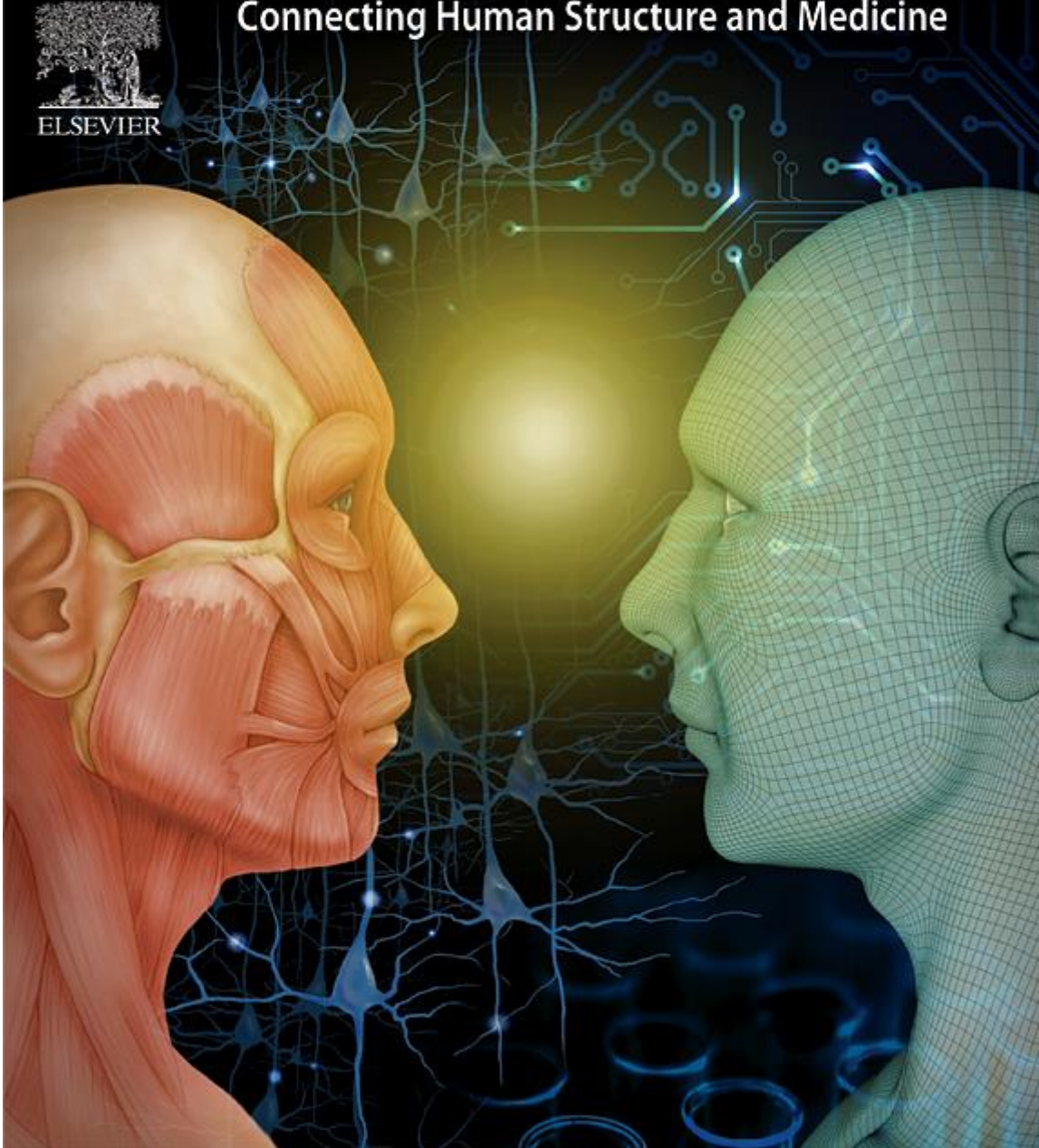


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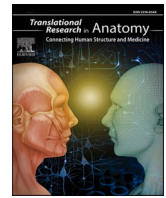
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Review

The Anatomia Universa (1823) of Paolo Mascagni (1755–1815): The memory of a masterpiece in the history of anatomy after two centuries

Davide Orsini^a, Daniele Saverino^{b,*}, Mariano Martini^{c,d}

^a University Museum System of Siena (SIMUS), History of Medicine, University of Siena, Italy

^b Department of Experimental Medicine, University of Genoa, Policlinico San Martino, Genoa, Italy

^c Department of Health Sciences, University of Genoa, Italy

^d UNESCO Chair “Anthropology of Health – Biosphere and Healing System, University of Genoa, Italy

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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 preoccupied Mascagni for most of his life: the Atlas of anatomy, which was the perfect replica on paper of the dissection, a fundamental part of the teaching of this discipline.

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.

1. Introduction

The human body has been an object of interest to scientists and a source of inspiration for artists for centuries [1].

Exactly two hundred years ago, in 1823, the first fascicle of the *Anatomia universa* was printed: the great atlas that Paolo Mascagni (1755–1815) had conceived and created to show medical students the human body in its entirety and complexity (Fig. 1). The fascicle was published after a long legal dispute between Mascagni’s heirs and Francesco Antommarchi, a dissector who had worked for the great anatomist and who subsequently plagiarized his work.

(Fig. 1)

Dedicated to Grand Duke Leopold II, this work consists of a part of text in small folio, the *Anatomia universa*, and a 44-plate atlas, the *Anatomiae universae Pauli Mascagnii icones*, in maximum folio format [2, 3].

Mascagni devoted his whole life to the study and teaching of anatomy.

If Berengario da Carpi (1466–1530), lector of anatomy at the University of Bologna, at the beginning of the sixteenth century had defined anatomy “alphabetum medicorum” [4], Mascagni considered it a fundamental teaching in *Medical Education*.

Immediately after the publication of his *Vasorum lymphaticorum*

historia et ichnographia in 1787 [5,6], he began to conceive his project for a new anatomical atlas that would represent the human body in life-size for the first time and also show the lymphatic system. The objective was to create an innovative teaching aid for medical students when they did not have the opportunity to practice directly on a corpse; this was the inception of the *Grande anatomia*, which will be published posthumously with the Latin title *Anatomia universa*, which virtually reproduces a dissection [2,7]. With this intent, the *Anatomia universa* was born.

In the Preface to this work, the great anatomist stated that in the field of studies on the human body, there are two possible methods of investigation. The first lies in the verbal description of the individual parts of the body, while the second, using images and representations, places the very organic and complete form of the human figure before the eyes that are not deceived. The latter is – according to Mascagni – the best way to anatomical knowledge.

In fact, his anatomical tables are the result of the observations that he obtains from continuous dissections that he carries out for his research and for educational purposes on a large number of cadavers.

Dissection is to be considered the anatomy lesson par excellence, at least since the beginning of the fourteenth century when it became fundamental in the new system of training and transmission of knowledge that was establishing itself following the birth of universities.

The plates, most of which were signed by the designer and engraver

* Corresponding author. DI.Me.S, University of Genoa, Via De Toni, 14 16132, Genoa, Italy.

E-mail address: Daniele.saverino@unige.it (D. Saverino).

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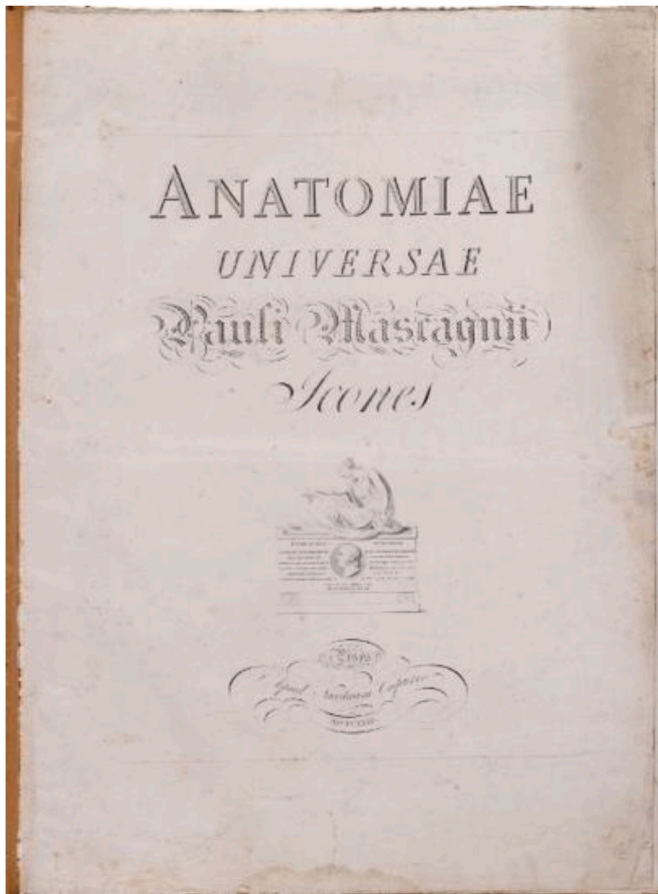


Fig. 1. Paolo Mascagni, *Anatomiae Universae Pauli Mascagnii icones*, 1823–1832.

Antonio Serantoni, are in black, but the work was also published with hand-watercolored plates (Fig. 2). The first 24 plates are designed in such a way that, when arranged vertically in threes, they depict life-size human bodies seen from the front and back, for a total of 8 complete figures.

In an absolutely innovative way for the time, the body is represented according to a stratigraphic criterion, from the subfacial muscular plane (*stratum primum*) to the intermediate plane (*stratum secundum*) and the deep muscular plane (*stratum tertium*), down to the skeleton.

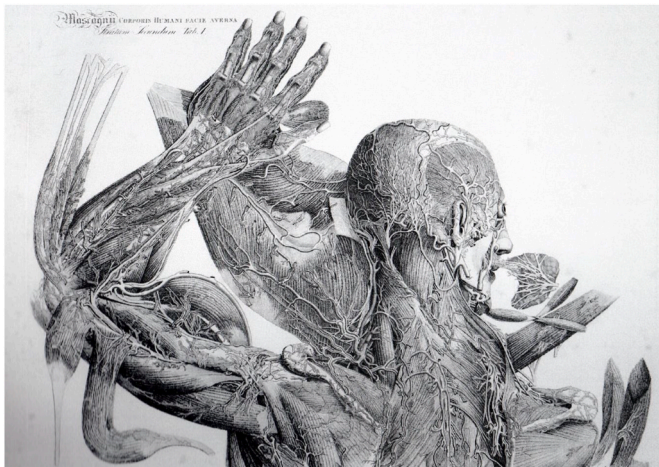


Fig. 2. Paolo Mascagni, *Anatomia Universa, stratum primum, facie adversa* (Sistema Museale Universitario Senese).

The remaining 20 plates represent the organs and other details of the internal structure, again in life-size, that the full figure could not illustrate.

Paradoxically, while Mascagni sought to demonstrate the fundamental role of the direct observation of bodies in the study of medicine, he achieved this objective through the mediation of the anatomical plates of his *Anatomia universa*.

Paolo Mascagni made a fundamental contribution to the teaching of anatomy, thanks not only to his propensity to synthesize both past and contemporary knowledge, but also to his ability to combine art and science. The *Anatomia universa* is a perennial testimony to his ability and his determination to contribute to the formation of a new medical class.

For this reason, upon his death, the Siene nobleman Giulio del Taia commissioned the artist Stefano Ricci to create a marble cenotaph for Mascagni, which is now housed at the Accademia dei Fisiocritici in Siena. His greatness in anatomical studies is testified in his cenotaph by the personification of Anatomy mourning the loss of his master [8].

2. Biography

Mascagni was born in Pomarance (Pisa) on 25 January 1755. His residence for study and work was in Siena until 1800, then in Pisa for a few months and finally in Florence. He died in Castelletto in the town of Chiusdino (Siena) on 19 October 1815 [2,9,10].

Mascagni is universally remembered as “principe degli Anatomici” (the Prince of the Anatomists) for his fundamental work in the study of Anatomy. At the same time, he was a personage of multifold and deep interests in various fields of knowledge.

From his early youth he manifested curiosity and interest in the sciences. In the course of medicine undertaken by Mascagni at the University of Siena there were also the teachings of natural history, chemistry and botany taught since 1759 by the Giuseppe Baldassarri, author of several essays on fossils and mineral waters. Baldassarri’s teachings instilled in the young student a love of research and certainly influenced his future studies. In fact the first scientific studies of Mascagni concerned the territory of the Metalliferous Hills in which he was born and where he had spent his adolescence (1779) [11]. Afterwards, although the fundamental theme of his research concerned medicine, to which he dedicated the winter months reserving others to observations on the territory, agriculture and chemistry, published in the last years of the eighteenth century the results of the analyses carried out to verify the presence of boric acid in water, in earth and in steam, determining its values, with a view to industrial exploitation [12].

These many interests are evidenced by his rich library, now preserved at the Academy of Sciences of Siena, which consists of 1108 volumes. Of these, 227 concern Medicine and 201 Anatomy [13], published between the 16th and 19th centuries. But there are also many publications related to Philosophy and Humanities, Natural Sciences, Chemistry and Agriculture.

Graduated in medicine in 1778 at the University of Siena, in the same year Mascagni became a reader of his teacher Pietro Tabarrani, passionate investigator of Normal and Pathological Human Anatomy, author of *Observationes anatomicae* (1753), who had been in turn a pupil of Giovanni Battista Morgagni ‘the father of modern anatomical pathology’ [14]. Upon Tabarrani’s death in 1779, he became an ordinary lecturer. On April 4, 1780, Mascagni was appointed, with motu proprio by Grand Duke Pietro Leopoldo professor of Anatomy at the University of Siena.

He was elected a corresponding member of the Royal Swedish Academy of Sciences in 1796, and president of the Academy of Sciences of Siena, called Accademia dei Fisiocritici, in 1798.

Appointed professor of Anatomy in the Pisan Studio by Grand Ducal decree of 1st January. 1801, however, he was called to give Anatomy, physiology and chemistry lessons in Florence, where a medical-surgical school was active.

Even before graduating, under the guidance of Tabarrani, he began

studies on lymphatic vessels highlighted by injections of mercury, describing their path, organization, functions and alterations. In 1784 he published *Prodrome d'une ouvrage sur le système des vaisseaux lymphatiques* [15], with which he participated in a competition organized by the French Academy. In 1787 the complete work was published under the title of *Vasorum lymphaticorum historia et ichnographia*, accompanied by a thorough examination of the present literature and 27 folio tables based on microscopic observations and 14 countertables with the contours of the figures and all the references necessary for the description [5].

In 1795 Mascagni published again the *Vasorum lymphaticorum historia seu totius operis pars prima* had a widespread diffusion, much more than folio [16]. Even more successful were the two editions translated into Italian, one in 1816 the other in 1820, of his pupil Giovanni Battista Bellini, published after the death of Mascagni [17,18].

After completing studies on the lymphatic system, Mascagni began to conceive a huge work, the 'Great Anatomy' (*Grande anatomia*) to describe the whole structure of the human body, accompanied by life-size tables and countertables with numbers referring to the explanations as in its previous publication, to make it a complete teaching aid for medical students and for all those who did not have the opportunity to practice on corpses. The work was partly realized in Siena (until 1799), then in Florence at the Arcispedale di Santa Maria Nuova [2,9,10].

In the Arcispedale there was a real school, where the graduates of Siena and Pisa had to take courses for two years to obtain the qualification to practice the profession.

Most of the drafting of the 'Great Anatomy', already begun during his stay in Siena, took place in Florence. "The preparation was long: every part of the human body was observed in different ways to have the certainty that it was not pathological anomalies, repeated many times injections with colored substances to know the course of veins and arteries, after reading in the publications of valuable anatomical theories on blood vessels in contradiction with his observations. To have the certainty of his investigations prepared a multitude of preparations that he kept drying in the Holy Field of the Arcispedale and also in his home in Florence. Mascagni did not only deal with Macroscopic Anatomy, but put sections of organs and apparatus under microscopic observation with the best equipment available at the time" [19].

During the Florentine period he was assisted by the draughtsman and painter Antonio Serantoni, who worked alongside Mascagni drawing his preparations, carving them in copper and then obtaining the printing with aqua fortis and, when necessary, coloring them by hand. Even the drawings made during the Siennese period were re-edited by this painter. Another important figure for the preparation of anatomical findings was the dissector. Upon his arrival in Florence Mascagni obtained that this figure be restored, abolished in 1793: Francesco Antommarchi (1780–1838) was one of the sectors that worked with Mascagni from 1812. Originally from Corsica, he proved to be unfaithful to the great anatomist after his death [20–22].

On October 1815, while he was at his home in Castelletto near Chiusdino, he was struck by 'pernicious fever' and in a few days he died, leaving the *Anatomia pittorica* and many tables of the *Grande anatomia* already printed or ready for printing and numerous manuscripts to be reordered. The heirs wanted these works, to which Mascagni had dedicated thirty years of his life, to be published. The first work to be published in 1816 was the *Anatomia per uso degli studiosi di scultura e pittura* [23]. Subsequently, the *Prodromo della Grande anatomia* was published in two different editions and finally between 1823 and 1831 the *Anatomia universa*.

3. The long and complex story of the publication of the *Anatomia Universa*

For almost two decades Mascagni worked on the project of the *Anatomia Universa* and that of the *Atalante* for art scholars. Sadly, due to his sudden death in 1815, these two works were published

posthumously. The *Anatomy* for the use of sculpture and painting studies in 1816 and the *Anatomia Universa* between 1823 and 1831, in 9 fascicles.

The two anatomical atlases represent the crowning achievement of Mascagni's life and professional career. In these works, Mascagni's greatness as a scholar and as a teacher of anatomy is evident; and his innovations in the study of anatomical sciences are universally recognized.

The *Anatomia Universa* came to be published after a long legal dispute between Mascagni's heirs and Francesco Antommarchi, Mascagni's dissector, who became the protagonist of the plagiarism of his main work.

Mascagni and Antommarchi met at the Arcispedale di Santa Maria Nuova in Florence. Mascagni had moved to Florence in order to "work in a vast arcispedale, [with] a large number of sick ... to better succeed in anatomical work" [22] and, therefore, with more corpses available.

With the *Grande anatomia*, Mascagni wanted his future treatise to serve the study of Anatomy even to those who did not have corpses. In fact, it was conceived with life-size tables and countertables with numbers that referred to explanations. Finally, Mascagni wanted to produce an editorial product that was scientifically valid and of great educational help.

The studies and preparation of the tables of the *Grande anatomia* had already begun during his stay in Siena but undoubtedly most of the writing took place in Florence.

Mascagni had to perform a very large number of dissections and prepare an infinite number of preparations to have the security of his inquiries [20,22].

Mascagni's sudden death interrupted his two major projects, leaving the 'Pictorial Anatomy' almost ready for printing and many manuscripts for the *Anatomia Universa*.

Moreover, almost all the tables and many countertables with explanations for the *Grande anatomia* [24] were already done. The heirs, knowing its importance, wanted these works, for the preparation of which Mascagni had committed at least thirty years of his life, to be published.

If the *Anatomia per uso deli studiosi di scultura e pittura* (*Atlanet for the use of scholars of sculpture and painting*) was published in 1816, the path that led to the publication of the *Anatomia Universa* was more complex.

In 1819, under the scientific direction of Francesco Antommarchi, a work was published in two volumes, one of text, the other with figures and their explanations: the *Prodromo della Grande anatomia* [25], actually more than an introduction is a real text of Anatomy and Histology, with many references to Physiology, Pathological Anatomy, and even therapy. It was published in a luxurious edition in folio. Relevant are the 5 pages of the *Preface of the Publisher*. First of all, it is emphasized that in Mascagni's work we start from the outside of the human body and not from the skeleton as it was normally done; we talk about the preparations of the parts of the human body before being drawn "for the knowledge not only of Anatomy, but also of the Physiological and Pathological Sciences".

The sales of the *Prodromo* curated by Antommarchi did not go well and the hopes of the Mascagni heirs to be able to print, with the proceeds from the sale of this work, the large anatomical tables were thwarted [26].

Antommarchi proposed to pay the Mascagni heirs, instead of the agreed 6,500 francs, with the *Prodromo* texts remaining unsold. Negotiations went ahead, but the family did not accept his proposed [26].

At this point (1822) the Mascagni's heirs sold texts, drawings and branches in their possession to 3 professors of Pisa - Andrea Vaccà Berlinghieri (1772–1826), Giacomo Barzellotti (1768–1839) e Giovanni Rosini (1776–1855) – so that they could publish the *Grande Anatomia*. Translated into Latin, it was published under the title of *Anatomia universa* [7]. As soon as the news of the sale arrived, Antommarchi tried to buy back all the material, without success.

On March 1, 1823, the three Pisan professors made public - as was

customary at the time - the detailed plan of the work, the modalities of publication in nine issues, with publication one per year, the list of Italian and foreign bookshops where samples of illustrations and conditions of sale would be deposited. They also reported the material in their possession and what had to be prepared: “they remain therefore to engrave six tables of the skeletons; three of the bowels, various special figures and the most part of the countertables” [19]. They informed that they had enriched the work with five special tables made with the details of the muscles drawn in the empty spaces between the legs and arms of the large figures and that the skeletons would be of the same size as these “with ligaments and with injected vessels». The explanations of the illustrations, which were not present in the material received by the family because they were in the hands of Antommarchi, were written with the collaboration of colleagues and fellow students of the same Mascagni” [19].

The first issue was published in June 1823 and the last in 1832.

The work, dedicated to Grand Duke Leopold II, consists of a small folio text part *Anatomia universa* and an atlas *Anatomiae universae Pauli Mascagnii icones*, in folio maximum (mm 1030x690), consisting of 44 tables; each table is accompanied by a copy (countertable) only traced with references to identify the anatomical parts in the joined volume of explanations. The tables are in black but the work was also published in a few copies with color tables finished by hand (much more expensive), with a degree of clarity and detail not present other [20–22,27].

Mascagni’s great originality in medical pedagogy is given by a completely new vision of the tools useful for a greater understanding of anatomy by students, even in the absence of dissection, which at the time was fundamental and irreplaceable.

The tables of the *Anatomia Universa* represent one of the most interesting motifs compared to previous anatomy texts.

In his work, Mascagni presents the human body, reproduced frontally (*facie adversa*) and posteriorly (*facie aversa*), as on a dissecting table. Twenty-four planks – each 102 cm long and 75 cm wide – are designed in such a way that, arranged 3 by 3 vertically, they form life-size human bodies, presented in front and rear position.

Anatomical formations are represented by stratigraphic criteria starting from the sub-fascial muscular plane (*stratum primum*) to the intermediate one (*stratum secundum*) up to the deep muscular plane (*stratum tertium*) and finally to the skeleton [28].

The first layer illustrates the skinned human figure (i.e. deprived of the skin) and shows superficial muscles, nerves and vessels; the second layer depicts muscles, nerves and deep vessels; while the third muscles, arteries and veins of the deeper layer until the fourth outlining the skeleton.

In the color plates, on a flesh-colored background, is given depth with darker lines and further illuminated with brush strokes; in the skeleton are drawn ligaments and tendons, beyond the blood vessels, lymphatics and nerves as in all other figures. In the other 20 plates are represented, always life-size, the organs and other details of the internal structure that the whole figure had not allowed to draw, often performed in different projections and in different stages of preparation.

This work, on which Mascagni worked for approximately thirty years, therefore appears extraordinary for the depiction - and it is the first time in history - of the lymphatic system in the tables, created at human scale. Consequently, Mascagni is remembered for his fundamental actions in the anatomical field but also for his specific teaching methods and high quality materials for the teaching and study of Anatomy.

Antommarchi did not give up and in the same year unced the publication of “his” *Grande anatomia* [29]. The illustrations consist of twenty-four tables arranged in three to three, as in *Anatomia universa* by Paolo Mascagni, representing the full-scale human body. In other sixteen tables are represented the bowels. All are accompanied by contraboards with indications in latin and numbers and letters that refer to explanations.

This publication was made possible by the fact that Antommarchi

had brought with him, first to Rome, then to St. Helena where he was Napoleon’s physician and finally to Paris, 34 plates already printed by Mascagni for the *Great Anatomy* and some of his writings.

Comparing the plates of the two works - Mascagni’s *Anatomia universa* and Antommarchi’s work - however, there are clear differences. The plates of the *Anatomia universa*, made with the etching technique, are lighter and have less marked nuances. Those of Antommarchi’s work, on the other hand, made with the new technique of lithography, have more marked lines that sometimes form a dark mass that makes the image almost unreadable.

In addition, Antommarchi lacked the tables of the skeletons that were then made from scratch. Antommarchi probably reproduced in greater proportions the skeletons made by Serantoni for use by scholars of sculpture and painting. The skeletons of the plagiarized work have much less detail than those of the *Anatomia universa*, resembling the skeletons of the *Anatomia per uso degli studiosi di scultura e pittura*. In conclusion, the lithographed tables of the publication of the Antommarchi are not at all up to the standards of those accompanying the *Anatomia universa* (Fig. 3, and Fig. 4).

4. Innovation and inheritance of Mascagni’s treatises

The man in the tables of Mascagni is a living machine body, a device, a mechanism to be explored and made recognizable in the trait which is on the septal table: this is the reason why the anatomist of the period also needed the knowledge of mathematics, physics and geometry. The bodies are no longer portrayed in splendid gardens or scenic spaces, even if the skeleton is represented in graceful positions. Mascagni in creating his tables is completely different from the examples, although aesthetically very beautiful, of some of the authors of the past: skeletons that cry, pray leaning on the sickle symbol of death, fix an hourglass in the hand as in Gaspard Bauhin’s *Theatrum Anatomicum* (1605) [30]; the ‘scorticati’ inserted by Bernhard Siegfried Weiss, better known as Albinus, in his *Tabulae sceleti et musculorum corporis humani* in gardens with classical statues and ruins including even an exotic rhinoceros (1736) [31]; the assemblages of skeletons presented by Frederik Ruysch in the *Thesaurus anatomicus* (1737-38) [32]; the skeletal figures that rise with pride and mastery of space in the seventeenth-century blood tables by Pietro Berrettini da Cortona, published in 1788 by Francesco Petraglia [33] (see Fig. 4). Unlike these examples, in which the skin and skeletons seem to survive medical investigation, assuming expressions and poses as actors, almost in the awareness of rendering a useful service to science, in Mascagni’s table the body is taken up and made ‘alive’ by the wise and very particular trait of the designer, attentive to the anatomical exercise from life.

Dissection becomes the art of knowledge and compulsory learning for the young student who, in the absence of practical practice, can always make use of the study on truthful tables, perfect replacements of dissection, instrument which, however, is considered irreplaceable for experimental research. Not least Mascagni, with the help of simple lenses and portable microscopes, managed to combine macro to micro observation with slide preparations that allowed to expand the knowledge of tissues, in the new field of microscopic anatomy or histology. Experimental dissection and microscope reading become the indispensable tools for research. From this moment next to the macroscopic Anatomy is flanked by the microscopic one, which then will lead to Histology.

Mascagni was also to the anomalies found in the autopsies, confirming the hypothesis that Vesalian corpse could not only learn the anatomical structure of the healthy subject, but also that of the patient, thus highlighting the outcomes of his pathology.

Finally, Mascagni makes a careful study of the correlation between pathology, organ damage and consequent infirmity. The disease began to be thought in «anatomical key»: symptom, pathology, injury, in an innovative methodological *consecutio* of which Mascagni is artefice: the modern anatomical-clinical notion of the disease, based on the

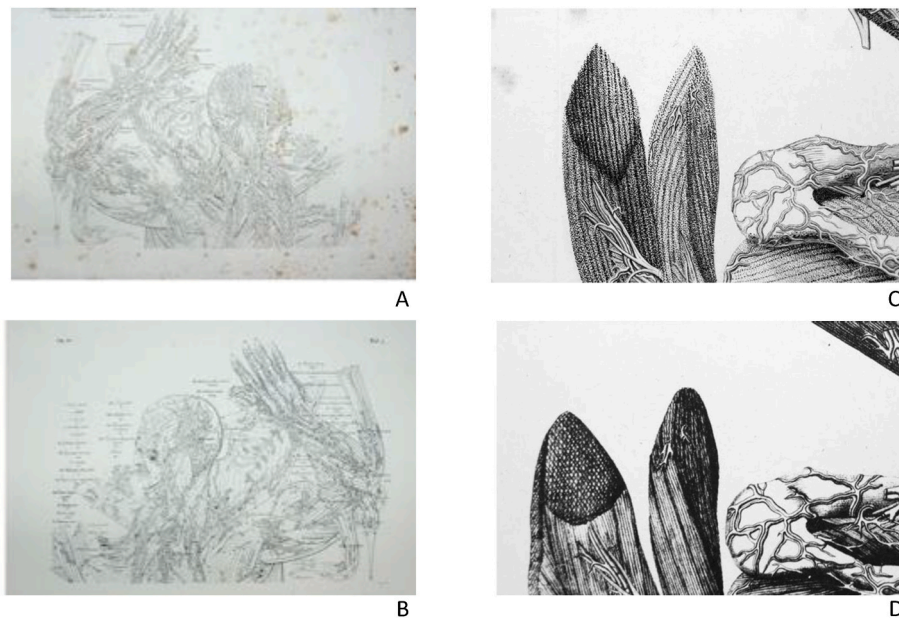


Fig. 3. The lithographed tables of the publication of the Antommarchi are not at all equal to those that accompany the *Anatomia universa*.
 Panel A. Paolo Mascagni, *Anatomia universa*, Corporis humani facie aversa, stratum secundum, tav. I, aqua fortis.
 Panel B. Francesco Antommarchi, *Planches anatomique du corps humain*, tav. X, fig. IV, countertable, lithography.
 Panel C. Paolo Mascagni, *Anatomia universa*, Corporis humani facie aversa, stratum secundum, tav. I, detail, aqua fortis.
 Panel D. Francesco Antommarchi, *Planches anatomique du corps humain*, detail, lithography.



Fig. 4. - Mascagni's representation of the human body is unique in its time: a comparison with other anatomical atlases of the time.
 Panel A. Gaspard Bauhin, *Theatrum Anatomicum*, Francofurti at Moenum, typis Matthaei Beckeri, 1605 [30].
 Panel B. Bernhard Siegfried Albinus (originally Bernhard Siegfried Weiss), *Tabulae sceleti et musculorum corporis humani* (1736) [31].
 Panel C. Frederik Ruysch, *Thesaurus anatomicus* (1737-38) [32].
 Panel D. Berrettini da Cortona, P. *Tabulae Anatomicae*. 1788 [33].

experimental method. Mascagni fits into the medical landscape of his time, that influenced the scientific world. In that period the necessary fusion between the theoretical teaching of medicine and its practical exercise took place, with the consequent definition of the modern professor of medicine, now far from both the physicist-philosopher and the empirical-practical, in favor of a well-trained teacher in the biological disciplines, also made of physiology, pathological anatomy, clinic, as clearly demonstrated by the multidisciplinary richness of Mascagni's treatises. The scaffold of the renewed medical science of the eighteenth century and then even more of the nineteenth century was increasingly resting on an Anatomy that was direct analysis of the body through systematic anatomical investigations on the body, that explained the essence of the disease and not just the symptom. An anatomical science that supported clinical reasoning, also making use of the contributions of other disciplines intended all to constitute the modern teaching programs of the medical faculties, in a close link between the university and hospital.

Today, 200 years after its publication, Mascagni's work continues to display the modernity of its approach to the teaching of anatomy. On the other hand, the role of virtual dissection in the teaching of anatomy (i.e. Anatomage and Z space) in medical schools becomes increasingly important and Mascagni with his *Anatomia universa* could be a precursor [34].

Ethical statement

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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