educate young people and to enable them to acquire the most perfect knowledge of the structure of the human body.

**Keywords:** Paolo Mascagni, *Anatomia universa*, history of medicine, medical training, teaching aids, anatomical tables.

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### INTRODUCTION

On 19 October 1815, while at home in Castelletto, near Siena, Paolo Mascagni (1755-1815) was struck by a pernicious fever. He died within a

few days, leaving his final works - *Anatomy for Scholars of Sculpture and Painting*, *Prodrome of Great Anatomy* and *Treatise on Anatomy for Medical Students* - partly complete and partly to be revised and printed. Paolo Mascagni summarized the figure of the scientist of his time, divided between rationalism of the Age of Enlightenment, development of scientific knowledge and the importance of agriculture, hopes in the new systems of government. All inserted in an era of revolutions and restorations. He was one of the most significant figures of his time so much so as to deserve a statue, commissioned by Ferdinand III of Lorraine, one of the great Tuscans, in Florence in the Uffizi square. He became famous for being the first anatomist to describe the lymphatic system in detail and to be the author of the first 'modern' anatomical atlas, conceived with didactic intent.

#### PAOLO MASCAGNI, "PRINCE OF ANATOMISTS" AND "INVENTOR OF THE LYMPHATIC VESSELS" [1]

Paolo Mascagni was born in Pomarance (Pisa) in 1755 to Aurelio Mascagni and Elisabetta Burrioni, both of whom belonged to ancient Sienese families.

He attended courses in philosophy and medicine at the University of Siena, but his knowledge went well beyond the boundaries of the medical disciplines; he was also particularly interested in *mineralogy, chemistry, and agricultural sciences*, as demonstrated by the numerous books on these subjects in his library.

Mascagni graduated in medicine in 1778 and, in the same year, became the assistant of Professor Pietro Tabarrani (1702-1780), a man particularly dedicated to studying organ pathology, and maintained constant scientific contact with Giovan Battista Morgagni (1682-1771), the "father of modern pathology" [2,3]. On the death of his mentor Pietro Tabarrani, on 4 April 1780, Mascagni was appointed Professor of Anatomy at the University of Siena, on the wishes of the Grand Duke Leopold II.

Even before graduating, Mascagni had started studying the lymphatic vessels on the invitation of Tabarrani. By injecting mercury (*Hydrargyrum*), he succeeded in highlighting the entire lymphatic network, its organization and its functions and alterations. In particular, he conducted his studies on subjects who had died in a state of anasarca (generalized massive edema), which is characterized by the accumulation of liquids in the interstitial spaces of the tissues and in the serous cavities; this enabled him to better visualize the lymphatic vessels, which were dilated as a result of the pathology.

This study was published in 1787 under the title of *Vasorum lymphaticorum historia et ichnographia* [4,5], the first description of the network of the lymphatic system. The text was accompanied by 27 plates drawn by the artist Ciro Santi, 14 counter-plates or linear plates, and the Catalogue of the anatomical preparations carried out in Florence to enrich the Grand Duke's collections.

Thus, Mascagni left aside clinical study and dedicated his entire life exclusively to the study and teaching of anatomy, which he considered a fundamental discipline in medical education. He taught anatomy at the University of Siena until 1800 and, by a decree of 1 January 1801, was appointed Professor of Anatomy at the University of Pisa, with the obligation to hold his lessons on anatomy, physiology and chemistry at Santa Maria Nuova Hospital in Florence, where a medical-surgical school was operative.

Immediately after the publication of the *Vasorum lymphicorum*, Mascagni began to conceive a new and particularly important project: "to exhibit by means of new plates, all the parts of the human body, and to present them precisely as they are in nature, with each retaining its proper order and position" [6].

Anatomy cannot be studied without a visual aid, whether it be a dissected body, a specimen, a model or drawing [7,8]. Moreover, the key phase of its teaching is dissection, which takes the form of a "representation" in a specially built facility, so that many spectators can observe the event. And from the theater - a word derived from the Greek *theàomai*, "I watch" - this facility took its name and purpose, becoming known as the "anatomy theater".

Over the centuries, however, as bodies on which to study were not always available, teaching aids such as anatomical plates were created. It was in this context that Mascagni conceived his *Anatomia Universa*, which virtually reproduced a dissection (9, 10).

His new anatomical Atlas was intended to describe the entire structure of the human body and became an innovative teaching aid for medical students when they could not practice directly on a corpse.

Mascagni represents the medical entourage of his time, which profoundly influenced the future of the scientific world, and which implemented the fusion between the theoretical teaching of medicine and practical activity. Mascagni defines the modern professor of medicine: far from both the physicist-philosopher and the empirical-practical of the past, he is a teacher deeply trained in biological disciplines, also made of physiology, pathological anatomy, and clinical, as evidenced by the multidisciplinary richness of Mascagni's treatises.



**Figure 1.** 19<sup>th</sup> century portrait of Paolo Mascagni: drawing by Roberto Focosi, engraving by Luigi Rados (Accademia dei Fisiocritici – Siena).

#### THE POSTHUMOUS WORKS OF PAOLO MASCAGNI

In 1815, at only 60 years of age, Mascagni suddenly died. This was also the beginning of the extremely controversial period in which his works were published. The climax came exactly 200 years ago, when, in 1823, the first volume of the *Anatomia Universa* was published. But the pathway to publication of his greatest work was far from smooth.

At the time of Mascagni's death, his *Anatomy for Scholars of Sculpture and Painting* [11] was almost ready for printing, and in 1816, just a year later, was published by his heirs – his brother Bernardino and his nephew Aurelio – who bore the costs.

The scientific aspects were handled by Mascagni's last dissector, Francesco Antommarchi (1780-1838), who in 1819 became Napoleon's personal doctor during his exile on Saint Helena. The text was accompanied by 15 plates featuring human figures posing, as if during a real-life drawing lesson, as the work was intended for the teaching of anatomy in art institutes.

In 1819, a limited company, established by Mascagni's family for the purpose of publishing his works, published the *Prodrome of Great Anatomy* [12] in a very rich folio edition.

- The first volume consisted of the following chapters: *Lymphatic vessels; Blood vessels; Nerves; Muscles; Ligaments and cartilages; Bones; Lung; Liver; Alimentary tracts.*
- The second volume comprised 20 plates, drawn and engraved by Antonio Serantoni (1780-1837), featuring images obtained from microscopic observation and particularly detailed macroscopic images.

More than an introduction to the main work, which had not yet been published, it was a text on anatomy and histology, and contained several references to physiology and pathological anatomy, the latter being an acknowledgment of the training received from Pietro Tabarrani. In this case, too, the scientific aspects were handled by Francesco Antommarchi.

Regarding the *Prodrome of Great Anatomy* [12] the innovative nature of Mascagni's work is noteworthy – as also explained in the five pages of the “Publisher's Preface”. Indeed, Mascagni represented the human body by starting from the superficial layer and not from the skeleton, as was normally the case at the time, indicating that anatomical works should represent a sort of dissection on paper.

In this respect, Mascagni distinguished himself from previous anatomists, who had adopted the approach prescribed by Leon Battista Alberti (1404-1472) in his *De Pictura*: “just as we dress a man, we first draw him naked, then we clothe him; thus, to paint the nude, we first place his bones and muscles, which we then cover with his flesh, so that it is not difficult to understand where each muscle is underneath” [13].

Two years later, in 1821, a second edition of the *Prodrome of Great Anatomy* [12] was published, again in two volumes, but this time in octavo format. Scientific editing was entrusted to Tommaso Farnese.

That the relationship between the Mascagni's family and Francesco Antommarchi had soured is demonstrated by what Farnese wrote at the beginning of the new edition of the *Prodrome* in his dedication to Professor Andrea Vaccà-Berlinghieri (1772-1826), a friend and great admirer of Mascagni: “I prepared to illustrate and publish the deceased author's genuine text of the *Prodrome*, purged of the excessively free variations made by a compiler”.

Early in 1822, Antommarchi obtained a court order to dissolve the limited company and disappeared. Mascagni's family sold his manuscripts, drawings and copper engravings to three professors of the University of Pisa – the above-mentioned Andrea Vaccà-Berlinghieri, Giacomo Barzellotti (1768-1839) and Giovanni Rosini (1776-1855) – so that the *Great Anatomy*, on which the Sienese anatomist had worked for decades, could be published. Translated into Latin, it was entitled *Anatomia*

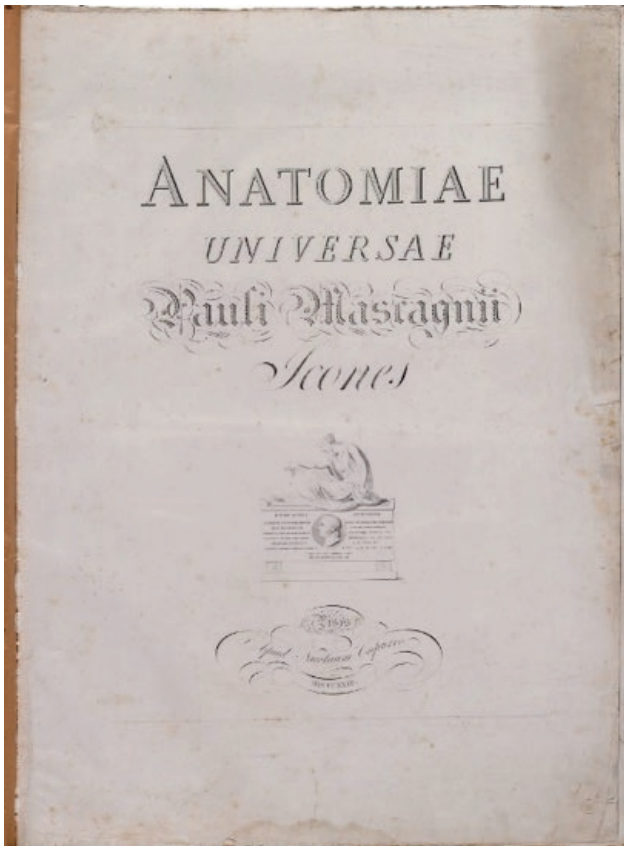
*universa* and published in nine volumes, issued one per year from 1823 to 1831.

Meanwhile, Francesco Antommarchi plagiarized Mascagni's work. When he moved to Saint Helena to join Napoleon, he took with him the notes and writings prepared by Mascagni for the great atlas and some print drafts of the anatomical plates.

Between 1823 and 1826, in Paris, he published this material, which he had revised, "passing off these works as his own" [15] and "having some plates engraved in lithography by using the proofs from the copper engravings" [10]. The ensuing situation was very complicated, but in the end, Paolo Mascagni was recognized as the true author of the work.

#### THE ANATOMIA UNIVERSA

Dedicated to Grand Duke Leopold II, this work consisted of a part of text in small folio, the *Anatomia universa*, and a 44-plate atlas, the *Anatomiae universae Pauli Mascagnii icones* (Fig. 2), in the maximum folio format.



**Figure 2.** Paolo Mascagni, *Anatomiae Universae Pauli Mascagnii icones*, 1823-1832.

The plates of the *Anatomia universa* were prepared by means of etching. A copper matrix was covered with black wax, on which the image to be printed was drawn. The matrix was then incised so as to leave the copper exposed in correspondence with the drawing. Subsequently, a mixture of nitric acid and water was poured over the matrix to corrode the parts that had been stripped of wax.

The principle of this technique is based on the protective power of black wax and the corrosive power of nitric acid. Once cleaned, the plate was ready for printing like a normal intaglio. Successive passages over the same matrix allowed further inking with different colors; for this reason, etching was better suited to color printing than burin engraving [16]. Thanks to this technique, as well as to the skill of the artists and engravers, Mascagni's plates are not only extraordinary in their precision and richness of detail, but they are also beautiful.

Mascagni's cenotaph is shown on the frontispiece of the work (Fig. 3); sculpted by Stefano Ricci, the cenotaph is preserved in Siena, at the Accademia dei Fisiocritici, where the University has deposited Mascagni's archival and book heritage and some of the preparations made for his first work, *Vasorum lymphaticorum historia et ichnographia*.



**Figure 3.** Marble cenotaph to Paolo Mascagni, with the personification of Anatomy mourning the loss of her teacher (photograph, Davide Orsini).

The originality of the *Anatomia universa* and its importance in the field of medical training stem from Mascagni's completely new vision of the tools that could enhance students' understanding of anatomy even in the absence of dissection, which at that time was fundamental and indispensable.



**Figure 4.** Paolo Mascagni, *Anatomia Universa*, *stratum primum*, *facie adversa* (Sistema Museale Universitario Senese).

In his work, Mascagni depicts the human body as seen frontally (*facie adversa*) and from the back (*facie aversa*), as on the dissecting table. Twenty-four plates (102 cm length, 75 cm width) are designed in such a way that, when arranged 3 to 3 vertically, they show life-size human bodies: an absolute novelty in the field of anatomical publishing (Fig. 4).

The human body is represented according to stratigraphical criteria, “*per diversa strata a cute ad sceletum*” (“through different layers, from the skin to the skeleton”): the first layer (“*stratum primum*”) illustrates the human figure deprived of skin and shows superficial muscles, nerves and vessels; the second layer (“*stratum secundum*”) depicts muscles, nerves and deep vessels, while the third (“*stratum tertium*”) reveals muscles, arteries and veins of the deeper layer down to the skeleton (“*stratum quartum*”).

These representations of the human body are followed by 20 plates illustrating viscera and various other organs, again in life size (Fig. 5).



**Figure 5.** Paolo Mascagni, *Anatomia Universa*, *Viscera*, *tabula I* (Sistema Museale Universitario Senese).

Mascagni's tables are absolutely perfect, as every detail was meticulously verified by the anatomist himself through hundreds of dissections; moreover, they were created by very talented artists and engravers: Ciro Santi in the case of *Vasorum lymphaticorum historia et ichnographia* and Agostino Costa and Antonio Serantoni for the *Anatomia Universa*.

Mascagni was meticulously attentive to the quality of the plates for his great *Atlas of anatomy* and determined to safeguard their beauty. Therefore, in addition to the 44 principal plates, he also commissioned 44 counter-plates showing only the outlines of the figures and the letters and numbers that refer to the captions. Thus, he was able to avoid spoiling the beauty and readability of the images in any way.

Mascagni's two anatomical atlases therefore mark the culmination of his life and professional work. In particular, the *Anatomia universa*, on which he worked for about 30 years, is extraordinary on account of its depiction - and this was the first time in history - of the lymphatic system. In it, his greatness as a scholar and as a teacher of anatomy is evident.

#### CONCLUSIONS

The publication of the *Anatomia universa* two centuries ago was a veritable milestone in the history of medicine and in the teaching of anatomy.

Paolo Mascagni's contribution to the teaching of anatomy is still considered fundamental today, thanks to his skill in evaluating and synthesizing the anatomical knowledge of the past and of his own era through the constant and meticulous practice of dissection. His great ability to conceive and create essential teaching aids to the study of the human body also stemmed from his ability to combine art and science.

The medical science of the eighteenth century and then even more of the nineteenth century is renewed, relying increasingly on an Anatomy that was direct analysis of the body through systematic anatomical investigations on the corpse, explaining the essence of the disease and no longer the only symptom. The new anatomical science supports clinical reasoning, making use of the contributions of other disciplines designed to constitute the modern teaching programs of the medical faculties, establishing a close link between the university and the hospital.

More than two centuries after his death, Mascagni is remembered not only for his fundamental work in the anatomical field, but also for his innovative teaching method and the outstanding quality of the tools that he created for the teaching and study of anatomy. Convinced

of the indispensable role of dissection and the direct observation of bodies in the study of medicine, Mascagni demonstrated this concept through the mediation of the anatomical plates of his *Anatomia universa*, which are as perfect as they are innovative in their 1:1 ratio.

Thus, Paolo Mascagni's *Anatomia universa* remains a truly unique work in the history of medicine, a perennial testimony to his extraordinary determination to contribute to the formation of a new medical class, in line with his unshakeable conviction that his main objective was to educate young people and to ensure that they acquired the most perfect knowledge of the structure of the human body.

#### NOTES ON CONTRIBUTORS

Davide Orsini: Conceptualization (equal); writing – original draft (equal); review and editing (equal). Maria-no Martini: Conceptualization (equal); writing – original draft (equal); review and editing (equal). Daniele Saverino: Conceptualization (supporting); review and editing (equal). Anna Siri: Conceptualization (supporting); review and editing (equal).

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