



From Cadavers to 3D Models: A Journey through Veterinary Anatomy Education

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INTRODUCTION

Imagine stepping into a veterinary anatomy laboratory a few decades ago. The room would be filled with cadavers, preserved organs, anatomical charts, models, and the unmistakable tools of dissection. Students would gather around a specimen, scalpel in hand, carefully uncovering muscles, nerves, blood vessels, and organs. Learning anatomy meant looking closely, touching, dissecting, and sometimes making mistakes along the way. Walk into an anatomy classroom today, and the picture can be very different. A student may hold a 3D-printed bone, rotate a virtual organ on a screen, explore a CT-generated model, or put on a virtual-reality headset to enter a three-dimensional representation of the animal body. The subject has not changed—but the way we learn it certainly has.

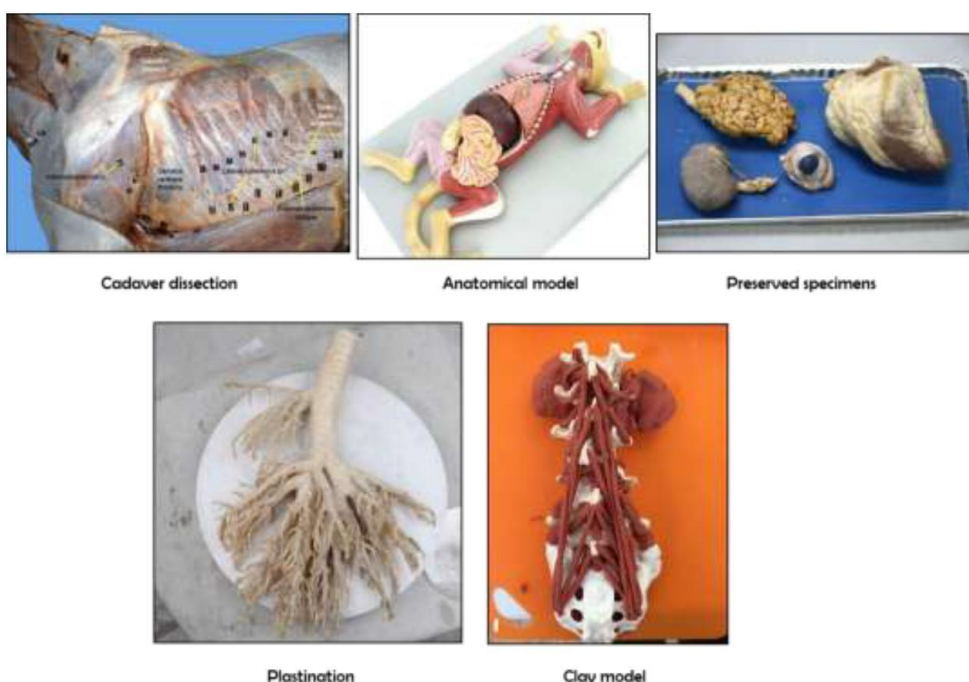
Veterinary education is shifting from traditional, lecture-based methods to studentcentred, technology-driven approaches. Anatomy and histology, foundational sciences to understanding animal health and disease, are undergoing digital and pedagogical transformation. For many years, education was closely connected with the physical classroom where students sat together, listened to teachers, took notes and used textbooks as their main source of information. Cadaver dissection has long been regarded as a cornerstone of anatomy education. The direct examination of animal cadavers provided students with an opportunity to move beyond textbook illustrations and observe the shape, texture, position, relationships, and variation of anatomical structures first-hand. Carefully prepared and preserved organs and body parts allow students to repeatedly examine anatomical structures without the need for continuous dissection. Physical anatomical models have traditionally helped students visualize structures that are difficult to appreciate in cadavers. Together, cadaver dissection, preserved specimens, models, and anatomical illustrations formed the traditional foundation of veterinary anatomy education.

Although this traditional system continues to play an important role even today, digital technology has introduced new possibilities. The growth of digital learning became particularly noticeable during the COVID-19 pandemic, when schools and colleges in many parts of the world had to shift to online mode. It served as a significant catalyst for the widespread adoption of digital learning tools. The necessity of remote instructions during prolonged campus closures prompted many institutions to adopt virtual anatomy as a core instructional modality, ensuring continuity in anatomy and pathology education despite physical limitations. Teachers and students had to adapt quickly to video conferencing, digital assignments and online examinations. Although this period created many difficulties, it also demonstrated how technology could help education continue during an emergency.

Further, in compliance with the Wildlife (Protection) Act, 1972, and the Prevention of Cruelty to Animals (PCA) Act, 1960, the University Grants Commission has prohibited the use of animals for dissection and experimentation in undergraduate and postgraduate programs in disciplines such as

zoology, physiology, and anatomy. A core responsibility of the veterinary profession lies in the protection and promotion of animal welfare. The use or harm of animals in educational settings may not only deter prospective students but can also be viewed as incongruent with the ethical foundations of veterinary practice. In alignment with this perspective, EU Directive 2010/63/EU asserts that “the use of animals for scientific or educational purposes should therefore only be considered where a non-animal alternative is unavailable.”

Creative programs such as prosections, plastination of specimens, whole organ plastination using laboratory wastes are equally effective in conveying anatomical knowledge. These modalities are particularly suited to a system-based approach of teaching anatomy, require fewer cadavers, and allow for similar exposure to information with less course time. This approach can foster creativity, fine motor skills, critical thinking, and a more hands-on understanding of anatomy. However, prosections and plastinations still require the expense of maintaining a gross laboratory and expose students and faculty to chemical fixatives.



Cadaver dissection

Anatomical model

Preserved specimens

Plastination

Clay model

The growing use of artificial intelligence (AI) is reshaping the landscape of veterinary anatomy education. From personalized learning resources and intelligent image analysis to interactive anatomical models and automated assessment tools, AI is creating new ways for students to explore and understand the complexities of animal structure. These technologies can make learning more engaging, encourage active participation, and help students develop the visual and analytical skills required in contemporary veterinary practice.

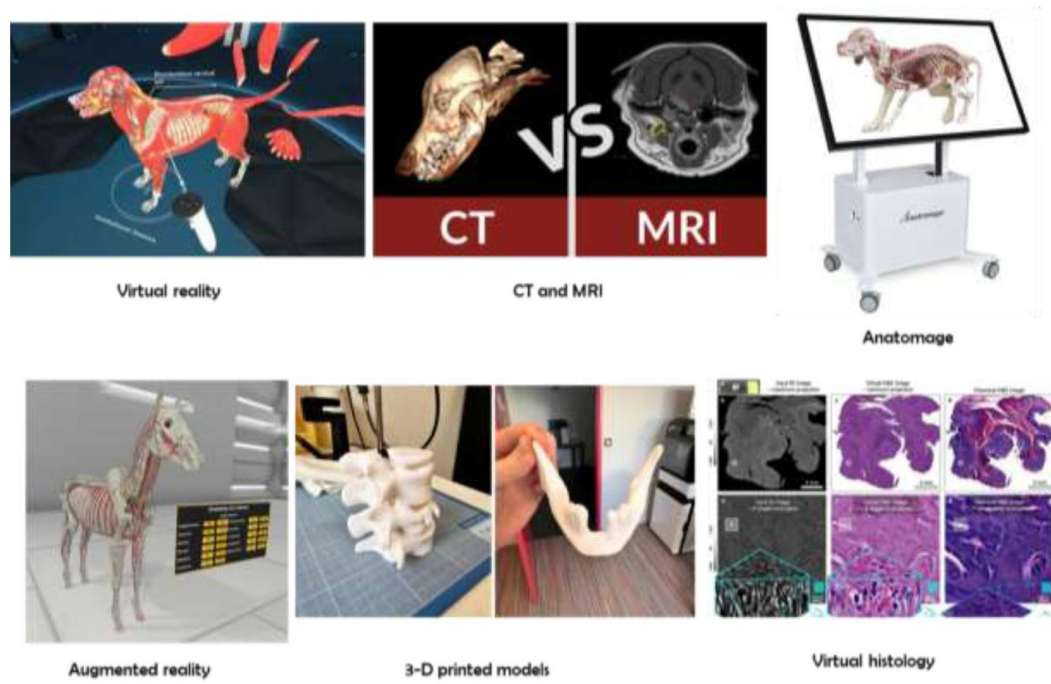
Among the most significant developments in anatomy education are virtual reality (VR) and augmented reality (AR), which are introducing new dimensions to the way anatomical structures are taught, explored, and understood. These digital platforms allow active learning helping students to study gross and microscopic anatomy without needing to obtain fresh animal tissue. Formalin is toxic and a potential carcinogen and virtual anatomy minimizes or eliminates the need for handling formalin-fixed tissue samples in routine educational and diagnostic viewing. With VR, students can enter a computer-generated anatomical environment and interact with three-dimensional models of organs, bones, muscles, nerves, and blood vessels. Structures can be rotated, enlarged, isolated, or viewed layer by layer, enabling learners to appreciate their spatial relationships more clearly. Virtual dissection environments can also allow students to explore anatomical regions repeatedly without damaging a physical specimen. AR takes a slightly different approach by bringing digital anatomy into the learner's physical surroundings.

Other programs seeking to remove cadavers completely from anatomy education have found themselves using a multifaceted approach incorporating medical imaging (ultrasound, computed tomography, and magnetic resonance imaging). Anatomage Inc. that originated in San Jose, California, is rapidly emerging as a leader in 3-dimensional

anatomy visualization. Advantages of the table over other programs include visualization of imaging of real cadavers gained from detailed post-mortem CT scans. The tables are modelled after the size and orientation of the traditional cadaver dissection table, so the entire male or female organism can be explored in life size. Different anatomical planes are easily “dissected,” and dissection can also progress superficial to deep. Systems are easily isolated, and the cadaver may be viewed in radiographic tones. These technologies allow students to examine anatomical structures and undertake simulated dissections without relying exclusively on conventional cadaver-based approaches.

Another dynamic shift in the field is virtual microscopy that augments histology education by providing an interactive, accessible, and scalable platform for the study of microscopic tissue structures. Through the use of high-resolution digital slides, students can explore histological specimens in detail, with the ability to zoom, annotate, and revisit materials as needed, features that are often limited or unavailable in traditional microscopy settings. One of the most impactful advances in this field are digital histological atlases that convert glass slides into high-resolution, annotated images accessible on various devices, supporting remote and blended learning. This innovation standardizes learning, enhances accessibility, and enables species-specific tissue categorization.

The arrival of three-dimensional (3D) printing has added a tangible dimension to digital anatomy. What was once confined to computer screens can now be transformed into physical models that students can hold, examine, and study from every angle! Bones, organs, and other complex structures can therefore be reproduced as accurate 3D replicas for classroom demonstration and hands-on learning. Importantly, these models can be developed from imaging data obtained from living animals, reducing the need to obtain specimens specifically through euthanasia.



Despite its advantages, digital education also has serious challenges. One of the biggest problems is the digital divide. Not every student has access to a reliable internet connection, a computer or a personal smartphone. Students from economically disadvantaged families may therefore find it more difficult to benefit from online learning. Smartphones and computers provide access not only to educational material but also to social media, games and entertainment. Students may find it difficult to remain focused when studying online. Long periods of screen use can also cause tiredness and reduce opportunities for physical activity.

The future of veterinary anatomy education is unlikely to belong to a single teaching method. Instead, it is moving towards

an integrated learning ecosystem in which traditional anatomical knowledge is supported by a wide range of emerging technologies. Cadaver dissection and prosection will continue to provide students with valuable hands-on experience, while imaging, digital reconstruction, 3D printing, virtual reality (VR), augmented reality (AR), and artificial intelligence (AI) can extend what can be explored beyond the physical specimen. The emerging model of veterinary anatomy education is therefore increasingly multimodal and may ultimately be defined not by how technology replaces traditional learning, but by how effectively both can come together to help students see, touch, explore, and truly understand the living architecture of the animal body.