

## DEVELOPMENT OF ANATOMICAL MODELS – CHRONOLOGY

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History of anatomy is full of data about continuous struggle between scientists, who fought to do their research by cadaver dissection, and the whole society, led by religious believes. Changes in society and religious organizations, dependent of religion and environment, often denied the possibility of doing that kind of research. Even when it was allowed to use cadavers in research, there was always a lack of legally provided cadavers, so the need for adequate replacement was always present. Apparently not so important for the history of medicine, anatomical manikins were used to educate generations in crucial moments and to continue scientific research in the area of human anatomy as one of the basic sciences of medicine. *Acta Medica Medianae* 2010;49(2):56-62.

**Key words:** anatomy, history, anatomical manikins

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### Introduction

“You can learn much more if you create rather than destroy, bringing together rather than tearing it apart, mimicking the dead rather than killing again something that has already been dead.”

Johann Wolfgang von Goethe,  
“Years of learning Wilhem Maister”

The interest in human anatomy had been recorded in the history of art much earlier than the science of anatomy was even invented. The first example we can find in the history of art is the Venus of Willendorf, dating from the period between 24.000-22.000 years BC.

The development of anatomy as a science is dating from Egypt, and the first use of cadavers with the aim of research took place in Alexandria, in the IV century BC, when Herophilus and Eristratus managed to get the license to perform vivisection on two offenders. Paradoxically, doctors returned to the animal vivisections in the following years. Arabic doctor *Ibn Zuhr* (1091-1161) is the first known doctor who performed a vivisection of the human corpse and post-mortem autopsy. *Ibn Jumay* performed it immediately after (1).

### Cadavers made of wax

The first wax models which represent body parts, organs and part of the organs, but with no details and therefore with no educational purpose, can still be found in catholic churches like Orsammichele and Santissima Annunziata in

Florence (2). The wax preservation method first entered the world of medicine at the beginning of the XIV century, when young female assistant of the famous Italian anatomist Mondino de Liuzzi, Alessandra Giliani, started to practice the technique of injecting wax directly into cadaver blood vessels. M. Medici states in his book *Compendio storico della scuola anatomica bolognese* (1857) that she became that precise in modeling because she could inject wax into smallest blood vessels (3).

The oldest model made of wax produced with the aim of education was “The anatomical head” made at the end of XVII century by Sicilian artist *Gaetano Giuliano Zumbo* who worked for *Cosimo III de’Medici*. He was educated in the first school of wax modeling (*ceroplastica*) at the Scientific Institute in Bologna. His work was continued in the XVIII century by famous Bologna painter *Ercole Lelli*, who assisted in the establishment of Anatomy Department at the University in Bologna by making remarkable anatomical manikins with the purpose of education. After Cardinal Lambertini II was introduced to *Lelli’s* work he started a project whose purpose was the foundation of a cabinet with eight exhibited anatomical manikins for education of students. After this project, *Ercole Lelli* continued his research in form of illustrating and making smaller anatomical manikins together with little wooden boxes for storage (3, 4). Following his work, *Anna Morandi*, the wife of professor of anatomy *Giovanni Manzolini*, started to model in wax. When her husband fell ill with tuberculosis, she received an exclusive right to teach anatomy instead of him. She was invited to lecture in many European Universities. At the peak of her career she was invited to the Russian court by Catherine II. She included gynecology into her work, where she included every detail of pregnancy and labor. The collection consists of: 30 tables with wax modeled sense organs, separate models of urogenital tract, cardiovascular system and

obstetrics (3). *Giuseppe Astorri* later continued working on collection in Bologna, and he was declared an official model maker of the Institute of Human anatomy in 1816. In his opus we find many works that study structure of joints, urogenital tract, anatomy of hermaphrodites, Siamese twins, etc. His most important achievement represents sculptures that show cranial nerves, cervical plexus and sympathetic nerves (5). *Cesare Betinni*, Italian painter, designer, illustrator and model-maker, best known for his works in the field of brain anatomy where models were made in size larger than natural was in the same team (6, 7).

Second formed school in Italy later known as "La Specola" was the school of the famous artist *Felice Fontana*, founded by Medicci family. Artists who made the collection in Florence were educated in Bologna. The first bond was made when Florentine gynecologist and surgeon visited Bologna and saw the works of *Lelli* and *Morandi*. Then he decided to form his collection of models dedicated to gynecology, made of wax and terracotta, with the help of Florentine sculptor *Giuseppe Galletti* in order to educate his students. That collection consisted of models that represented positions during labor and most frequent labor complications. After anatomical model use started in Florence, *Felice Fontana* realized that production of a large number of wax models would solve existing problems in education. *Fontana* hired *Giuseppe Ferrini* as his chief model maker and *Antonio Matteucci* and 19-year old *Clemente Susini* as assistants. *Susini* produced more than 2.000 models until his death. In 1780 „La Specola" was visited by Austrian tsar *Joseph II* when he ordered from *Clemente Susini* a large number of figures for Museum Josephinum (8). *Specola* workshop made models that were transported also to: Pavia, Bologna, Cagliari, Budapest, Paris, London, Leiden, etc. In 1790, *Felice Fontana* got the idea to form the collection of wooden models that would prove the way organs function in cooperation with his team. The project failed since it was impossible to make models due to the war that was currently going on, so only a few failed attempts survived, among them „Venere medica", a pregnant woman whose organs could be taken off (2, 9). The most fascinating model that was made in that period was a model of a man standing, made of 3000 pieces of wood that could be moved. Every piece showed up to 100 details. It took *Fontana* 10 years to make this model, and interesting fact is that this model could be both male and female. In 1796, *Napoleon Bonaparte* ordered a copy of this model, but he changed his mind after the war, since making of the model cost about 30.000 liras (10). After *Fontana's* death, Museum continued with its work, but never restored the old glory (2, 9). „La Specola" later became the first museum that held the permanent exhibition of its displays that could be visited by wider audience, in separate terms people from lower classes and in separate people from higher classes (4, 11). Model of "Anatomical Venus" from XIX century that can be seen in „Museu d'Historia de la Medicina de Catalunya" reminds us of models made in „La Specola" especially if

we pay attention to her movement and the way she is made. It is impossible to determine neither the exact date of her making nor the artist who made it (12).

Another woman who was successful in wax modeling was *Marie-Catherine Bihéron*, a French-woman. Academics considered her to be the most successful artist in her field. Since she never worked on an Institute and she was making profit only by opening the doors of her studio to people once a week and lectured anatomy, doctors considered her to be the competition. They accused her of paying people who illegally excavated corpses from the graveyard, to provide adequate models. Soon after she was forced to move out of France and went to London in order to find a job, without success (13).

The most notable work in the XVIII century was the work by *Andre-Pierre Pinson*, surgeon, anatomist and sculptor. He was finding his inspiration in artistic paintings by *David* and *Ingres*. He exhibited his works in the Academy of Science and in the Louvre, and later his works became a part of the collection by duke *Orleans*, after whose death collection became the property of the „Musee national d'histoire naturelle" (14). Collection of wax figures in the Obstetric Museum "Giovan Antonio Galli" is extremely interesting because it is dedicated only to gynecology. The purpose of this collection was training of midwives and doctors how to perform labor. *Giovan Antonio Galli*, a doctor in Bologna, noticed that surgeons have more theoretical than practical knowledge and that midwives used to rely on experience and good fortune. In collaboration with Pope Benedict XIV, who donated funds, he formed a collection. The central place in museum exhibition had a soft model of fetus inside a glass uterus. Students' task was to simulate labor in front of professors with a piece of cloth over their eyes (15). A smaller collection is located in the Museum of Science in London, but the author of that collection is unknown (16).

The *William Bonard* collection was founded by Swiss painter *Leonce Schiffman* in the early XX century. Besides its educational purpose in medicine, the collection was extremely important in education of people in several German cities (17). Author of these models is unknown, but it is well known that it was later inherited by owners of a "carnival freak show", *William Bonard* and *Lily Binda*. They made their funds by exhibiting these figures in settlements. She said: "I saw people entering the show drunk, and went out completely sober" (18). After legislation in 1960, when carnivals were prohibited, *Binda* continued to travel across the whole Europe with figures, exhibiting them in amusement parks (19, 20).

Collection of wax figures in the Guy Hospital's Medical Faculty Museum in London was modeled by the English sculptor *Joseph Towne*, known in the History of art by anatomical models. When he was 17, he started to work on laborious project-making a sculpture of a human skeleton even if he had never seen one. When he wanted to donate his sculpture to Cambridge, he received an answer that the sculpture is "too artistic". He wanted his sculpture to be "realistic" not "artistic", so he insisted to know where he made

a mistake. He met a famous surgeon *Astley Cooper*, whose dream was to make a collection of wax figures that could be compared to Florentine collection. His work seriously improved, so the next year he won the first place on contest with his work "Dissection of a head". In 1852, he sculptured a remarkable model "Amazing bust of Towne". Stories about his success spread across the whole world so he sculptured more than 200 models for India and America. *Joseph Towne* remained loyal to *Guy's* hospital until the end of his career, even when he wasn't paid for his work (21, 22). At about same time, *Jules Baretta* was sculpturing models of dermatological diseases and his models were extremely successful but devoted only to lecturing pathology in „*le Musee des Moulages*" (*Hospital St Louis*) (23).

#### Wood, papier-mache, ivory, silk

China was one of the first countries to introduce anatomical models into medical practice, but their models dating from XIV and XV century were mostly the models with pierced wholes at specific acupuncture points (24). During the XVIII and XIX century, the Japanese doctors left the work that was similar to Chinese and began to make wooden dolls, anatomical models that were used for patients and scholars' education. Until this very moment the only way to explain anatomy to students and patients was using sewed organs made of silk. Two Japanese wooden dolls can be found in the National Museum of health and medicine in Washington (25). The other type of models were Japanese pregnant

women that were part of carnival named *misemono*, dating from VIII and XIX century.

From the XIV until XVIII century in France, Germany and Italy, anatomy was studied with the help of ivory figurines made by artists. Those figurines were sculptured out of single piece of ivory, with organs that were movable and hands that could change position. Similar figurines were also made of wood, but ivory figurines were considered a luxury. One of the most famous artists who made those figures was *Stephan Zick* from Nurnberg, from a family of ivory sculptures. He formed a school in Nurnberg in which many students were educated. He was best known for making anatomical models of pregnant women as well as for making models of the eye in natural sizes. *Giovanni Baptista Verle* was making similar models. Ivory and glass models of the eye that showed all details of an eye bulb were being made in Italy at the same time and they were coming together with rose-wood boxes. In models of pregnant women it was possible to remove the front part of abdominal wall and some organs in order to see the uterus and fetus in development that was connected with placenta by fetal cord made of silk. Figurines were usually made in that manner so that they could fit into little wooden coffins. The size and lack of anatomical details in anatomy models of pregnant women show that their purpose was sexual education of wider population. Some other artists that were making similar models were *Johan Martin Teuber* from Regensburg and *Johann Michael Hann* with his two sons (24, 26).



Figure 1. Anatomical model of pregnant woman, ivory, Germany, 1601-1800.  
Taken from the web site of Science Museum in Londonu.  
<http://www.sciencemuseum.org.uk/broughttolife/objects/display.aspx?id=10406>

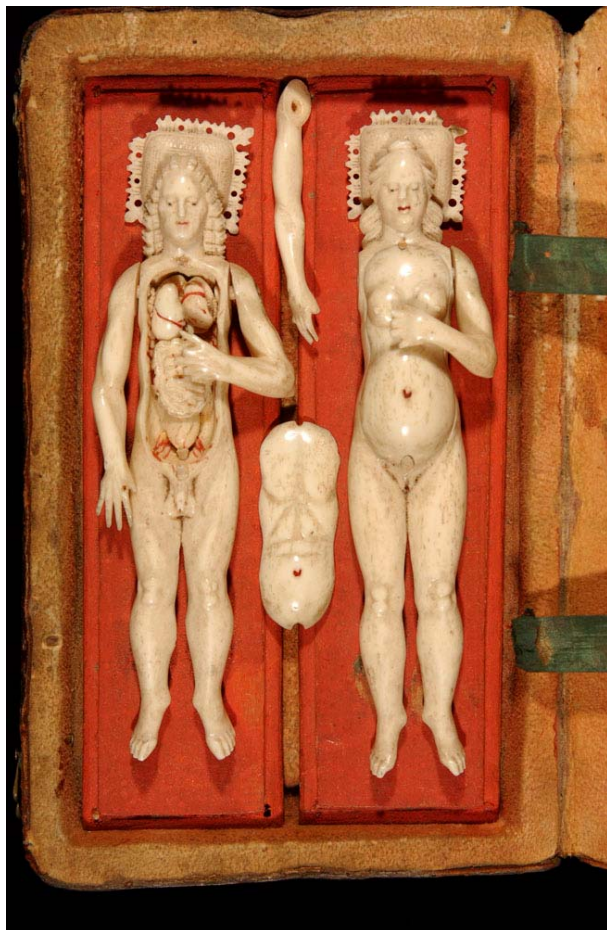


Figure 2. Anatomical models of man and pregnant woman, Europe, XVIIIth century. Harvey Cushing/John Hay Whitney Medical Library, Medical History Library, Yale University. Taken from the web site: <http://www.med.yale.edu/library/historical/founders/donors.html>

Frederik Ruysch, born in Hague studied at the University in Leiden. His main method was preserving organs and cadavers by special secret *liquor balsamicum*. In that way, he formed one of the most important and most famous anatomical collections in Europe. Peter the Great was so impressed by his works that he kissed one of child models because it looked so natural. Collection was sold to Peter the Great in 1717 for 30.000 guilders, together with the secret recipe for *liquor balsamicum* (clotted pork blood, Berlin blue and mercury oxide). Collection can still be found in Petrograd. Ruysch started all over again and formed a new collection that was later sold to August the Great (26, 27).

In the XIX century in Paris, a medicine student Louis Thomas Jérôme Auzoux noticed a permanent lack of cadavers in practical classes of anatomy. That is why he developed a special technique called papier-mache and thereby formed a large collection of anatomical models that are now being kept in museums all over the world. After a few years, Auzoux earned enough money to open his own factory of anatomical models that were made to be suitable in complexity dependent of student's age. Auzoux's models were extremely important all until concurrent companies started to produce plastic

and plaster models at the end of XIX century (10, 28, 29).

Certainly less scientifically significant, but still valuable is a plaster statue showing the open chest and all of its organs. This statue was modeled by an English sculptor Christopher Hobbs in 1970. He used a German graphic from the XV century as the basis for the sculpture. We can see that skin, muscles and bones are removed from the chest in order to highlight the heart, lungs and part of the liver. The purpose of this statue is not known, but it is known that it was used in the movie "The Devils" by Ken Russel. After that it was donated to the Wellcome Institutu by the Pinewood studio (30).

### Fight for wax models in Germany

In XIX century in Germany Johann Wolfgang von Goethe, the Minister of Government, put out a proposal which he called "the plastic anatomy". The idea meant that the Institute for plastic anatomy in Berlin was supposed to be founded. A few weeks before his death, the proposal was rejected. However in 1842, a young sculptor Paul Zieller started to work on wax anatomical model in Munich, the Bavarian centre of arts and science.

The leading anatomist in Munich Ignaz Dollinger considered Fontana's experiment a failure, and Auzoux's models made of papier-mache not enough precise. But Zieller continued his work and his and his wife's Franziska's works can now be found in The Antropological Museum. After Zieller set free from the impact of anatomist Dollinger, he formed a collection of extreme quality with models of: locomotor apparatus, sense organs, brain and embriology (31).

### Modern days

After invention of plastic, new opportunities in studying of anatomy were developed. That is how a model named "transparent woman" was constructed in 1930 in Germany for the needs of the German Museum of Hygiene, as a couple for a "transparent man". A "transparent woman" was represented to public for the first time in 1936 in the Museum of science in New York. According to press in those days, a transparent life-size woman had 40 lamps inside herself that alternatively lit the organs made out of a special material called "cellhorn". A tragic story was behind that sculpture. Namely, the bones were taken from the body of a young woman from Dresden who died in a car crash, and then were covered with paraffin. Thirty years later, a new generation of "transparent women" was constructed, and they were taken from town to town with the purpose of educating society, until they finally became a part of museum exhibitions. It is interesting to notice that it is almost impossible to find figures of "transparent men". One of them was a part of the exhibition in the Museum of Meyo Clinic until it was closed. In 1968, an American designer Richard Rush constructed the first Transparent Anatomical Manikin (TAM). It was made out of plastic

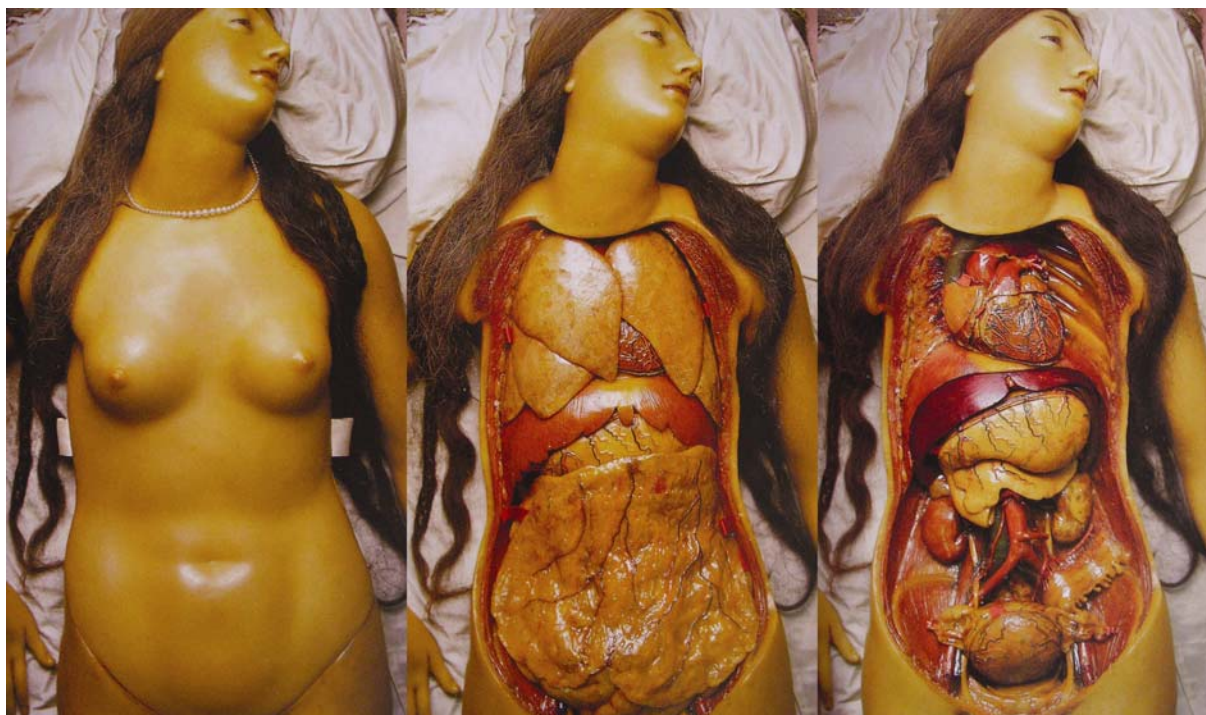


Figure 3. Anatomical Venus, Museo La Specola, Florence, Italy  
Taken from the book Museo La Specola Florence. Encyclopaedia Anatomica. Köln: Taschen; 2006

and had a possibility of lightening organs with the purpose of education. *Richard Rush* constructed 42 TAMs, and most of them still work. These models became extremely popular when one of them was printed on the front page of CD "In Utero" by American band Nirvana, as well as "Music from the body" by Roger Waters. In 1980, *Rush* created a cheaper version, the so-called Mobile TAM, and only 35-40 of them were sold. Most of them can be found in museums, and some of them are still a part of educating traveling groups. In 1992, Studio Rush was bought by a larger company and manufacturing of TAMs stopped since then. It is believed that one of the reasons for this is a start of interactive CD production. The most popular figure is "Juno", that can be found in Cleveland, constructed by *Franz Tsahackert*, who worked in Dresden Museum until the beginning of the World War II, and escaped in the USA in 1950. This figure is a replica of a 28 year-old woman that can rotate and talk its story by pressing a button. The same fame is shared by the Transparent Twins in *The Fort Crawford Medical Museum in Prairie du Chien*. The extreme example of a transparent woman is called "Tess" and she is about 15m high. She can be found in LA (32).

In the XXI century, anatomy gets an artistic dimension owing to *Gunther von Hagens*, who is known across the whole world by his technique called plastination. In 1993, he formed the Institute for plastination in Heidelberg. At the beginning, plastination was used for organ and body parts preservation, and then in 90's *von Hagens* invented a way to preserve the whole body and to make artistic figures out of bodies. Now he is exhibiting his collections as a part of Body World exhibitions in more than 50 cities around the world. His work is meeting a very sharp criticism by the Catholic Church (33,34).

When we consider all the artists and scientists who were involved in debate, struggle and making of models out of different materials, we find it devastating to conclude that we came back to making anatomical models out of cadavers at the end of the XX century. Science of anatomy is inherently linked with art and we can only guess what will happen after *von Hagen's* and plastination. The only thing we can conclude is that despite the efforts of top anatomists and artists, the anatomy of a human body can only be studied by using human body in the true sense.

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## HRONOLOGIJA RAZVOJA ANATOMSKIH MODELA

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Istorija anatomije je prepuna podataka o neprestanoj borbi između naučnika koji su se borili da svoja istraživanja vrše disekcijom kadavera i celokupnog društva vođenog verskim načelima. Promene u društvu i crkvenoj organizaciji, zavisno od vere i područja, su veoma često to pravo uskraćivale a čak i kada je to bilo dozvoljeno javljao se manjak legalno obezbeđenih kadavera, tako da su uvek postojale potrebe za adekvatnom zamenom. Naizgled za istoriju medicine nedovoljno važni, anatomske modeli su služili za obrazovanje generacija u presudnim trenucima i za održanje neprekidne niti naučnog istraživanja u oblasti anatomije kao bazične grane medicine. *Acta Medica Medianae* 2010;49(2):56-62.

**Key words:** *anatomija, istorija, anatomske modeli*