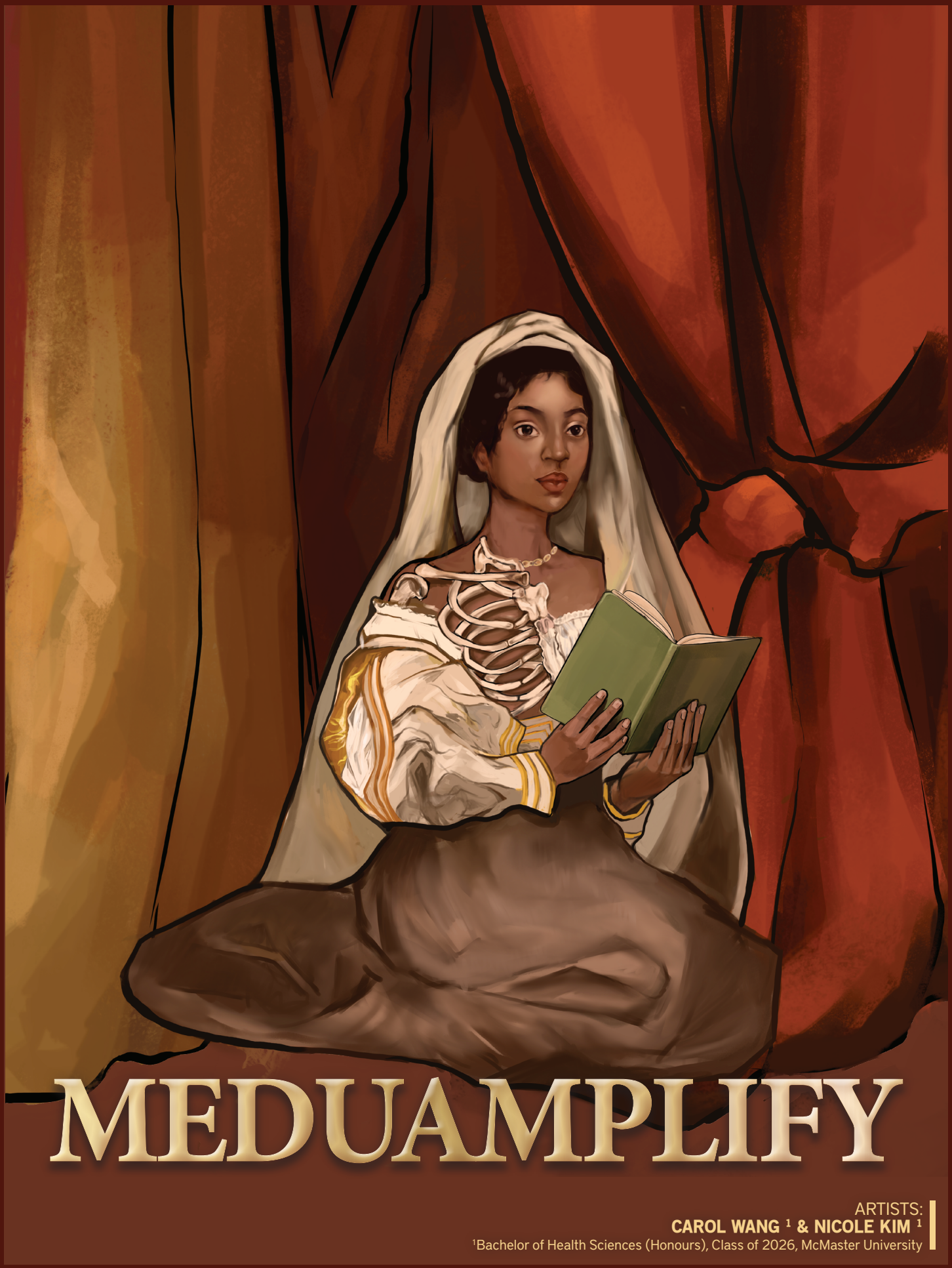

MEDUAMPLIFY

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SCULPTING A NEW FRONTIER:
The Evolution of Art in Medicine

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INTRODUCTION
Across human history, the intersection between the visual arts and human anatomy has revealed an unlikely partnership between scientific accuracy and creative artistry. From historical anatomical sketches to current 3D medical models, the visual representation of the human form has facilitated the advancement of modern medicine throughout the world. This relationship has changed the methods of dissemination of healthcare information, aided in the understanding of anatomy, and led to anatomical accuracy in historical works of art. However, the methods by which artistic and anatomical knowledge have been acquired throughout history were not always ethical. In fact, non-consenting marginalized populations were often the victims of human cadaver dissections that were later adapted to visual representations. Despite this fact, anatomical illustrations in historical and contemporary scientific texts still exhibit a lack of diversity and clear biases toward a depiction of the white male archetype. An improved understanding of the complex interplay between art, anatomy, and the abuse of marginalized groups in these fields is crucial to foster inclusivity and protect the rights and autonomy of all individuals involved in anatomical art–both in the past and the future.

EARLY DEVELOPMENT OF ART IN ANATOMY: A GLOBAL PERSPECTIVE
Although the Renaissance period is often cited as the era of anatomical revolution, it is important to note that advances in art and anatomy are not limited to this era, nor Western civilization. In fact, the convergence of art and anatomy dates back to over 25,000 years ago, with evidence of anatomical artifacts, sculptures, and drawings found in caves across Western Europe, Africa, Asia and Australia.[1]

Ancient Egypt
Some of the earliest records that contributed to modern knowledge of human anatomy are credited to the Ancient Egyptians. While their knowledge was crude, Ancient Egyptian sculptures and drawings marked a turning point where the perception of medicine moved away from a simple practice to a highly regarded and skillful craft.[1]

Persia
A Persian anatomist, Mansur ibn Elyas, is credited with publishing the first illustrations of the human body in its entirety in his manuscript, *Tashrih-i Badan-i Insan*. The book contained six coloured figures, each detailing a different anatomical system: the skeletal system, the nervous system, the muscular system, the veins and arteries of the cardiovascular system, and the female reproductive system via a pregnant woman delivering a breech baby.[2] The colour illustration of the pregnant uterus is thought to be the first depiction of the gravid uterus. Each illustration was accompanied by detailed descriptions of various systems of the body, including the visual pathway and the development of the embryo.[2] Despite some deficits in accuracy, the diagrams in *Tashrih-i Badan-i Insan* were so significant that they were still used in Persian and Arabic medical manuscripts for more than two generations after their original publication.

Figure 1: The illustration of nerves (right) and skeletal system (left) from Tashrih-i Badan-i Insan.[2]

Ancient China
Early anatomical illustrations also developed throughout Ancient China. Artist Yan Luozi drew six human anatomical maps, titled *Illustrations of Inner Body*, that depicted various parts of the human body. Figure 2 displays a drawing made by Yan of the inner body as viewed from the back. This particular illustration correctly identified the existence of various internal organs, despite placing these organs in the wrong locations. Notably, *Illustrations of Inner Body* accurately depicted the location of the kidneys. *Illustrations of Inner Body* constitutes one of the earliest attempts at visualizing anatomy, ending the era of "talking without drawings" in China and permanently altering the way of communicating medical information.[3]

Figure 2: Back view of inner body as depicted in Illustrations of Inner Body.[3]

Ancient Greece and Ancient Rome
The Greeks and Romans, too, dominated much of early anatomy. Due to the strong influences of religion, the use of human cadavers was forbidden, and animal dissections became increasingly popular in advancing medical knowledge.[1] During this time, theories in the field of anatomy were predominantly governed by physician Claudius Galenus, whose anatomical theories were misinformed. Anatomist Andreas Vesalius took note of these inaccuracies and challenged societal norms by incorporating the dissection of human cadavers into his understanding of anatomy, challenging centuries of medical dogma and encouraging a more empirical approach to medicine and science. These dissections and studies led to the creation of Vesalius' work, De Humani Corporis Fabrica (Figure 3), published in 1543. His textbook contained

numerous detailed drawings completed by disciples of the great Italian Renaissance painter, Titian. Both a groundbreaking exploration into human anatomy and an astounding artistic work, this textbook revolutionized the understanding of anatomy with didactic text and accompanying imagery.[4] The work was comprehensive, covering the full spectrum of human anatomy in unprecedented detail. This allowed for a more nuanced understanding of the human body, facilitating advancements in surgical techniques and medical treatments. The anatomical drawings in particular served as crucial pedagogical tools, aiding in the dissemination of knowledge throughout the medical and artistic communities. This was a significant advancement in medical education and meant that those who might not have direct access to human dissections could still learn about medicine. In addition, the direct observation and dissection methodologies introduced by Vesalius have persisted into modern medical education, emphasizing the importance of experiential learning.

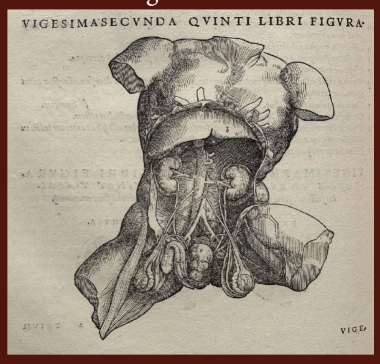

Figure 3: An anatomical sketch by Andreas Vesalius from the De Humani Corporis Fabrica.[1]

Ancient India

As medical advancements were made, anatomical knowledge permeated artistic communities across the globe. Modern analyses of historical artworks have concluded that ancient artists actually possessed a firm grasp on human anatomy—a fact that is frequently overlooked due to the separation of these fields. The Fasting Buddha sculpture is one such example. Carved by Ancient Indian sculptors of the Gandhara region in the 2nd or 3rd century AD, the statue depicts the fasting, emaciated Buddha seated in a meditative pose (Figure 4).[5] The statue was carved with generally correct muscle, neck, bone, and joint anatomy, demonstrating the expansive knowledge that the ancient artists possessed regarding the approximate shape, size, and position of various musculoskeletal features.[5] In addition, the sculpture exhibits an understanding of the physiological changes that occur during starvation, evident by the Buddha's skinny appearance.[5] Certain errors were noted, including an extra number of ribs and a segmented sternum.[5] However, this statue still demonstrates the undeniable connection between art and medicine—a connection marked by a shared pursuit of understanding the intricacies of the human form. This connection can also be considered symbiotic in nature; anatomists benefit from artistic visual depictions, and artists infuse scientific accuracy into their work based on anatomical knowledge. marked by a shared pursuit of understanding the intricacies of the human form. A symbiotic relationship of sorts; anatomists benefit from artistic visual depictions and artists infuse scientific accuracy into their work based on anatomical knowledge.


Figure 4: The Fasting Buddha statue.[3]

Italy

Renowned figures such as Leonardo da Vinci and Michelangelo also epitomize this unique relationship between science and art. Da Vinci's detailed anatomical sketches, like the famed Vitruvian Man, reflect an astute understanding of anatomy that transcends artistic boundaries.[6] Similarly, Michelangelo's meticulous dissections, notably of human cadavers, informed his masterpieces like the Statue of David.[7]

ANATOMY IN THE 19TH AND 20TH CENTURIES

The visual language developed in eras past became a crucial tool for conveying complex anatomical concepts and dismantling anatomical misconceptions, laying the foundations of art in medical anatomy into the 19th and 20th centuries. By the early 19th century, the use of human cadavers became commonplace.[8] In fact, demand for human bodies grew so high that professors and surgeons in England turned to an unethical and nonconsensual practice. Anatomists often acquired cadavers from 'body snatchers', who illicitly removed corpses from burial sites.[9] As the study of medical science and practice grew, anatomists began to favour direct engagement with human cadavers, and wax models of the Renaissance and Enlightenment were quickly disparaged.[10]

TThe uptick in the use of cadavers led anatomist Wilhelm Braune to adopt a new technique in anatomical study.[11] In 1870, Braune received a cadaver of a young woman who had committed suicide during the last month of her pregnancy. Braune froze the body before slicing it into sections and traced the outlines of the tissues and cavities, creating a drawing that would be reproduced, debated, and replicated in several publications.[12] Braune's frozen sections simplified the three-dimensional intricacies of the human body onto a precise and detailed two-dimensional surface. Proponents of this practice hailed these frozen sections as revolutionary for understanding the body's spatial relationships, but those traditionally opposed to artistic aid in anatomy argued that direct engagement with bodies through dissection was the only reliable way to acquire anatomical knowledge.[12] Nonetheless, frozen sectioning spread across Europe and North America, marking a reconvergence of art and anatomy.[13] Little information is available on the pregnant woman that Braune dissected, including her race, income, and the circumstances of her death. It is likely that she did not provide consent for her body to be used in such a manner. The authors wanted to highlight the inherent trauma ingrained into this practice and emphasize that despite the medical advancements made from this act, the immorality and breach of autonomy should not be overlooked.

The use of art in medical anatomy continued through the next century. Published books of anatomical illustrations became richer in detail and more vivid in color, revealing intricate details of skin, muscle, tendons, nerves, and bone. However, as seen above, the routes to this enhanced artistic production were often unethical. At the University of Vienna, Eduard Pernkopf received enhanced artistic production were often unethical. At the University of Vienna, Eduard Pernkopf received the bodies of executed prisoners for dissection, including political dissidents and members of historically marginalized populations. Using such unethically obtained information, Pernkopf published the *Atlas of Topographical* and *Applied Human Anatomy.* His atlas features over 800 illustrations, which despite having roots in violence and trauma, is still used today.[14] It is essential to

recognize that the continued influence of works like Pernkopf's atlas, partnered with the lack of transparency regarding the dark history of the information featured in this work, underscores the lengthy road toward reconciliation that still remains in this field.

ETHICS

The discussion of art in anatomy is inextricably tied to a discussion of ethics, with considerations oscillating between the pursuit of medical advancement and the preservation of human sanctity and autonomy. Much of our past and present understanding of anatomy is tied to unethical dissections and graphic distributions of unconsenting people. From ancient Greece to the 20th century, vivisections were conducted on prisoners under the rationale of utilitarianism, which stripped individuals of their rights and autonomy and led to societal criticism and scrutiny. Grave robbing and burking for the purpose of dissection particularly plagued communities of low socioeconomic status, further demonstrating the horrific ethical transgressions in anatomical practice.[15] In 1942, Germany passed legislation that denied families of executed Poles and Jews the right to claim the bodies.[16] Countless more examples across history demonstrate a complete lack of regard for the respect of human life, particularly for historically marginalized populations. These tragedies should serve as a reminder that the advancement of anatomical understanding cannot justify the disregard of moral values. Ethical considerations must be paramount in all scientific and artistic endeavours.

Currently, it is widely accepted that prisoners have full rights over their bodies, and after death, their rights are then passed on to their next of kin. Furthermore, body donor programs are now the most common way of receiving cadavers, with a significant emphasis on respect, controlled graphic distribution, and informed consent. Activism and other progressive movements have also considerably reshaped the educational landscape, promoting awareness for inclusivity and equity.[17] A prominent manifestation of these movements is the decolonization of education, which aims to address and rectify the historical biases and injustices found within anatomical curricula. This effort involves recognition of the injustices committed against minorities for scientific advancement and an overall reflection of how these events have shaped knowledge dissemination and the perpetuation of unjust social structures. More emphasis has been placed on diversifying anatomical information and moving away from the colonialist view of anatomy.[18] In addition, the model of the white male is often presented as the universal standard of the human form, which is an untrue and incorrect perspective. This misrepresentation has led to an underrepresentation of certain bodies in anatomy, both in terms of cadavers used and educational imagery such as textbook diagrams and physical models.[18] The omission of diverse bodies in education perpetuates biases and discrimination within the healthcare system, and educational and medical professionals must work to undo these unjust representations.

MODERN USES OF ART IN ANATOMY

With the increasing emphasis on ethics in anatomy, modern educational systems have experimented with the visual mediums used during education. Interestingly, the visual medium used in a course has been proven to impact the engagement of students with the material presented. In a 2020 study conducted at The University of Thessaly, researchers found that the use of painted models in anatomy lectures improved interest and understanding in undergraduate students as opposed to classical images. Further, many students hoped that this would become a permanent hallmark of the curriculum.[19] These applications extend beyond undergraduate education. Medical students at Yale University are already required to participate in a program which involves learning through museum observations. The philosophy behind this method rests on visual literacy—the idea that meaning can be derived from the visual cues of an object. The program encourages students to first understand and see structures before applying their knowledge to a clinical setting. Following exposure to a piece, students are asked to observe and inventory the artistic details. They are then asked to analyze and derive meaning from their observations, prompting them to draw conclusions about the piece. According to the program director, this method of study allows the students to emulate the act of observing signs and symptoms, and providing an analytical diagnosis to a patient. A randomized controlled study was conducted to test the effectiveness of this intervention, and found that with this program, students identified visual cues required for a diagnosis with greater accuracy.[20] Applications of art in medical education have found their way into residency programs as well. A systematic review conducted in 2022 showcased various art-based humanities approaches to teaching surgical residents, as well as the effects on their performance. The review concluded that anatomical drawing and modeling was found to enhance surgical learning. One example involved trainees creating three-dimensional models out of Play-Doh based on two-dimensional images, enhancing their ability to better conceptualize the three-dimensional conformation of various structures. An additional observation derived from this review indicates that art training helped enhance drawing and communication of their operations. This was exemplified in one study which found that with an increased focus of drawing, sculpting, and casting in classroom education, residents were better able to grasp the technical aspects of operations. Finally, drawing was actually found to be a particularly useful evaluation tool. Whether artistic competence was evaluated through sculpting exercises, the ability to draw accurate surgical markings, or the drawing of a therapeutic operative procedure, the ability to perform well in these tasks was associated with improved performance in the associated procedure.[21]

CONCLUSION

From historical compositions to educational methods, the art of anatomy has become a hallmark of human history within the last few centuries. The intersection of art and anatomy over the centuries has brought about significant ethical concerns. However, the evolution of ethical approaches to artistic anatomical practices reflects moral progress within society and a newfound responsibility to uphold the respect for and autonomy of every individual in pursuit of scientific knowledge. Nonetheless, art will continue to shape our perception of the human form and its complexities for generations to come.

THIS ARTICLE WAS ANONYMOUSLY REVIEWED BY AN ASSISTANT PROFESSOR OF PATHOLOGY & MOLECULAR MEDICINE AT MCMASTER UNIVERSITY.

References can be found on our website: www.themeducator.org