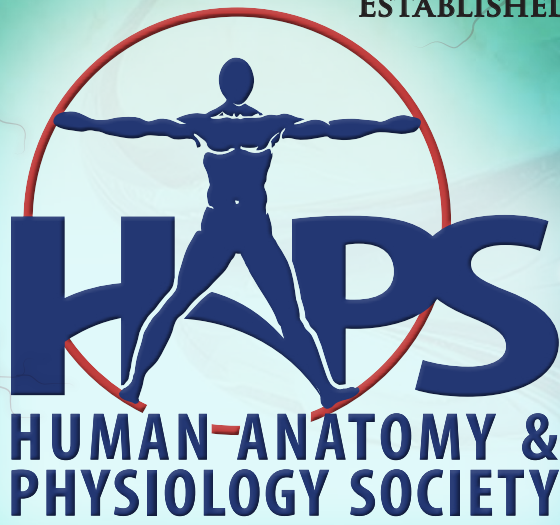


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*Brain Morphology by Cesare Bettini (1814-1885), Luigi Cattaneo Museum of Anatomical Waxes,
Bologna Institute of Human Anatomy, University of Bologna.*

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COVER ART - Brain Morphology by Cesare Bettini (1814-1885), Luigi Cattaneo Museum of Anatomical Waxes, Bologna Institute of Human Anatomy, University of Bologna.

In this ceroplastic model, Bettini beautifully demonstrates a midsagittally sectioned brain within the cranial vault. Beyond the anatomical accuracy and incredible detail, the technical capacities of Bettini are astonishing as this sculpture is approximately four times life-sized. Bettini was particularly skilled at creating large-scale anatomical preparations, many of which are on display in the Luigi Cattaneo Museum. The art and science of sculpting human organs from wax was founded at the University of Bologna in the 18th century as the supply of human cadavers for medical education was unable to meet demand, and the preservation of human specimens was problematic. Ceroplastic models provided a valuable three-dimensional alternative to human dissection, and are an important element in the history of anatomy education. Works by Bettini and other renowned anatomic artists are on public display at the University of Bologna where their artistic beauty and scientific importance can be appreciated. These treasures in the history of anatomy education are explored in this issue of the HAPS Educator in the article Marvels of the Bologna Anatomical Wax Museum. The authors suggest that these centuries old sculptures could be used in medical education today, connecting art and science in the modern curriculum.

Image and text provided by Dr. Francesco M. Galassi and Emeritus Prof. Alessandro Ruggeri, University of Bologna, and Prof. Kevin Petti, San Diego Miramar College. Special thanks to the Luigi Cattaneo Museum of Anatomical Waxes and the Sistema Museale d'Ateneo (SMA), University of Bologna.

Marvels of the Bologna Anatomical Wax Museum: their theoretical and clinical importance in the training of 21st century medical students

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Abstract: The purpose of this paper is to draw the attention of history of anatomy enthusiasts to the anatomical wax sculpture treasures located at the University of Bologna, using a recent exhibition as a vehicle for this examination. After briefly recalling the history of the University and its anatomical wax collection, some of the major specimens chosen for this recent exhibition are described. The paper concludes with a commentary suggesting the reintroduction of anatomical wax models into the education of contemporary medical students as a useful enterprise for connecting art and anatomy, and enriching the educational experience.

Key words: history of anatomy, anatomical waxworks, medical education, anatomy teaching, University of Bologna, Italy

INTRODUCTION

The Museum of Human Anatomy at the University of Bologna is home to world-renowned artistic/anatomical treasures from the 18th and 19th centuries (Scarani et al. 2001). Visitors from across the globe, anatomists and artists alike, frequently travel here to enjoy anatomical wax sculptures that uniquely blend art and science. In addition to the beauty of such works, their scientific relevance has left its mark on the history of medical education. For legions of anatomy students generations ago, they served as an invaluable substitute for first-hand dissection, as well as stylized, two-dimensional textbook images. This was especially true in the past when the supply of cadavers for medical education was limited, and the preservation of dissected specimens was problematic. While the dissection experience was considered the ideal method for teaching and learning human structure, ceroplastic models provided a valuable three-dimensional alternative, and are an important element in the history of anatomy education (Miraldi et al. 2000).

The Luigi Cattaneo Museum of Anatomical Waxes, located in the Bologna Institute of Human Anatomy, houses a significant portion of the collection. The exhibition *Amazing Models*, which ran from November 16, 2012 to March 15, 2013, celebrated the rich history of the collection at the Bologna Institute and served to revive the interest in anatomical waxworks. This exhibition was a collaboration between several European university museums: the Boerhaave Museum, Leiden, the Netherlands; the Josephinum Museum

at the Medical University of Vienna, Austria; and the Luigi Cattaneo Museum at the University of Bologna, Italy. The direct involvement of medical students in assembling the exhibition highlighted the tight bond between education, art, and science, and served as an opportunity to reintroduce to today's medical students the historic practice of teaching with anatomical waxworks.

The purpose of this paper is to describe the exhibition, provide a historical account of the Bologna Institute, and discuss some of the more intriguing specimens that were displayed. Additionally, the authors will describe the nexus between art and anatomy, and present the notion of reintroducing into modern anatomy education the historic practice of utilizing ceroplastic models. Considering the historic and fragile nature of these artifacts, the context proposed is one of examination in a museum setting, as opposed to direct physical manipulation.

THE EXHIBITION

This was the first time these three long-operating institutions joined forces to promote the reconsideration of anatomical models as a didactic tool in the field of medical studies. Bologna inaugurated the exhibition that then traveled to Vienna, and finally Leiden later in the year. Strong symbolic value justified Bologna as the first seat of the exhibit. Indeed, Bologna is the oldest continuously operating university in the Western world, tracing its foundation back to the year 1088 (Verger 1992). It was here that medicine as a component of university training in the modern sense emerged from

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the errors and superstitions of the Dark Ages. Indeed, the oldest surviving, and most significant statutes for the medical curriculum date back to 1405 at the University of Bologna. Outlining medieval medical practice, these texts endured for two centuries and were influential beyond Bologna (Grendler 2002).

In a centuries-old style reminiscent of a bygone era, the exhibition, *Amazing Models: 3D anatomical models between the 16th and 19th centuries*, opened with Latin quotations delivered by Rector Magnificus of the university, Ivano Dionigi, emphasizing the gravitas of this exhibition at such a historic institution. The opening ceremony was held in the Aula Magna of the Institute of Anatomy, overlooked by inscriptions of the historic professors of the Anatomical School. Most notable of these is Mondino de' Liuzzi (1275-1326), considered to be the founder of anatomic studies in the Middle Ages. Indeed, it was Mondino who reinstated human dissection into the medical curriculum (Maraldi et al. 2000), and authored the *Anathomia* in 1316, which was the most widely used anatomical text across Europe until the 16th century (Cunningham 1997).

The exhibition is a collection of historic and amazingly accurate anatomical models that are also works of art. The wax sculptures of the Bologna and Josephinum collections were joined by papier-mâché models from the Boerhaave Museum. Displays exhibited exquisite representations from muscles, nerves, and brains, to pathological preparations. An entire room was dedicated to a more strictly didactic section on oncology, particularly the evolution of theories and therapies for breast cancer. This unique collection demonstrated both normal and pathological anatomy in multiple media in an effort to revive the connection between art and anatomy, and was likely reminiscent of an era when students used these specimens for their studies. Brochures organized in thematic itineraries (neurology, obstetrics, teratology, normal anatomy, etc.) were written by tutors of the Bologna Department of Anatomy and accompanied every showcase as testimony to the inclusion of modern students into a teaching modality used centuries ago.

THE BOLOGNA MUSEUM OF HUMAN ANATOMY

The totality of the historic anatomical wax model collection at the University of Bologna resides in two locations: the anatomical chambers of the Academy of Sciences (Palazzo Poggi) and the Luigi Cattaneo Museum at the Institute of Human Anatomy. Artist Ercole Lelli (1702-1766) produced the core of the collection although the oldest anatomical specimens date to those produced under the direction of Antonio Maria Valsalva (1666-1723) (Maraldi et al. 2000). A pioneer in anatomical wax modeling, Lelli created a

collection that was unparalleled in accuracy. Using a technique of sculpting wax musculature upon natural bone, Lelli focused his work on osteology and myology. Lelli worked with other artists/anatomists such as the husband wife team of Anna Morandi (1714-1774) and Giovanni Manzolini (1700-1755) who constructed models of the organs of sensation, digestion and reproduction. The result of their combined efforts created the world's first and greatest collection of anatomical waxes for medical education. This collection was enriched through the work of modelers Clemente Susini (1757-1814) from the school of the abbot Felice Fontana (La Specola in Florence), Giuseppe Astorri (1785-1852) and Cesare Bettini (1801-1855) (Miraldi et al. 2000).

Professor Luigi Calori (1807-1896) played a decisive role in the process of expansion, both by establishing a collection of approximately 2000 natural bone human skulls for his anthropological studies, and collaborating with artist Cesare Bettini to produce wax models representing both normal and pathological anatomy. By 1804, a collection of pathological anatomy waxes had been established and markedly expanded under the direction of Cesare Taruffi (1821-1902) who was the first scholar to be appointed as professor of anatomical pathology at the University of Bologna.

In the last decade of the previous century, the original nucleus of 18th century waxes by Lelli, Manzolini and Morandi (along with waxes by other modelers) were moved to the original seat of the Academy of Sciences. The portion of the collection remaining at the Institute of Human Anatomy bears the name of professor Luigi Cattaneo (1925-1992) who directed the restoration and reorganization of the wax model assemblage (Ruggeri 2003) and served as home for *Amazing Models*. While containing representations of normal anatomy, the majority of the models in the Luigi Cattaneo collection however, focuses on pathology and contains mostly 19th century specimens. Bolognese anatomists consider the collections at the University Museum of Palazzo Poggi, and the Institute of Human Anatomy as a whole, and represent a continuum in the history of anatomical teaching.

SOME SPECIMENS

Four of the more impressive wax sculptures that were included in the *Amazing Models* exhibit are discussed below. These models portray a midsagittal section of a brain within the cranial vault; a fetus, umbilical cord, and placenta; the teratological condition pygopagus; and the oncological condition of lower limb melanoma.

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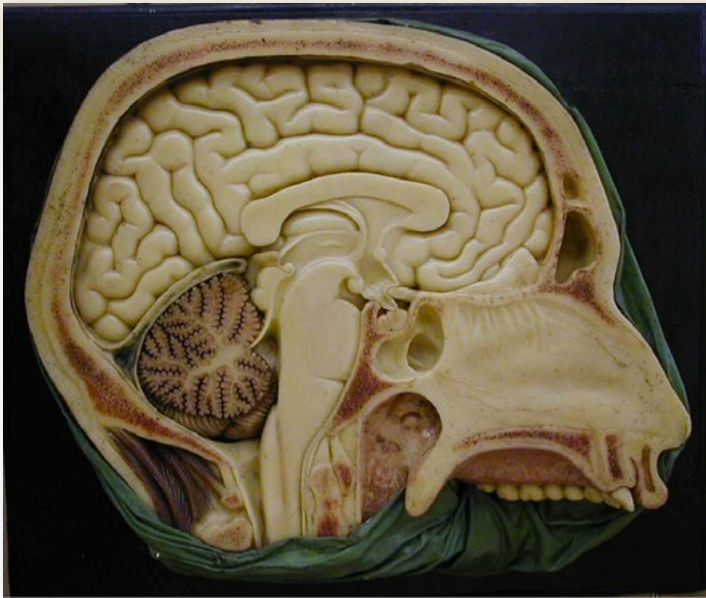


Figure 1



Figure 2

The extraordinary 19th century wax sculpture in Figure 1 by Cesare Bettini represents a midsagittal section of the skull. It can be seen that the whole brain is exposed within the skull and divided exactly into two halves. Note that the septum pellucidum is entirely intact. Bettini impressively demonstrates an array of anatomical detail: the cerebral convolutions of sulci and gyri; a well-defined tentorium cerebelli separating the hemispheres of cerebellum from those of the cerebrum; the communication between the cerebral aqueduct and fourth ventricle; and the sinuses of the sphenoid and frontal bones. Shown in all of its colorful intricacies, the cerebellar arbor vitae is perhaps the most striking feature of this model.

With the appointment of Bettini as official sculptor, the usefulness of producing very large models became clear. Indeed, this specimen is several times life-sized. The scale of Bettini's work can be best appreciated in Figure 2. Compare the life-sized skull and brain specimens on the bottom two shelves with Bettini's oversized brain model from Figure 1 (hanging above on the right). In fact, Bettini sculpted all of the hanging neurologic models in Figure 2. Illustrating fine workmanship and subtly different shades of color, these preparations were extremely beneficial to medical students in helping them understand difficult spatial relationships, and indeed sometimes proved to be "more accurate" than a dissected cadaver (Pigozzi and Ruggeri 2010).

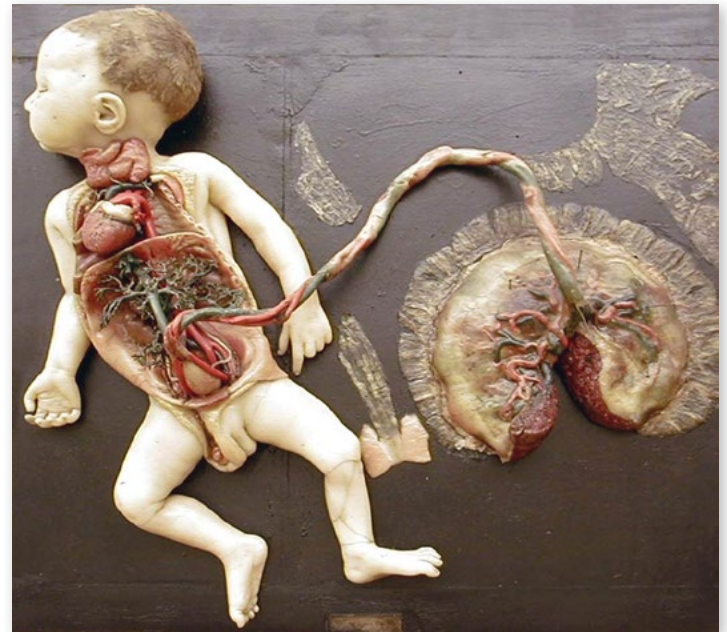


Figure 3

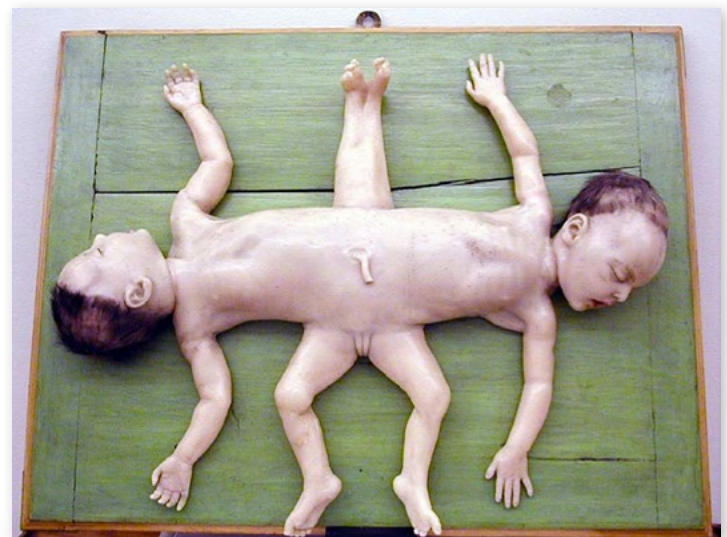


Figure 4

The ceroplastical artist Giuseppe Astorri sculpted these 19th century obstetric models. Not long before Astorri's day, obstetrics had been regarded as a practice for

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midwives, and was just admitted into the family of medical specializations (Tega 2001). A collection of normal and pathological obstetric teaching models for physicians was needed.

Figure 3, also larger than life-size, deftly depicts the communication of the umbilical cord with the fetus and placenta. The heart is awkwardly represented perhaps to reveal its posterior structure. Figure 4 demonstrates the conjoined twins condition pygopagus, where the two fetuses are joined at the sacrococcygeal region. This model is important as it represents an early element of the pathological collection of the Institute of Anatomy. These two ceroplastic sculptures together represent just a fraction of the didactic models used for 19th century obstetric training at the University of Bologna.



Figure 5

The final wax model represents melanoma of the great toe (hallux) and was sculpted by an unknown artist in the 19th century. The model appears to be extremely accurate as it shows both a voluminous mass and the dissemination of the neoplastic process. The main formation ends up capping the entire toe in a fungoid pattern. The onlooker can easily observe how along the thigh and leg several smaller and more delimited malignancies are distributed, easily gaining an insight into how the process spreads in vivo. Moreover, the upper portion shows the presence of a swollen chain of lymph nodes pervaded by metastases, just another sign of tumoral infiltration and dissemination. Finally, on the proximal-medial thigh is what appears to be a larger lymph node that has been dissected so the viewer may have a better look at its inner area.

DISCUSSION

“This (anatomy) is a science which is better learnt and retained by watching and touching than by speaking about it or spending many hours reading about it” (Calori 1850). Such a powerful statement by Luigi Calori marked the success of demonstrative, three-dimensional anatomy over its textbook counterpart; an evolution that included the rise of anatomical wax sculptures.

This movement was born when Professor Mondino de' Liuzzi was at the University of Bologna. His 14th century treatise on anatomical dissection broke with the old Galenic tradition and paved the way for an era of

precise anatomical dissections and direct observation of nature by medical students and faculty (Cunningham 1997). Among others, Mondino's work was reinforced and expanded upon by Berengario da Carpi in his *Commentaria super anatomia Mundini* in 1522 with what can be considered the first truly illustrated anatomical text for medical education (Rifkin et al. 2006). The science of anatomy and its connection to art reached a crescendo in the work of Leonardo da Vinci and Andreas Vesalius who both used artistic methods to accurately illustrate human anatomy for didactic purposes (Saunders and O'Malley 1982, Clayton and Philo 2012). Although Leonardo never published the anatomical text he was authoring Vesalius produced the most richly illustrated and important anatomical text of the Renaissance (Saunders and O'Malley 1982, Clayton and Philo 2012).

At best, medical students from the 14th to 18th centuries participated in one or two public dissections annually that were confined to the winter months; hardly adequate to acquire a command of the discipline. By the 17th century, the difficulty in acquiring enough cadavers to meet the growing demand of anatomy students resulted in the need to produce a nonperishable substitute. The inevitable result was the highly accurate anatomical wax models (and to a lesser extent papier-mâché) that were sculpted through direct observation of dissected cadavers (Ballestriero 2000). Such models were continuously available, and proved essential to the education of generations of medical students who could then conclude their studies with a solid understanding of human anatomy. Students then had a knowledge based on the three-dimensional observation of accurately represented human organs. This was substantially different from that which was characteristic of pre-18th century students who had modest exposure to actual dissection, and largely possessed a theoretical knowledge acquired through the written word, which had for centuries been regarded as superior to experience (Aldini 2010).

Furthermore, these models were works of art in their own right, and continued the tradition of anatomists collaborating with artists. Vesalius in the 16th century employed artists from the workshop of Titian, most likely by artist Jan Stephan van Calcar, to produce the famous woodcuts in his magnum opus *De Humani Corporis Fabrica* (Saunders and O'Malley 1982). And although the projects never came to fruition, Leonardo and Michelangelo Buonarroti (with Realdo Colombo) were each working to illustrate anatomy texts intended for medical education (Clayton and Philo 2012, Carlino 1994). Indeed, the earliest use of wax to demonstrate human anatomy was most likely by Leonardo who injected liquid wax into the brain to demonstrate the shapes of the ventricles (Clayton and Philo 1982).

Undeniably, the historic connection between artists and anatomists can be viewed as unique and unbreakable (Laurenza 2012). Giorgio Vasari, Renaissance artist

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and historian, tell us in his *Lives of the Artists*, that Renaissance masters conducted human dissection to heighten their painting and sculpture (Laurenza 2012). It is as though anatomist and artist were fused into a single entity. Art was at the service of anatomy, while anatomy provided art with the foundation for magnificent representations (Scarani et al. 2001).

The models and the specimens produced in the past are far more than artistic sculptures; rather, they are the products of active scientific research and production, and the nexus of anatomist and artist. They are capable of furnishing students with practical knowledge for their future careers as physicians, while at the same time allowing them to admire artistic beauty and anatomical accuracy. Such an interdisciplinary enterprise is likely to deepen and enrich anatomical science education in a unique manner. The intimate relationship between art and science was celebrated in a captivating fashion in the *Amazing Models* exhibit, and was a persuasive vehicle for discussion about this connection.

CONCLUSION

It seems compelling to suggest that the study of ceroplastic models should be reconsidered as an integral tool in expanding students' understanding of human anatomy. This endeavor is valuable on many levels. It provides students with a three-dimensional vision of human structures otherwise barely comprehensible if solely studied with books. These models are also a valid adjunct to the modern plastic models ubiquitous in today's anatomy laboratory. Further, ceroplastic models can prove particularly useful in countries where dissection is not a regular component of the anatomical syllabus. It has been suggested "even today these collections (in Bologna and Florence) could serve for gross anatomy demonstrations, especially for rare entities, to medical students and pathology residents" (Nicosia 2006).

Certainly, a host of wax sculpture alternatives exists today that can provide effective anatomy education. Such options include three-dimensional computer modeling, colored radiography, photographic atlases of dissected human tissue, and plastinated human organs. Indeed, plastination can be considered a furtherance of the wax modeling practice (Maraldi et al. 2000). It seems self-evident however, beyond their actual didactic usefulness, that there is great value in exposing contemporary students to a glorious bygone age of scientific creativity, when anatomists employed the skills of artisans to produce anatomical wax sculptures sufficient for medical education. Students are likely to gain an appreciation for the history of their discipline, meant as a sense of continuity with the past, and perhaps connect art and anatomy for the first time in their minds. In addition, such an approach would presumably allow students to investigate beauty in the human body, even appreciating the body itself as a work of art.

The difficulty with this concept is that these specimens reside in the holdings of a small number of university anatomy museums, limiting availability to students. Fortunately, these museums are open to the public and welcome students to examine their collections. The *Amazing Models* exhibit, with its large collection that traveled across Europe, served as a vehicle for increased student access. Perhaps in the future a virtual exhibition of these historic, artistic anatomical specimens will make them available to the whole world via the Internet.

Anatomy programs may consider incorporating into their curriculum visits to the museums that participated in the *Amazing Models* exhibit. This includes the University of Bologna anatomical wax collections at the Luigi Cattaneo Museum, and the Academy of Sciences (Palazzo Poggi), as well as the Josephinum Collection of wax sculptures in Vienna, and the papier-mâché models from the Boerhaave Museum. Other important wax anatomical collections include Clemente Susini's models at the University of Florence (La Specola), and the University of Cagliari (Riva et al. 2010).

While a contemporary need for uniform, quality-assured teaching methods is the norm in anatomy education, we are persuaded that rediscovering the beauty and teaching usefulness of anatomical wax sculptures – even as an optional curricular opportunity – should be taken into consideration. For many students across the globe, a visit to any one of these venues would be a once-in-a-lifetime opportunity. The result however, is likely to be an interdisciplinary understanding of the art and science of human anatomy for an entire career.

The authors wish to thank the scientific director, teaching staff, administrative body and student tutors of the Bologna Institute of Anatomy and the "Luigi Cattaneo" Museum.

CONFLICT OF INTEREST STATEMENT - The authors declare that they have no conflict of interest.

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FIGURE LEGEND

(Photos courtesy of the *Luigi Cattaneo Museum of Anatomical Waxes*)

Figure 1. *Brain morphology* by Cesare Bettini. This waxwork model is three to four times life-sized.

Figure 2. Display cabinet, Luigi Cattaneo Museum of Anatomical Waxes. The size of Bettini's *Brain Morphology* wax model in Figure 1 is demonstrated as it hangs above shelves containing natural skulls.

Figure 3. *Fetus linked to the placenta via the umbilical cord with demonstration of fetal circulation* by Giuseppe Astorri.

Figure 4. *Pygopagus* by Giuseppe Astorri.

Figure 5. *Wax model of lower limb melanoma* by unknown artist of the University of Bologna.

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