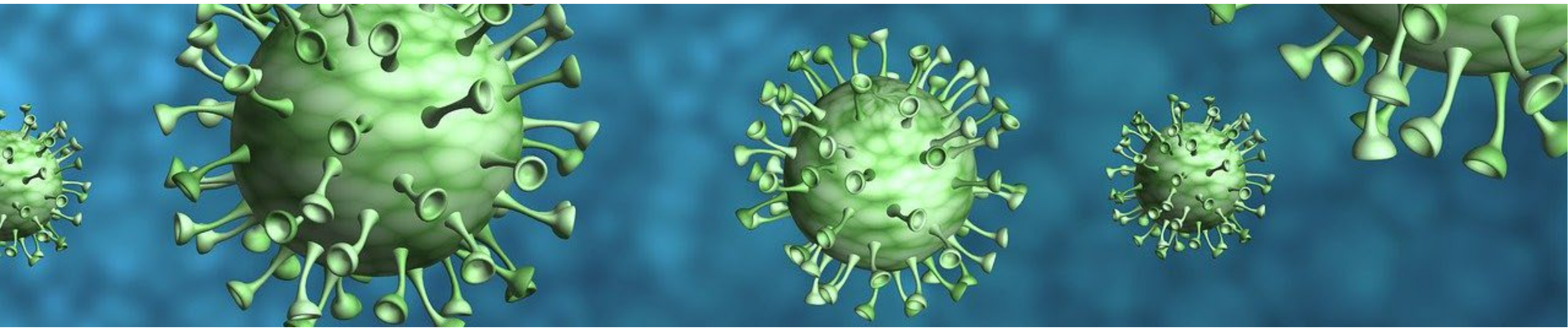


GROSS ANATOMY DURING THE PANDEMIC

Cadaver dissection is essential as a learning tool

The SARS-CoV-2 (COVID-19) pandemic has caused many unforeseen hardships and challenges. Most aspects of life have changed, not the least of which includes delivery of education, especially higher education.

As anatomy educators, we have been forced out of our comfort zones and into unfamiliar environments using technology to substitute for the rich, multi-sensory experience of cadaveric dissection. While using technology to substitute for face-to-face instruction with dissection may appear to be an adequate educational alternative, instructors of anatomical sciences in general and human gross anatomy in particular argue that there is no substitute for use of cadavers for the most effective student learning.

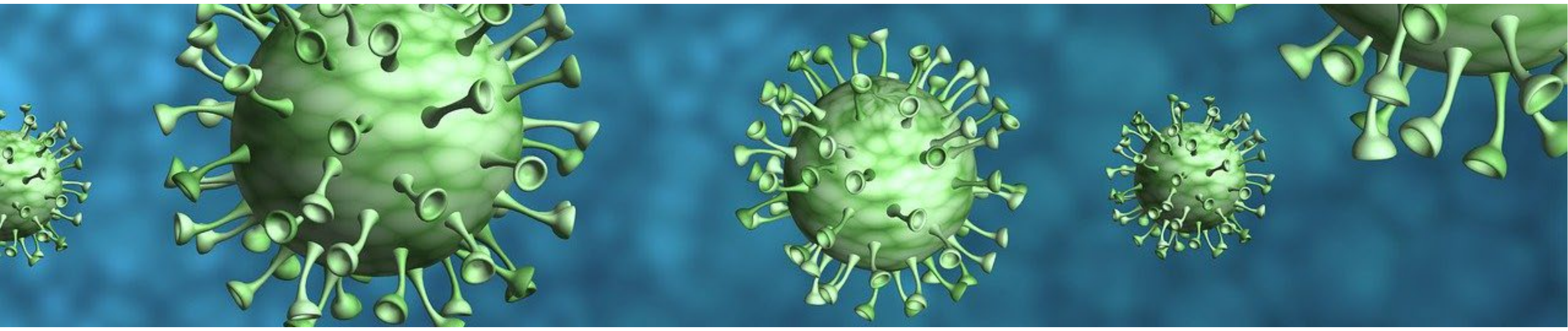
ADVANTAGES OF CADAVERIC LEARNING

Cadaver dissection provides a number of advantages not possible nor available with present technologies. We want to elaborate on this for those who may be unfamiliar with the most current anatomy technologies, and those who have not learned anatomy through dissection.

Shared language and space

Anatomical education is critical to healthcare professionals. The ability to understand medical and anatomical terminology occurs through the application of this language as it relates to the donor-cadaver. Cadaveric anatomy is a unique learning modality that mandates students to be respectful of persons and acutely aware of the responsibility of caring for another human.

Most healthcare gross anatomy courses with cadaveric dissection assign teams of students to dissect collaboratively. As a non-technical and intangible professional skill, these courses enforce team negotiations, conflict management, and the convergence of diverse thought to accomplish one main goal. The process of cadaver dissection challenges each student to choose the role of leadership, task management, or team player at different times during the course. Self-advocating skills and confidence are developed and learned in a group of equally qualified professionals as students navigate space concerns, instrument use, and acquisition of anatomical knowledge.



An aspect of the importance of face-to-face instruction over virtual instruction is that much student learning occurs from face-to-face interactions with peers, especially in the gross anatomy laboratory. Adult learners value active learning experiences with opportunities to check their knowledge. Students quizzing one another is a hallmark of the anatomy lab experience. Having faculty available to reinforce and answer questions further enhances the learning experience.

This type of complex collaboration and learning is almost impossible with remote instruction. While software solutions do provide a pathway for the individual to encounter anatomy, those solutions are not inherently structured for collaborative learning.

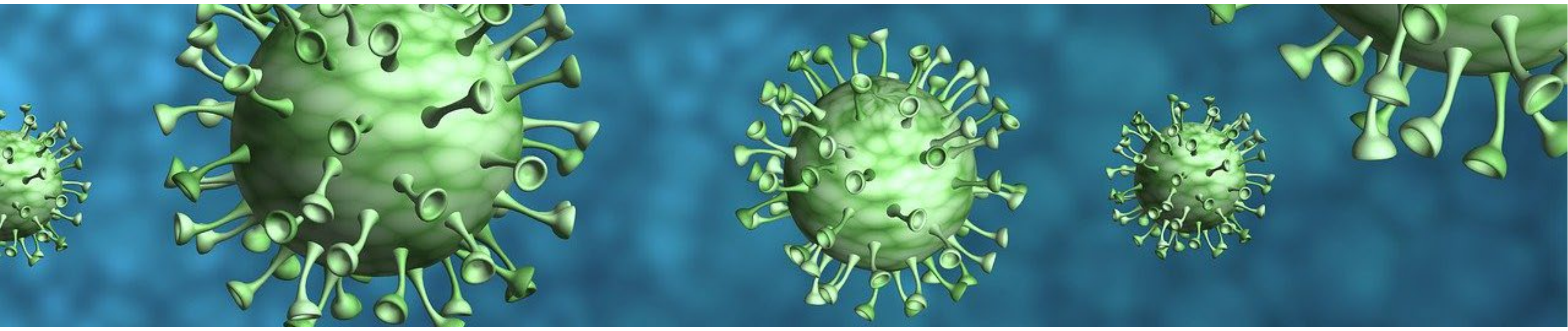
The donor-cadaver as the 'first teacher'

Often cadaveric courses are the first course students take as a cohort, with some consideration of shared professional space within the lab. Healthcare professionals do not work in silos, so the ability to have medical, dental, physical therapy, occupational therapy, physician assistant, and other professional students potentially share space and language is unique to the cadaver laboratory. Placing the donor-cadaver in a position to be the 'first teacher' encourages students to respond to unexpected variations from those found in textbooks and atlases, incorporate critical thinking skills, and appreciate the uniquely diverse and dimensional tissues that makes us human.

Death and sensory learning

Empathy in death and dying is difficult to teach if one has not previously confronted death. As such, affective benefits of cadaveric anatomy courses include death as an invaluable educational experience. Donor blessing services, guided student reflections, memorial services, celebrations of life, and the many wonderful demonstrations that show appreciation of the gift of the donor-cadaver's body for student learning encourage confrontation with death. These experiences challenge the dissociation that healthcare professionals must accomplish to treat efficiently amid traumatic situations, but they also bring in the humanity of personal care when interacting with patients and clients.

Students are allowed to appreciate the complexity of the human body through touch, smell, sight, and sound. Experiences in the cadaver lab are so entwined with an empathetic view of life, diversity, similarities, and blatant curiosity that those experiences are seldom easily forgettable. As students marvel at the awesomeness of the human body, an acceptance evolves that with health, life, and wellbeing is the dichotomous concern of illness, death, and dying.



Surprising spatial relationships

Anatomical concepts are easier to understand with actual dissection or prosection (previously dissected specimens) than through manipulation of virtual models. Students learn spatial relationships (*e.g.*, the precise location of each structure of the body relative to other structures around it); texture, weight, and depth of tissues; relative size and scale of body structures; and variations among bodies.

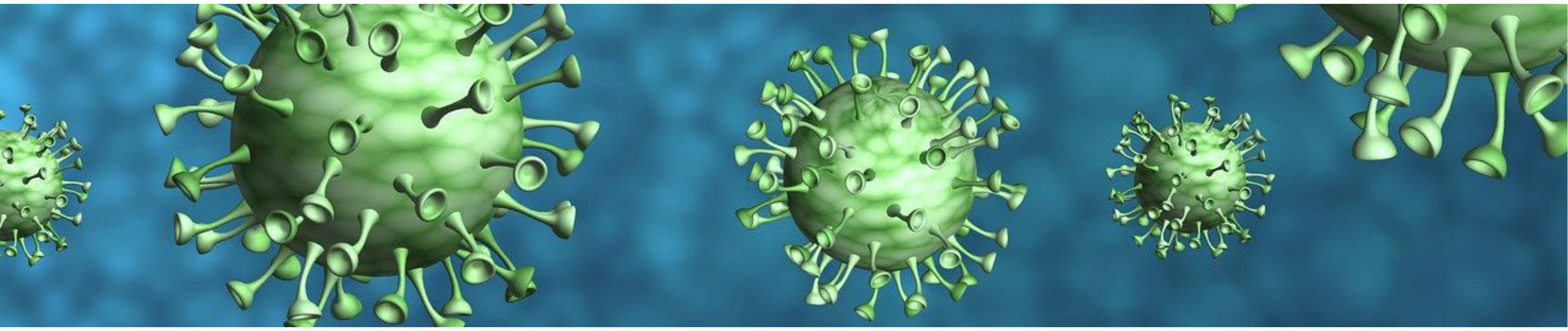
Spatial relationships are both more intuitive and more specific when observed on a cadaver. Students are surprised at the compact nature of abdominal contents within the abdominal cavity. An example regarding depth of tissues is having to move the viscera one direction or another to appreciate the posterior placement of the abdominal aorta and inferior vena cava. Another example: realizing the actual size of the spinal cord *in situ* compared to the typically large cross-section illustrated in most anatomy texts. In contrast, students are surprised by the large size of the sacral plexus and sciatic nerve in the donor body.

Somatosensory observations regarding texture, relative size, and weight of tissues gained in the anatomy cadaver lab cannot be reproduced with virtual technology. The struggles of exploring through dissection give way to an appreciation of the layers of fat, fascia, and connective tissue. In the cadaver lab, students can observe and understand common clinically relevant anatomical landmarks (*e.g.*, triangles of the neck, Calot's triangle, zones of the hand, inguinal triangle, and inguinal canal). Additionally, students learn instrument handling and development of fine motor coordination that may benefit them later when they learn procedural skills.

Enhanced learning through variation

Among the advantages of learning anatomy in a cadaver lab is the opportunity to grasp normal variations among bodies. Observing a brachial plexus that does not match the typical atlas depiction and following its branches to surmise what peripheral nerves they have discovered offers students insight into variability. Differences in blood vessel distribution, extra or missing structures, or the variable location of the appendix all demonstrate anomalies that make us each unique.

Students can view different pathologies (*e.g.*, cancers and space occupying lesions) and their effect on surrounding tissues. Depending on their donor-cadaver's history, students may also benefit from seeing the effects of disease in the body, (*e.g.*, joint replacements, an enlarged polycystic kidney, or coronary artery bypass grafts). In contrast, while some software packages include disease conditions as textural changes on the surface of an organ, there is no substitute



for when students witness a tumor in the thoracic region and see its effect on lung shape and size. This causes students to appreciate the plasticity of organs in the face of pathology and empathize with the donor as to what they possibly endured during the end stages of their life. This type of reaction is not possible when viewing such pathology on a monitor.

Similarly, variations of what is considered normal are also important for students to understand. For example, students of anatomy may see three different origins of the dorsal scapular artery when dissecting three different cadavers, whereas their software may show only one origin. Those three arterial branching patterns are all functionally normal, and part of the body's variation.

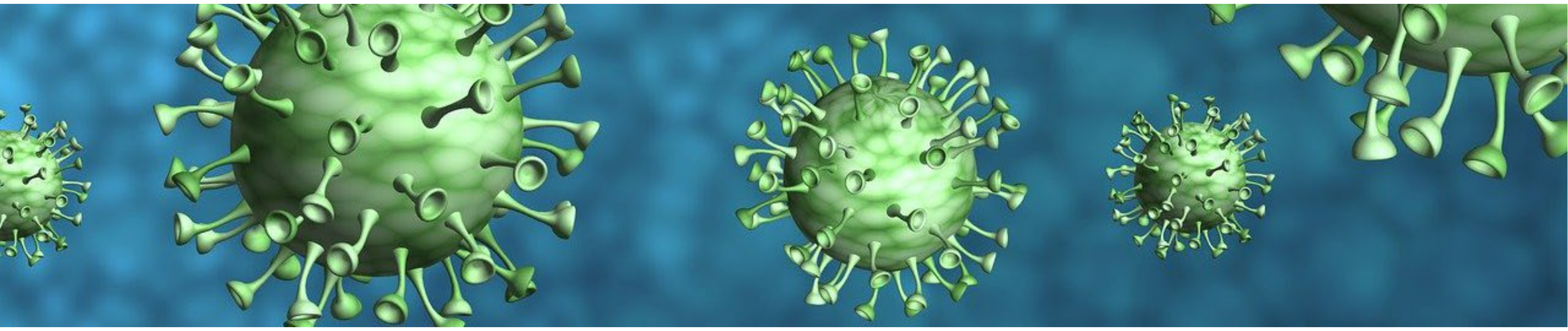
There is also limited diversity in body types represented in today's technology. Most programs use a white mesomorphic male as their prototype. However, as healthcare professionals know, typical patients do not always match this body type, nor do most body donors fit the prototype used in anatomy teaching software. Variations in body type that reflect the reality of our population is another example of the benefits of cadaver dissection over limitations in technology.

Technology acquisition vs. teaching time

For those instructors of gross anatomy who were forced by this pandemic to use available software, much energy and angst were expended in having to learn how to use the available technology in a short period of time. Then, they had to quickly turn around and try to teach their students how to use this software.

This reveals an important observation about technological approaches: time allotted to software instruction is time taken from anatomy instruction. Now, students must learn not only anatomy, but also the software that will teach them anatomy. Moreover, the learning curve for this software is not the same for all students, which may quickly lead to frustration and stress, causing them to fall behind in their coursework.

Furthermore, some software programs require hardware and processing speeds that are not available to all students. Most require strong and reliable Internet connections that students in rural areas may not have access to, and many programs require access to campus networks rather than remote access. Moreover, some high-end programs that utilize virtual reality may be difficult for some (*e.g.*, those with vestibular or visual disorders).



Cost considerations

Costs associated with the use of cadavers, especially in those programs that purchase cadavers from outside sources, are a top-of-the-list consideration for administrators who ask why anatomy cannot be taught solely using technology. However, these technologies are not low-cost. Software solutions that operate at scale for an entire class of healthcare professional students can easily cost in the tens of thousands of dollars, and hardware-based solutions can run into the hundreds of thousands of dollars. This also does not include the hidden costs of developing IT infrastructure to support these applications, nor training and troubleshooting the technology for every student, every year. These costs are not unfair; they are simply a fact of integrating cutting-edge technology at the scale of our large training programs.

PRIORITIZING CADAVERIC DISSECTION

As a community of anatomy educators, we have felt the effects of COVID-19 in our courses, our laboratories, and our learners. The inability to hold dissection labs over the spring and summer months of 2020 led to much disappointment, yet it gave us an opportunity to explore many different anatomy technologies and pedagogies.

As we move into the fall, we are compelled to state that cadaveric dissection must be safely available as a learning tool for anatomy, even in these uncertain times. While we have learned that virtual anatomy technologies are outstanding as reference resources and they provide students new ways to explore anatomy in their own homes, these benefits do not replace the many unique features of learning through cadaveric dissection and its lifelong impact on healthcare professionals. The permanence of student memories—as most can recall their experiences relating to their time dissecting—is evidence of the longevity of the cadaver use investment.

To ensure the healthcare workforce is afforded an opportunity to develop their professionalism, their personal attitudes about death and dying, and a sophisticated sense of the complexity and variation of the human body, we must prioritize cadaver dissection as an essential learning experience. We encourage colleges and universities to make this investment in our future healthcare professionals.

Authored by Melissa A. Carroll, PhD, MS; Darren S. Hoffmann, PhD; James L. Karnes, PhD, PT; and Sheryl L. Sanders, PhD. © 2020 American Association for Anatomy.