HISTORICAL NOTE

Anatomical Waxwork Modeling: The History of the Bologna Anatomy Museum

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In order to describe the Museum of Human Anatomy of the University of Bologna, one must also introduce the institution which houses it. The *Alma Mater Studiorum Bononiensis,* the oldest university in the world, was founded at the beginning of the second millennium. The Medical School of the University of Bologna is less ancient; nevertheless, with more than 600 years of history, it represents a formidable piece of evidence for the development of human thought. The birth of the Medical School was around 1288, the period in which Taddeo Alerotti gave the first public anatomical lectures. In 1316, the anatomical treatise *Anathomia Mundini* of Mondino de' Liuzzi (1270–1326) was published, which reintroduced the use of anatomical dissection abandoned since the 3rd century B.C. (Erofilo and Erasistrato of the Alexandrine School).

The anatomical tradition, based on the use of human cadavers, represents the basis of anatomical waxwork modeling. The first documentation of the use of this technique in Bologna is found in the biography of the abbot Gaetano Zumbo (1656–1701). Born in Siracusa, Zumbo went to Bologna around 1695 to improve his knowledge of anatomy. Some waxwork models attributed to Zumbo are conserved at the Specola Museum in Florence.

The first group of anatomical preparations of the Museum of Bologna collection was originally located at the Institute of Sciences, founded in 1711 by Luigi Ferdinando Marsigli. This institution was designed to renew attention to scientific observation and experimental research in all fields of natural sciences which, in the academic tradition, tended towards abstract theorization. Marsigli addressed a document to the University asserting that the study of anatomy required, as in foreign medical schools, a direct exhibition of the corpses and the use of dissection. The Institute of Sciences, whose origin and development diverged from that of the University, included the Anatomical Chamber, which initially received a group of dry specimens (mummified parts of cadavers), as a gift of the family of the famous anatomist Antonio Maria Valsalva (1666–1723) to be used for practical demonstrations to medicine students.

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As a result of constant use, this material progressively deteriorated. Therefore, an anatomical collection of models made of a durable material was commissioned by the painter Ercole Lelli (1702–1776). This artist, who won the Marsigli prize for human figure drawing, had a special interest in the study of anatomy, which he considered as a sort of grammar for representing the language of the human body. In this contest, the use of the so-called *notomie,* statues of skinned bodies, was considered essential for reaching truth and beauty in reproducing reality by artistic interpretation. Artistic *notomie,* in clay, wood, and wax, were the first models of the human body, whose anatomical perfection, obtained by careful representation of cadavers used for dissection, might serve as a reference standard for the study of anatomy. In this way, foundations were laid establishing the art of waxwork modeling of anatomical specimens for the study of medical practice at the University of Bologna (Ruggeri and Bartoli Barsotti, 1997).

The nucleus of the historical collection of the Museum of Anatomy is represented by the eight models of the whole human body commissioned to Ercole Lelli by the Bologna Cardinal Prospero Lambertini, when in 1742 he became Pope Benedetto XIV. Two wax statues represent male and female nudes; the other skinned statutes represent the different layers of the muscles, to the skeleton (Fig. 1). These specimens, as well as those representing all the muscles made by Lelli between 1745 and 1766, are located in the principal corridor of the Museum, housed inside the original showcases. The marble dissecting table utilized by the famous scientist and anatomist Luigi Galvanti is placed at one end of the corridor. The collection increased during the following 100 years, reaching more than 1,000 specimens by the mid-19th

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century. About 200 fully restored specimens are now exhibited in the museum which also includes a specialized library with very rare anatomical in folio works (Ruggeri, 1988).

THE ORIGINS OF THE MUSEUM

The study of anatomy has been widely practiced in Bologna since 1595, when the Anatomical Theater was established inside the *Archigymnasium*. The Anatomical Theater was utilized mainly during the Carnival feast to perform public demonstrations on the cadavers of executed criminals. The cold weather at that time of the year was suitable for dissection and cadaver preservation. However, at the end of the 17th century, the University of Bologna underwent a cultural crisis due to the dogmatism of the public teaching. To compete with the University, several private academies were founded in Bologna in the fields of Arts, Philosophy, and Sciences. Among them, the most famous was the Academy of Sciences, housed in the Poggi Palace, in which each branch of the natural sciences was represented in a *cabinet,* where specimens, machines, and designs were exhibited and used for experimental training. The Cabinet of Anatomy, commissioned by Pope Benedetto XIV to Ercole Lelli, was built in six years, and the Anatomy Chamber was designed to contain the eight wax statues and the exhibits of single bones and muscles made by Lelli with the assistance of the sculptor Domenico Piò and of Giovanni Manzolini. In addition to the exhibition rooms, the institution, named *Suppelletile Anatomica,* included dissection and wax modeling rooms, in order to improve the medical studies with practical training, since "Anatomy must be studied more with eyes than with ears," as stated by the Academy Institutional Act (Manzoli and Mazzotti, 1987).

The wax modeling at the Academy was also done by Giovanni Manzolini, Lelli's coworker in the period 1740–1745, and by his wife Anna Morandi Manzolini, who was appointed an Anatomy teacher in 1760. Following Lelli's death in 1766, his work was continued mainly by Anna Morandi Manzolini until her death in 1774. The works by Ercole Lelli represented the artistic gold standard of the Bolognese wax modeling school, while those of Anna Morandi Manzolini attained an absolute anatomical accuracy. The Museum now houses 61 specimens handmade by Anna Morandi Manzolini, probably under the supervision of Giovanni Manzolini. The specimens deal with different parts of the human body, including ear, nose, tongue, larynx, pharynx, heart, lungs, female genitals, and the fetus. The most impressive one, which confirms the advanced knowledge of physiological connections between the nervous system and the muscles, is the tablet of the extrinsic muscles of the eye (Fig. 2).

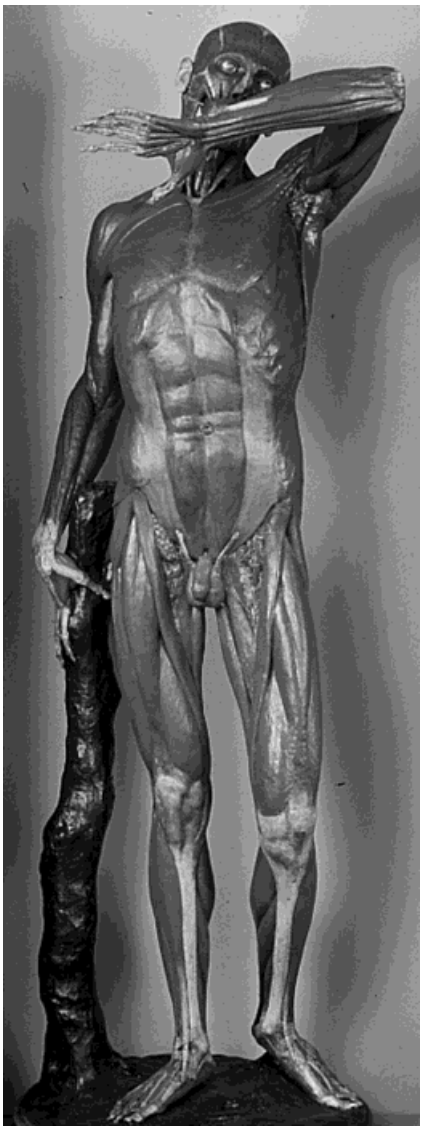

Figure 1. The *Skinned Man* by Ercole Lelli. Waxwork on a natural skeleton showing the surface muscles.

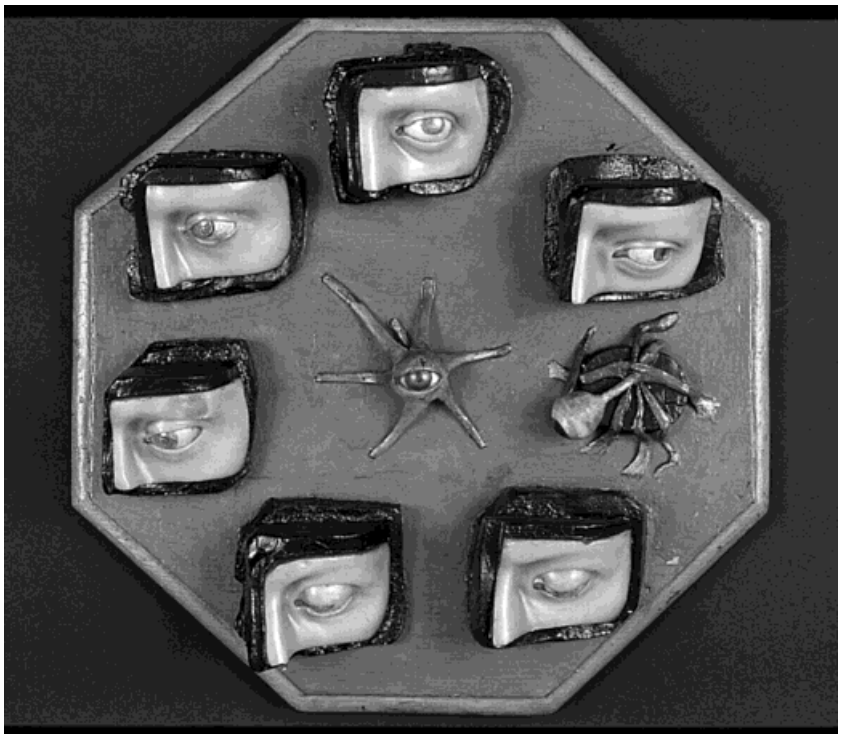

Figure 2. Detailed reproductions of the human eye, by Anna Morandi Manzolini. At the center of the tablet: the eye bulb with the extrinsic muscles. The specific action of each muscle on eye position is represented in the six peripheral waxworks.

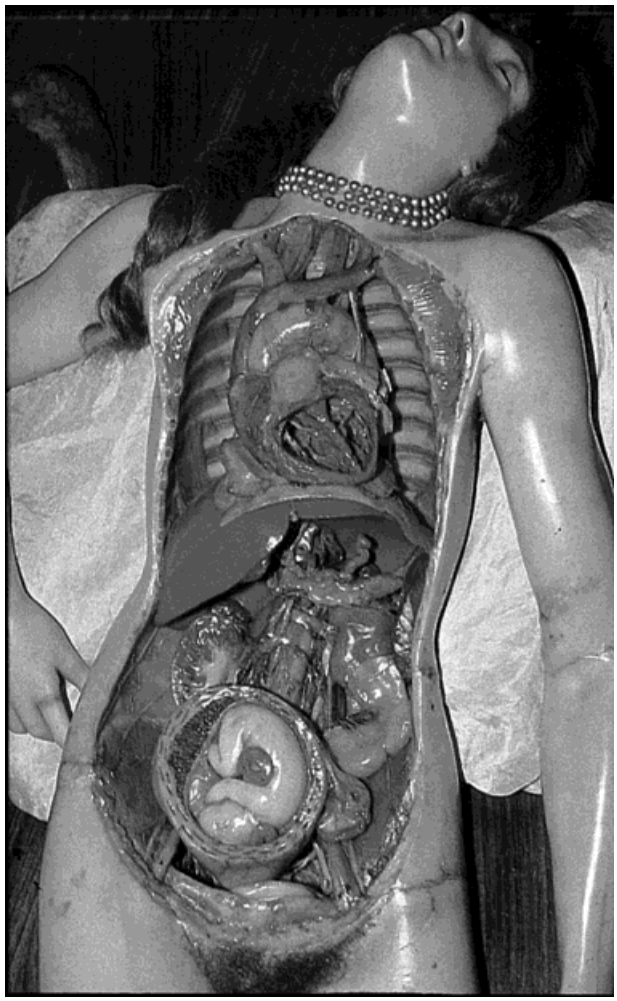

Figure 3. The *Venerina* by Clemente Susini. The surface layers and the organs are removable and can be taken apart. The heart valves and the fetus inside the uterus are visible.

Between 1789 and 1815, the collection was improved by the acquisition of wax models made by Clemente Susini. Working at the Specola Museum in Florence from 1782, this outstanding artist produced about 2,000 anatomical wax reproductions during his 40 years of activity. Some of these samples are preserved in Italian universities such as Padova, Pavia, Siena, and Cagliari, as well as in other European institutions; the bulk of them, more than 800, are at the Military Academy Museum Josephinum in Vienna.

Some of the 23 Susini's specimens in the Museum of Bologna reach the highest level of the entire artist's production. The most famous is a young lady's body called *Venerina,* which presents several unique characteristics (Fig. 3). The body is represented in a sleeping attitude and the surface layers are removable in order to reveal the inner organs, many of which are also removable. A fetus is visible inside the uterus, and the heart and vascular system present alterations typical of Fallot's syndrome, which could have been the cause of the pregnant woman's death. Other specimens of the first period of Susini's production reveal an admirable balance between artistic reproduction of the truth and perfect knowledge of anatomy. The latest group of waxworks, made during the final part of Susini's life, when he was affected by familial mourning, are impressive copies of cadaver preparations characterized by a sharp veristic sight.

Some interesting preparations of Giuseppe Astorri can be dated between 1816 and 1825. They represent alterations of the urinary and genital apparatus in hermaphrodites, and the organization of the cervical, brachial, crural, and ischiatic plexus. A few waxworks from the second half of the 18th century are part of the collection. Among them, the eight great models of the brain made by Cesare Bettini under the guidance of the anatomist Luigi Calori around 1850, and the skull with a very accurate representation of the brain by Leonida Berti. The Museum also includes the Calori collection consisting of about 1,500 human skulls. The collection maintains its anthropological interest, although the scientific validity of its classification has been disputed.

WAXWORK MAIN COLLECTIONS

Ercole Lelli (1702–1766)

Eight display cabinets made from painted wood and glass of the 18th century, restored after World War II, contain the representation of the whole body motor apparatus. They are aligned along the right side of the monumental corridor on the first floor of the Institute of Human Anatomy. The first two cabinets, one in front of the other, contain the nude statues of a young man and a blond woman, referred to as Adam and Eve, whose surfaces are carefully modeled to underline the muscular and vascular structures. Four statues are dedicated to the representation of the myological system from the more superficial muscle layers to the deeper ones. All these statues were made according to the classical Bolognese school technique by Ercole Lelli, by assembling the waxworks of the muscles onto the bones of human skeletons. The first one, referred to as the "skinned man," shows in great detail all the surface muscles (Fig. 1) and resembles the two wood statues by Lelli of the Dissection Table in the Archiginnasio Anatomy Hall in Bologna. However, the colors of the muscles, tendons, fatty deposits, and bones make the waxwork much more realistic and impressive than the wood statues. The other three statues represent the muscles in increasingly greater depth, according to a still-accepted classification of the muscle layers. The most impressive statue is that of the deeper muscle layer, in which a great number of the skeletal bones are visible, with the tendon insertions and the joint-

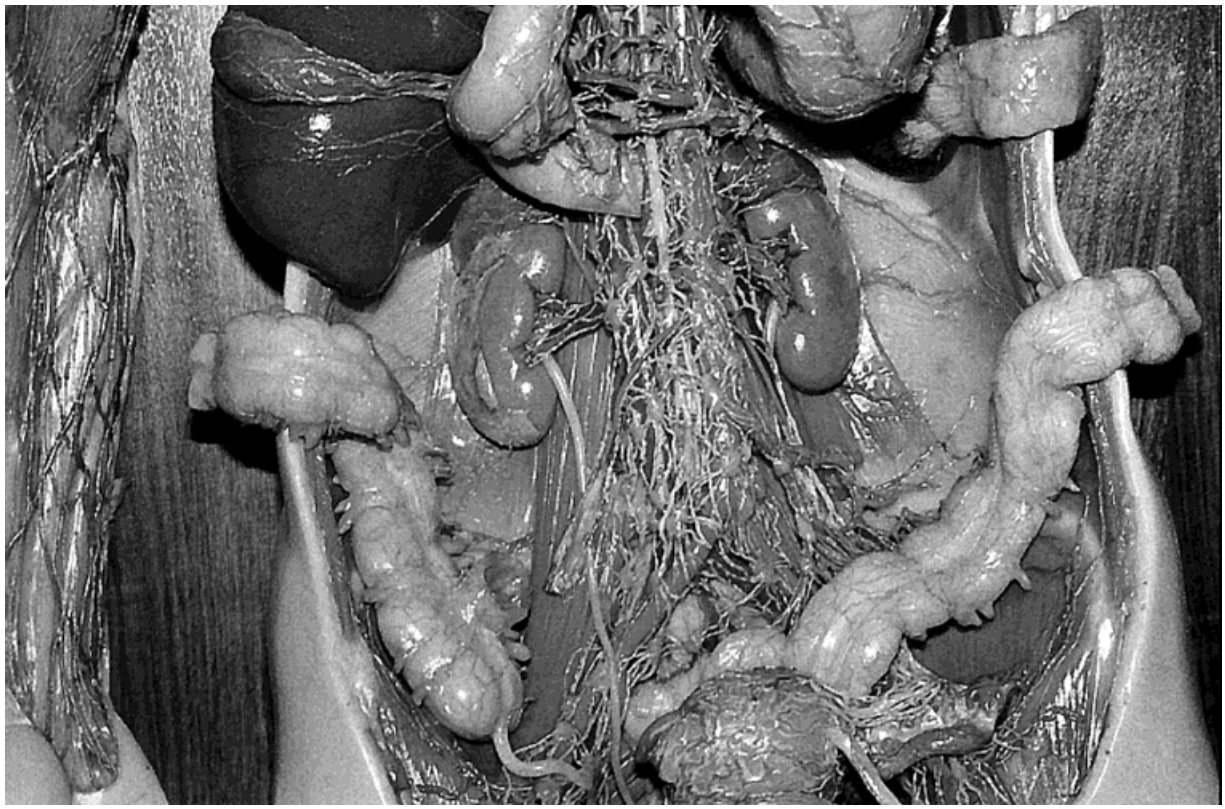

Figure 4. Detail of the lymphatic system of the abdominal region after the removal of the intestine (also in this case some organs can be taken apart), by Clemente Susini.

capsules represented with astonishing realism. The last two cabinets contain two skeletons, one of a woman with a sickle in her hand, the other of a man with a scythe, which recall the usual representation of Death. In the female skeleton, the joint-capsules and ligaments are modeled by wax, while in the male skeleton, the bones are assembled with artificial joints in iron, which allow the bones to be moved according to the functional requirement of the joints.

On the other side of the corridor, at both sides of Galvani's dissecting table, two vertical cabinets contain other works of Lelli. The largest collection is dedicated to the muscle apparatus. Wood panels display single isolated muscles with their tendons or groups of functionally-related muscles. An historically important exhibit displays both the normal kidneys and abnormal horseshoe kidney. This first Lelli work, presented to the Academy of Sciences in 1742, was so impressive that the Academy commissioned him to make the eight statues and the other panels. A large collection of bone segments, with artificial iron joints and wax-made ligaments and capsules, shows the technical procedures used in the skeleton assembly.

Anna Morandi Manzolini (1714–1774)

At one extremity of the corridor, a large room contains all the other waxwork collections of the Museum. Two vertical cabinets exhibit the wax self-portrait of Anna Morandi Manzolini and the portrait of her husband Giovanni Manzolini. Both are represented in the attitude of dissecting, in one case a skull to show the meninx, in the other, the liver to show the gall bladder. Manzolini's other works, which reveal her interest in detecting the functional connections among the organs of a given system, are shown in a large vertical cabinet and in a showcase table. Among them, eight wood panels, delimited by gauze materials as in an actual dissection field, show the muscles of the limbs, exhibiting the tendon insertions and the nerves. In addition, the 28 models describing in very realistic detail the senses of sight (Fig. 2), hearing, taste, smell, and touch, and the nine tables dedicated to the organs of the pelvis and of the chest are modeled as dissection preparations to underline functional details of the vascularization and innervation of the organs.

Clemente Susini (1754–1814)

In a showcase table beside the famous *Venerina* (Fig. 3), some of Susini's waxworks are shown, all characterized by an impressive accuracy of anatomical description and by the realistic representation of the cadaver face and body details. For example, the typical colors of the cadaver skin are reproduced as never before, and both the down of the body and the beard are made of actual hairs dipped into the wax and then trimmed. The main work is the representation of a dissected female body showing the lymphatic system of the head, neck, chest, and abdominal organs (Fig. 4), as well as of the upper limb. Two impressive works of the late period of Susini's activity represent dissected men's heads. One of them shows the brain, the oral cavity with the

Figure 5. Dissected man's head showing the meninx, the tongue, the neck, and the orbital cavities, by Clemente Susini. Lymphatic vessels are erroneously represented in the brain.

tongue, the orbital cavity with the eye, and the neck cavity with blood vessels, nerves, and lymph vessels (Fig. 5). The other one displays the mimic and masticatory muscles and the parotid gland.

Giuseppe Astorri (1795–1852)

Another showcase displays some waxworks by Giuseppe Astorri, which show the influence of the Florentine school, although the technique used is based on the Bolognese tradition of the utilization of the bones of the skeleton. In fact, plaster molds taken from the cadaver organs have been used, but they have been assembled onto the skeleton. Moreover, the details were obtained with original techniques, mainly those regarding blood and lymph vessels, utilizing silk and cotton threads soaked in wax, and applied on the surface. Of particular interest are the models of the upper and lower limbs, with an extremely realistic representation of the sheaths, obtained by silver and gold powder dissolved into transparent wax. Among Astorri's works, 25 models of the joints were done to complete Lelli's project of the entire motor system.

THE WAX MODELING TECHNIQUE

The technique used for anatomical wax modeling varied according to the periods and the different workers. Wax was initially used instead of, or associated with, other fluid substances, such as mineral oil, turpentine, and quicksilver, to inject the vascular system. This technique, used also by Leonardo da Vinci, was fully developed during the 17th century, mainly by Swammerdam (1637–1680) and Ruysch (1638–1731). Some anatomical specimens, obtained by wax injection into the vessels and by the digestion of the organic components by acids, are conserved in the Museum. Obviously, this technique is particularly suitable for showing the vascular tree of parenchymal organs, such as kidney or lung, but does not allow the reproduction of the whole organ structure (Legèe, 1979). However, the technical basis for the wax modeling was derived from vascular injection.

The specimens at the Museum of Bologna were made essentially by two techniques: the superimposition of wax handmade models of organs on the original skeletal bones, and the fusion of the wax into a plaster mold of the organs. The first technique was used by Lelli's school in Bologna, the second by Susini's school in Florence. In the first case, the specimens are the only copy extant; in the other, several copies could be obtained. The use of molds allowed the artist to make variants of the same specimen, with changes in surface details or colors. In both cases, cadaver organs are needed either to be carefully copied or to serve as molds. The use of skeletal bones, reinforced by a metal scaffold, allowed Lelli to arrange the statues in anatomical or artistic positions and to ensure an absolute balance of the relative proportions of the different parts of the body. The bone skeleton was generally coated with tow or cloth to prevent the detachment of the wax from the bone surface and to reduce the amount of the wax. The single parts were modeled by hemp soaked with wax diluted in turpentine and mixed with bran, using the cadavers as models. Some specimens were modeled *in situ*, while others were made separately and then assembled (Pike, 1973).

The wax used for the modeling work was that secreted by the honey bee *Apis mellifica* to construct the

honeycomb. After the removal of the honey, the honeycombs were melted in boiling water and the filtered product constituted the wax, whose color depended on the age of the honeycomb and the flower species of the territory. The waxes were of different origins, characterized by their melting point and color; the Italian wax was an intense yellow, the German one a light yellow, and the waxes coming from Eastern countries were characterized by a dark red color. The most-used waxes were the so-called *Levante* and *Sottana,* diluted in turpentine or melted with tallow and putty. Different colors were obtained either by melting or painting the wax with silver, gold, carmine red, lapis-blue, cinnabar, ceruse, minium, and China ink. The Florentine school required four phases: coating the anatomical specimen with clay, making the plaster mold, casting the melted wax in the mold utilizing superimposed layers of differently colored waxes, and manually finishing the surface. Small structures, such as surface vessels and nerves, were obtained by coating iron or cotton threads with the wax. Lymphatic vessels having a knobby appearance were obtained by extracting in an intermitted way a silk thread from the melted wax. The metal brightness of the tendons was obtained by gold powder entrapped in a transparent paint coat.

CONCLUSIONS

At medical schools, the teaching of anatomy evolves and education in the dissection laboratory is frequently supplemented by laptop computers just like at the School of Medicine of the University of Bologna. The modern plastination technique (infiltration and embedding of the organs by polymerizing resins) represents a continuation of the wax modeling tradition. The wax models and the plastinated organs provide suitable facilities, when associated with some practical dissections and views of previously recorded dissections, for acquiring the fundamental elements of gross anatomy.

Recently, a project has been advanced by the trustees of the University of Bologna which could involve key choices in the near future for the Museum of Anatomy, and is now stimulating a cultural debate. The project provides the displacement of a great part of the wax models from the Museum of Anatomy to the Academy of Sciences. This would allow the revival of the ancient collections which covered all the different fields of knowledge of the 18th century. On the other hand, the anatomical wax models, separated by the context in which anatomy studies are continuously improved, could represent a great loss for medical culture. In order to partly prevent this loss, all the wax material at the Anatomy Museum has been made accessible by the Internet, and the historical, artistic, and anatomical catalog will be continuously improved.

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