# *Anatomical Waxes in 18th Century Italy*

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## Introduction

Since the antiquities wax has been regarded as prodigious material. Egyptians, Greeks, Etruscans and Romans used it to create religious and commemorative figurines. Plinius the Elder' Natural History treatise described the medical, cosmetic, industrial and religious properties of wax. In 14th century Italy, wax modeling was an established craft that produced large numbers of life-sized statues and votive limbs, organs or parts of organs for churches and the public. In the 15th and 16th centuries, Leonardo da Vinci and Michelangelo Buonarroti began to experiment with the flesh-like properties of wax and created three-dimensional and life-like representations of the human body.

## Waxes as Didactic Tools in Medicine

The earliest surviving anatomical wax model specifically produced for medical didactic purposes is the "Anatomical Head" created toward the end of the 17th century by the Sicilian Gaetano Giuliano Zumbo (1656-1701) who worked for Florentine Cosimo III de' Medici and attended what was to become the first school of wax modeling or "*ceroplastica*" at the Institute of Sciences of the University of Bologna (1). This school was founded in 1711 by Luigi Ferdinando Marsigli under the auspices Pope Benedict XIV and was active for over 150 years (2-3). A second and equally eminent school, active for almost a century, was later founded in 1771 by Felice Fontana (1730-1805) at the Florentine Museum of Physics and Natural History, later called "La Specola", under the auspices of the Grand Duke of Tuscany Peter Leopold of Habsburg-Lotharingen whose love for the sciences was inherited by his grandson Leopold II nicknamed "*canapone*" (from *canapa* or hemp) by the locals for his white hair (4). La Specola was the first museum of its kind to admit general public albeit at separate hours for "cleanly clothed" lower class people and "intelligent and well-educated" higher class individuals (4). Its collections included 19 full anatomical male and female wax figures, over 1,400 wax models of human organs and body parts, comparative anatomy and zoological specimens. The greatest Italian wax modelers ("*ceraioli*") worked at these two schools including Ercole Lelli (1702-1766), Giovanni Manzolini (1700-1755) and his wife Anna Morandi (1716-1774), Felice Fontana (1730-1805), Clemente Susini (1757-1814), Giuseppe Astorri (1785-1852), Cesare Bettini (1801-1855), and Luigi Calamai (1800-1851). These and other modelers produced artistic and accurate models that would obviate the need to exhume corpses for medical education and surgical training at several European universities.

## Technique of Anatomical Wax Modeling

Little is left of the armamentarium utilized by the Italian wax modelers. The Specola's archives maintain documents that registered the purchase of copper containers to melt wax, modeling tools including iron filaments, marble slabs to flatten the wax, balances, stove tripods, blackboard slabs to sketch and annotate anatomical parts during the autopsy, baskets with handles for transportation of cadavers, wooden boxes to transfer waxes, glass and clay vases to store pigments and other substances that were to be added to the wax (4-5). Because of the lack of effective preservatives, an average of two hundred cadavers was required to make preparations that captured the anatomical details needed to create a full anatomical wax figure! There was a close collaboration between anatomists, who performed careful dissections following the drawings of anatomical treatises, and the modelers who then produced the waxes. The technique for creating wax specimens probably varied from modeler to modeler but specific details are sketchy due to the secretiveness of the trade. Zumbo's Anatomical Head was gruesomely modeled directly on the decapitated head of an executed citizen from Genoa while later modelers made first a copy of body parts using inexpensive wax or clay. A plaster cast was then created that could be utilized as a template more than once. The definitive wax was the white Smyrna or Venice wax mixed with Chinese or plant waxes, mastic, tallow, turpentine, and fats to increase the melting point and elasticity. Once melted, the wax was mixed with finely ground and pre-filtered pigments of body part-specific color previously dissolved in turpentine. Various layers of wax were then stepwise poured into the plaster cast previously moistened with warm water and soft soap to facilitate the detachment of the cured wax. Smaller models made entirely of wax were built around an inner cavity filled with plaster or clot while larger specimens, such as full figure models and their parts, were built around an inner metal or wooden armory. Using fine brushes or silk threads and freshly prepared waxes of various colors, specialized teams would then create blood vessels, lymphatics, nerves, tendons, fasciae or other needed refinements. Models were finally covered with transparent varnish. Alterations and restorations were done when anatomical reproductions were deemed inaccurate or deteriorated.

**Wax Modeling in Bologna**

Why anatomical waxes? The answer may be found in a document by Marsigli entitled "Parallels between the University of Bologna and Institutions Abroad" that advocated a drastic revision of the methods to teach anatomy introduced over four centuries earlier by Mondino da Liuzzi (2). However, cadavers were scarce and dissected body parts or organs could not always be well preserved, even with the dry preparations suggested by Valsalva (1666-1723). These preparations did not always faithfully reproduce morphological reality and spatial relationships. Thus, the need to explore other pedagogic modalities lead to the development of anatomical models precisely reproducing the findings in dissected cadavers and made of wax, a long lasting and easy to mold medium. As indicated by Fontana, wax models were meant not just to represent but also to replace anatomical parts and avoid physicians "soiling their own hands". The wax of a horseshoe kidney modeled on a specimen discovered at a "public dissection" was the first demonstration project in 1705 that displayed the artistic and anatomical talents of Lelli in Bologna. As this city was part of the Papal State, Pope Benedict XIV commissioned Lelli the creation of a "wax school of anatomy" and the replacement of all dry specimens in Bologna's Institute of Sciences with wax models, at a cost of 17,000 liras. Lelli took up this charge with enthusiasm by creating a series of eight statues beginning with two intact statues ("Adams and Eve") and continuing with statues deprived of skin integument (so-called "*scorticati*" or skinned) depicting muscular layers of various depth and skeletons with movable parts. Lelli was nominated *motu proprio* by Benedict XIV as keeper and illustrator of the Institute's "Room of Anatomy" for which he even designed elegant wooden cabinets to house the anatomical models.

Anna Morandi was the professional heir to Ettore Lelli and together with her husband Giovanni Manzolini distinguished herself in Italy and Europe as the creator of a rich series of thirty tables with wax models representing the organs of sense, and other work displaying the urogenital apparatus, the cardiovascular system and obstetric anatomy. In 1758, three years after the death of her husband, she was nominated official modeler for the Chair of Anatomy by the Bologna Senate at an annual stipend of 300 liras with a lifetime supplemental stipend derived from

University taxes and was also given the choice to teach either at the University or at home. She received invitations to speak at several European universities and the Royal Society of London and to meet with the Russian Empress Catherine II. Upon her death in 1774, Luigi Galvani referred to "*that extraordinary Lady who set the example for our and foreign men in moulding with equal skillfulness even the most tenuous…the thinnest…and most diaphanous parts, those that would almost escape from the sight…*" (3). Her entire collection of wax models, including wax tables commissioned by Professor Giovanni Antonio Galli (1708-1782) for his domestic school of obstetrics, was purchased by the Academy of Sciences for 3,000 shields (3). Among other modelers in Bologna, one must mention Giuseppe Astorri and Cesare Bettini who produced excellent anatomical and pathological waxes, Giovan Battista Manfredini (1742-1829) who produced several wax models of "internal organs, vessels and nerves in natural size", and Pietro Sandri (1789) who created a wax statue with removable elements to demonstrate the second and third trimesters of pregnancy.

**Clemente Susini and the Florentine School**

The Italian collection was later enriched by the contributions of other anatomic wax modelers at Florence's La Specola such as Felice Fontana, Luigi Calamai and Clemente Susini whose collective works were admired among others by Goethe, Stendhal and even the Marquis De Sade. Susini produced there an Anatomical Venus, the so-called "*Venerina*", and other waxworks including the lymphatic system and the "organ of hearing and balance". Susini's fame was sealed through the commission by the Austrian Emperor Joseph II, Peter Leopold's brother, for a complete collection of anatomical wax models in Vienna. At the agreed cost of over 30,000 florins, work begun at the house of Felice Fontana resulting in the production of more than 800 specimens delivered in 1786 to the Josephinum's Museum in Vienna after a perilous voyage by mules over the Italian Alps (4). Susini produced over 2,000 models and, through an extensive use of prototype molds, several copies of the same model. For instance, Bologna's "*Venerina*" is reclining and modeled onto a natural skeleton while the Florentine's "*Venerina*" is reinforced by iron support. Both models come apart layer by layer to reveal both breasts, the rib cage, successive layers of muscles, heart and lungs, the intestines and other major organs to finally demonstrate a pregnant uterus. Susini's anatomical waxes extended the artistic beauty of Italian waxes while attempting to maintain anatomical reality as he adopted a hedonistic and sensual approach in tune with the Romantic tendency of his time. His dual passion for art and science was reflected by overlapping activities at La Specola and the Fine Arts Academy in Florence where he taught nude drawing.

**Pathological Waxes in Bologna and Florence**

The development of pathological waxes was a logical outcome of the pedagogic success of their anatomical counterparts. Even with the basic contributions of Morgagni (1682-1771), pathology did not exist as a specific branch of medicine before the $19^{th}$ century and consequently pathological and anatomical demonstrations, including wax models, shared same professors and institutes. In 1840, this situation changed with the creation of the first Italian Institute of Anatomic Pathology in Florence where several pathological waxes housed since 1824 at the Academy Museum and Santa Maria Nuova Hospital, were transferred (6). Here and at the Bologna's Institute of Anatomic Pathology chaired by the teratologist Cesare Taruffi (1821-1902), collections of waxes were developed representing congenital abnormalities, infectious processes, dermatological disorders, cardiovascular diseases and neoplasms (6-7). Notable among these waxes were the “man with scabies” (so-called “leper”) and a congenital hydrocephalus by Luigi Calamai, a perforated septal aneurysm and a gangrenous bowel, a tibial osteomyelitis by Giuseppe Ricci, a pseudo-hermaphrodite and a *pygopagus* by Cesare Astorri as well as a tuberculous scrofula and a fibrinous pericarditis by Egisto Tortori. Illustrious visitors including Virchow, Meckel, Hodgkin and Dupuytren commented favorably on these collections, which even today could serve for gross demonstration, especially of rare entities, to medical students and pathology residents. Visiting the Taruffi museum in Bologna, Virchow was particularly impressed by the skeletal changes of one if its waxes, the so-called “Bottaro” by Pietro Sandi. Both Taruffi and Virchow failed to associate these changes with acromegaly as this entity would be recognized ten years later!

**Conclusions**

The contribution of Italian wax modelers to anatomy and pathology is undeniable and is a witness to the Italian genius and to a time when participation in gross demonstrations was a proven tool that effectively complemented lectures and book readings (8). Building on the anatomical discoveries made in the age of scientific Enlightenment, wax models afforded medical students and surgeons comprehension of normal and aberrant processes with a physical immediacy not afforded by fixed organs and tissues as in addition to tridimensionality they offered the dimension of color, an essential element to successful gross diagnosis. Waxes also accomplished their intended purpose through a pleasing artistic rendition of reality even if fragile and unauthentic reproductions of the living. To paraphrase 18$^{th}$ Century Pope Benedict XIV, anatomy and pathology must be appreciated more “with the eyes than with the ears”!

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***Teaching with the Preserved Body: From Desiccation to Plastination***

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## Introduction

A theme throughout the history of medicine has been the quest for knowledge about the interior of the human body. Much of this knowledge has come from dissection. The knowledge gained has been disseminated in various ways including the elegant manner presented in the first paper of this symposium: the use of anatomical waxes to preserve structures that in themselves could not be saved. But the wax models were not entirely adequate. Why was this art not continued?

The use of wax models in the 18th century helped overcome two difficulties: 1) the scarcity of cadavers, and 2) the lack of adequate preservation techniques. But waxes, despite their often incredible realism, are a wholly artificial re-presentation of the body, lacking the horror factor brought about by wetness and smell, as Goethe noted, but also lacking the impact factor that Gunther von Hagens has called "unadulterated authenticity," that here is something that was once living. Waxes, for the most part, lack the touchability and immediacy factor. Most are fragile and are meant to be viewed, not handled. Thus, when preservation techniques improved, waxes waned, for preserved bodies could then meet the challenge of cadaver scarcity.

## Preservation of the Body

Modern techniques used to preserve the human body for didactic purposes build on methods that began in the time of the Egyptian pharaohs. Desiccation was the primary means of mummification in the Early Dynastic period, and this same general technique was one of the first means used to preserve specimens for teaching, rather than religious, purposes. These desiccated specimens included both individual organs and whole body sets of nerves and vessels. Antonio Marie Valsalva (1666-1723) produced some of the earliest preparations of dried teaching specimens, and his family donated many of these to the Institute of Sciences in Bologna where they were used so extensively they were virtually destroyed. This gave impetus to the beginning of ceroplasty. Honoré Fragonard (1732-1799), who taught at both the medical and veterinary schools in Paris, invented a secret varnish to coat his desiccated specimens. Later improvements came by placing the specimen in alcohol or spirits of wine. The Meckel family of physicians, especially Johann Friedrich Meckel the Elder (1724-1774) and the Younger (1781-1833), prepared a large group of specimens that was quite famous in its day. Many surviving pieces can be viewed in the anatomical collection of Martin-Luther-Universität Halle-Wittenberg. The use of arterial injections, which added a life-like color and preservation of deeper structures, was developed by Frederik Ruysch (1638-1731) and improved by the Hunter brothers, William (1718-1783) and John (1728-1793). Embalming solutions were later developed that were better able to preserve whole bodies. One of the most important of these that greatly improved the quality of teaching specimens was formaldehyde. William Keiller (1861-1931) at the University of Texas Medical Branch in Galveston was one of the first to use this chemical in embalming medical school preparations. Later additions to embalming solutions included phenol and glycerin.

## Plastination

A further advancement in preservation of the body was made through the replacement of the remaining fluids in an embalmed body with a polymer. This technique was invented in 1977 by

Dr. Gunther von Hagens (1945- ), who called the process “plastination” and acquired numerous patents for the process. This technique again builds on earlier ones. Once the body has been embalmed, a careful dissection is performed to expose the parts chosen for display. Then the body is placed in an acetone bath. The acetone is absorbed through diffusion and dissolves fats. After the body has been thoroughly impregnated with acetone, it is placed in a polymer such as silicon. The acetone is extracted with a steady vacuum, while the polymer is drawn into the body, replacing the acetone. The body is then posed into its desired position, and depending on the polymer used, the plastic is hardened by gas or by heat. The final plastinate has flexibility and a life-like color and lacks the smell or toxicity of other methods.

**Plastinates and Pedagogy**

As plastinates enter the academic arena, what are their advantages over the other preservation techniques? In comparison to desiccation, the plastinated body can preserve the normal appearance, e.g., color, size and shape, of the living being and the important relationships of organs, vessels and nerves. In comparison to storage in alcohol, the plastinated specimen remains dry, touchable, and is more visible. In relation to embalming, plastination removes the horror factors such as smell and wetness, but the immediacy remains. There is touchability, a sense of authenticity, and, indeed, a certain beauty. The plastinated specimen can take on the same sense of artistry that is apparent in the anatomical waxes.

Plastinates are valuable in the education of health care professionals. They have been used to great advantage as adjuncts in the dissecting lab as well as in residency programs. One is able to preserve excellent dissections, display anatomical abnormalities and disease processes, and also demonstrate the results of various surgical procedures.

But plastinates are also useful in museum exhibits that educate the lay public, not only the highly selective health care professional. This is an important extension of the museums that the parent society of the USCAP was formed to preserve. If the public is well educated, they will not entertain a fear or suspicion of the unknown and will be more inclined to endorse and support medical research. The enthusiasm for Gunther von Hagens’ *Body Worlds* exhibits has demonstrated the interest that the public has in being educated about their bodies. Von Hagens’ work in bringing medical science to the public can be compared to the programs that Carl Sagan developed in astronomy and Steven J. Gould developed in natural history. Although, these contributions are held in low esteem by some academics, these programs reach far more individuals than those in university classrooms and can have as great or even greater consequences.

With the use of real cadavers, the *Body Worlds* exhibits have engendered controversy from the church as well as from academics, particularly in Europe. The arrival of the exhibits in America has not engendered such a strong debate. The American museums have formed ethics boards that include academics as well as religious and community leaders. This has brought about an understanding and enthusiasm for exhibits that endorse the democratic ideal of providing medical information that is available to all.

**Conclusions**

The plastinated specimen has brought tridimensionality to teaching in the form of clean, touchable, authentic, non-smelly, non-toxic, non-biohazardous specimens. But is this enough? The remaining presentation in this symposium may provide some answers.

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***Digital Anatomy for the 21st Century: Creating the Virtual Patient***

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The development of a virtual patient is highly dependent upon the availability of both a high level of computing capability and a detailed set of data from which to construct the virtual model. During the past three decades great strides have been made in both of these areas. We are entering an era in which virtual patients will become not only useful but essential for the training and practice of modern medicine.

**Advances in Computer Technology**

The late 1970's to early 1980's witnessed the release of the Apple II desktop computer (1977); the first portable computer, the Osborne 1, that weighed 24 pounds and featured a 5-inch display, 64 kilobytes of memory, a modem, and two 5 ¼ floppy disk drives (1981); and the IBM PC-AT (1984), based on the Intel 80286 chip, featuring a high-density 1.2-megabyte, 5 1/4-inch floppy disk and the Microsoft Disk Operating System (MS-DOS). The workhorse of the research computers was the VAX 11/780 from Digital Equipment Corp. which was able to address up to 4.3 gigabytes of virtual memory. In 1984 the object-oriented programming language C++ was introduced providing greater ease and versatility in software development. By the late 1980's computer technology advanced to a point that computer simulation was first possible. In the late 1980's the concept of virtual reality became a hot topic. Silicon Graphics computers were optimized to maximize the features of computer-aided design software. Computer-generated 3-D environments were produced that allowed users interaction. One of the most successful of these endeavors was the flight simulators that are in common use today. Throughout the 1990's the number of simulations grew as did their sophistication. Simulations such as SimCity, allowed the user to create his own city with buildings, roads, and waterways. Basic services like health care and education and challenges in the form of natural disasters, airplane crashes, and monster attacks could be added to the simulation. By the late 1990's computer technology had advanced to the point that companies such as Reachin Technology (Stockholm, Sweden) and Immersion Technology (San Jose, California) began research and development of surgical simulation workstations. New societies such as Medicine Meets Virtual Reality (MMVR) were initiated where researchers could share research data and demonstrate state-of-the-art computer simulation devices.

**Medical Imaging Technology**

During the 1970's computed tomography (CT) and magnetic resonance imaging (MR) became a core component of clinical medicine. In 1975, Robert S. Ledley (Georgetown University) was granted a patent for a "diagnostic X-ray systems" also known as CAT-Scans. For the first, time detailed images could be obtained of the internal organization of the body by way of a series of two-dimensional slices. By imaging and looking at a series of these slices a doctor could tell not only if a tumor was present, but roughly how deep it was in the body. Initially these slices were no less than 3-5 mm apart. Advances in both computer and imaging technology during the past decade resulted in development of the advanced spiral (also called helical) CAT scanners which can now produce high resolution, contiguous, 1 mm slices through the body in a matter of seconds.

Magnetic resonance imaging (MRI) technology was not far behind the development of the CT scanner. A physics phenomenon, called nuclear magnetic resonance or NMR, was identified by Felix Bloch (Stanford) and Edward Purcell (Harvard) in the 1930's. With this technology magnetic fields and radio waves caused atoms to give off tiny radio signals. This led to the development of NMR spectroscopy which is still routinely used in laboratories around the world in the study of the composition of chemical compounds. By modifying the use of NMR technology, magnetic resonance (MR) imaging devices were developed for medical imaging. In 1970, Raymond Damadian (SUNY), reported that different kinds of animal tissue emit response signals that vary in length, and that cancerous tissue emits response signals that last much longer than non cancerous tissue. Less than two years later he filed his idea for using magnetic resonance imaging as a tool for medical diagnosis with the U.S. Patent Office, entitled "Apparatus and Method for Detecting Cancer in Tissue." A patent was granted in 1974. It was the world's first patent issued in the field of MRI. This work coupled with seminal experiments by Paul Lauterbur (SUNY) and Peter Mansfield (Nottingham, England), both of who received the Nobel Prize in Physiology and Medicine in 2003, culminated in the development of today's MR imaging technology. The medical use of magnetic resonance imaging developed rapidly. MR imaging equipment was first available at the beginning of the 1980s. By 2002, approximately 22,000 MRI scanners were in use worldwide, and more than 60 million MRI examinations were performed.

**Virtual Cadavers**

In order to produce a computed virtual human, a high resolution image data set from which to build the 3D morphology is essential. In 1989 the National Library of Medicine initiated the Visible Human Project (1-2). The intent of this project was to build a digital library of volumetric data representative of normal male and female anatomy. The first Visible Human data set was released in 1994. In addition to CT and MR images of a male specimen, 1,871 cross-sectional images were released in 24 bit color. Image dimensions of 2,048 pixels by 1,216 pixels with each pixel being 0.33 mm in size resulted in an image size of 7.5 megabytes which collectively produced an image data set of greater than 9 gigabytes. In 1994 this set of images exceeded the graphic display capabilities and the data storage capacity of most existing computers. In 1995, a Visible Human female image data set was released containing 5,189 images composing a data set approaching 40 gigabytes in size. Since the mid 1990's these image sets have proven to be invaluable resources in the development of computer-based virtual cadavers and patients. Through continued funding from the NLM, suites of visualization software toolkits have been developed allowing the user to build both 3D volumetric and surface models from the Visible Human Project image data. The results have been the development of education-based products such as the *Interactive Series of Human Anatomy* (Primal Pictures, London) and the *VH Dissector* (Touch of Life Technologies) for the teaching of human gross anatomy.

**Virtual Human Anatomy Navigation System and a Three Dimensional Cartesian Coordinate System**

Until recently it was not possible to objectively measure and statistically compares morphological features between individuals or patient populations. In 2005, a framework for a 3D Cartesian coordinate system for human anatomy was proposed (3). With this coordinate system, an exact 0,0,0 point is defined for all human beings. Using this coordinate system, it is now possible to register volumetric image data in 3D space. Once registered, specific anatomical features such as the shape, size or position of a structure can be accurately and reproducibly measured in 3D space. This data can be used to follow morphological changes that take place during growth and development or to measure anatomical alterations that occur with aging or specific disease conditions. This system is resolution independent and lends itself to increasing detail and complexity as the resolution of medical imaging increases.

**Virtual Patient**

So where does this leave us in our pursuit of the development of a virtual patient? There is no doubt that medical imaging technology is at a point that it can provide us with relatively detailed morphological information of an individual patient. Medical imaging which has historically been a two dimensional technology is now evolving to routinely provide volumetric three dimensional data. Medical imaging researchers are now focusing on the development of scanning devices that capture multimodal (CT, MR & PET) data simultaneously. With development of these new devices the capture of structural and functional data for individual patients that is also registered in 3D space will be possible. This should provide us with confidence that virtual anatomical models of individual patients is not far away.

During recent years the research focus has shifted to an interest in developing not just accurate visual anatomical models but has broadened to include dynamic functional models that reflect the biological nature of the organism. These virtual functional models would realistically simulate the body’s physiological reaction to injury, manipulation or disease. Private companies have been taking the lead in this aspect of virtual patient development. Most of these simulations are mannequin-based with substantial integrated interactive computer components. One such company is Entelos (Foster City, California) who describe their system development as follows: “After modeling human health, we introduce a disease state parametrically, based on disease data, creating virtual patients by changing variables within the system. In simple terms, we "give" the healthy human a disease, creating a virtual patient. We can create many virtual patients that represent known and hypothesized causes for the disease and, using biosimulation experiments, test therapies to understand the patient's likely response to treatment” (Entolos, 2005).

One of the most advanced efforts currently underway is the Virtual Soldier Program initiated in 2003 with supported of the Defense Advanced Research Projects Agency (DARPA) Defense Sciences Office (DSO). The goal of the initial phase of this project is to build a virtual torso with morphological details extending from the gross anatomical to a cellular level. Drawing on the depth and breath of current research and clinical data, the project is an attempt to incorporate a range of physiological components into the virtual computed model. The end point for this initial project is to demonstrate that a detailed computer-based simulation can be built that can accurate predict and display in real time, the complete range of morphological as well as physiological changes that occur immediately following a bullet wound to the chest and heart of a virtual soldier.

Just as the engineering industry has learned that computer aided design (CAD) and finite element (FE) testing of virtual models provide significant advantage, so the medical community will find major opportunities in virtual modeling of the structural and functional components status of their patients. Detailed volumetric images, objective quantitative measurements, and statistical analysis of patient populations will support normative database development to serve as a yardstick for better and earlier diagnoses of a wide range of pathologies. Patient-specific virtual anatomical modeling will provide an opportunity for surgical procedures to be tested or practiced on the virtual patient prior to the actual surgery. The medical imaging and computer technologies have advanced to a level that virtual patient modeling can now be a reality. The virtual patient is about to become a reality that will play an ever increasing role in the practice of medicine of the 21rst century.

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