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Anatomy and anatomists in Tuscany in the 17th century

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Summary

The 17th century was characterized by a real revolution in the field of scientific research due to the introduction of the experimental method, promoted by Galileo Galilei who was the most representative scientist of this period. Therefore, medical disciplines, particularly Anatomy, underwent innovative and deep changes shattering traditional culture and representing the background for the modern science. In this fermenting period, Tuscany played a significant role since numerous distinguished scientists were gathered by Medici Grand Dukes (especially Ferdinando the 2nd and Cosimo the 3rd) at Pisa University and at their court in Florence. Among them, it must be mentioned Giovanni Alfonso Borelli, creator of iathromechanics, Marcello Malpighi, founder of microscopic Anatomy, Francesco Redi, who denied the insect spontaneous generation, Nils Steensen who continued in Florence his anatomical studies on lymph nodes and salivary glands while setting also the bases of modern geology. Moreover, at the end of the 17th century, the anatomical wax modelling techniques arose and developed in Florence thanks to the work of Gaetano Zumbo (or Zummo), capable of creating some real masterpieces, still very well preserved and collected in the Museum of Natural Sciences "La Specola".

Key words

History of anatomy, history of medicine, 17th century, wax modelling, experimental method

In the course of the 16th century the medical disciplines, and particularly Anatomy, which represented and still represents the necessary background to understand and interpret most pathologies, had undergone a prodromic revolution thanks to the masterpiece of Andrea Vesalio (or André Vésale or Andreas van Wesel, Bruxelles 1514 - Zante 1564): "*De humani corporis fabrica libri septem*" published in Basel in 1543. This great Flemish anatomist and physician indeed set the bases for modern science, breaking the strong theoretical conception dating back to Claudio (?) Galeno (Pergamo 129 – Rome 201?), which had ruled along the centuries: he gave, in fact, a detailed and systemic description of the human body utilizing, for the first time, the dissection techniques, based on the direct study and *description* of cadavers, the *evaluation* of the observations and the *comparison* with the classical Author's reports. In such instance, the physician descended his Chair, personally executing the anatomical dissections, the book representing just a tool to describe what the eyes had observed.

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Anatomy therefore became *history,* in its meaning of progressive description, or *fabrica* (manufactory) in the sense of image of the basic structure of the body.

At the beginning of the 17th century, the cultural elites of Italy and Europe were deeply engaged in a continuous struggle between two different conceptions of knowledge, philosophy and science: from one side the "conservation" of a dominant traditional culture linked to the political institutions and defended by the Church, and from the other side the "innovation", that is a liberal, reforming culture, linked to the onset of new scientific methods and criteria, no longer compatible with the dogmatic statements of the past, and projected to a rational idea of the Universe.

The liberal component of the 17th century, whose highest expression was represented by Galileo Galilei (Pisa 1564 – Arcetri, Florence 1642), attained an increasing relevance, thus developing the experimental scientific principles as well as the conception of a quantitative, and not just qualitative, evaluation based on the mathematical analysis of the observed data.

As far as Anatomy was concerned, it appeared clear that this discipline could not accept any intrinsic limitation to its development since "knowledge had to be freely verified until the observations could be experimentally proven" (Mezzogiorno, 1998).

An outstanding exponent of such line can be considered Giovanni Alfonso Borelli (Naples 1608 – Rome 1679). He studied in Neapolitan Medical School as a pupil of the anatomist and surgeon Marco Aurelio Severino (Tarsia 1580 – Naples 1656), author of some non conformist papers, such as Historia Anatomica and Zootomia Democritaea. After this period Borelli lived some years in Rome where he was accepted in the close court of Pope Urbano VIII together with his mentor, the renowned Dominican philosopher Tommaso Campanella (Stilo 1568 – Paris 1639). In Rome he perfected his formation under the guide of the mathematician Galileo's pupil Benedetto (Antonio) Castelli (Brescia 1577 – Rome 1644), remaining fascinated by the new experimental approach to scientific research.

In 1635 he accepted the chair of Mathematics at the University of Messina, a small but very active city which was experiencing an extraordinary period of economic welfare, without any influence of "Barons" and "High Clergy" (Mezzogiorno, 1991). During his stay in Messina, Borelli proposed a pathogenic explanation of fevers, which represented an abrupt deny of the Galenic humour theory and fixed the principles of the epidemic nature of contagion. His work "Delle cagioni delle febbri maligne" (About the reasons of malignant fevers) appeared as the first medical manifesto of Galilei's theories setting also the bases for future infectivology. Called by the University of Pisa to the chair of Mathematics, under the auspices of Ferdinando the 2nd Grand Duke of Tuscany, he founded in 1657, together with the man of letters Lorenzo Magalotti (Roma 1637 – Florence 1712), the "Accademia del Cimento" (Academy of experiencing), a real melting pot for the liberal conception. In this period he tried to apply to biology the geometric-mathematical method, that Galilei used for mechanics. And indeed Borelli described a mechanical concept of living nature, thus transforming medicine in "iathromechanics", i.e. iathrophysics and iathromathematics, reporting all his knowledge in the work "De motu animalium" (About the movement of animals). He compared the human body to a machine, composed of several levers, in the firm belief that God should have created the whole world based on geometrical principles: since the movements of humans represent the real object of mathematics, they can be understood in terms of levers, pulleys, spirals a.s.o.,

calculating the forces exerted by muscles with varying resistance (Lippi and D'Este, 1991). Thanks to the identification of their behaviour, he divided muscles in agonists and antagonists according to their function. In his attempts to interpret the different physiological processes, even if unable to identify the underlying mechanisms, he set some hypotheses that were successively confirmed, i.e. urine production by blood filtration and not by chemical fermentation.

In the same period, a new discipline was arising which should reveal critical for the understanding of the human body structure, that is Microscopic Anatomy. One of the highest exponent of this science was Marcello Malpighi (Crevalcore 1628 – Rome 1694) who, after his formation at the Medical School of Bologna, was asked by Ferdinando the 2nd to teach at Pisa University. He became there a member of the Accademia del Cimento and a friend of Lorenzo Borelli, being initially fascinated by his mechanical theories. However, his strong desire to unravel the deep organization of the human body pushed him to the use of microscope, by which the physicist and naturalist Robert Hooke (Freshwater 1635 – London 1703) shortly before had described in plants, the existence of minute elements gathered together in the form of beehive and therefore called cellulae (small cells) or pores. Similarly to Galilei who, by means of the telescope, had started the exploration of Universe, Malpighi, by means of the microscope, had the aim to describe the hidden structure of the human body machinery. His research began in Pisa, continued in Bologna, Messina, once again in Bologna and eventually in Rome. His studies on lung alveoli represented the ground for the theory of respiration whereas his description of the complex system of follicles, tubules and vessels in the kidney allowed the development of a new model for urine production. By expanding and extending the research of Lorenzo Bellini (Florence 1643 – Florence 1704), who was a pupil of Borelli and wrote the tome "De structura et usu renum" (About the structure and function of kidneys), he enriched morphology with the beautiful description of renal glomeruli, named since then malpighian corpuscles. He stated that blood, through arteries, reaches glomeruli, where urine becomes separated and flows into the tubules, whereas blood returns into the blood stream through veins; these assumptions gave rise to the modern nephrology. He described, in a frog, the existence of a network of minute blood vessels (capillaries) interposed between arteries and veins, thus definitely outlining the blood circulation cycle, proposed, shortly before, by the English physician William Harvey (Folkestone 1578 – London 1657). In addition, he studied taste buds, showing that a thin nerve twig entered each bud, and described into the blood the presence of small globular structure (the future erythrocytes), that he interpreted as lipid droplets. Nevertheless, in Bologna Medical School he raised envies and jealousy and some threats he received, forced him to accept the offer of Pope Innocenzo XII of moving to Rome, where he was welcome with high honours and nominated "cameriere segreto partecipante" (pontifical archiater). Three years later, on November 19th 1694, he suddenly died upon a stroke.

Within the multifaceted scientific milieu of 17th century Tuscany a special place shall be reserved to the eclectic personality of Francesco Redi (Arezzo 1626 – Pisa 1697), physician, naturalist and man of letters. He graduated in Medicine and Philosophy in Pisa and, after a period in Rome, he reached Florence in 1655 soon becoming first archiater of the Grand Dukes, both Ferdinando the 2nd and Cosimo the 3rd, as well as member of the "Accademia della Crusca" and the "Accademia del Cimento".

Being a clever and acute observer, he faced some of the hardest biological questions, adopting the Galileo's model as main methodological assumption. In such perspective he was able to shatter the ancient theory of insects spontaneous generation, demonstrating that flies were generated in putrid flesh only when other flies had laid eggs ("Esperienze intorno alla generazione degli insetti" Experiences about insects generation, 1668). He stated that putrid matter is not an intermediate between life and death and that life does not arise from putridity (Cosmacini, 1987). Such concept, further expanded and developed in the following decades, reached its final seal almost two centuries later in the aphorism "omnia cellula e cellula" of the German Pathologist Rudolf Virchow (Schivelbein 1821 – Berlin 1902), the father of cell pathology. Redi was also the author of texts on snakes venom and, together with his coworkers Giovanni Cosimo Bonomo (Livorno 1633 – Florence 1696) and Giacinto Cestoni (Ancona 1637 – Livorno 1718), of the first extended and systematic research on human parasites, particularly the scabies acarus, which since then had been considered not just the cause but rather the effect of the disease: the latter discovery gave rise to a new branch of medicine, i.e. parasitology. His fame increasingly grew in Firenze, also due to his ability as physician and man of letters: his main work, the "polimetro" (various-measured poem) "Bacco in Toscana" (Bacchus in Tuscany), was printed after several adaptations in its definitive form in 1685. In 19th century a statue of him was posed in a niche within the Uffizi arcade (Fig. 1A) and, successively, an

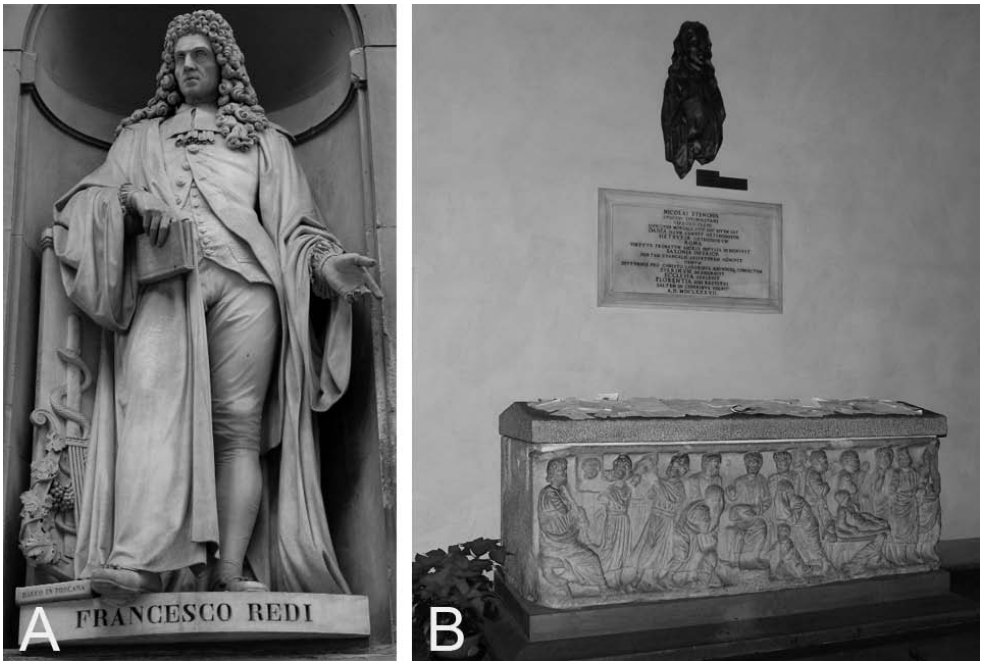

Fig. 1 – A) Francesco Redi. Uffizi Arcade, Florence (Statue by Pietro Costa, 1854). B) Niels Steensen's Chapel, Basilica of San Lorenzo, Florence. The mortal remains were buried October 25th, 1953 in a Roman sarcophagus.

impact crater on Mars of 62 Km in diameter was named after him according to the International Astronomic Nomenclature.

A close friend of Francesco Redi was Niccolò Stenone (Niels Steensen, Copenhagen 1638 – Schwerin 1686), who arrived in 1666 at the court of the Grand Duke of Tuscany, Ferdinando the 2nd following his world-wide fame as scientist. Stenone, of Lutheran religion, started the medical studies in Copenhagen under the guidance of Thomas Bartholin (Copenhagen 1616 – Copenhagen 1660), an anatomist renowned for his wide description of the lymphatic system, and father of Caspar (Copenhagen 1655 – Copenhagen 1738) who would have discovered the sublingual gland excretory duct as well as the female major vestibular glands. He continued his studies in Amsterdam and then in Leiden where he got his medical degree under the supervision of famous anatomists, first of all Franciscus Sylvius (Franz de le Boë, Hanau 1614 – Leiden 1672) who had described in full detail the morphology of human brain. After his graduation Stenone moved to Paris as guest of Melchisédech Thévenot (Paris 1620 - Issy 1692), a patron who was able to gather the most brilliant scientists of the age. In the course of his wandering (and indeed some years later Francesco Redi would have called him "the pilgrim of Europe") Stenone had already discovered the parotid gland excretory duct, had correctly discriminated the gland from the lymph nodes, had shown that saliva was derived from blood, and not from nerve humour, had stated that the heart was neither a source of heat nor the seat of the soul, but rather a muscle organ, with specific structure and function, and eventually had deeply investigated the gyri cere-bri, attributing them the highest cognitive functions (Lippi and Baldini, 2006). His starting point for the scientific research was the statement of the mathematician and philosopher Cartesio (René Descartes, La Haye 1569 – Stockholm 1650): *de omnibus dubitandum est* (it's necessary to doubt anything), and indeed he wrote in his "Discorso sul cervello" (Discourse around the brain): "I'm trying to follow the laws of Philosophy, which teaches us the pursue the truth, doubting its certainty and not becoming satisfied until a confirmation is achieved through demonstration".

In Florence Stenone collaborated with other scientists, in particular Francesco Redi and Vincenzo Viviani (Florence 1622 – Florence 1703), who claimed himself to be the last official pupil of Galileo Galilei, whereas he did not come in close relation with Giovanni Alfonso Borelli, the most famous and active scientist of that period in Tuscany. Besides pursuing his studies on skeletal muscles and lymph vessels, he broadened his research fields towards zoology and geology. His 1669 paper: "*De solido intra solidum naturaliter contento dissertationis prodromus*" threw the bases of geology and palaeontology, with the introduction of the fundaments of tectonics thanks to his studies on the ground and on fossil shells that he performed in the course of his travels through Tuscany (Pisa, Volterra, Livorno, Elba Island). He was converted in 1667 to catholic religion, in such a convinced manner that he was ordained priest in Florence Cathedral in 1675 and, two years later, appointed bishop of Tiziopoli (Turkey) and apostolic vicar for Scandinavia. After his death, occurring in Schwerin on November 25th 1686 (January 5th according to the Gregorian calendar) his body, by will of Medici Grand Duke Cosimo the 3rd, was moved to Florence and placed in S. Lorenzo Basilica (Fig. 1B) to testify not only his undisputed scientific discoveries, but also his faith path that would have brought him to be beatified, three centuries later, by Pope Giovanni Paolo II.

Toward the end of the 17th century, a peculiar artistic-didactic-scientific activity developed in Florence: the anatomical wax modelling, which almost one hundred years later (1771) would have deserved the institution of a specific workshop by the naturalist Felice Fontana (Pomarolo 1730 - Florence 1805) under the auspices of Grand Duke Pietro Leopoldo of Asburgo Lorena (Martelli, 1977; Poggesi, 1999; Riva *et al.*, 2010).

Nevertheless, it must be remembered that already in 1598 the painter, sculptor and architect Ludovico Cardi named "il Cigoli" (San Miniato 1559 - Rome 1613, Fig. 2A), who lived for many years in Florence, had prepared the first anatomical model of a male human body using monochromatic red wax. This model was based on his observations of cadavers dissected in a cell of the S. Lorenzo Basilica cloister and in the "Santa Maria Nuova" Hospital. This statuette, 61 cm. high called "Anatomia del Cigoli" (Cigoli's Anatomy) or "lo scorticato" (the skinned man), is still well preserved and exposed in the National Museum of Bargello together with a bronze copy.

About one century had to elapse before wax was used again for anatomical demonstration. The Grand Duke Cosimo the 3rd, in fact, in February 1691 called at his court the abbot Gaetano Giulio Zummo or Zumbo (Siracusa 1656 - Paris 1701). It is not known where Zummo had learnt the wax modelling techniques, but clearly the youth period he spent in Rome and Naples had a relevant influence on his artistic training. With such a skill, halfway between handicraft and art, Zummo performed in Florence real masterpieces, utilizing, for the first time, polychrome waxes. In all his work it's possible to track the evolution of wax modelling for human representation, starting from a religious/votive significance, rather common in that period and particularly in Naples, to didactic anatomy, passing through artistic/edifying depiction. He succeeded in melting a brutal, direct anatomy, derived from precise corpse dissection, with an artistic representation within always novel scenarios inspired to Bernini

Fig. 2 – A) Ludovico Cardi (Il Cigoli), Self-portrait (1606). Uffizi Gallery, Florence. B) Gaetano Zumbo, The plague (1693): detail. Museum of Natural History, University of Florence - Section of Zoology 'La Specola'.

or even Poussin (Didi-Huberman, 1999). His wax models are represented by the four "Teatrini" (small theatres) which show the various stages of cadaver putrefaction and which, by their realistic appearance, "evoke a sense of an overwhelming stench" (De Ceglia, 2005). Later in 1707 an anonymous writer pointed out that: "the talented sculptor's (Teatrini) resemble reality so much that those who look upon them are inevitably seized by horror" (De Ceglia, 2005). The four models are named: "il Trionfo del Tempo o Corruzione I" (the Triumph of Time or Corruption I), "la Peste" (the Plague, Fig. 2B), "la Vanità della Gloria Umana o Corruzione II" (the Vanity of Human Glory or Corruption II), and "il Morbo Gallico o Conseguenze della Sifilide" (the French plague or Consequences of Syphilis); the latter was donated by Cosimo III to prince Filippo Corsini and was partially destroyed by the flood of Arno in 1966. In the Museum of Natural History, Section of Zoology "La Specola", also a remarkable male human head partially dissected is exposed, that he prepared moulding the wax on a real skull, and presumably representing the cadaver of an executed man. In 1695 he suddenly abandoned the Medici court for obscure reasons, leaving Cosimo III deeply sorry to lose such an artist. In taking leave of him the Grand Duke, as reported in the chronicles of the period (Azzaroli Puccetti,1988), appealed to him in French saying "Vous pouvez trouver un Maître plus grand que Moi, mais jamais persone qui sache mieux que Moi ce que vous valez" (You might find some Lord greater than myself, but never someone who appreciates your value more). After Florence Zumbo continued his activity of wax modeller in Bologna, Genova, in cooperation with the French surgeon Guillaume Desnouses, Marseille and eventually, under the patronage of King Louis XIV, in Paris, where he suddenly died by haemorrhage on December 22nd 1701.

With such an artist/scientist it came the end of 17th century, a century in which a new scientific mentality had insolently sprouted and matured in spite of strong oppositions, developing to characterize the modern age. A fascinating century, somewhat revolutionary, dominated, in the scientific field, by eclectic figures who applied - not only to the medical sciences but even to the natural ones, from botany to zoology, from geology to astronomy - innovative research methods and criteria, based on speculative empiricism.

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