Highlights from the 30th Annual HAPS Conference, Atlanta Georgia, 2016:

From the President
Awards and Scholarships
Update Seminars
First Timers Experiences

Educational Research Featuring:
- Biological Anthropologists as Anatomy Educators
- Use of Pre-recorded Videos in Lab
- Cortisol Determination in Lab
- An Online Approach for Large Classes
- Prerequisite Concept Mastery

Current Topics Featuring:
- Bioengineered Skin Substitutes
- Gender Differences in ACL Injury

Perspectives on Teaching Featuring:
- A Round Robin Model for Lab Review
- Enhancing Histology with an In-House Atlas
- Reaching the Millennial Student
- The Active Learning Classroom
- A Regional Approach to Teaching Anatomy
- Re-Inflation of the Subarachnoid Space
- How to Humanize your Online Course
- Surprising Pronunciations of Common Terms
- Synthetic Cadavers vs. Real Cadavers
The ADInstruments Human Physiology Collection gives students the opportunity to get hands-on as they learn fundamental physiological concepts, recording and analyzing their own biological signals.

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### PERSPECTIVES ON TEACHING

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The HAPS Educator aims to foster teaching excellence and pedagogical research in anatomy and physiology education. The journal publishes articles under three categories. Educational Research articles discuss pedagogical research projects supported by robust data. Perspectives on Teaching articles discuss a teaching philosophy or modality but do not require supporting data. Current Topics articles provide a state-of-the-art summary of a trending topic area relevant to A & P educators. Additionally, the Summer edition of the HAPS Educator provides extended summaries of selected oral and poster presentations as well as the abstracts from the HAPS Annual Conference. All submitted articles undergo peer-review. Educational Research articles will additionally be reviewed for the quality of the supporting data. All submissions are disseminated to non-HAPS members one year post-publication via the Life Sciences Teaching Resource Community database.

Submission Guidelines for Authors

Information for authors is available at http://www.hapsweb.org/?page=hapsed_submissions

Terms of submission

The HAPS Educator publishes manuscripts consisting of original material that is not currently being considered for publication by another journal, website, or book and has not previously been published. Publication of the manuscript must be approved by all of the authors and have the approval of the appropriate institution(s). Manuscripts are to be submitted via the blue submission button (Submit an Article to the HAPS Educator) available at http://www.hapsweb.org/?page=hapsed_submissions. Materials for EDU-Snippets can be submitted at: http://bit.ly/HAPS_Snippet.

Formatting

Manuscripts are to be submitted in rich text format (rtf.), .doc, or .docx, in Arial (10) font with 1" margins on all sides. Accompanying the text, authors should submit an Author Submission Form consisting of a title page that lists the full name, associated institution and address, and email address of each author. A short Abstract of 150 to 200 words that explains the primary thesis of the submission should be included. Photos and illustrations should not be included in the body of the manuscript but they should be submitted, clearly labeled, with the manuscript. They should be submitted in JPEG form or in some other appropriate and usable form.

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It is the responsibility of the author to make sure that the information on each reference is complete, accurate and properly formatted. References should be included in the body of the manuscript where appropriate using the following format: Author’s last name and date of publication, (Martini 2011). A list of ‘Literature Cited’ should appear at the end of the paper alphabetically by author’s last name. Example references are available at http://www.hapsweb.org/?page=hapsed_submissions

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Deadlines for specific issues are:
- March 15 for the Spring Issue
- July 15 for the Conference Issue
- November 15 for the Winter Issue

You do not need to be a member of HAPS to publish in the Educator. For more information see the complete submission guidelines using the link above.

Human and animal research subjects

Research that includes dissection and manipulation of animal tissues and organs must adhere to the Human Anatomy and Physiology Society (HAPS) Position Statement on Animal Use (Adopted July 28, 1995, modified January 2001, Approved April 29, 2012), which states that the use of biological specimens must be in strict compliance with federal legislation and the guidelines of the National Institutes of Health and the United States Department of Agriculture. The use of humans or animals in research must fulfill clearly defined educational objectives.

Experimental animals must be handled in accordance with the author’s institutional guidelines and informed consent must be obtained for studies on humans. It is the responsibility of the author(s) to secure IRB approval for research on humans.

How your submission will be handled

The editor will assign the manuscript to a minimum of 2 and a maximum of 4 members of the HAPS-Educator editorial board for Educational Scholarship review. The reviewers will evaluate the manuscript for scientific accuracy, appropriateness to the audience, readability and grammar. The reviewers will submit their reports along with a recommendation that the manuscript be (a) published unaltered, (b) published with minor changes, (c) published with major changes or (d) not published at all. The editor will then decide what action will be taken with the manuscript and the author will be notified to prepare and submit a final copy of the manuscript with the changes suggested by the reviewers and agreed upon by the editor. Once the editor is satisfied with the final manuscript, the manuscript can be accepted for publication.

If the editor recommends rejection of the manuscript due to inappropriateness of its subject, lack of quality in its presentation or incorrectness of grammar or style, it will be rejected. If two reviewers recommend rejection of the manuscript made on the basis of inappropriateness of its subject, lack of quality in its presentation or incorrectness of grammar or style, it will be rejected. The review process is single blinded which means that the reviewers know the identity of the authors of the manuscript but the authors do not have access to information regarding the identity of the reviewers.

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CONTACT THE HAPS-Educator Editor: editor@hapsconnect.org

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President’s Medal
Presented by Past President, Betsy Ott

Since 2005, HAPS has recognized a member who has shown exemplary service to the society by bestowing the President’s Medal. In the ensuing decade, the list of distinguished recipients reveals a variety of members who have expressed, through their actions, a level of commitment and generosity to HAPS. All have shown a sustained gift of their time and expertise to improve the society for all members.

I had the great pleasure of choosing Dee Silverthorn as the 2016 President’s Medal recipient. Dee has served the society with her time and talent since 1993. We have worked together on every regional and annual convention held in Texas since then. That meant not only traveling considerable distances for organizational meetings in Fort Worth and Corsicana, but also developing forms, reviewing submissions, assisting with planning every little detail, and preparing and delivering talks. As anyone who has helped with a HAPS meeting can attest, every committee member works to pull off a successful meeting, but no one carries as much of the load as the host. At the Austin conference, Dee carried that load with grace under pressure. Since then, Dee has served as HAPS president and she is still active on the testing committee and as a presenter. She also represents HAPS within other professional societies, including APS and AIBS.

Dee’s impact on my professional life is a bit of a challenge to calculate. Her position at UT Austin carries weight in Texas, and my personal interactions with her no doubt enhanced the perception of my own professionalism among my college administrators and peers. The latitude that I have had to travel to meetings and participate in professional activities has benefitted me enormously, and I consider Dee to have been a mentor – whether she knew it or not. I particularly remember participating in a workshop Dee ran in her own lab at UT; she

Dee Silverthorn (left) is presented the President’s Medal by Betsy Ott

is an excellent teacher for students at all levels. That particular workshop involved not only sharing teaching methods with college instructors, but also sharing grantsmanship and leadership with two-year college instructors.

Dee’s legacy is already secured, through her textbooks, her students, and her position (now at the new medical school in Austin). I feel a great deal of satisfaction in staking our claim, in HAPS, to a piece of that legacy, through awarding her the President’s Medal. I look forward to many more years of watching and helping as Dee continues to serve the membership of HAPS.

Dr. Betsy Ott has been teaching at Tyler Junior College, in east Texas, since 1982. Betsy completed her B.S. and M.S. degrees in Biology at the University of Alabama, and her Ph.D. at Stephen F. Austin State University in Nacogdoches, Texas. She has completed several HAPS-I courses, contributed to several annual and regional HAPS meetings in Texas, and served as HAPS secretary-treasurer. She is currently HAPS President.

Betsy Ott
President’s Remarks

I begin my 2016-2017 term serving as your HAPS president at an exciting time as our organization goes through some important milestones. The conference issue The HAPS Educator marks some changes in format and shares information from many of the presentations at our 30th HAPS conference in Atlanta this past May. This year also marks the mid-point of our 2014-2019 Strategic Plan.

**HAPS EDUCATOR CHANGES** - Under the collaborative leadership of Kerry Hull, HAPS Educator committee chair, Sarah Cooper, HAPS Educator Editor-in-Chief, and Wendy Riggs, Communications committee chair, the HAPS Educator has been reorganized to publish peer-reviewed articles in three categories: Current Topic updates for difficult concepts in anatomy and physiology, Perspectives on Teaching for articles about teaching and learning without data, and Educational Research for articles with data. The EDU-Snippets column will soon find a new home on the HAPS Blog. Roberta Meehan is collecting the EDU-Snippets through a new online submission form, which can be accessed at: (http://bit.ly/HAPS_Snippet). So, please keep sharing those class-tested teaching ideas and demonstration inspirations coming. A future project will eventually link past EDU-snippets to the HAPS Learning Outcomes on our web site so that members can more easily access them in a teaching context without having to dig through old HAPS Educator issues.

**THIRTY YEARS AND MOVING ON** - In the Spring 2016 issue, Betsy Ott, now in the important role of past-president, shared an enlightening retrospective of HAPS conferences and biological advances over the last thirty years. Our 30th anniversary conference in Atlanta was a big success, thanks to the hard work of Kyla Ross, Adam Decker and all of their team. Mark Nielsen and his conference host team are reviewing the valuable participant feedback as they make plans to welcome all of us to Salt Lake City in May 2017. Cheryl Purvis Lechnar is ready to welcome us to Fort Lauderdale for the October 2016 Southern Regional conference. The organizational support is available for others who would like to host a future conference, so please send me a message if you are interested or want to learn more.

**STRATEGIC PLAN** - While the conferences are an exciting opportunity to learn, recharge and reconnect, they are certainly not the only work of your society. Throughout the year, even if you can’t attend a conference, HAPS supports professional development that facilitates enhanced student learning in anatomy and physiology. The five-year strategic plan sets forward a clear vision of how we will continue to meet our HAPS mission while becoming the premiere organization for anatomy and physiology teaching. All members can review the full document from our HAPS web site. It identifies three specific strategies: cultivate a thriving membership, improve and ensure a financial solvency of HAPS, and expand programs and special projects. One of my goals this year is to have the HAPS leadership team at all levels assess how well our strategy is succeeding. We will examine outcome indicators and identify any necessary adjustments, so we can best leverage and allocate our resources to realize the mission and vision for HAPS.

**GETTING INVOLVED** - We will also communicate that status with the membership. But as an inclusive organization, that communication must also include listening to the membership so we can continue to respond to the collective needs and challenges of all our members and take advantage of evolving opportunities. So as you make the most of all HAPS offers as a member benefit, also think about how you can be heard and become more involved, whether by posting on the List-Serv or commenting to a Blog, or sending me a message and joining one of the committees that really accomplish all the work of our organization with the support and guidance of the leadership.

It will be my privilege to work this year with you, your Board of Directors, the Steering Committee and all committee members, the presidents emeriti, and our management staff. Together we will keep our society on track as we progress toward another 30+ years of organizational development and growth. I look forward to a wonderful year.

**Terry Thompson** is a Professor of Biological Sciences at Wor-Wic Community College in Salisbury, MD where she has been teaching anatomy and physiology since 2002. She has Master’s degrees in Ethology (University of Maryland, 1982) and Human Anatomy and Physiology Instruction (New York Chiropractic College, 2014). Prior to joining Wor-Wic faculty, Terry had varied experience as a naturalist/educator in schools, museums, parks and field stations. She worked as a field researcher/conservationist with the National Zoological Park Conservation Research Center, the Virginia Institute of Marine Science, and the Nature Conservancy. Being able to share her personal love of science and her enthusiasm for life-long learning, while involving students in hands-on experiences and critical thinking, are the things she enjoys most about teaching. She joined HAPS in 2003, has been active with the Curriculum and Instruction committee since 2005, was part of the original cohort of HAPS-Institute students starting in 2007, and she hosted a regional conference in October 2015.
Awards and Scholarships

HAPS-Thieme Award for Excellence in Scholarship

The HAPS-Thieme award is given to recognize and reward excellence in undergraduate anatomy and physiology instruction. Individuals who demonstrate the core values of HAPS are nominated by their colleagues for this award. The winner of this year’s award is Mary Tracy-Bee.

Mary Tracy-Bee, is a Professor of Anatomy at University of Detroit Mercy where she has been teaching anatomy to graduate students as well as undergraduate biology students since 1999. She has also served as an adjunct professor at Oakland University and Wayne State University where she has taught medical students, other graduate health professional students and many undergraduate pre-professional students. Mary holds appointments at three hospitals where she reviews anatomy with residents from many programs including general surgery, orthopedic surgery, GI, ENT, OB/GYN, OMM and neurology. She has published three anatomy texts and workbooks as well as e-books and many journal articles. Her research involves engaging students in interactive anatomy education and investigating age-related changes in the morphology of the common carotid artery.

HAPS Institute Scholarship

The HAPS Institute Scholarship is awarded quarterly to provide financial support to instructors of anatomy and physiology who wish to take a HAPS Institute course. The winners of this year’s awards were Sara Sloan, Wendy Bruffy, Bobbie Leeper and Eva Murdoch.

Wendy Bruffy teaches Anatomy and Physiology at West Essex High School and Caldwell University in North Caldwell, NJ. She has written the curriculum for a course in sports medicine and a new elective course in biotechnology and she proactively serves her students by reaching out to the support staff, parents, and her colleagues. Outside the classroom, Dr. Bruffy advises the WE CARE Club and the National Honor Society. Together with her students, Wendy plans to create an outdoor oasis using funds from a New Jersey Sustainable Grant.

Bobbie Leeper is a physical anthropologist with a specialization in forensic anthropology. She teaches Human Gross Anatomy, Human Anatomy & Physiology, and Comparative Vertebrate Anatomy as an assistant professor in the Biology and Physician Assistant Programs at Seton Hill University. Bobbie loves teaching anatomy through human and animal dissections. Her current research involves testing the effects of soft tissue removal on bone.

Eva Murdoch is an associate professor in the department of Natural Sciences at Joliet Junior College in Joliet, Illinois. She serves as the biology coordinator and she teaches Human Anatomy and Physiology and Cadaver Dissection courses. She is also the advisor for the Natural Sciences club at the college. Eva has recently joined HAPS, and “Teaching Central Nervous System Concepts” is her first HAPS-I course. Eva is grateful to be one of the scholarship recipients and she looking forward to being a member of the Human Anatomy and Physiology Society.

Dr. Sloan is a full time instructor at Northeastern State University teaching Advanced Human Anatomy with Cadaver dissection. She is also a faculty member in the Occupational therapy department at NSU where she teaches Neuroscience and Functional Human Anatomy. Dr. Sloan brings 10 years of clinical experience to her classes as a licensed chiropractor working in multi-disciplinary settings with orthopedic surgeons, medical doctors, physician assistants, physical therapists and occupational therapists. She has practiced in Alaska, Texas, and Oklahoma and has taught students in the cadaver lab at Northeastern State University and the University of Oklahoma Physician Assistant Program and Physical Therapy Program.

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Awards and Scholarships

Faculty Scholarship and Grant

The Faculty Scholarship Award is given for proposals that integrate innovative and/or alternative pedagogy into existing instructional programs. Grant recipients are strongly encouraged to present their project results in the form of a workshop or poster session at the annual conference following completion of the project. The winner of this year’s award is Katherine Whitcome.

**Dr. Katherine Whitcome** is a biological anthropologist at California Northstate University who is interested in comparative and evolutionary aspects of human posture and locomotion. Her research focuses on the functional anatomy and biomechanics of female positional behavior because both clearly played a major role in shaping our species, not only in the past but also in the present. She is interested in all research that links anatomy and performance. She applies diverse methodologies including 3D kinematics of natural motion, musculoskeletal modeling, comparative morphometrics and primate field study. Katherine served as a Co-Investigator and Collaborating Faculty at the Center for Prevention of Preterm Birth at Cincinnati Children’s Hospital from 2012 to 2015 and as an Assistant Professor in Department of Anthropology at the University of Cincinnati from 2009 to 2015. Additionally, she has taught at Harvard University as a Postdoctoral Research Fellow and as an instructor at the University of Texas, Austin.

Travel Awards

**The Sam Drogo Technology in the Classroom Award** is given for the innovative use of technology to engage undergraduates in human anatomy and physiology. The award enables recipients to attend the HAPS annual conference where they are encouraged to conduct a workshop featuring innovations in educational technology. This year the award winners are Mary Vagula and Wendy Riggs.

**Mary Vagula** is a professor of biology at the Morosky College of Health Professions and Sciences at Gannon University, Erie, PA. She teaches upper level physiology, both lecture classes and labs, to biology majors and pre-professional students. In addition to physiology, she teaches human biology, anatomy and physiology, and animal form and function. Dr. Vagula has authored 40 research articles and commentaries in journals, conference proceedings and books. She has previously received the Excellence in Undergraduate Research Award from Gannon University and a Faculty Scholarship Grant from HAPS for her innovative teaching methods.

**Wendy Riggs** is a tenure-track Professor of Biological Sciences at College of the Redwoods, a two year community college in Eureka, California. She has been teaching Human Anatomy, Human Physiology, and General Biology at CR since 2009. Wendy is active in HAPS leadership and has been the Communications Committee Chair since 2014. She is a passionate educator and loves opportunities to become a better teacher. She is a tech-nerd and enjoys integrating technological tools into her classroom. She has been flipping her classes since 2012. When Wendy isn’t teaching, she enjoys hanging with her two small male humans who are currently obsessed with Minecraft and Rubik's cubes.
The Robert Anthony Scholarship for New Instructors in Anatomy and Physiology is given to encourage faculty during their first five (5) years of teaching anatomy and physiology to network with seasoned professionals by attending the HAPS annual conference. The award pays for the registration fee at the annual conference. This year the award winners are Derek Kendig and Eleanore Hempsey.

Derek Kendig joined the Department of Biology at Loyola University Maryland (Baltimore, MD) as a tenure-track assistant professor in July 2015. He currently instructs Anatomy and Physiology I & II lectures and labs and will be introducing a course in Pharmacology next year. His current research examines the effects of nutrients and bacterial metabolites on intestinal motility through activation of nutrient-sensing receptors. Derek was a Virginia Commonwealth University (VCU) IRACDA postdoctoral fellow for 3 years and instructed Anatomy and Physiology at both Virginia State University and VCU before joining the faculty at Loyola.

Eleanore Hempsey teaches at Northland Pioneer College in northeastern Arizona, based at the Winslow campus. In addition to teaching anatomy and physiology, she teaches General Biology and Biology Concepts, a one-semester survey course. Eleanore taught for a year at the University of Redlands before coming to Arizona, and she completed a three-year postdoc at Texas A&M in Animal Science in Genetics. She is a new HAPster, and new to the field of anatomy and physiology so she has found that getting to meet others in the field and being able to see what her fellow instructors are doing is very helpful.

The Contingent Faculty Scholarship award is given to encourage part-time faculty, temporary contract length faculty, and faculty teaching at more than one institution to achieve full-time employment, to network with seasoned professionals by attending the HAPS annual conference. The award covers the registration fee at the annual conference. This year’s winners are Melanie Fraites and Julian Raffoul.

Melanie Fraites is an adjunct instructor at William Paterson University and Passaic County Community College in northeast New Jersey. She teaches a pathophysiology course for upper level pre-nursing and biology students as well as microbiology lecture and lab. She has also taught anatomy and physiology lecture and lab to biology majors and non-majors. Dr. Fraites has authored more than a dozen research articles and a book chapter. She previously shared a U.S. Environmental Protection Agency Bronze Medal for her contributions in understanding neuroendocrine effects of pesticides and received a Toxicology Scholar Award from the Society of Toxicology to promote undergraduate awareness of toxicology and toxicology careers.

Dr. Julian Raffoul is a practicing physician in Atlanta, GA. He is a graduate of Wayne State University School of Medicine in Detroit, MI, where he first fell in love with teaching Human Anatomy and Physiology. Dr. Raffoul is currently an Instructor of Anatomy and Physiology at Perimeter College, Georgia State University, Atlanta, GA, where he is an adjunct faculty member. As a physician, Dr. Raffoul brings a unique perspective to the laboratory and classroom setting where he enjoys incorporating clinical aspects of Human Anatomy and Physiology. As a proud member of HAPS since 2015, he aims to continue teaching anatomy and physiology using available HAPS resources to help students achieve their goals.
The **HAPS Graduate Student/Postdoctoral Travel Award** is given to enable a graduate or postdoctoral student to attend the HAPS annual conference and deliver a presentation there. Along with this award, the registration fee for the annual conference is waived. This year’s winners are Allison Foster, Jacqlyn Hyler-King and Megan Sugrue.

**Allison Foster** is a graduate student pursuing a PhD in Anatomy in the Division of Anatomy at The Ohio State University, Columbus, Ohio. She is entering her second year as a Graduate Teaching Associate at OSU working primarily with the undergraduate human anatomy courses. Allison presented a workshop titled, An E-Learning Approach to Spinal Cord Cross-Sectional Anatomy at the 2016 HAPS Conference. She thoroughly enjoyed her first-timer experience and is looking forward to being a second-timer next year!

**Jacqlyn Hyler-King** is a PhD candidate in the department of human physiology at the University of Oregon, where she has had the unique opportunity to serve in a number of teaching roles. In addition to serving as the donor body laboratory preparator and teaching assistant coordinator for the last three years, Jacqlyn has also taught lecture and laboratory courses in gross dissection, biomechanics, nutrition, and anatomy and physiology. Prior to pursuing her doctorate, Jacqlyn earned her BS in exercise science from Fresno State and MS in human physiology from the University of Oregon. Her current research focuses on understanding how biological sex and chronic pain influence sensory and motor control across the upper extremity.

**Megan Sugrue** is completing a Masters Degree in Anatomy Education at Indiana University in Bloomington. Over the past six years she has taught the laboratory portion of the undergraduate anatomy courses at Indiana University and the University of Alabama at Birmingham. Megan’s research examines the effects of using yoga poses to teach the names, locations, and functions of anatomical structures in undergraduate anatomy labs. This year she had the opportunity to present a Yoga Anatomy Workshop at the 2016 HAPS conference in Atlanta and was thrilled to share her research findings and passion for kinesthetic learning techniques with other science educators.
Using Gaze Tracking to Document Learning

Ann Zumwalt, Associate Professor of Anatomy and Neurobiology at Boston University School of Medicine

Reviewed and summarized by: Zoë Soon, PhD, University of British Columbia Okanagan

“How is the art of seeing things invisible” ~ Jonathan Swift

How does visual learning behaviour change through the different phases of learning? Ann Zumwalt teaches the gross anatomy course at Boston University School of Medicine and she is currently researching changes in individuals’ perception as they transition from naïve learners to more experienced learners and finally experts.

Ann has noted that radiology experts can quickly look at a radiograph and immediately spot pathologies, whereas beginners take much longer and have difficulty locating abnormalities. In fact, most of the time, dissections, images, and figures all look like confusing messes to students. It would be wonderful to know that the skill of looking at and effectively deciphering a specific anatomical image could be measured, predicted, and then taught to novices. This would be particularly helpful if non-invasive measurements were used in assisting the process.

Ann has found that measures of gaze direction, blinking, and head position were very useful in gathering information regarding the differences between how students and experts look at anatomical images. In general it is noted that with all types of course material, students tend to first learn things by cramming facts and treating all facts equally. Experts on the other hand, can quickly focus on the relevant data and “tune out” data that is irrelevant. Ann has found these generalizations can be carried over when observing how students look at images compared to how experts do. Ann and others have found that compared to novices, experts focus more quickly on fewer locations in the visual field and use fewer, longer fixations to focus on salient locations. Specifically fewer saccades were required in making a diagnosis.

Ann introduced us to the term “Gestalt Perception”, which she defined as being the initial “holistic” perception of a scene that is without foveal clarity, yet still informative to experts. Identifying familiar faces at first glance would be a good example of this. Ann has found that this first second of viewing is used widely by experts, and that experts can extract important information from a single glance before eye movements or clear foveal vision.

Kundel and Nodine (1975) found that in 200ms, 10 expert radiologists could accurately recognize 70% of chest X-ray abnormalities if they were large and in high-contrast (e.g. mass, pneumonia, and enlarged hearts). Understandably, the experts had more difficulty in identifying smaller or low-contrast targets (e.g. lung nodules or histoplasmosis) within 200ms. Interestingly, in 1983, Kundel and Nodine found that radiologists and laypersons drew schemas of radiographs images differently. Laypersons focused more on the background features, whereas radiologists depicted specific image objects.

In 1987, Nodine and Kundel hypothesized that the following steps take place during image identification and analysis:

1. Glancing without focusing: cognitive schema (knowledge of anatomy and pathology) and expectations help to inform...
   a. a global impression of image (which is reliant on the immediate perception of image orientation, symmetry and anatomic layout)
   b. holistic object recognition (potential target sites and deviations are noted)

2. Scanning: The eyes scan the image and focus on details
   a. Local feature analysis (closely-spaced fixations occur)
   b. This focal attention (on image abnormalities) allows for the forming of diagnostic hypothesis
   c. At this time, plausible perceptual interpretation occurs (first impressions may be modified or rejected)
   d. Finally, a diagnostic decision is evaluated and solidified (during this time, fixation clusters may move to other areas of the image, especially if initial findings are inconclusive or other abnormalities are of interest and help to inform a diagnosis)
In this study by Nodine and Kundel (1987), it was found that experts could identify the image and make a diagnosis properly 70% of the time in 200ms. Furthermore, experts could correctly identify the problem region of the photo 97% of the time, if given unlimited time. Interestingly, Nodine and Kundel (1987) found that it took experts approximately 18 fixation clusters to adequately assess a chest X-ray. In order to provide a valid and reliable test within this study, 120 chest images were viewed, 60 of which had tumors, and 60 of which were normal. Interestingly it was found that identification of true negatives took the fewest numbers of fixations per cluster (mode=2), followed by false negatives (mode=3-4), and lastly true positives (mode=5) took the greatest number of fixations. In this study, true negatives were defined as the absence of a tumor coupled with fixations on truly normal features. False positives are characterized by tumor absence in the image coupled with fixations clustering on abnormal features. True positives are depicted as being cases where the tumor is present and gaze fixations are clustered on abnormal image features. Diagnostic decisions thus relied on rejecting true and false negatives and confirming true positives within the image. In terms of how this data might inform learning strategies, in the final part of the study, it was found that providing immediate feedback after each image improved subsequent decisions with an increase in the number of true positives correctly identified.

More recently, in 2007, Kundel et al. found that mammogram interpretation by experts was similar to that of their previous study of expert radiologists. The more experienced observers used a rapid initial gaze fixation on a true abnormality, while more novice observers exhibited “less efficient initial search-to-find strategies” and more errors. In addition it was found that expert mammographers also use search-to-find strategies, but frequently with magnification and after the initial holistic recognition (Kundel et al. 2007)

Kundel et al. (2007) refer to an interesting study by Charness et al. when hypothesizing what is required for students to achieve expert-like ability. Charness et al. (2005) found that the main factor influencing the acquisition of chess expertise was deliberate practice, which is defined as solitary practice with the goal of improving personal skill. Previous studies (Chase and Simon, 1973) estimate the amount of deliberate practice that is needed to become a top-level player is approximately 10 years (5000 hours). It is thought that becoming an expert at reading medical images also requires deliberate practice.

Ann talked about two really interesting experiments her team has performed which complement the studies done by Nodine and Kundel. In the first set of experiments, 31 first-year Boston University School of Medicine (BUSM) students were selected to participate in a gaze-tracking study (Zumwalt, et al. 2015). These experiments were performed in 2013, and the students were selected carefully to ensure that only right-handed students without brain injury and no prior experience with the courses participated. As a first step, these students were baseline tested before the BUSM Gross Anatomy course, and then randomly divided into three groups for the course, as there are three different sections of course: back and limbs; thorax-abdomen-pelvis; and head and neck. Group A (n=10) were tested after the first section (back and limbs). Group B (n=11) were tested after their second section (thorax-abdomen-pelvis) and Group C (n=10) were tested after the third section (hand and neck). Both the baseline test and the post-section test contained the same images. During the testing, students were asked to identify and type the anatomical name or feature within 1 minute for 30 images. The images were photos of cadaver dissections from class that were tagged with arrows. Therefore the images would be familiar to the students after seeing them during the course. The post-section test included images from the baseline test plus seven obscure images of animal dissections that the students had not seen before. Ann’s research team used gaze tracking, and it was possible to map out important regions on each image ahead of time for scoring purposes e.g. familiar vs. unfamiliar images. It was thought that experts would spend more time on salient parts, exhibiting fewer fixations overall, and be more correct in identifications.

It should be noted that students were also given the Mental Rotations Test (MRT), which is a validated test measuring visuospatial ability (Vandenberg and Kuse, 1978). In terms of results, as was expected, students performed poorly on the baseline test (scoring an average of only ~5% correct). On the second test, after learning the material, all 3 groups did much better scoring an average of 76-83%. During this second test, all students spent more time viewing each image compared to that of their baseline test. On images that they had seen before (during the baseline test), the students spent a large number of short fixations focusing their gaze on important regions than they had during the baseline test. This was the opposite of what was predicted in that experts typically exhibit as small number of long fixations on important regions of an image. Perhaps this means the students had become “experienced learners”, but were not yet experts.

Also of interest, it was found that while viewing the unfamiliar images (animal photos) the students spent less time viewing these images and did not focus as much on the important regions. Thus the gaze tracking data for these images was more similar to those observed during baseline test, although as the course progressed, students spent more and more time viewing unfamiliar images.

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In addition, it was found that students forgot 10-20% of material over two sections (during the course). As well, there were no differences in gaze tracking results between high and low students (i.e. the number of fixations and duration of fixations). Furthermore, there were no correlations found between MRT score and test performance. However, there were slight differences in the amount of time individuals with high visuospatial ability (VSA) spent examining images compared to students of low VSA, possibly indicating they are more patient at scanning images and a little more adept at finding important regions (Ghebremichael et al. 2014).

In the second set of experiments described by Ann, the role of memory was investigated (Zumwalt et al. 2015). She was interested in determining whether EEG and gaze tracking data could be used to predict which anatomical structure images would be forgotten or remembered 6 months later. During this study, students (n=22) were asked to either identify the named structure of interest by visually fixating on it or to stare in to the top left corner if they did not know the answer. Tests at the end of term were compared to tests taken six months later. At the end of term, it was found that students answered more quickly when they knew the answer and exhibited more expert-like gaze patterns compared to images that they did not know.

Of the three sections of the course, six months later only ~15% of the head and neck material was forgotten and ~5% of the back and limb and thoracic material was forgotten. Overall compared to at the end of term, students answered more quickly six months later on questions they answered incorrectly and for questions that they did not know. It was found that the fixation frequency was higher six months later and students took longer to correctly identify structures. Fixation duration was lower for images they did not know but same for images that they correctly identified. Interestingly at the end of term, students exhibited longer fixation on material they will be correct on and then forget six months later suggesting that this was material that they hadn’t mastered as well.

To conclude, Ann presented so many interesting results in this seminar. Firstly, students gaze patterns do change as they become masterful in identifying anatomical structures and there are definitely novice, experienced learner, and expert stages. Secondly, visuospatial ability as tested by MRT, does not appear to be a major factor in students’ ability to become better at anatomical identification. Thirdly, there are visual stages in each correct identification, starting with holistic gestalt perception, and proceeding to fixations to ascertain important regions and reject unimportant regions, before a final diagnosis is completely decided. Fourthly, students’ retention of their gross anatomy course material six months later was very impressive. Although as might be expected, the students were slower in delivering correct responses and their gaze patterns revert to becoming slightly more novice like. Lastly, the longer fixations observed at the end of term on particular images may indicate that these are the images most likely to be forgotten 6 months later.

Ann’s seminar was followed up by some excellent questions from our colleagues that I am sure will lead to future research. These questions included:

1. Does the novelty of picture and background information affect gaze patterns? What if it is a structure that they should know, but using an image of it that they have not seen before?
2. How do gaze patterns change when looking at a simple diagram compared to a complex diagram?
3. What if there is a figure legend? Do students fixate on this? And if so when and for how long?
4. Did you measure pupil dilation and stress/alertness levels during these tests?
5. What if you provide questions or feedback during the test to tease out the answer? What would happen to gaze patterns?
6. Why did students have more difficulty remembering the head and neck section? Was it more complex?

So it is likely that there will be some exciting experiments to look forward to in the future. In addition, for those interested in more information on long term learning, refer to Krupinski et al. (2013) for a long term study of gaze tracking of relevant images by medical students over the course of four years.

Thank you, Ann, for a wonderful eye-opening seminar on visual learning!

**Literature cited**


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**Zoe Soon** has been an Instructor in the School of Health and Exercise Sciences, Faculty of Health and Social Development, University of British Columbia, Okanagan, Canada since July of 2011. She holds patents in elemental analysis of tagged biologically active materials and high-throughput screening of metabolic disorders using a laser desorption ion source coupled to a mass analyzer. Her areas of expertise include skeletal and cardiac muscle cell biology and pathophysiology.
Ann Zumwalt began her seminar with an enlightening explanation of what it means to look at material as a novice. She opened her talk with her experience as a newly minted PhD working at a medical school and sitting in on a radiology lecture. The radiology lecturer put up a slide of a radiograph and said, “As you can clearly see there is a very obvious pathology in the shoulder joint.” Dr. Zumwalt, who thought she knew a fair bit about radiology, was stuck. She found herself staring at an x-ray of a glenohumeral joint and struggling to see what the expert claimed was obvious. Dr. Zumwalt then projected a similar radiograph on the screen and asked the seminar attendees to find the ‘obvious’ pathology.

I could not ‘clearly’ see the obvious pathology and a survey of my fellow attendees revealed that they could not find it either. This is when Dr. Zumwalt said, “This is how our students view the material we present to them.” They don’t see what is obvious to us, just like we did not see the ‘obvious’ pathology because we lacked the training to do so. Before Dr. Zumwalt could go on, a fellow attendee asked, “Out of curiosity what is the pathology?” To which Dr. Zumwalt replied, “There was none.” As much as we were fooled, by using this example we were able to step into our students’ shoes and see how difficult it can be for a novice to make sense of visual material.

So how exactly does an expert see things so differently from a novice? After all, we are looking at the same material! The use of gaze tracking could be a useful biological indicator as demonstrated by the work of Kundel and Nodine (1975). “Visual gaze patterns are defined as the timing and order of eye movements through which individuals visually explore their environments” (Zumwalt at al. 2015). Kundel and Nodine (1975) found that experts interact differently with material. They focus more quickly on fewer locations in the visual field and they have longer fixations on the material. Through their study of radiologists analyzing chest radiographs it appeared that experts have a more Gestalt perception, a more holistic approach to viewing the material (Kundel and Nodine 1975). In a 0.2-second flash 70% of the experts were able to identify all of the abnormalities; given unlimited time 97% of experts were able to identify all of the abnormalities in a given radiograph (Kundel and Nodine 1975).

It is possible to measure ‘learning’ using gaze tracking? Learning in this sense is defined as being able to track the progression of an individual’s gaze pattern from a novice gaze pattern to one that is progressively more expert-like. Dr. Zumwalt found a study conducted by Krupinski and colleagues (2013) that demonstrated the use of gaze tracking with pathology residents to document ‘learning’ through their four years of training. The data from this study indicated that gaze patterns changed over time, with forth year residents taking significantly less time with fewer fixations in their analysis of digitized breast biopsies (Krupinski et al. 2013).

Can we apply this to document learning in medical gross anatomy? Dr. Zumwalt and her colleagues published a study in 2015 that did just that. The team tagged photographs of cadaver dissections, delineating what in their opinion were the cognitively salient areas of interest. The study found that students ‘forget’ about 10-20% of the previous topic. As for gaze patterns, students were focused, but not expert in their gaze pattern. They spent more time with more fixations on images they were familiar with due to their experience in the course.

Can we predict forgetting? Student knowledge decreased from 84% to 78% in a six-month period of time. They tended to forget the head and neck material, which was the last section of the course. Interestingly, the time students took to take the test six months later decreased. Correct identifications were called to mind more quickly. The frequency (number of fixations per second) six months later was faster with fewer fixations — a more expert pattern. For questions that students answered correctly initially and forgot 6 months later, the gaze time was slower with fewer fixations. This may mean...
that students spend more time on items that they are most likely to forget. It appears that longer fixations indicate a lack of student confidence with the material and may be indicative of material that is likely to be forgotten.

For more information about Dr. Zumwalt’s study, I refer readers to her published article in Anatomical Sciences Education.

**Literature cited**


**Alicja Lanfear** teaches anatomy and physiology and non-majors Biology as a lecturer at Middle Tennessee State University. A human biologist and forensic anthropologist by training, she has spent the past year formalizing her career in science education research. Alicja is interested in collaborating with fellow HAPSters on analyzing and improving undergraduate anatomy and physiology laboratories as well as evaluating active learning strategies in large lecture classes. She currently serves on the HAPS Educator committee and the cadaver use committee. She attended her first conference in Atlanta this year.
Human Skin as a Model Circulation for Examining Mechanisms of Microvascular Dysfunction

Lacy Alexander, Associate Professor of Kinesiology at Penn State University

Reviewed and summarized by: Zoë Soon, PhD, University of British Columbia Okanagan

Cardiovascular diseases (CVD) are amongst the leading causes of morbidity, disability and death in North America. Unfortunately there are several risk factors for vascular damage including: atherosclerosis, ageing, heart failure, obesity hypercholesterolemia, rheumatoid arthritis, cardiovascular disease (CVD), cirrhosis, sepsis, smoking, diabetes, high blood pressure, and family history. Lacy Alexander spoke about the potential benefits of assessing cardiac health based on that of cutaneous microvasculature. She pointed out that microvasculature is subject to the same potential damage as larger vessels. In fact, one of the first predicting signs of CVD is endothelial dysfunction. Assessing cutaneous microvasculature instead of larger vessels is less invasive, carries less risk to the participants and is thus a good model for measuring vascular function.

Lacy referred to the review article written by Seals et al. (2014) which emphasizes the effects of ageing on endothelial function. Ageing leads to nitric oxide insufficiency, oxidative stress, and chronic low-grade inflammation. Nitric oxide (NO) is a vasodilator and is also thought to have other vascular-protective roles. It is also known that the balance between molecules produced by the endothelium (vasodilators, anti-coagulants, and anti-inflammatories) is disrupted with ageing. As a result, as one ages there is less NO-mediated endothelial-dependent dilation (EDD) in response to blood flow or exogenous acetylcholine. This has been noted in several types of experiments three of which Lacy highlighted in her introduction. In the first type of experiment, endothelial function was examined in cultured endothelial cells (EC) using NO-specific fluorescent probes and microscopy (Seals et al. 2014). The amount of NO-specific fluorescence in EC isolated from young animal/human models is greater (by ~2x) compared to the amount of fluorescence emitted from old animal/human endothelial cells. In the second type of experiment, arteries were isolated from young and old mice (or humans) and their diameters can be measured as acetylcholine (ACh) is added. The results show that compared to old arteries, young arteries are capable of greater maximum dilation as well as greater sub-maximal dilations at each ACh dosage level. In the third type of experiment, flow-mediated dilation (FMD) of arteries (in vivo and ex vivo) show that young arteries permit (~2x) greater blood flow compared to older arteries.

Unfortunately, as mentioned, reduced EDD occurs with ageing and is a predictor of future CVD, as well as brain ageing and sarcopenia (Seals et al. 2014). It appears that age-related reduction of EDD is primarily due to decreased levels of NO coupled with an increase in vasoconstrictor prostaglandin and endothelin-1 production. It is hypothesized that NO levels decrease with ageing as a result of increased levels of superoxide production, together with decreased antioxidant enzyme defenses, which creates oxidative stress (Seals et al. 2014). Unfortunately, this oxidative stress is associated with chronic low-grade inflammation and increases in pro-inflammatory chemicals (cytokines and adhesion molecules) (Seals et al. 2014). With growing knowledge of the underlying molecular causes of age-related vascular dysfunction, it is hoped that possible strategies for maintaining endothelial function may come to fruition. Interventions may include: stimulating NO release, production, or availability (Seals et al. 2014).

Thankfully Lacy and her colleagues have been busy contributing to the knowledge base concerning endothelial function and dysfunction. In her seminar, Lacy explained that a common way to assess endothelial function is to measure the amount of vasodilation (specifically EDD) in the arm, produced by inducing a sudden increase in blood flow (or shear rate). This is done by uncuffing a proximally placed sphygmomanometer after 5 minutes of 200mmHg pressure. The extent of vasodilation that results in the distal portion of the limb is measured using ultrasound of the brachial artery. This type of flow-mediated dilation (FMD) experiment induces a vasodilation response that is caused by production and release of NO and other local endothelium-derived relaxing factors (EDRFs), in addition to neuropeptides which stimulate second messengers that then elicit the relaxation of smooth muscle of the tunica media.

In addition to this type of testing, Lacy listed several other techniques that are useful in inducing skin specific microvasculature vasodilation or vasoconstriction during experimentation. These methods include: 1) reactive hyperemia; 2) direct drug delivery (e.g. acetylcholine); 3) applying local heat or cooling; 4) inducing whole body heat or coldness; and 5) performing spectral analysis. Interestingly, Lacy and her colleagues recently published a paper examining whether there are differences in the molecular processes...
mechanisms for passive heat induced and exercise induced cutaneous vasodilation (McNamara et al. 2014). NO is known to contribute ~30-45% to reflex cutaneous vasodilation during passive heating (Dietz et al. 1994; Kellogg et al. 1998, Wilkins et al. 2003, Kellogg et al. 2009) and the source of that NO is neuronal NO synthase (Kellogg et al. 2008, Kellogg et al. 2009). Interestingly, McNamara et al. (2014) found that eNOS (endothelial NO synthase isoform) is primarily responsible for NO production during exercise induced vasodilation.

Lacy went on to explain how intradermal micro-dialysis is performed. The dime-sized area of skin used (typically on the forearm) is prepared with appropriate washing and antiseptic wiping. A needle is then placed just under the skin, and the lumen of the needle is used to guide very thin probes (the width of 6 human hairs) into and then out of the skin’s surface. The needle is then removed, leaving the probe in place (within the subcutaneous space). The probe is on a semipermeable membrane allowing bidirectional flow. Researchers are then able to study the effects of different agonist or antagonist drugs, as exogenous drugs can be applied and will diffuse into the local endothelium and smooth muscle of blood vessels. It is then possible to measure blood flow (and even control local temperature). The pros for this technique are that a cardiologist is not required for placing an arterial line and two micro-dialysis set-ups can be placed in the same arm (so that one can be used as an ideal control). The cons for this technique include the amount of time that this set-up must remain in the arm for an experiment to take place. As the insertion of the micro-dialysis set-up irritates the skin, there must be a wait period after the initial set-up to allow for the redness and swelling to go down, which can take several hours. Total time for having this device placed in the arm may be 4-6 hours or longer.

Utilizing this set-up Lacy and her research team, were able to examine differences between non-hypertensive individuals and individuals with essential hypertension (that are non-medicated). Previous results show that individuals with un-treated essential hypertension have an attenuation of eNOS-derived NO dependent vasodilation in their cutaneous microvasculature (Smith et al. 2011). Interestingly, anti-hypertension pharmacotherapy has been shown to improve vasodilation responses to both heat and acetylcholine, but maximum vasodilation is still less than that of individuals with normal blood pressure. In a recent paper, essential hypertension is associated with an increase in molecular Rho/Rho-Kinase (ROCK) vasoconstrictive signalling mechanisms (Smith et al. 2011). Specifically ROCK is known to inhibit eNOS gene expression and eNOS activation, which leads to less NO production (Eto et al. 2001, Ming et al. 2002, and Takemoto et al. 2002).

In the final portion of her talk, Lacy talked about recent work with the novel gasotransmitter hydrogen sulfide (H2S). This work began by hypothesizing that as H2S is a gasotransmitter similar in nature to NO and CO, possibly it also plays a role in vasodilation of microvasculature. H2S is already known to play a role in ACh-dependent vasodilation in larger vessels (e.g. rat aortas). Indeed it was found that H2S also increases vasodilation of mammary arteries and future studies may show that H2S signalling is dysregulated in individuals with CVD. In fact, knockout mice with no H2S producing enzymes are hypertensive (Yang et al. 2008, Mustafa et al. 2011).

Lacy and her colleagues found that H2S producing enzymes (CSE and 3-MST) are expressed in microvasculature of the human skin (Kutz et al. 2015). Furthermore, Kutz et al. (2015) found that H2S induced vasodilation occurs in a dose-dependent manner within cutaneous microvasculature. In addition, they found that NO and COX by-products are required for full expression of H2S mediated vasodilation (Kutz et al. 2015). This likely means that H2S and NO work together synergistically in the induction of vasodilation. The exact manner remains to be elicited. However, in previous studies, it was found that H2S-induced vascular smooth muscle relaxation occurs within in vitro and in vivo animal preparations due to simulation of ATP-sensitive potassium channels (KATP), which results in smooth muscle hyperpolarization (Zhao et al. 2001). Lacy’s study of human microvasculature yielded slightly different results (Kutz et al., 2015). In contrast to KATP channels being involved in H2S induced hyperpolarization as was observed in the animal study by Zhao et al. (2001), Kutz et al. found that KCa channels played a larger role in the H2S induced hyperpolarization of cutaneous tunica media smooth muscle in human subjects.

Thanks, Lacy for a fascinating glimpse at current research involving cutaneous microvasculature. The implications for monitoring health in a minimally invasive way are exciting, as well as production of more details about the molecular mechanisms of thermoregulation, general endothelial function and pathogenesis of endothelial dysfunction.

For those that are interested in this field, I would highly recommend Lacy’s 2014 publication entitled “Sex- and limb-specific differences in the nitric oxide-dependent cutaneous vasodilation in response to local heat”. Spoiler alert: 1) NO-dependent contributions to heat-stimulated cutaneous vasodilation is greater in their forearms compared to their calves; 2) NO-dependent vasodilation was lower in the forearms of women compared to men (Stanhewicz et al. 2014).
References


Zoe Soon has been an Instructor in the School of Health and Exercise Sciences, Faculty of Health and Social Development, University of British Columbia, Okanagan, Canada since July of 2011. She holds patents in elemental analysis of tagged biologically active materials and high-throughput screening of metabolic disorders using a laser desorption ion source coupled to a mass analyzer. Her areas of expertise include skeletal and cardiac muscle cell biology and pathophysiology.
Dr. Chang is a mechanical engineer and physiologist, and his research interests lie in the field of biomechanics. As a graduate student, Dr. Chang used his expertise to consult with Pixar on the movie Monsters Inc., assisting in making the monsters move more realistically. Since Monsters Inc. is one of my favorite movies, Dr. Chang had my attention!

It is interesting that although we take thousands of steps daily without thinking about it, the principles of this movement are still poorly understood. Researchers have mastered the mechanics of the movement, but the fine details of how movement is actually controlled remains unknown. This is most evident in our ability, or more appropriately our inability, to create realistic prostheses in the event that parts of the lower limb are missing or damaged.

With research we have come to understand walking as a movement analogous to an inverted pendulum. The leg is a ridged strut, which saves energy. However, we also have a great deal of complexity in joints and muscles. How do we control the act of movement simply? Does the nervous system have its own gestalt? What about when parts are missing, damaged, etc.?

Previous research by Bosco and Poppele (2000, 2003) indicates that when spinal cord electrical impulses are measured they correlate with whole limb movement rather than segments. This suggests that the central nervous system has simple parameters and that these simple commands are decoded into complex output. Chang et al. (2009) set out to demonstrate this, first in rat leg injuries and then using cat models in which a nerve is cut and grows back in ~one year. Chang et al. (2009) found that when injured, every joint changes trajectory while the hip-toe angle is maintained indicating that the central nervous system takes a holistic perspective with limb vectors, keeping limb kinematics identical.

Extrapolating this information to human subjects, a controlled experiment studying human hopping was performed by Dr. Chang and his colleagues (Yen et al. 2009). This experiment suggests that joint torque variance is unimodal with the variance in the middle of the hop. The local minimum – where is it most consistent – is the force on the ground. This applies to walking and indicates that when we walk, the push off force is critical, and ankle torque is directly related to the force on the ground. The knee torques co-vary with what the ankle is doing; this is termed the ‘motor-brake’ idea. In amputees there is no inter-joint coordination. It is possible to modulate ankle prosthetic torques but the amputee is unable to work the knee-brake.

How do you re-learn walking? Adaptation is observed in individuals who walk on a split-belt treadmill. On this kind of treadmill there are two belts, one for each foot to walk on. The speed of each belt can be modified independently from the other. Normal walkers were asked to walk on a split belt treadmill with one belt running at twice the speed of the other. When the belts were configured as in a normal treadmill (both belts running at the same speed) these individuals walked with a limp. Researchers wanted to determine if this knowledge could be used to revert asymmetric to symmetric gaits but they found that only 50% of patients with gait asymmetry responded to this treatment.

Why is it that only 50% of people with gait asymmetry respond to the split treadmill treatment? It comes down to the reason behind the adaptation in the first place, which is metabolic cost (Finley et al. 2013). Adaptation takes place in order to use less energy. In order for the adaptation – in this case symmetrical walking – to persist it must use less energy. Thinking back to the inverted pendulum analogy with one foot on the ground, it is in the step-to-step transitions – where we have two feet on the ground – that energy is lost. Experiments have found that the sum of mechanical work on the split belt is high, and gradually decreases over time as a result of adaptation (Finley et al. 2013). The physiology data show the same thing. Early in adaptation, pendular work is expensive; in later adaptation step-step transition is more economical. Over time this adaptation is stable and economical. The joint primarily responsible for this is the ankle. Through observation it is seen that the step on the slow belt is longer and the foot moves further back on the treadmill. So, the reason why 50% of people cannot transfer this adaptation to stable ground walking is because in ground walking energy cannot be “stolen” like it is on the belt.

For an accessible in depth discussion of limb compensation strategies I refer the reader to Dr. Chang’s book chapter on the topic published in 2009.
Dr. Chang finished his seminar by describing his research on flamingos with Lena Ting. Flamingoes stand for long periods of time on either leg without preference. They weigh about 2kg with a knee to ground distance of 50 cm. The question here is: Why do they do a one legged stance? Several hypotheses have been proposed: body heat conservation, tree trunk limitation, and keeping one leg dry. Chang and Ting observed eight juvenile flamingoes at the zoo. The flamingoes had a 16cm² foot area with a 1-2 cm² center of pressure. They also examined a dead bird on a stick. This specimen required a one-legged stance for stability. Without muscle function this stance supported the bird’s weight. Observation of the skeleton found that the antetrochanter was pronounced creating a double opposing ball and socket joint. Dr. Change and Lena Tung concluded that a one-legged stance acts as a low energy gravitational stay that is easily disengaged and requires the foot to be placed medio-laterally under the body. Flamingos are not the only birds to adopt a one-legged stance.

**Literature cited**


Sometimes There are Zebras: Challenges in the Investigation of Emerging Zoonotic Diseases

Darin Carroll, PhD. Director, Environmental Safety and Health Compliance Office, CDC

Reviewed and summarized by: Alicja K. Lanfear, PhD, Middle Tennessee State University

Dr. Carroll was deployed in the Congo area when a Marine told him, “You’re the guy that goes in when everyone is leaving”. His time at the CDC started out as a two-year fellowship after which he planned to teach at a university. He ended up (happily) “stuck” at the CDC. Dr. Carroll made it a point to let us know that the CDC has a need for comparative vertebrate anatomists and physiologists. He asked the seminar attendees to keep this in mind when we are advising students.

Dr. Caroll started his talk by introducing pox viruses. Pox viruses have double stranded DNA ~240kB, cytoplasmic replication and the ability to turn off the immune system of the host. Smallpox, the variola virus, is extinct other than in the laboratory. However, monkeypox is current in Africa. The variola virus, is exclusively a human pathogen, a property that allowed it to be eradicated because no animal model exists. Both the CDC and WHO worked very hard to eradicate the variola virus. Li and his colleagues (2007) stated that it is likely the original rodent that carried variola virus lived in West Africa 70,000 years ago and migrated to Asia 16,000 years ago. The human population had grown large enough by that time to sustain the variola virus and it lost its ability to infect the original host (rodents).

Monkeypox was first observed in 1958 at a primate research colony. The second recorded outbreak of the disease was observed in giant anteaters. In 1970 it was documented as a human disease, endemic to the Congo basin. It is a less fatal virus species that variola virus, with low human-to-human transmission. In 2003 monkeypox was imported into the US from Ghana when 800 exotic rodents infected with the virus were flown via commercial aircraft to South Texas and housed in aquariums in the basement of an animal dealer. Some of the infected rodents apparently escaped and came in contact with prairie dogs, infecting them through fomite transmission via contaminated bedding. The infected prairie dogs were then sold at national swap meets where animals and humans are in close proximity, which allowed the monkeypox virus to be transmitted to humans. The response from the CDC was fast and the spread of monkeypox was limited to 43 cases, with no deaths.

There are two strains of monkeypox. The strain that was imported to the US from West Africa is the less severe strain. The strain from Central Africa is more lethal. To date there are no human cases of monkeypox related to the Ghana strain of the virus. However, researchers looking for a model animal for monkeypox research in Ghana have found the first cousins of the rodents that brought the virus to the US. This is important because normal rats/mice do not work as models for the monkeypox virus. Prairie dogs are also being investigated as a possible model organism for the study of monkeypox. Using the principle of commonality of vertebrates, the disease process in the model animals is identical to that of humans and discoveries related to monkeypox could possibly assist in our understanding of variola (smallpox).

Recent advances in monkeypox research have included the use of in vivo imagery. This technology uses a firefly gene to make the monkeypox glow in the dark, while still acting in the same way as the wild type. The fluorescence indicates that mice actually do get some small amount of infection, although no lesions are present in mice. Areas of fluorescence in mice include the kidneys and ovaries. Does this mean that monkeypox as it occurs in animals is perhaps an STD?

Dr. Carroll then switched gears to discuss the zoonotic approach, what happens on the animal side. Once the virus/disease is in people it is already a problem. If we can work to limit the virus on the animal side of things we can prevent diseases in humans. Dr. Carroll then discussed the ‘hunting’ era for viruses and his view that there is a major shift away from this. He believes that the newest advancements will come from the laboratory, rather than the field. He discussed how computer modeling (ecological niche modeling) allows for analysis of the founder effect and can trace the subsequent expansion of monkeypox after the last glacial maximum. This sparked an investigation into suspect rodent species in Ghana, leading to the discovery of the pouch rat, which sheds virus particles profusely from the oral cavity. The pouch rat may be a good candidate for the maintenance of the monkeypox virus in research studies. CDC researchers were able to inform the locals of this so they will refrain from eating pouched rats.

continued on next page
For additional information and specifics about monkeypox virus I refer the reader to the CDC's website http://www.who.int/csr/disease/monkeypox/en/

Literature cited


Alicja Lanfear teaches anatomy and physiology and non-majors Biology as a lecturer at Middle Tennessee State University. A human biologist and forensic anthropologist by training, she has spent the past year formalizing her career in science education research. Alicja is interested in collaborating with fellow HAPSters on analyzing and improving undergraduate anatomy and physiology laboratories as well as evaluating active learning strategies in large lecture classes. She currently serves on the HAPS Educator committee and the cadaver use committee. She attended her first conference in Atlanta this year.
The lifetime probability of developing cancer in any organ/system in men is 50% and in women it is 33%. Those odds are definitely not encouraging even when we look at organ specific probabilities. The American Cancer Society (ACS) funds most innovative cancer research and invests early to jump-start the careers of the most promising young scientists and health professionals. The ACS Medal of Honor is awarded to those who have made the most valuable contributions and impact in the fight to end cancer through basic research, clinical research, cancer control, or philanthropy. Cancer immunotherapy represents the most promising new cancer treatment approach since the development of the first chemotherapies in the late 1940s, and, in 2015, the ACS awarded the Medal of Honor to James P. Allison and Steven A. Rosenberg for their innovative research in this field.

Talk of Anti-cancer immunotherapy has gained entry into mainstream discourse especially following President Carter’s much advertised and talked about therapy for his liver and brain lesions. While some in the media raise the eternal paradigm of “science versus faith”, investigators, armed with their knowledge of cellular functions, toil away at their benches to devise ways to combat diseases. Dr. Charlie Garnett Benson and Dr. Susana Greer’s update seminar talk centered on the topic of cancer and “Cancer Immunotherapy”. Dr. Garnett Benson opened her talk with a reference to President Carter’s case, and pointed out the launching of the “Cancer Moonshot” initiative by President Obama, the task force – involving the heads of numerous federal agencies – is being headed by Vice President Biden. The designation of this task force as the “Moonshot” is an obvious allegory that draws upon the mission to the moon during President Kennedy’s term in office. Armed with immunotherapy tools, the investigators involved in cancer research are excited and, I think, perhaps more optimistic about reaching their goal than were the scientists and engineers about their mission to the moon.

Monoclonal antibodies, immune checkpoint inhibitors, cancer vaccines, and some other non-specific immunotherapies that provide a helping hand to the body’s immune system are all actively being used for treatment and investigative purposes. Indeed, since the year 2013, when cancer immunotherapy was deemed the “breakthrough of the year”, the FDA has approved a host of immunotherapies. Since 2015 alone, close to a dozen such therapies have received FDA approval. Dr. Benson-Garnett stressed that while CD8+ killer T cells are the primary players in the body’s cancer fighting mechanism; other components of the immune system play important roles in tumor eradication and control. The tumor associated antigens (TAA), expressed in different types of cancer cells, are recognized by the antibodies as well as the T cells and are being used in immunotherapy (Table 1).

<table>
<thead>
<tr>
<th>Table 1: Common TAA’s used in immunotherapy (GarretBenson and Greer seminar)</th>
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<tbody>
<tr>
<td>• CEA–carcinoembryonic antigen (colon, lung)</td>
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<tr>
<td>• PSA–prostate specific antigen (prostate)</td>
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<tr>
<td>• MUC-1 (mucin –1) (lung, colon, prostate, breast, pancreatic)</td>
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<tr>
<td>• Her-2 (breast)</td>
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<tr>
<td>• CA125 (ovarian/cervical cancer/breast)</td>
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<tr>
<td>• Gp100 (melanoma)</td>
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<td>• MART (melanoma)</td>
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<td>• hTERT (all)</td>
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The CD+8 cell’s essential ability to recognize the tell-tale signs of cellular transformation that lead to cancer is at the heart of their role in immunosurveillance. Once the Killer T cell recognizes the cancer cell, it injects cytotoxic proteins and enzymes into the target cell, leading to the onset of apoptosis and eventual lysis. Cancer development has many possible causes, from genetics and diet to avoidable and unavoidable environmental factors; and the plurality of the disease makes the development of a “silver bullet” inconceivable. However, there some cytological and histological commonalities in transformed cells that have been of interest to molecular biologists and oncologists who have been working at developing a cure for cancer. Two of such commonality among the “hallmarks of cancer” are the ability of the transformed cells to switch off apoptotic pathways and to evade death by oncogenic signaling pathways.
immunosurveillance. (Hanahan and Weinberg 2000, 2011). Hence, the implication of the cytotoxic T-Cell (Tc) function cannot be overestimated.

The T cells, having given rise to memory T cells, can also later mount the systemic response on any future transformed cells. Since, development and establishment of cancer results from these transformed or abnormal cells escaping the immune system, cancer immunotherapy works through the stimulation of the patients’ own immune system that, evidently, failed to work efficiently. Even if the body’s immune system recognized the cancer cells, the response might not have been robust enough. Sometimes, the cancer cells themselves also give off substances that keep the immune system in check.

If the antigen presenting mature dendritic cells (APC) are able to present the tumor associated antigens effectively, then the body’s own immune system is capable of ridding the body of transformed cells. To this job efficiently, the activation of cytotoxic T cells needs to happen through interactions between several molecules expressed on the surface of the CD8-Tc cell and those on APC. Helper T cells (TH) would play an important role in costimulation of the Tc cells through cytokines. A simplified schema of the process of Tc cells was presented (Figure 1).

Dr. Garnett-Benson discussed a few immunotherapy protocols that essentially take advantage of the knowledge of the pathways for CD8 Tc Cell activation. One such personalized therapy involves the dendritic cells (DC) of the patient. The first to be approved for prostate cancer was the vaccine Sipuleucel-T, prepared by the company called Dendreon. The idea is to induce effector T cells that are very specific towards the patient’s tumor cells. This is achieved by culturing, ex vivo, the DCs derived from the patient with an adjuvant and the tumor-specific antigen (the patient’s own PSA, in this case), and then returning these cells back into the patient (Figure 2). These DCs then would activate the immune response towards the specific cancer cells that carry the specific PSA. The median survival rate was about 4 months following this treatment as compared to patients receiving the placebo.

While the dendritic cell-based therapy uses a step in the middle of the immunological process – starting with activated APC – another method seeks to utilize the entire pathway in vivo, mimicking a prophylactic vaccination. One of the melanoma immunotherapies uses oncolytic virus. In 2015, Talimogene laherparepvec (Imlygic), also known as T-VEC, was approved by the FDA. Among the several viruses that have been tested for oncolytic activity (Donnelly et al. 2000, Kelly and Russel 2007), the melanoma immunotherapy uses a modified Herpes Simplex Virus (HSV). The virus, injected directly into the tumors, lyses the tumor cells leading to shrinkage of the tumor. It is also shown to shrink tumors in other parts of the body. This is by virtue of the fact that the T cells are activated by the released virions and the usual immunological pathway is activated, where the killer T cells destroy cancer cells wherever they encounter them in the body (Figure 3).

Figure 1

Figure 2

Figure 3
Dr. Garnett Benson then described the “adoptive cell therapy” which she called skipping “right to the point”. The logic behind this form of approach is that instead of waiting for the body’s own immune system to kick in and activate either the T cells or the whole pathway, it would be faster and more targeted if already activated T-cells are used (Figure 4). The premise on which this is based is that the tumor mass would already be infiltrated by Tumor Infiltrating Lymphocytes (TIL) population and some of those cells would already be recognizing the tumor associated antigens. For this “adoptive cell therapy” (ACT), a melanoma is removed from the patient and the T-cells specific to the tumor antigen are isolated. Subsequently, these cells are activated, cultured *ex vivo* in the laboratory and a much higher population of the tumor specific activated T-Cells are re-infused back to the patient. The results of this treatment in a 55-y-old male were quite dramatic, with almost complete regression of even bulky tumors (Figure 5).

In another twist to this line of therapy, the T cells were genetically engineered to produce special receptors on their surface called chimeric antigen receptors (CARs). CAR’s allow the T-cells to recognize a specific antigen on tumor cells. These engineered CAR T-cells are then grown in the laboratory and reinfused into the leukemia patient where the results were even more dramatic than what was seen with ACT in melanoma. Figure 5 illustrates the complete remission within 177 days of the therapy in the B cell population (Figure 6). The traditional T cells would have to see their antigen through the TCR displayed through the MHC Class-I protein. In the engineered CAR cells, the external receptors don’t look like the TCR’s at all, but like a B-cell Receptor (BCR). So, this can directly recognize the antigen on the tumor cells.

These are, however, quite labor-intensive processes and, being very personalized, quite expensive. According to Dr. Garnett Benson, a lot more work needs to happen before they become routine. Some adverse events were also reported with the CAR T-cell therapy (Morgan *et al*. 2010).

As mentioned at the beginning, one of the hallmarks of cancer cells is their ability to evade immunosurveillance, and it remains a major stumbling block in designing effective anticancer therapeutic strategies. A number of factors are in play in contributing to persistence (and growth) of tumors in spite of a normal immune system. One such mechanism is the tumor cells ability to evade detection by T-cells by downregulating the MHC-I protein. This is just one of many ways that the tumor may establish in the host. One of the targets for immunotherapy for cancer cells is that of blocking specific “immune checkpoints” – a mechanism that prevents autoimmunity – which cancer cells utilize to evade detection. In 2014, the FDA approved the use of Nivolumab and Pembrolizumab, two antibody based drugs that disrupt the apoptosis protein PD1/PDL-1 interaction between the T cell and the cancer cell, thus preventing tumor cells from “camouflaging” as “self” cells.
An important down-modulator of T-cell activation is the Cytotoxic T-lymphocyte-Associated Antigen 4 (CTLA4), which is implicated in antitumor immunity. Clinical studies using antagonistic CTLA4 antibodies demonstrated activity in melanoma. Anti-CTLA4 therapy with Ipilimumab demonstrated a survival benefit in patients with advanced melanoma and it was the first agent to be approved by the FDA in 2011.

Looking ahead, Checkpoint Inhibitor Therapies (CIT) seem to hold tremendous promise and the investigators hope to get more of them approved. The CIT’s will be more tailored for specific cancer types and will be used in combination with other therapies. Research is also focused on the reasons behind patient-specific responses to these immunotherapy drugs and on increasing specificity of responses while reducing any side effects. The American Cancer Society has been at the forefront of these investigations. Along with the development of therapies to fight cancer, general awareness about the preventable causes of cancer needs to develop. ACS is also actively engaged in such advocacies, including a campaign against obesity, which a leading cause of cancer.

References:


Hiranya Roychowdhury’s Masters and PhD are in Biochemistry and Molecular Biology. He received an M.Sc. from Jawaharlal Nehru University, New Delhi in a multidisciplinary field of “Life Sciences”. His second M.Sc. in Molecular Genetics and his PhD in Molecular Biology were both earned at the University of Calgary, Alberta. Hiranya moved to New Mexico in 1993 and started his work at the New Mexico State University. His post-doctoral work revolved around enzyme biochemistry (Fatty Acid Biosynthesis) and molecular biology of apoptotic pathways. Although Hiranya enjoyed research at the bench he saw his true calling as teaching. For the past ten years, Hiranya has taught biology and human anatomy and physiology at New Mexico State University’s Dona Ana Community College where he is a tenured full professor.
In 2013, cancer immunotherapy was recognized by Science magazine as the Scientific Breakthrough Treatment of the Year and, more recently, it has been identified by Vice-President Biden as a key focus for the National Cancer Moonshot Initiative. Dr. Charlie Garnett-Benson is an Associate Professor in the Department of Biology at Georgia State University. Her strong research background in immunology and molecular pathogenesis has provided her with the necessary expertise to currently explore the use of immunotherapy in combination with traditional approaches to the eradication of cancer cells. In the first part of this two-part update seminar, Dr. Garnett-Benson described the cellular basis for the success of recent cancer immunotherapeutic modalities and outlined the mechanisms used by two promising categories of immunotherapy that have been recently approved for use by the United States Food and Drug Administration (FDA). These approaches act either to enhance the rate of cytotoxic-cell-mediated elimination of cancer cells or to interfere with the ability of tumor cells to escape immune system detection by targeting cancer-cell-derived checkpoint inhibitors.

Cancer cells express cell surface antigens that are different from the markers expressed by healthy tissue cells. When these abnormal antigens are recognized by cytotoxic T cells of the adaptive immune system (CD8 cells), the killer cells are often activated so that they can destroy the abnormal cells before they have a chance to proliferate. However, Dr. Garnett-Benson also conceded that, for a variety of reasons, our immune systems cannot work with 100% efficiency to continuously eliminate cancerous cells as quickly as they develop. In some cases, the cell surface antigens expressed by cancer cells are not sufficiently different to be recognized by CD8 cells as abnormal and so cells displaying those antigens escape detection unscathed. If cell proliferation occurs too rapidly, then there may not be a large enough subpopulation of the appropriate CD8 cells to mount an effective and complete immune response. Finally, some cancer cells are able to escape immune-system-mediated destruction by increasing their expression of checkpoint inhibitors. Checkpoint inhibitors are expressed by healthy cells to reduce the activity of the immune system so that they can be protected against unnecessary destruction. Unfortunately, these molecules provide the same sheltering effect for abnormal cells when they are produced in large quantities during cancer development.

As described by Dr. Garnett-Benson, new and exciting cancer immunotherapies have achieved success either by stimulating the production of large armies of specific CD8 cytotoxic cells that can thoroughly eradicate populations of cancerous cells or by interfering with the action of checkpoint inhibitors that have been upregulated by cancer cells. A number of these therapies have received FDA approval and hundreds more are in development.

Promoting Elimination of Cancer Cells

Provenge is a therapeutic vaccine that has been shown to provide a modest (4 month) increase in survival for patients suffering from advanced prostate cancer. In this patient-specific immunotherapy, immature dendritic cells are isolated from the patient’s blood via leukopheresis and incubated with a marker common to many prostate cancers as well as a factor to promote their maturation to active antigen presenting cells. Upon infusion back into the patient, these cells activate and promote the replication of CD8 cells specific to prostate cancer, in this way enhancing a specific immune-system-mediated attack against these malignant cells.

T-VEC is a very different immunotherapy approach that has been shown to be effective against melanoma. Patients are injected with an oncolytic virus that steadily destroys the cancer cells when the viral particles use them to support their replication. It is self-sustaining attack against the cancer cells in that each cell lysis event leads to the release of viral particles that go on to invade and destroy neighbouring cancer cells.

A final therapy in this category, Dr. Garnett-Benson described Adoptive Cell Therapy (ACT), an expensive, genetic-engineering approach that shows promise against advanced acute lymphoblastic leukemia as well as lymphoma. Cytotoxic T-cells are induced to express a chimeric antigen receptor (CAR) directed toward a cancer cell antigen. What is very helpful when targeting cancer cells is that CARs have the ability to recognize and bind to that antigen regardless of whether or not it is expressed via a Class 1 major histocompatibility complex (MHC). Within the laboratory,
the CAR T cell population is increased by several orders of magnitude, following which the cells are infused back into the patient, primed to recognize and destroy any cell displaying that antigen.

**Checkpoint Inhibitors: Blocking Escape Mechanisms Employed by Cancer Cells**

Dr. Garnett-Benson stressed that an equally important therapeutic approach is to stop cancer cells from suppressing normal immune responses, a strategy that all too many of these cells use to hide from the immune system so they can gain a stronger foothold within the body. Two important checkpoint inhibitors normally expressed by activated T cells are CTLA4 and PD-1. Their role is to protect healthy cells by limiting the extent of the cytotoxic activity of these T cells should they bind to them. However, cancer cells are known to also produce factors that increase the expression of these checkpoint inhibitors.

Yervoy, the first checkpoint modulator to receive FDA approval, has been shown to be effective against melanoma by inhibiting the dampening effect of CTLA4 on cytotoxic T cell activity. Two other checkpoint modulators, Keytruda and Opdivo, block PD-1 and also have been shown to have beneficial effects in the treatment of melanoma, in addition to lung and kidney cancers. FDA approval for a final checkpoint inhibitor, Tecentriq, was obtained May 18, 2016. This important therapy targets PD-L1, a protein that links tumor cells to the PD-1 protein on activated T cells, thereby reducing the ability of cancerous cells found within the bladder to interfere with attacks of the immune system against them. As with other labor-intensive cancer immunotherapies, treatment with checkpoint inhibitors is expensive, but preliminary results indicate that these approaches show a considerable promise.

In conclusion, Dr. Garnett-Benson provided an informative and engaging update seminar on an important emerging field relating to the treatment of cancer. She closed her talk by stressing that the work is far from over and that much remains to be done. Hundreds of immunotherapeutic protocols are in development and require FDA approval. The best approach for each type of cancer needs to be defined in terms of the optimal single or combination of immunotherapies that will be effective while limiting unpleasant and sometimes very serious side effects.

**References**


Update Seminar VI
30th Annual Conference, Atlanta, Georgia, May 21-25, 2016

Cancer Immunotherapy: From Bench to Bedside (Part 1)

Charlie Benson-Garnett, Georgia State University, Atlanta, GA

Reviewed and summarized by: Phyllis Brown, MS MPH, The University College of the Cayman Islands, Grand Cayman, Cayman Islands

One of the two update seminar VI speakers was Dr. Charlie Garnett-Benson, an Assistant Professor at Georgia State University. Dr. Garnett-Benson has a background in immunology research and currently focuses on defining the mechanisms of enhanced immune attack against sub-lethally irradiated carcinoma cells. During the session, Dr. Garnett-Benson discussed the National Cancer Moonshot Initiative, main players of the immune system, and current cancer immunotherapies.

National Cancer Moonshot Initiative

During the 2016 State of the Union Address, President Obama called on Vice President Biden to lead the national “Moonshot” initiative. This $1 billion initiative aims to eliminate cancer by accelerating cancer immunotherapy (CIT). A recent advance that activates the immune system against cancer cells. This approach has been successful with melanoma, leukemia, and lymphoma. Additionally, the National Cancer Moonshot will enhance data access, facilitate collaborations with researchers, doctors, and biotechnology and pharmaceutical companies, make more therapies available to more patients, and improve prevention and detection of cancers (The White House, 2016).

Main Players of the Immune System

The basis of immunotherapies and the key players are tumor-specific cytotoxic T lymphocytes (CTLs) and activated natural killer (NK) cells (Cacan et al. 2015). Cancer immunotherapy introduces functional immune cells in order to generate CTLs that attack and kill tumor cells (Kumari and Garnett-Benson 2016). In order for CTLs to become activated antigen presenting cells (APCs) such as dendritic cells, macrophages and B lymphocytes must “present” antigens in a form that T cells can recognize (Anassi and Ndefo 2011). When T cells recognize an antigen it is stimulated to produce cytokines and other chemical messengers such as granulocyte-macrophage colony-stimulating factor (GM-CSF), interleukin-12, tumor necrosis factor-alpha, CTLs, and B cells as result an immune response is launched (Anassi and Ndefo 2011).

Cancer Immunotherapy

Cancer immunotherapy is an exciting and promising new approach to cancer treatment. This treatment works by stimulating the patient’s immune system to work harder or smarter to attach cancer cells and enhance the immune system with man-made immune system proteins (American Cancer Society 2015). Examples of immunotherapies mention in Dr. Garnett-Benson’s presentation were Sipuleucel-T (Provenge), Imlygic, chimeric antigen receptors, and checkpoint proteins.

Provenge is used to treat prostate cancer, which is the second leading cause of cancer-related deaths and the most frequently occurring noncutaneous cancer among men in US (Anassi and Ndefo 2011). Currently, Provenge is the only vaccine approved in the US to treat cancer (American Cancer Society 2015, Garnett-Benson et al. 2015). The development of Provenge was based on antigen-presenting cells specifically dendritic cells, the most potent of APCs. APCs “present” antigens to B and T lymphocytes and they are critical for priming CTLs, which are effective at destroying cancerous cells (Anassi and Ndefo 2011). Provenge does not cure prostate cancer, however treatment has extended patient’s lives by an average of four months (Ledford 2015).

Talimogene laherparepvec (Imlygic) is an oncolytic virus that has been modified to release GM-CSF, a protein that boosts immune response, which is used to treat melanoma (American Cancer Society 2015). Imlygic uses a modified version of the herpes simplex virus to attack cancer cells. Scientists delete certain genes from the herpes virus to ensure only cancerous cells are attacked (Burlingame Cancer Research n.d.). Once Imlygic has been injected into the tumor, the virus continues to replicate until the cell ruptures. The ruptured cell releases bits of the tumor, thus causing an immune response. The immune system then “hunts” and kills the cancer cells.

Chimeric antigen receptor (CAR) T-cell therapy uses T cells to fight cancer by attaching chimeric antigen receptors (CARs) on their surface. The process is completed with continued on next page
adoptive cell therapy (ACT), which is the administration of a patient’s own lymphocytes following a lymphodepleting preparative regimen (Roshenberg et al. 2008). ACT is a labor intensive process that requires laboratory expertise. Then the CARs attach to proteins on the surface of cancer cells, thus launching an immune attack against the renegade cells. This therapy is primarily used to treat leukemias and lymphomas.

Lastly, checkpoint proteins such as CTLA-4 were included in the presentation. CTLA-4 proteins prevent the immune system from attacking normal cells, however cancer cells use the proteins to their advantage by avoiding detection by the immune system (American Cancer Society 2015). One benefit of treatments that target the immune system’s checkpoints is that these checkpoint inhibitors target different types of cancers (American Cancer Society 2015).

To summarize, the National Cancer Moonshot Initiative aims to double the rate of progress toward a cure and has established a Cancer Moonshot Task Force to bring together every federal agency that has a part to play in the fight against cancer. The National Cancer Moonshot Initiative plans to fund cutting edge research opportunities such as cancer immunotherapy and combination therapy (The White House 2016). Several immunotherapies are at the forefront of cancer treatments. Dr. Garnett-Benson, an immunology researcher, discussed the following cancer immunotherapies: dendritic cell vaccines (Provenge), Imlygic, and checkpoint proteins. Some CITs such as CAR T-cell therapy are still in clinical trials and showing promise to treat various types of cancers. Unfortunately, Dr. Garnett-Benson’s research cannot be adequately summarized in this brief article. Instead, I refer readers to the following: Garnett-Benson et al. (2015), Kumari and Garnett-Benson (2016), and http://inflammation.gsu.edu/profile/charlie-garnett-benson/ for more information.

**Literature cited**


**Phyllis Brown** is a Senior Lecturer of Biology at the University College of the Cayman Islands (UCCI). Currently, she teaches all biology courses offered at UCCI which includes: anatomy & physiology I/II, biology I/II, concepts of biology I/II, epidemiology, and microbiology. She has earned her MS in Biology and MPH in Epidemiology & Biostatistics. Phyllis plans to graduate with a PhD in Research, Evaluation, Statistics, & Assessment from the University of Southern Mississippi in 2017. Her research focuses on innovative pedagogical methods in anatomy and physiology. Since 2015, she has attended the HAPS Conference and served on the HAPS Educator Committee.
First Timer Experiences and Impressions

Valerie Lee
Assistant Professor of Biology and Allied Health, Southern Adventist University

I attended my first HAPS conference last year in San Antonio. I had such a great time meeting new people and learning about teaching anatomy that when I realized that the 2016 conference was only two hours away from my university, I knew I had to try and bring some students with me. Due to the generosity of my department and its donors, I brought four undergraduate students with me to Atlanta this year. Three other colleagues of mine attended, one a first-timer. To qualify for a spot, each girl submitted a proposal for a poster session. All four poster proposals were accepted and three of the girls presented their poster during one of the three poster sessions. One girl was not able to present at the HAPS Conference because her research was also accepted at a later conference that did not allow her to present the research information ahead of time. I asked each girl to write a paragraph about her experience and would like to share those paragraphs with the HAPS community.

Molly Theus, BA in Biology, 2016

I went to the HAPS conference as an outsider of sorts. I just graduated with a degree in Biology and am headed to Vet School in the fall. I knew that a human anatomy and physiology conference was a little out of my comfort zone, but I also want to earn a Master’s in Public Health, so I tried to be open-minded. I was unprepared, however, for just how much crossover I would experience. The update seminar on animal limb movement was especially applicable for a student like me. Seeing again how much animals can be used to benefit humans, and indeed the other way around, was very beneficial. Additionally, the seminar on zoonotic disease seemed to be presented just for me. Improving the way animals are managed can benefit not only the animals themselves but the people who are interacting with them. After attending workshops across many disciplines, my horizons were broadened once again. Specifically, the workshop on correct pronunciation was just as useful for me as it would be for my human anatomy and physiology counterparts. I might have gone to the HAPS conference feeling like an outsider, but I left feeling like part of the family.

Emily Scriven, BS in Health Science, 2016

I am so grateful that I got to attend the HAPS conference with some of the biology staff at Southern Adventist University this year. This was one of the best experiences I have had in my college career. Not only was I able to see how professional research is presented; I was also able to learn so much about the amazing human body. I was so fascinated by all of the incredible research that is going on, especially with the American Cancer Society, and the opportunity to learn - even about terms that I’ve been pronouncing wrong since I was a freshman! This conference only helped solidify my interest in the human body and I was very impressed with the organization and learning opportunities. I would recommend that anyone attend the conference and I am definitely considering attending again in the future.

Nicole Sacdalan, BS in Nursing, 2018

Attending the HAPS conference was the best opportunity I have had thus far in my college career. I am currently a level 3 Nursing student who has been involved with the biology department at Southern Adventist University since my freshman year. I was invited to go on this trip and was able to present some research on a program called Peer-Assisted Study Sessions, which was developed in 2009 and is used at my school. I was able to share my research with professors from several universities, and many professors were interested in using this program at their own schools. I felt very fortunate that my topic interested so many people. Toward the end of the conference, workshops were held at Georgia Institute of Technology. These workshops were continued on next page
definitely the highlight of the conference! I learned about anatomy and physiology in the Italian Renaissance, proper pronunciation of medical terms, and extensive history of pituitary gigantism. Most importantly, during the conference I was able to connect with my university professors. We grew together in knowledge and friendship, and that is truly irreplaceable.

Elizabeth Paiva, BS in Nursing, 2016

I want to thank the Biology department at Southern Adventist University for sponsoring me and allowing me to experience HAPS 2016 in Atlanta. To be completely honest, my nerves were all over the place before I had to present the research poster my team and I had prepared for the poster session. I was scared that someone was going to nitpick and criticize me but I found the opposite happened. No one criticized me but rather asked questions that could help further future research. The poster session experience was definitely a confidence booster and I learned that people genuinely want to help other people and not bring them down. I also really enjoyed that I took away amazing teaching strategies that can engage students, which I can implement when I teach in the future. I attended a workshop that combined the history of art and anatomy. Combining hobbies that students enjoy and anatomy in the classroom setting can help students who are visual learners and make art more appealing. Another workshop I attended focused on helping students learn how to study. This workshop would help students learn how to dissect a book, look at key points, and talk about those key points. I cannot wait to integrate these strategies into the classroom setting one day. If I had not attended this conference I would not have thought to incorporate these strategies! Thanks to the Biology department at Southern, I now have this knowledge that will one day help my students.

Valerie Lee is an assistant professor in the Biology/Allied Health department of Southern Adventist University and has been teaching Anatomy and Physiology since 2012. She also teaches Ornithology, a freshman orientation class, and a non-major introductory biology course. Valerie is a co-sponsor of the pre-med club and really enjoys seeing her students obtain their professional goals by working hard.
First Timer Experiences and Impressions

Allison A. Foster
The Ohio State University, Columbus, Ohio  Foster.941@osu.edu

I arrived at the Human Anatomy and Physiology Society (HAPS) 2016 National Conference as a true “first-timer”. This would not only be the first national professional conference I had ever had the opportunity to attend, but it would also be the first workshop presentation I had ever delivered at a conference.

Upon my arrival in Atlanta, I quickly learned that HAPS is a meritorious community of uplifting individuals. Throughout the week, HAPSters provided me with support ranging from introducing me to members and cheering me on during my workshop presentation to listening to me excitedly describe 4D movies and keeping me on task with the homework I was completing during social hours. However, that support began even before I arrived at the conference through the organization awarding me The HAPS Graduate Student/Postdoctoral Travel Award earlier this year. I would like to extend my gratitude to HAPS for granting me that allowed me to attend and present at the 30th Annual Conference held in Atlanta, Georgia.

Many attendees I met at the conference originally formed a love for anatomy and physiology when they were given an anatomy and/or physiology course as a teaching assignment. In a number of cases, attendees were put into a teaching role for a course they had never taken as a student themselves. The opposite experience is true for me: I began my teaching journey with a strong background in Anatomy, a distant background in Physiology, and very little teaching experience. This upcoming academic year will mark the first physiology course I have taken as a student in five years. This conference helped immerse me in the world of both anatomy and physiology education and research. The added perk of attending an A&P conference as an anatomist, is that you can be pointed towards some great resources and tips on being a physiology student from some of the best physiology instructors!

The HAPS national conference is the perfect conference for both students and instructors to attend. My favorite aspect of the HAPS conference experience is that it focuses on workshops rather than presentations; HAPSters want to talk with you, not at you. I found the workshop interactions, in particular, to be invaluable because they provided me with methods that I could take back and implement in courses immediately. For instance, after attending Jon Jackson’s workshop, Using Repeated Low Stakes (Formative) Assessment to Maximize Student Learning in Your Courses, exit quizzes have been successfully implemented into our undergraduate anatomy exam review laboratory lessons. I have also been able to extend what I learned at HAPS to my personal life; I am planning a trip to Italy for Christmas and many anatomical artifacts from Kevin Petti’s workshop, Anatomica Italiana: Art and Anatomy in the Italian Renaissance have made my must-see list!

I do have one concern about the conference experience; specifically, I am afraid I will not be able to outdo myself in the number of nametag ribbons when I attend the 31st Annual National Conference in Salt Lake City, Utah. This year I proudly displayed four ribbons on my name badge: Central Region, First-Timer, Student, and (Workshop) Presenter. You will have to meet me at the conference next year to see if I am able to set a new personal ribbon record! See You Next Year in Salt Lake City!

Allison Foster is a first year graduate student pursing a PhD in Anatomy in the Division of Anatomy in the College of Medicine at The Ohio State University, Columbus, Ohio, from which she earned a MS in Anatomy in May 2016. She is entering her second year as a Graduate Teaching Associate at OSU, working primarily with the undergraduate human gross anatomy courses.
A good book will teach you something you never knew before. A great book will tear the floor out from under your feet and show you things you have never noticed about the places you think you know best. The Man Who Touched His Own Heart is just such a book.

A couple of years ago, when I was directing the seminar course for first-year biomedical science graduate students on the breadth and nature of scientific inquiry, I was wonderfully pleased to get Rob Dunn to agree to come up to the tundra and give a talk. I had heard about Rob’s work while visiting North Carolina State University with my in-laws, who are alumni members of the Wolfpack Nation; Dunn’s work was being featured locally in the alumni magazine and nationally in the pages of Scientific American and Smithsonian. Rob was making a name for himself with his studies of the varieties of microbiomes from different locations, both between different bodies, and in the same body at different times. He was also a good writer and story-teller: a clear and true voice in the wilderness preaching the gospel of scientific literacy. At the time we agreed he would come to Grand Forks, he was waiting to hear about his tenure decision, so we had difficulty finding the right weekend.

The following year we tried again, but to no avail — his lab had just published some high-flying papers, and as he said, “I’m swamped with (no offense) high falootin’ interview and talk offers.” We demurred until the following year. Well, as luck would have it, he was granted a sabbatical that year and could not come. He was off to some pseudo-Mediterranean climate writing a book, as it turned out.

And the book, as it turned out, is one worth reading. The Man Who Touched His Own Heart tells the stories of some of the pioneering work that has illuminated our understanding of the heart, the principal organ of our body. Of course it features the usual suspects, Galen, Vesalius, and Harvey, but also introduces us to less-recognizable surgeons and medical pioneers such as Maude Abbott, Werner Forsmann, and Norman Shumway. Their names may be less familiar to us and to the generation of students we now teach, but the work of these scientists has no less profoundly affected our understanding of this marvelous organ, than the discoverers of the distant past.

In addition to giving some rather straightforward historical descriptions of evolving medical and interventional therapies to treat heart disease, Dunn’s scientific acumen also has him looking critically at how well these various types of treatment are at preventing recurrence of heart disease. Depending on one’s level of cynicism, his descriptions of state-of-the-art cardiac medicine will either surprise you or confirm your suspicions: the treatments that are most often prescribed and undertaken in the US to combat atherosclerosis are costly, invasive, and have no better outcomes than more conservative, less-costly alternatives. This is particularly noteworthy for people like me, living in the West Central U.S., where in a number of nearby states the largest private employer is a gigantic medical conglomerate (Sanford Health) that derives a disproportionate share of its clinical income from interventional cardiology procedures.

For all of the science and technology that has embraced the heart, and has in turn been embraced by the medical community, Dunn’s book is quick to highlight the notion that there is still a lot of mystery surrounding this marvelous organ, and more for each and every one of us to master, even after we have read and learned the information of this book by heart. It’s definitely worth reading, if not deserving of a place on your bookshelf.

Jon Jackson is a “seasoned” anatomy (and physiology) professor. He lives and writes as a Fellow in the History & Philosophy of Science at The Institute for Philosophy in Public Life in Grand Forks, North Dakota.
Biological Anthropologists as Anatomy Educators

Valerie Dean O’Loughlin, PhD
Professor of Anatomy, Medical Sciences, Indiana University, Bloomington, IN  47405

Abstract
As the pool of experienced gross anatomy educators declines, universities are increasingly worried about where to find the future generation of gross anatomy instructors. Many Anatomy PhD programs do not require their students to learn gross anatomy, and the teaching of gross anatomy is considered a “time sink” for those running bench research programs. The recent educator track Anatomy PhD programs are not yet large enough to fill all future faculty vacancies. Universities need to explore another option: the biological anthropologist as anatomy educator. As a biological anthropologist who has “crossed the threshold” into the field of anatomy, the author presents data about nationwide biological anthropology programs and the state of readiness of biological anthropology graduate students for teaching gross anatomy. Rewards and challenges of being a biological-anthropology-trained anatomy educator are discussed, and how this coupling of anatomy and biological anthropology can be a symbiotic relationship for both fields.

Keywords: physical anthropology, biological anthropology, anatomy education, gross anatomy, teacher-scholar, anatomy educator

Introduction
As the pool of experienced gross anatomy educators continues to decline, universities are becoming increasingly worried about where to find the next generation of anatomy instructors (Cahill et al. 2000, McCuskey et al. 2005). McCuskey et al. (2005) cited survey results that stated more than 80% of chairs whose departments teach anatomy predict “great” or “moderate” difficulty recruiting qualified faculty to teach gross anatomy. Why the current shortage? Many biomedical graduate programs (including those listed as “anatomy” programs) focus teaching and research more on the molecular biology versus organismal or gross anatomical analyses (Cardell 1998). Many traditional bench-research anatomy PhD programs no longer require their students to learn gross anatomy, and have their students focus more on molecular training. As institutions rely more and more on external research funding, faculty must devote a significant part of their time to their research. Courses such as gross anatomy are very time intensive, and the teaching of such a course is considered counterproductive for individuals trying to maintain an active, well-funded research program. As a result, many bench-research-trained anatomy PhDs tend not to pursue anatomy education positions and the need for anatomy instructors has reached crisis levels.

So where will these anatomy educators come from, if most traditional anatomy PhD programs don’t prepare their students for this path? Accreditation programs for anatomy educators have been discussed at past Experimental Biology meetings, but the challenges in implementing an international program are numerous (Rizzolo and Drake 2008). There are several educator-based anatomy PhD programs that have been developed (e.g. Albertine 2008, Brokaw and O’Loughlin 2015), as well as international anatomy educator training programs (Fraher and Evans 2009), but these programs don’t have the capacity to fill the need for future anatomy instructors. Surgeons have been suggested as a potential source for anatomy instructors (Haubert et al. 2011), but it is difficult for most surgeons to maintain a clinical practice and teach time-intensive courses such as gross anatomy.

Universities need to explore more fully another option: the biological anthropologist as tomorrow’s anatomy educator. Biological anthropologists have been and continue to be excellent educators of anatomy. Burr and Haines (1984) noted that physical anthropologists who are trained to teach anatomy are more marketable, and those who understand biomedical research techniques will produce better research projects in the long run. They noted anecdotally about the anthropologists they knew who were hired in medical and dental schools, and taught a range of anatomy courses. Others have commented that the strongest anatomy departments are those that are augmented by fields from molecular biology to functional anatomy and biological anthropology. (Jones 2000, Peck and Skandalakis 2004). Much of the biological anthropology research examines form and function, and as such complements the field of anatomy wonderfully.

Many biological anthropology PhD programs require gross anatomy as a core course, and numerous graduate students have experience teaching these courses. As a biological anthropologist who has “crossed the threshold” into the field of anatomy, I present data about nationwide biological anthropology programs and the state of readiness of these biological anthropology graduate students for teaching gross anatomy.

continued on next page
Materials and Methods

The online survey was developed by the author using the Automated Survey Creation feature on the Sociology Workbench website, a free social science resource developed by the Education Center on Computational Science and Engineering at San Diego State University (2005). The goals of the survey were multifold: 1) to collect information about the quantity and quality of anatomy education required or encouraged of anthropology graduate students, 2) to determine the current numbers of biological anthropologists in anatomy education, and 3) to determine the perceived positives and negatives of being a biological anthropologist in anatomy education. Data was collected and housed on the Sociology Workbench website, and results were presented at the 2005 Experimental Biology meetings (O’Loughlin 2005). Although the data is not recent, many of the trends listed from the 2005 data still hold true today, and provide a benchmark for future surveys and trends.

Prior to administering the survey, this project was submitted to Indiana University’s IRB (Institutional Review Board) and Human Subjects approval was received. The URL for the survey was graciously posted on the AAA (American Association of Anatomists), AAPA (American Association of Physical Anthropologists) and Human Biology websites. In addition, the survey was advertised via several anatomy and physical anthropology listserves, as well as directed e-mailings to physical anthropologists. Data collection was completed in 2005.

Qualitative (textual) data was collected from the Sociology Workbench website and analyzed. Quantitative data was exported from the site in a comma delimited file and analyzed using SPSS 12.0.1 for Windows (SPSS 2003).

Results

A total of 181 survey participants responded online. Of those, 170 were biological anthropologists who had complete data for analysis. Detailed discussion of the data is presented below for these 170 individuals.

survey participant demographics

Of the 170 biological anthropologists, 87 were males (51.2%) and 83 were females (48.8%). Thus, the sexes were equally represented in this study. Table 1 shows the basic demographic information for these participants. The sampling of age ranges (after age 25) was fairly equal among all groups, with the highest level of participation (32.9%) being those aged 25-34. Virtually everyone had an advanced degree, with almost 75% of the sample having a PhD, MD, EdD, or equivalent degree. The vast majority (61.7%) of respondents were those who received their highest degree within the past 15 years. Approximately 30% of the respondents received their highest degree between 1970 and 1989, and only a small percentage who received their degrees earlier than this time responded to this survey.

Survey participants also were asked to describe the specific field of anthropology in which their highest degree was awarded. (Note that some biological anthropologists may have been awarded a degree entitled “physical anthropology”, while others may have their degree specifically say “biological anthropology.”) Degrees in biological anthropology were most numerous (45.9%), followed by physical anthropology (39.4%), bioarchaeology (4.7%) and forensic anthropology (1.2%). The remaining (8%) had degree names such as biological anthropology and anatomy, osteology, anthropology, human biology, functional anatomy and evolutionary biology, and paleoanthropology.

Survey participants received their Masters or Doctorate degrees from a wide array of universities. No single university predominated in the survey sample, and participants were well distributed among the universities represented. Most participants received their degrees from universities in the United States, although a few individuals listed universities in the UK, Canada and Australia.

Table 1: 2005 Demographic Data of Biological Anthropology Participants

<table>
<thead>
<tr>
<th>Age</th>
<th>Percentage of sample</th>
<th>Highest Degree</th>
<th>Percentage of sample</th>
<th>Year highest degree awarded</th>
<th>Percentage of sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;25</td>
<td>1.2</td>
<td>BA or BS</td>
<td>2.4</td>
<td>2000-2005</td>
<td>38.2</td>
</tr>
<tr>
<td>25-34</td>
<td>32.9</td>
<td>MA or MS</td>
<td>22.9</td>
<td>1990-1999</td>
<td>23.5</td>
</tr>
<tr>
<td>35-44</td>
<td>21.8</td>
<td>PhD, MD or Equiv</td>
<td>74.7</td>
<td>1980-1989</td>
<td>15.9</td>
</tr>
<tr>
<td>45-54</td>
<td>24.7</td>
<td></td>
<td></td>
<td>1970-1979</td>
<td>14.1</td>
</tr>
<tr>
<td>&gt;54</td>
<td>19.4</td>
<td></td>
<td></td>
<td>1960-1969</td>
<td>5.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1959 or earlier</td>
<td>2.4</td>
</tr>
</tbody>
</table>

1Percentages are based out of a total n=170
Most Biological Anthropologists are Encouraged or Required to Take Anatomy Courses

Table 2 shows the responses to the following survey question: “As part of your graduate training in anthropology, were you encouraged or required to enroll in some form of anatomy education?” The vast majority of biological anthropologists (88.9%) were either encouraged or required to enroll in some form of anatomy education. Of those who did not take anatomy courses, several commented later in the survey that their institution did not have any anatomy courses for them to enroll in, or that the anatomy courses available were limited to medical students only.

Table 2: Biological Anthropologist Survey Responses to Question: Were you Required or Encouraged to Take Anatomy Courses?

<table>
<thead>
<tr>
<th>Response</th>
<th>N</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neither Encouraged nor Required</td>
<td>19</td>
<td>11.2</td>
</tr>
<tr>
<td>Encouraged but not Required</td>
<td>80</td>
<td>47.1</td>
</tr>
<tr>
<td>Required to take Anatomy courses</td>
<td>71</td>
<td>41.8</td>
</tr>
</tbody>
</table>

Table 3 lists the most common anatomy courses in which biological anthropologists enrolled. The 2nd column lists the percentages of individuals who were encouraged to take a course, and the 3rd column lists the percentages of individuals who were required to take the course. Not listed in the table are percentages of those who either did not answer the question or responded that they were neither required nor encouraged to enroll in anatomy. Graduate or medical school level human gross anatomy was the most common course among the biological anthropologists, which 35.3% of the entire sample required to take the course, and 47.1% encouraged to enroll in it. Thus, most biological anthropologists have been trained in gross anatomy and of these, most already have experience as to how gross anatomy is taught to medical students (since they took a medical school course in gross anatomy). Comparative anatomy was the next most common course (10% required to take and 32.4% encouraged to take). Many biological anthropologists were encouraged or required to take one or more of the following courses: embryology, neuroanatomy, microscopic anatomy, and an undergraduate level human anatomy. Other anatomy or medical courses taken include primate gross anatomy, biomechanics, dental anatomy, physiology and endocrinology.

Many Biological Anthropologists Have Anatomy Teaching Experience

The online survey demonstrates that most biological anthropologists have done some anatomy coursework. Many anthropology graduate students gain teaching experience during their graduate careers. But do any of them gain teaching experience in anatomy?

Table 4 examines the responses to the survey question: “During your anthropology graduate training, did you gain any teaching experience in anatomy?” Individuals checked all responses that applied. Almost half of the respondents (46.5%) taught an anatomy course as a teaching associate (TA) or associate instructor (AI) during their anthropology graduate career. Over 20% of the respondents gained teaching experience in anatomy in some other fashion, such as being hired as a prosector, being appointed as a “lecturer” in a

Table 3: Anatomy Courses In Which Biological Anthropologists Enrolled

<table>
<thead>
<tr>
<th>Name/Type of Anatomy Course</th>
<th>Percentage of Individuals¹</th>
<th>Percentage of Individuals¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undergraduate level: Human Anatomy</td>
<td>15.3</td>
<td>5.3</td>
</tr>
<tr>
<td>Undergraduate level: Microscopic Anatomy</td>
<td>4.7</td>
<td>0.6</td>
</tr>
<tr>
<td>Graduate-Medical School Level: Human Gross Anatomy</td>
<td>47.1</td>
<td>35.3</td>
</tr>
<tr>
<td>Graduate-Medical School Level: Microscopic Anatomy</td>
<td>12.9</td>
<td>6.5</td>
</tr>
<tr>
<td>Comparative Anatomy</td>
<td>32.4</td>
<td>10.0</td>
</tr>
<tr>
<td>Neuroanatomy</td>
<td>12.9</td>
<td>2.4</td>
</tr>
<tr>
<td>Embryology</td>
<td>19.4</td>
<td>5.9</td>
</tr>
<tr>
<td>Other²</td>
<td>18.8</td>
<td>8.8</td>
</tr>
</tbody>
</table>

¹ Out of N=170. Not listed are the percentages of individuals who did not answer the question and those who said they were not required or encouraged to enroll in anatomy.

² Includes primate gross anatomy, biomechanics, dental anatomy, physiology, endocrinology.

continued on next page
Many Biological Anthropologists Already work in Medical/Health Schools

When asked what best describes their type of employment, 74.7% stated they were staff, non-tenure track faculty, or tenure-track faculty at a college or university. Table 6 shows the percentages of biological anthropologists in various places of employment. The majority (55.9%) are at a 2 or 4 year college or university, while 25.9% are employed at a medical school. Several individuals had appointments at multiple institutions.

Table 7 shows the types of primary appointments of the survey respondents. Anthropology was the most common primary appointment (40%), followed by an appointment in anatomy (17.1%) or “other” (15.3%). “Other” appointments included those in radiology, medical sciences, public health, medical school while completing the anthropology degree, teaching their own course in comparative primate anatomy or undergraduate anatomy, or being a full-time adjunct assistant professor in anatomy at another institution while completing the anthropology degree.

Table 5 lists the types of courses in which the biological anthropologists were teaching assistants or associate instructors. Over 34% of the survey sample had teaching experience in a graduate or medical school level gross human anatomy course, followed by an undergraduate level human anatomy course (18.2%) or some other anatomy-related course (12.4%). So before biological anthropologists finish their graduate training, they already are acquiring more anatomy teaching experience than some newly hired assistant professors!

Table 4: Survey Responses to Question: Did You Gain Anatomy Teaching Experience During your Anthropology Graduate Training?

<table>
<thead>
<tr>
<th>Response</th>
<th>N</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>66</td>
<td>38.8</td>
</tr>
<tr>
<td>Yes, via tutoring students</td>
<td>22</td>
<td>12.9</td>
</tr>
<tr>
<td>Yes, via being a T.A. (teaching asst.) in an anatomy course</td>
<td>79</td>
<td>46.5</td>
</tr>
<tr>
<td>Yes, other(^1)</td>
<td>35</td>
<td>20.6</td>
</tr>
</tbody>
</table>

\(^1\) “other” includes prosector, full-time adjunct assistant professor, lecturer

Table 5: Anatomy Courses In Which Biological Anthropologists Were Teaching Assistants

<table>
<thead>
<tr>
<th>Name/Type of Anatomy Course</th>
<th>N(^1)</th>
<th>Percentage(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undergraduate level: Human Anatomy</td>
<td>31</td>
<td>18.2</td>
</tr>
<tr>
<td>Undergraduate level: Microscopic Anatomy</td>
<td>4</td>
<td>2.4</td>
</tr>
<tr>
<td>Graduate-Medical School Level: Human Gross Anatomy</td>
<td>58</td>
<td>34.1</td>
</tr>
<tr>
<td>Graduate-Medical School Level: Microscopic Anatomy</td>
<td>8</td>
<td>4.7</td>
</tr>
<tr>
<td>Comparative Anatomy</td>
<td>11</td>
<td>6.5</td>
</tr>
<tr>
<td>Neuroanatomy</td>
<td>5</td>
<td>2.9</td>
</tr>
<tr>
<td>Embryology</td>
<td>7</td>
<td>4.1</td>
</tr>
<tr>
<td>Other(^2)</td>
<td>21</td>
<td>12.4</td>
</tr>
</tbody>
</table>

\(^1\) Out of N=170. Not listed are the percentages of individuals who did not answer the question or were not teaching assistants.

\(^2\) Other courses include primate gross anatomy and comparative mammalian cranial embryology
endocrinology, and Chair of the Basic Sciences department of a Podiatric College. Over 40% of these individuals also had a secondary appointment in another department, such as anthropology, anatomy, biology, plastic surgery, orthopedic surgery, neuroscience, department of oral biology and radiology. Thus, while a primary appointment may be in an anthropology department, individuals frequently had a secondary appointment in a medical or health related field.

The Special Contributions of the Biological Anthropologist in Anatomy

For those who had an anatomy, medical, or allied health appointments, the survey asked them what they perceived were the positives of having an anatomy/medical/health appointment versus a traditional anthropology appointment. Many answered employment stability. As Burr and Haines (1984) noted years earlier, physical anthropologists often can get at least temporary jobs teaching anatomy, especially when traditional anthropology jobs are scarce. In addition, an anatomy/medical appointment frequently comes with a higher salary and a reduced teaching load than that of a traditional anthropology appointment. The reduced teaching load allows them to do more research. A medical school appointment and have a passion for the anatomy material. Several stated that have received teaching awards and that their enthusiasm spreads to their students and classes.

The Positives of Teaching Anatomy for Biological Anthropologists

For those who had an anatomy, medical, or allied health appointments, the survey asked them what they perceived were the positives of having an anatomy/medical/health appointment versus a traditional anthropology appointment. Many answered employment stability. As Burr and Haines (1984) noted years earlier, physical anthropologists often can get at least temporary jobs teaching anatomy, especially when traditional anthropology jobs are scarce. In addition, an anatomy/medical appointment frequently comes with a higher salary and a reduced teaching load than that of a traditional anthropology appointment. The reduced teaching load allows them to do more research. A medical school appointment and have a passion for the anatomy material. Several stated that have received teaching awards and that their enthusiasm spreads to their students and classes.

Table 6: Places of Employment for Biological Anthropologists

<table>
<thead>
<tr>
<th>Type of Institution</th>
<th>N</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government</td>
<td>6</td>
<td>3.5</td>
</tr>
<tr>
<td>Private Business</td>
<td>10</td>
<td>5.9</td>
</tr>
<tr>
<td>2 or 4 Year College or University</td>
<td>95</td>
<td>55.9</td>
</tr>
<tr>
<td>Medical School</td>
<td>44</td>
<td>25.9</td>
</tr>
<tr>
<td>Denistry School</td>
<td>4</td>
<td>2.4</td>
</tr>
<tr>
<td>Osteopathic or Chiropractic School</td>
<td>4</td>
<td>2.4</td>
</tr>
<tr>
<td>Physical Therapy/Nursing/other Allied Health School</td>
<td>5</td>
<td>2.9</td>
</tr>
<tr>
<td>Other</td>
<td>15</td>
<td>8.8</td>
</tr>
</tbody>
</table>

1Sample is n=170, but some individuals had multiple appointments.
2Includes individuals who were still working on their degree or were retired.

Table 7: Primary Faculty/Staff Appointments for Biological Anthropologists

<table>
<thead>
<tr>
<th>Type of Appointment</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthropology</td>
<td>40.0</td>
</tr>
<tr>
<td>Anatomy</td>
<td>17.1</td>
</tr>
<tr>
<td>Biology or Genetics</td>
<td>5.2</td>
</tr>
<tr>
<td>Health Science</td>
<td>2.4</td>
</tr>
<tr>
<td>Kinesiology</td>
<td>1.8</td>
</tr>
<tr>
<td>Pathology</td>
<td>1.2</td>
</tr>
<tr>
<td>Physical Therapy or other Allied Health School</td>
<td>1.2</td>
</tr>
<tr>
<td>Other</td>
<td>15.3</td>
</tr>
</tbody>
</table>

1Sample is n=170, and 17.1% of the sample did not have a faculty or staff appointment.
carries more prestige than an anthropology appointment, and in a medical school, start-up funds are higher and research equipment typically is better. Several believed that funding agencies, particularly NIH, look more favorably on an individual with an anatomy/medical school appointment. Some mentioned that an anatomy/medical appointment allows one to interact with other health fields more easily.

The Negatives of Being a Biological Anthropologist in an Anatomy/Medical Department

These same individuals were asked what were their perceived cons or “negatives” of being a biological anthropologist in an anatomy/medical department. Many felt there was too much pressure to publish and generate grant money. While the pay and prestige may be higher at a medical school, there also are much higher acceptable “levels” of grant funding in a medical school. For those who are primarily interested in educational issues, they typically have the non-tenure-track teaching positions. Thus, many biological anthropologists who focus on education and educational research stated they sometimes feel like “second class citizens” in their departments, a finding also mentioned in McCuskey et al. (2005).

Several anthropologists stated that some biomedical scientists question the validity of biological anthropology research, and one has to “prove oneself” in the medical world. A few individuals mentioned leaving institutions because of the hostility or negativity from fellow faculty whose degrees were in more traditional biomedical fields. Also, by having an appointment in a medical school, some felt they were isolated from other anthropologists and some anthropology research. In fact, “professional isolation” was a common complaint among survey respondents.

Discussion and Conclusions

In separate surveys of U.S. and Canadian medical schools, Fitzharris (1998) and Drake et al. (2002, 2009, 2014) found that most gross anatomy courses spend the majority of the course hours with cadaver-based laboratory dissection. Mameren (2004) emphasized that a teacher of anatomy should be an experienced gross anatomy dissector, not just someone who has viewed some prosections. Unlike many molecular and cell biologists (Mameren 2004), most biological anthropologists have taken gross human anatomy and thus have experience in cadaver dissection. Further, many of these biological anthropologists have extensive teaching experience in anatomy, even before they finish their anthropology graduate training. As the comments have shown, many of these individuals have received teaching awards and have been praised by their students as enthusiastic and excellent educators. Thus, biological anthropologists have the anatomical course knowledge, teaching experience, and enthusiasm desired in an anatomical educator.

However, as McCuskey et al. noted in 2005, the culture needs to change. Anatomy departments need to recognize the contributions of individuals devoted to quality teaching of gross anatomy, and realize that quality teaching takes time and effort. Anatomy/medical departments should recognize that funding expectations are different for biological anthropologists (versus a traditional clinical researcher) and so biological anthropologists should not be penalized in promotion and tenure decisions as a result. Perhaps institutions would be wise to follow the advice of Peck and Skandalakis (2004: 367) who state that those that teach in the basic sciences “should actually do research in those subjects, or, better yet, research on teaching methodology for them.” Biological anthropologists study the human form, and thus perform research in human anatomy.

The data presented in this study provides a benchmark for how and to what extent biological anthropologists contribute to the anatomy education mission. A decade has passed since the original data collection, and future studies should re-examine and resurvey the anatomy and biological anthropology populations, to see what trends persist and what has changed in recent years.

Acknowledgments

This publication is based on an earlier invited symposium given at the 2005 Experimental Biology Meetings (O’Loughlin 2005). Many thanks to Dr. Kurt Albertine for inviting me to participate in the Symposium: “Endangered Species: Who Will Teach Anatomy in 2010?” I greatly appreciate the efforts of the Education Center on Computational Science and Engineering, who were responsible for providing the survey creation and analysis resource known as Sociology Workbench. I am indebted to all of the survey participants for taking the time to contribute data for this effort. Finally, I thank the individuals at AAA, AAPA and Human Biology who were responsible for graciously allowing the survey URL to be advertised on their websites.

Valerie Dean O’Loughlin, Ph.D., is a professor of anatomy and cell biology in the Medical Sciences Program at the Indiana University School of Medicine, Bloomington, Indiana, where she teaches undergraduate human anatomy, medical gross anatomy, and pedagogical methods in health sciences. Her research interests are in anatomy education and teaching assistant pedagogical development. She is the recipient of numerous teaching awards, including the IU School of Medicine Scholar Educator Award, and the American Association of Anatomists’ Basmajian Award for teaching excellence and outstanding accomplishments in scholarship of education.

continued on next page
Literature Cited


SPSS, Inc. (2003) SPSS 12.0.1 for Windows. SPSS, Inc.

Valerie Dean O’Loughlin, PhD, is a professor of anatomy at Indiana University where she teaches undergraduate human anatomy, medical gross anatomy, and pedagogical methods in health sciences. Her research interests are in anatomy education and teaching assistant pedagogical development. She is a President-Emeritus of HAPS.
Enhancing the Learning Experiences of Undergraduate Students through Pre-Recorded Video Lectures

Mary Vagula and He Liu
Department of Biology, Morosky College of Health Professions and Sciences, Gannon University, Erie, PA

Abstract
To enhance the learning experiences of undergraduate students enrolled in physiology laboratories we provided them with prior access to online pre-recorded video lectures in five physiology lab experiments. Five other lab experiments were taught using traditional face-to-face lectures. Student performance in exams was compared between the two methods of teaching and student feedback was collected through an anonymous survey. Although the correlation between student use of the prerecorded material and their grades appeared to be weak, students gave overwhelmingly positive feedback on the video lectures, suggesting that their confidence in the subject improved significantly.

**Mary Vagula and He Liu presented a poster on this study at the 30th HAPS Annual Conference in Atlanta, Georgia in May 2016**

Key Words: Pre-recorded video lectures, Learning objectives, undergraduate physiology laboratory

Introduction
The physiology laboratory course (BIOL369) is offered concurrently with the physiology lecture (BIOL 368) course at Gannon University, Erie, PA, USA. It is a required course for students in the pre-professional health track and an elective for biology majors. Each semester we teach four to five sections of this laboratory and provide ten unique laboratory experiments for our students. Each laboratory exercise starts with a 30 to 40 minute lecture that explains the principles and purpose of the lab and provides detailed instructions on how to perform these exercises. Following the lecture, students perform these laboratory exercises in small groups. Some of the physiology laboratory exercises are quite extensive requiring more than three hours to complete them; so spending the first 30 - 40 minutes lecturing is not an ideal use of lab time. In order to optimize the use of lab time, to deliver uniform content to all lab sections, and to continue to provide quality-learning experiences, we developed pre-recorded online videos using ‘Kaltura’, a video platform. Using ‘Kaltura’ we recorded and uploaded videos with voice over PowerPoint explaining the laboratory principle/ purpose/instructions for five lab experiments. The videos were made available to students on Blackboard. This saved about 30 minutes of our lab time in those experiments. Students were instructed to watch the videos before coming to the laboratory. To compare the usefulness and efficacy of the online video lectures with traditional methods, another five lab experiments were taught using traditional face-to-face lectures. Student test scores, with or without access to video lectures, were compared and the results are presented in this report. Anonymous student responses were obtained through a post-lab questionnaire. The data from these laboratory investigations is shown in Figures 1-6. The purpose of this study was to compare the efficacy of the video lectures in increasing student comprehension and student confidence in the subject matter.
Materials and Methods

Voice over PowerPoint video lectures were developed using Kaltura, a video platform (http://corp.kaltura.com/) that is integrated into Blackboard, our learning management system at Gannon University. For each lab, we uploaded two to three video lectures each lasting eight to twelve minutes. Pre-recorded video lectures were made available to students through Blackboard at least three to seven days prior to the labs. The students were advised to watch the videos and complete an online quiz pertaining to the video lecture. The online quizzes, which consisted of randomized questions, were not timed. They were graded and recorded automatically using the Blackboard system. This ensured that students watched the videos before coming to the laboratory. Another quiz with similar questions was given at the beginning of each lab to make sure that each student had independently completed the online quiz. After very brief instruction on the lab activities, students performed the exercises as usual. In order to see the usefulness of these video lectures, we taught the first half of the semester (5 lab experiments) with traditional lectures and the second half (5 lab experiments) with video lectures and compared student performance. After the first half of the semester a midterm exam was administered and after the second half of the semester a non-cumulative final exam was administered. The scores from midterm and final exams were compared. At the end of the semester students were asked to complete an anonymous questionnaire that contained eight questions. Student feedback from this questionnaire is shown in figures 1-7. Student scores were compared with past semesters that were taught without video lectures, shown in figures 8 and 9.

Results

Student feedback to questions in an anonymous questionnaire is shown in Figures 1-6. Most of the students in this laboratory were highly motivated and interested in learning the concepts taught in this lab (74%) Figure 1. About 58% of students indicated that online pre-recorded video lectures increased their level of engagement compared to 16% who expressed that this method of instruction was less engaging and the remaining 26% students indicated it was about the same (Figure 2). About 78% students felt that video lectures were comparatively more effective in imparting background knowledge compared to traditional methods (Figure 3). The majority of students (69%) reported that these videos also were more effective in directing the laboratory activities than the traditional method (Figure 4). The overwhelming majority of the students (92%) reported that online quizzes were effective in preparing them for the laboratory (Figure 5). Seventy-seven percent of students preferred the online pre-recorded videos to traditional lecturing (Figure 6). Although students reported increased engagement and learning with online pre-recorded video lectures there was no significant increase in their exam scores from midterm and final exams were compared. The scores from midterm and final exams were compared. At the end of the semester students were asked to complete an anonymous questionnaire that contained eight questions. Student feedback from this questionnaire is shown in figures 1-7. Student scores were compared with past semesters that were taught without video lectures, shown in figures 8 and 9. Student feedback to questions in an anonymous questionnaire is shown in Figures 1-6. Most of the students in this laboratory were highly motivated and interested in learning the concepts taught in this lab (74%) Figure 1. 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scores. We observed over several years, prior to adopting online videos for instruction, that final exam scores were comparatively lower than the midterm exam scores (Figure 7). Even after administering the online video lectures we continued to see the same trend (Figure 8).

**Discussion**

The present study attempted to provide enhanced learning experiences to undergraduate students enrolled in physiology labs by providing them with pre-recorded video lectures. The study was also designed to save valuable time in the laboratory in order to facilitate the development and incorporation of more laboratory exercises into future labs. It is clear from this study that the majority of students (77%) preferred video lectures and they felt online video lectures were effective (78%) in equipping them with background knowledge. The overwhelming majority (92%) of students felt that online quizzes following these videos were helpful in preparing for the labs. The overall analysis of student responses indicates online video lectures enhanced student satisfaction and their learning experiences.

Although there was positive feedback on the use of video lectures, comparison of student average scores in the final exam (post-video lecture) with the midterm test (pre-video lectures) indicates no improvement in their scores (Figure 7). Over the span of several years we observed that student scores are consistently better in the midterm test compared to the final test. We observed the same trend even with this method of instruction. The results of the present study indicate that there is no significant correlation between the use of online video lectures and student performance. Though the lecture/lab correlation was comparable in both the tests, the authors assume certain variables, which are not in our control, might have contributed to this observation. For example, the final lab exam is scheduled in the busiest time of the semester and with several end-of-semester tasks at hand, students might not had enough time to prepare for this test. It is also possible that the video lectures generated overconfidence, which might have prevented students from reading the textbook/lab manual carefully.

It is important to note that our students are mostly pre-professional health majors with interest in PA and PT and biology majors in pre-med programs. They are highly motivated students with well-defined career goals and therefore they worked very hard with either teaching method. It is hard to track whether the prerecorded videos saved time for the students when they were reviewing the class material or whether this method more rapidly increased their comprehension of the subject matter.

Smith and Fidge (2008) reported making observations similar to ours, i.e. no significant improvement in student grades, when they implemented mini online prerecorded videos to help students in computer programming. The report of Hsin and Cigas (2013) on enhanced student motivation and satisfaction following short videos lends support to our observation. However, some studies report that video presentation of the material is very effective in the learning process (Gia et al. 2015, Isiaka 2007). Since there is no one method of instruction that will work all of the time and under all the circumstances (Dyer 1999), we will continue to explore and test different teaching strategies and approaches.

In conclusion, our data clearly suggests that our students liked the ability to rewind and watch the lectures numerous times. However, further studies are needed to determine the optimal use of video lectures in the laboratory setting.
times. Though this increased their satisfaction it has not resulted in better grades. The key point to be learned from this study is that student satisfaction with the learning process is not sufficient to result in good student grades. Good grades are the result of students gaining proficiency in the subject matter. This can be only accomplished when students take it upon themselves to read the textbook and the laboratory manual, watch the videos, and explore the kind of learning method that works best for them. In the future, students in our classes and laboratories will be advised to identify the learning strategy that works best for them.

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The authors would like to thank Gannon University, Erie, PA for awarding the Faculty Scholarship Grant and the Faculty Development Grant and Ms. Catherine Datte, Director of the Center for Excellence in Teaching and Learning (CETL) and Dr. Tinukwa Boulder, Instructional Designer, CETL, Gannon University, Erie, PA for their help in developing the online videos with Kaltura software. The authors would also like to thank Dr. Sarah Ewing for her support throughout this study. Mary Vagula wishes to specifically thank the Human Anatomy and Physiology Society and AD Instruments for the Sam Drogo Award.

Literature Cited


A Modified Protocol of Salivary Cortisol Determination to Optimize Undergraduate Laboratory Learning Experiences

He Liu and Mary Vagula
Department of Biology, Morosky College of Health Professions and Sciences, Gannon University, Erie, PA

Abstract
In this study, we tested different conditions, identified optimal conditions for an undergraduate laboratory activity, and developed an improved protocol for the determination of salivary cortisol levels without compromising the sensitivity of the assay. In this modified method the overall incubation period was shortened from 90 minutes to 40 minutes, the first incubation temperature was increased from room temperature to 37°C without compromising the accuracy in the cortisol measured, and the solution decanting step was altered for conserving time and improving the efficiency in performing the assay. In addition, other learning activities such as showing videos on ELISA technique, data analysis and laboratory practices were integrated in waiting period. We strongly believe these modifications have made this laboratory module more suitable to be used in an undergraduate teaching lab.

* He Liu and Mary Vagula presented a poster on this laboratory module at the 30th Annual HAPS Conference in Atlanta, Georgia in May 2016

Key words: undergraduate education, physiology lab, salivary cortisol, ELISA, protocol

Introduction
The authors previously presented an undergraduate physiology laboratory activity developed for students in health profession and biology majors, using a commercially available ELISA kit (Eagle Biosciences, COR32-K01) to measure cortisol levels in saliva samples (Liu and Vagula 2015). In this lab, students measured the cortisol concentrations in saliva samples that were collected the evening prior to the scheduled laboratory and the morning of the scheduled lab. The aim of the lab was to introduce students to the ELISA method for quantifying hormone levels and to instruct them in the use of computational/statistical data analysis using Microsoft Excel. This lab activity was well received by students. However, one major complaint was that the lab required incubations of 60 minutes and 30 minutes. Undergraduate students often became less enthusiastic and less engaged during long waiting periods. Therefore we modified the protocol of the original laboratory in order to promote student engagement in this investigation. The modified protocol shortened the total incubation time from 90 minutes to 40 minutes while maintaining the same measurement accuracy and the time frame of the lab is now more suitable for undergraduates. We also incorporated additional learning activities during the shortened waiting periods, thereby keeping the students more engaged in the learning process throughout the duration of the laboratory.

Materials and Methods
Materials needed: Ultrasensitive Cortisol Saliva ELISA Assay Kit (Eagle Biosciences, Nashua, NH) was used for this lab. One kit (96 wells) is sufficient for 44 students. A set of wells is required to construct the standard curve. Other necessary equipment includes a microplate reader (Promega, Madison, WI) that is equipped with a 450nm filter, micropipettes and tips, and a heated horizontal shaker (MAXQ 4324, Thermo Scientific).

Figure 1. Comparison between the original and the modified protocols. The original protocol can be found at the manufacture’s website http://www.eaglebio.com/content/COR32-K01_Cortisol_ELISA_Saliva_Assay_kit.pdf

Original
1. To GARGG microplate pipet 50 μl saliva sample, 50 μl of Cortisol-HRP working reagent, and 50 μl of Cortisol ELISA antibody into each well.
2. Cover microplate with plastic sealer. Incubate by shaking on a microplate orbital shaker set at 900 rpm for 60 minutes at room temperature.
3. After incubation, decant the contents of the wells with vacuum apparatus. Wash 3 times with 300 μl of diluted wash solution. After the 3rd wash, invert GARGG microplate on an absorbent paper and tap dry.
4. Pipet 100 μl of Color Development into each well. Shake briefly (manual). Incubate for 30 minutes at room temperature.
5. Pipet 100 μl of Stopping Solution into each microtiter well. Shake briefly (manual). Color changes from blue to yellow.
6. Read at 450 nm on a microplate reader within 30 minutes.

Modified
1. To GARGG microplate pipet 50 μl saliva sample, 50 μl of Cortisol-HRP working reagent, and 50 μl of Cortisol ELISA antibody into each well.
2. Cover microplate with plastic sealer. Incubate by shaking on a microplate orbital shaker set at 900 rpm for 30 minutes at 37°C.
3. After incubation, decant the contents of the wells to three layers of paper towel. Wash 3 times with 300 μl of diluted wash solution. After the 3rd wash, invert GARGG microplate on an absorbent paper and tap dry.
4. Pipet 100 μl of Color Development into each well. Shake briefly (manual). Incubate for 10 minutes at room temperature. Monitor and record color change, discuss how color intensity correlates with cortisol concentration.
5. Pipet 100 μl of Stopping Solution into each microtiter well. Shake briefly (manual). Color changes from blue to yellow.
6. Read at 450 nm on a microplate reader immediately.

Figure 1. Comparison between the original and the modified protocols. The original protocol can be found at the manufacture’s website http://www.eaglebio.com/content/COR32-K01_Cortisol_ELISA_Saliva_Assay_kit.pdf

continued on next page
Standard sample measurements: The standard cortisol samples (0.1, 0.3, 1.0, 3.0, 10.0 and 30 ng/ml) supplied with the Ultrasensitive Cortisol Saliva ELISA Assay Kit were used to construct the standard curves with different experimental conditions. The original protocol recommended by the manufacturer and the modified protocol is shown in Figure 1. In addition to the conditions used in the modified protocols, different combinations of incubation temperatures and durations were used to construct standard curves for comparison (Figure 2).

Standard curve construction: The standard curves were constructed using the log-log method (Plikaytis et al. 1991).

Results
The results (Figure 2) show that, compared to the measurement with the original protocol:

1. Reduction of the first incubation time to 30 minutes lowered the OD values and reduction of the second incubation time further reduced the OD values slightly (Figure 2A).
2. The higher temperature at 37°C in the first incubation increased the OD values even with shortened incubation times. The values are comparable to the original condition.
3. All of the conditions gave comparable and good correlations in the standard curves, as the square values of Pearson's correlation coefficients vary in a narrow range between 0.95 and 0.97 (Figure 2B), indicating that all the standard curves can accurately show the quantitative trends of the concentrations.

Since our lab has only one vacuum apparatus, we changed the manner in which solutions were decanted in the washing steps. Students flipped the ELISA wells on multiple layers of paper towels and tapped on the back to remove the solutions. This reduced student waiting time and showed no change in measurement accuracy (all results in Figure 2 were obtained using the paper towel method).

We also added activities in the waiting periods to increase student engagement. In the first incubation of 30 minutes, we showed students a video on the ELISA technique then had discussions on data analysis and statistical tests. In the second incubation of 10 minutes, we asked students to record observed color changes and discussed how color intensity correlates with cortisol concentration. A visible inference in color was usually apparent after 5 minutes of incubation.

Conclusion
In conclusion, we tested different combinations of temperature and incubation times in the protocol. All combinations gave satisfactory results compared to the original protocol, as the correlation coefficients were almost the same in the standard curves constructed. Having the first incubation at 37°C for 30 minutes and the second incubation at room temperature for 10 minutes is recommended if a heated shaker is available. The modified protocol shortened the waiting time from 90 minutes to 40 minutes with the same measurement accuracy and gave students more time to understand and practice data analysis. The modified protocol increased student engagement in an active learning process and therefore we believe the lab is now more suitable to be used in an undergraduate teaching lab.
References Cited


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Online Assignment Approach for Large Classes Engages Students, Promotes Higher-Order Cognitive Skills and Allows the Efficient Provision of Instructive Feedback

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Abstract

Students welcome opportunities to demonstrate their creativity through completion of assignments for credit. Such assignments can promote the development of higher-order cognitive skills (HOCS), especially if students are provided with specific and timely feedback. However, challenges facing instructors of large classes include the time required to assess submissions and provide that individualized feedback. In this project, 290 undergraduate students enrolled in a first-year course in anatomy and physiology were randomly assigned one of five applied questions pertaining to the cardiovascular system. Each student was to submit a PowerPoint presentation (10 slides maximum including title slide and references) via the Assignment function of Blackboard Learn. Within the assignment platform, a comment box provided space for typed provision of slide-specific feedback (strengths and weaknesses), following which a single mouse click sent the grade plus feedback directly to the student and into Gradebook, allowing the entire assessment process to be completed within minutes.

Key Words: assignment, active learning, feedback, cognitive skills, large classes

Introduction

The study of anatomy and physiology involves committing to memory a considerable volume of factual information as well as the development of an in-depth understanding of body function and its regulation with the ultimate goal that students will be able to apply that new knowledge and understanding within a variety of contexts. Indeed, an important goal of post-secondary science and the health sciences education is the promotion of scientific literacy by fostering within learners an ability to carry out higher-order cognitive skills (HOCS), such as evaluation, analysis and the creation of solutions to novel problems (Zoller 1993, Bailin 2002, Crowe et al 2008). Unfortunately, this does not always happen. Instructors of first- and second-year university and college basic science courses (especially when course enrolments number in the hundreds) have been frequently criticized for placing too much emphasis on the memorization of large quantities of factual information and testing primarily lower-order cognitive skills (e.g. recognition of the names of structures, listing the order of events in physiological processes) through the use of multiple-choice-question-based summative examinations (Momson 2010, Rowe et al 2015). Students subsequently find it difficult to transition from this passive form of learning to active learning where they are challenged to logically link and apply basic science principles within suitable contexts (Zoller 1993, Bailin 2002, Crowe et al 2008).

In the 1980s, Malcolm Knowles recognized the importance of self-directed and task-oriented learning within adult educational programs (Knowles et al. 1984). He presented these approaches as a means of engaging learners and improving their understanding, retention and knowledge translation skills in response to opportunities for practice application (Knowles et al. 1984; Pratt 1993, Smith 2002). Various studies have also demonstrated that enhanced in-

Figure 1. Assignment grading platform within Blackboard Learn, showing navigation, provision of feedback and recording/submission of outcomes.
depth learning and understanding occur when students are asked to develop their own explanations (Chi et al. 1994, Roy and Chi 2005). However, equally important to asking students to generate their own explanations is the timely provision of feedback so that students can be aware of both the strong points and the weak points and/or errors associated with their answers (Gagné et al. 1992, Carnegie 2015). And that represents an enormous hurdle for instructors of large classes. How to find the time to evaluate each submission and to convey that feedback to the submission author within a short period of time?

This project integrated a PowerPoint (PPT)-based project using a course management system (Blackboard Learn) in an effort to promote student engagement and a deeper understanding of cardiovascular physiology while allowing students to benefit from personalized feedback that addressed both the strong and the weak points of their presentations. The assignment provided students with opportunities to hone their presentation skills, link concepts learned in class to novel applied problems and receive type-written and personalized feedback sent directly to their inboxes as soon as their submissions were assessed.

Methods

This study involved 290 undergraduate students who completed a first-year, first-semester course in anatomy and physiology (ANP1105: Basic cellular physiology and the anatomy and physiology of the cardiovascular, lymphatic and respiratory systems). Three per cent of the student’s final grade was allocated to the submission of an online assignment that provided an opportunity to extend their understanding of certain aspects of cardiovascular structure and function beyond what was covered in class. The assignment took the form of questions related to diseases or changes in blood components in response to an event, and students were asked to explain the physiological concepts related to one of five possible scenarios (Table 1A).

Assignment questions were developed with the goals of engaging the interests of students and encouraging them, through application and explanation, to further explore how physiological concepts with which they were already acquainted could be used to explain certain situations. For example, Question 1 (blood volume in an astronaut) encouraged students to hunt out diagrams of astronauts in order to describe the physiological basis for blood redistribution in zero gravity and Question 3 (hemochromatosis) led students through a brief exploration of the historical use of bloodletting and the physiology behind its considerably more limited use today. Students had to extend their understanding of carriers of genetically-based diseases when answering Question 2 (sickle cell anemia) in order to explain how possession of a single copy of a defective gene for hemoglobin can confer a level of resistance to malaria, while students answering Question 4 (fetal hemoglobin) had to revisit the oxygen dissociation curve that they explored at length in class, this time comparing two different types of hemoglobin rather than different tissue environments. Finally, Question 5 required students to apply their understanding of the vasodilation-inducing properties of nitric oxide, a gaseous product of endothelial cells, to the practical problem of how to best store blood if it is not to be transfused immediately.

Students were randomly assigned to a question using the last digit of their University of Ottawa student number (Table 1A). They were instructed to prepare an engaging PowerPoint (PPT) presentation (maximum length of ten PPT slides) to answer their question using slide 1 as the title slide and slide 10 as their concluding remarks/list of references slide. Instructions provided to students stressed that their work had to be presented in their own words and that penalties for plagiarism could be severe. Each student was provided in advance with the marking rubric that would be

<table>
<thead>
<tr>
<th>Table 1. Assignment questions, random allocation of students and marking rubric.</th>
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<tbody>
<tr>
<td><strong>A. QUESTIONS</strong></td>
</tr>
<tr>
<td><strong>Q1.</strong> (last digit of student number 0 or 5): Why does blood volume decrease in an astronaut? What happens to the hematocrit?</td>
</tr>
<tr>
<td><strong>Q2.</strong> (last digit of student number 1 or 6): Why does the gene for sickle cell disease confer resistance to malaria?</td>
</tr>
<tr>
<td><strong>Q3.</strong> (last digit of student number 2 or 7): Historically, blood drawing was carried out for a number of illnesses. Of course we now know this practice is not usually a good idea. But what is an example of a disease for which this is a valid treatment and why?</td>
</tr>
<tr>
<td><strong>Q4.</strong> (last digit of student number 3 or 8): How is fetal hemoglobin different from maternal hemoglobin? Why does this make sense?</td>
</tr>
<tr>
<td><strong>Q5.</strong> (last digit of student number 4 or 9): Donated blood that has been stored for more than three weeks may be deficient in nitric oxide (NO). Why is that a concern?</td>
</tr>
<tr>
<td><strong>B. RUBRIC</strong></td>
</tr>
<tr>
<td><strong>1 Mark:</strong> Content presented is accurate and answers the question</td>
</tr>
<tr>
<td><strong>1 Mark:</strong> Content is presented in an original manner, at a student level, and is engaging</td>
</tr>
<tr>
<td><strong>1 Mark:</strong> Title and concluding slides are complete; quality of references is appropriate</td>
</tr>
</tbody>
</table>

continued on next page
used for assignment assessment (Table 1B) and informed that their presentation should be submitted as either a PPT or a portable document format (PDF) file via the Assignment function of Blackboard Learn. Students were given 44 days (October 14, 2015 – December 4, 2015, 10:00 PM) to complete the assignment, but were also told that they could submit it online at any time prior to the deadline.

Evaluation of assignments commenced once the submission deadline had passed; the assignments were graded (and outcomes immediately forwarded to each student) in chronological order based on date of submission. Assessment was facilitated by the use of two linked computer screens: one to display the assignment, slide by slide, and the other to allow the recording of comments and score for each assignment as well as navigation from one submission to the next within Blackboard Learn. Comments were entered in the box entitled “Feedback to Learner”, following which a score out of 3 was assigned and the “submit” button in the bottom right corner selected in order to simultaneously send the grade plus comments directly to the student and to Gradebook (Fig. 1). Navigation between assignments was permitted by clicking on the “Grade Next Item” option at the top left of the screen (Fig. 1) so that the evaluation process could begin once again.

A possible influence of submission time on assignment outcomes during deadline day was assessed by one-way analysis of variance (ANOVA). Because requirements for homogeneity of variance were not met (Levene’s test for equality of variances), comparisons between means of time-dependent data subsets were carried out using the Games Howell post hoc test. Comparison of mean student course outcomes (assignment scores omitted) between those students who completed the assignment versus those who chose not to participate was done using the independent-samples t test accompanied by Levene’s test for equality of variances (data found to be compliant regarding homogeneity of variance). For all statistical evaluations, differences were considered significant at \( p < 0.05 \).

**Results**

Of the 290 students who completed the course, 276 (95.2%) submitted assignments. The mean assignment score (± S.D.) was 2.64 ± 0.39 and assignment outcomes ranged from 0 (only one student; a last-minute submission tarnished by blatant plagiarism) to a full 3 out of 3 for assignments of superlative quality. However, as illustrated in Figure 2 and revealed by a median value of 2.80 for the assignment outcomes, the distribution of assignment scores was heavily skewed in favour of higher results for students.

The majority of students met the deadline of 10:00 PM on December 4, 2015. Indeed, 263 of the 276 submissions (95.3%) were received on time. Eleven of the thirteen overdue submissions were received between 10:00 PM and midnight of December 4 while the remaining two late submissions arrived on December 5. While students had the option to submit their work at any time after the assignment had been posted (October 14, 2015), only 3 (1.1%) submissions were received during the month of October, a further 45 (16.3%) during mid-to-late November, and the majority (228; 82.6%) during the period of December 1 – December 5 (Fig. 3).

Taking a closer look at the time course of assignment receipt during the final day revealed a steadily increasing rate of submission right up until the final half-hour before the 10:00 PM deadline (Table 2). A comparison between time of submission and assignment score suggested that, for the 132 students who submitted on December 4, the rush to complete assignments on time for those who left it until the final day did not \( p > 0.05 \) have a detrimental effect on student outcomes as long as the deadline of 10:00 PM was met. Only the final set of average scores (from submissions received after 10:00 PM but before midnight) were lower \( p < 0.05 \) (Table 2) than some of the mean scores obtained during earlier time periods that day (before noon, from 3:00-6:00 PM, 8:00-9:00 PM, and 9:00-9:30 PM). However, it must be noted that there was a penalty (0.5-1.0 mark, depending on extent of lateness) assigned to each assignment received after the
deadline, an important contributor to the lower outcomes for the tardy submissions.

Fourteen students chose not to participate in the assignment. While final grades for the nonparticipants ranged from a low of 34% to a high of 83%, this was a population of students whose mean (± SD) final outcome for the course (52.4 ± 15.0%) was considerably lower (p < 0.5) than that of the 276 students who chose to complete the assignment (70.6 ± 13.3%; assignment score not included).

Assignment assessment times varied somewhat, depending on the quality of each submission and the amount of feedback required. On average, it took approximately 3 minutes per submission to review the PPT slides, type in slide- and content-specific feedback, assign a score based on that feedback and the assignment rubric (Table 1B), and submit the results, both to the student and to Gradebook. In general, the instructive feedback recognized the quality of the information and the presentation format, addressed any errors in physiological reasoning, suggested additional content that could have been included, corrected spelling, grammatical and referencing errors, and sometimes made suggestions regarding formatting and choices of illustrative material. While the instructions presented in class and online regarding submission format were clear and most students did comply, four students submitted their work in a format that could not be opened (as a .key file instead of .ppt or .pdf). Each of these students was assigned a 0, and in the comments section, asked to resubmit either as a PPT or a PDF right away. All four students complied immediately and were able to get credit for their work.

**Table 2.** Investigation of the relationship between time of submission and mean score for the 133 students who submitted their assignments on the final day.

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Number of Submissions</th>
<th>Mean Assignment Score ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before noon</td>
<td>14</td>
<td>2.82 ± 0.18&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>12:00-3:00 PM</td>
<td>16</td>
<td>2.61 ± 0.41</td>
</tr>
<tr>
<td>3:00-6:00 PM</td>
<td>23</td>
<td>2.73 ± 0.21&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>6:00-8:00 PM</td>
<td>22</td>
<td>2.60 ± 0.34</td>
</tr>
<tr>
<td>8:00-9:00 PM</td>
<td>20</td>
<td>2.68 ± 0.34&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>9:00-9:30 PM</td>
<td>10</td>
<td>2.80 ± 0.16&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>9:30-10:00 PM</td>
<td>17</td>
<td>2.38 ± 0.34</td>
</tr>
<tr>
<td>10:00 PM - midnight</td>
<td>11</td>
<td>1.95 ± 0.58&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup> out of 3  
<sup>b</sup> includes a penalty for late submission  
<sup>c</sup> significantly different from mean score for submissions received on December 4 after the 10:00 PM deadline

**Discussion**

These assignments provided an opportunity for students enrolled in a large class to be creative, explore a topic, plan how to present it in an effective an engaging manner and receive feedback about their work that recognized both its good points and areas for further development. Efficiency of the process was promoted through the use of a course management system (Blackboard Learn) that supported easy navigation from one submission to the next and allowed legible and specific feedback. Scores were sent directly to the student at the same time that assignment outcomes were recorded in Gradebook.

The assignment questions were designed to guide students through the learning cycle processes of exploration followed by concept formation and finishing with application (Vanags et al. 2013). Indeed, Bloom’s revised taxonomy uses six verbs (remember, understand, apply, analyze, evaluate and create) to describe a hierarchy of cognitive learning objectives (Anderson et al. 2001) and this assignment required students to work especially with those objectives located at the higher end of the spectrum. More specifically, students were required to gather relevant information (from their textbook, from their course notes and from internet-based resources), organize it in a way that was logical and that answered a question that was new to them, that had not already been discussed in class. This required that they understood what they were reading and, through analysis and evaluation, were able to select those items of information that pertained to their assigned question. Their ability to do that was scored using primarily the first element of the marking rubric and, to a much lesser extent, the third element (quality of references). They then needed to present their answer in a concise and engaging manner, using illustrations to support their arguments. This final step in the project called upon them to synthesize a PPT presentation that conveyed their answer effectively and this educational objective was evaluated primarily using item two in the marking rubric. This is active learning, in which students are not simply acquiring new knowledge and committing it to memory, but revisiting concepts and supportive facts and working with that reservoir of information to evaluate a novel situation and to generate explanations (Michael 2006). Learning how to apply information to the solution of a problem and, even more importantly, how to select from long term memory

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only those pieces of information that apply to the particular situation being addressed and to forge appropriate links between related concepts promotes a deeper form of learning that has been shown to improve retention and promote the acquisition of HOCS (Chi et al. 1994, Miller et al 2002, Pandey and Zimitat 2007, Carnegie 2012, Lin et al 2012).

While a class size of almost 300 did not lend itself to individual oral presentations, the requirement for students to submit their work as PPT presentations combined both oral and written components within a single assignment. Students had to design their submissions in a way that they could be presented to the class while at the same time paying attention to the organization, clarity and conciseness of the text used to convey their ideas and supportive information. Communication skills need to be an important focus of postsecondary curricula. Employers are looking for college and university graduates with good oral and written communication skills in addition to an ability to think critically and to problem-solve (AUCC 2013, Adams 2014). Furthermore, the possession of strong scientific communication skills has been linked with an interest in the pursuit of a career in biomedical research (Cameron et al 2015) and “Communicator” has been identified as one of the seven CanMEDS roles to be targeted by Canadian medical schools (Royal College of Physicians and Surgeons of Canada 2016). While the assignment itself encouraged students to work on their communication skills, the feedback provided during assignment evaluation provided additional opportunities for strengthening those skills. These included the correction of minor errors in spelling and grammar as well as the use of nonprofessional language. However, they also included the provision of guidance regarding more serious deficiencies such as poor organization of the presentation, absence of important pieces of information, inability to make links between related concepts and/or develop clear explanations, all the time making specific reference to the location of those errors within the presentation so that the feedback was formative.

The high participation rate, despite the fact that the assignment was worth only 3% of their final grade, suggested that students were attracted by the content of the questions and the opportunity to be creative. This was further evidenced by the high quality of the majority of the submissions, despite the fact that most were submitted during the final day. The markedly lower course outcomes for the very small number of students who chose not to participate in the assignment suggests that many of them may not have been as engaged in the course as a whole. When dealing with large classes in which there is little one-on-one contact between student and instructor, it is challenging to develop assignments that stimulate the interest of all students. But it is important that instructors do just that in order to encourage students to organize new knowledge in ways that are meaningful to them and, through interaction with course content outside of lectures, become more actively involved in the learning process (Smith et al, 2005; Carnegie, 2012). Online course management systems (e.g. Blackboard Learn, Desire2Learn, Moodle) have the potential to facilitate this process for large student populations in a number of ways (Rangin et al, 2013). They provide a means to randomly subdivide students into groups, a platform for online assignment submission, efficiency of navigation between assignments and the ability to provide student-specific feedback and scores quickly and easily.

In conclusion, it is important to give students in large classes the same opportunities for creativity, critical thinking, problem-solving, self-expression and the receipt of personalized instructive feedback as experienced by students enrolled in small classes. The ability to accomplish this with efficiency is facilitated through the careful design of assignment questions that encourage HOCS, the use of PowerPoint to encourage students to present their ideas clearly and concisely, and via the effective use of assignment functions embedded in learning management systems so that student submissions can be accessed and evaluated quickly and individualized feedback provided to students in a timely manner.

Acknowledgements

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Literature cited


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Reinforcing and Tracking Prerequisite Concept Mastery Using a Two-Stage Collaborative Review Activity

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Abstract

Instructors and administrators frequently establish prerequisite requirements to ensure that entering students possess the background knowledge to succeed in their course. However, prerequisite courses can only benefit students if they have mastered the course concepts and can only benefit instructors if they can accurately measure student mastery. In this study, a no-stakes, two-stage collaborative quiz was used to assess and reinforce student understanding of key prerequisite concepts across a two-course physiology sequence. The final exam of the first course included ten questions addressing concepts particularly relevant for the second course. During the first week of the second course, students were given a paper quiz consisting of the same ten questions, and asked to provide their individual answer and confidence level for each. Students provided their name for tracking purposes, but were assured that the activity was not for marks. Students subsequently worked in small groups to come up with a first group consensus answer and then used IF-AT scratch cards to discover the correct answer. The activity was followed with an extensive instructor debriefing and students recorded when they first understood the concept and their perceptions of the activity. Individual scores were used to identify students that might potentially benefit from additional remediation, and the pooled scores for each question revealed which topics needed to be revisited in greater detail. The average individual quiz scores were 63 +/- 2.8%, vs. 88 +/- 2.4% for the first group answer. When the data from all questions and students were pooled, students reported that they understood the concept addressed by the question prior to the activity 52% of the time. Of the concepts that were not understood prior to the activity, 56% were understood after the group discussion and 41% after the instructor explanation; only 3% were not understood after the activity. Student perception data revealed that they found the activity useful and enjoyable. In conclusion, no-stakes collaborative testing can be an effective introductory activity for courses with prerequisite requirements, enabling students to activate previous knowledge and to prepare for future collaborative learning activities. This activity also enables instructors to identify prerequisite concepts requiring remediation prior to covering new material, and to identify students needing extra help.

Key Words: collaborative testing; knowledge activation; prerequisite courses; homeostasis

Introduction

Physiology, like many sciences, is relatively hierarchical: understanding advanced concepts (e.g. blood pressure control) requires mastery of numerous prerequisite concepts (e.g. the autonomic nervous system, muscle contraction, action potentials, and negative feedback, among others). This requirement is usually addressed using prerequisite courses and thoughtful course design; however, instructors assume mastery and retention of these prerequisite concepts at their peril (Hailikari et al. 2008). Moreover, prior knowledge that is primarily declarative (that is, based on rote learning) does not significantly relate to student success (Hailikari et al. 2007); only procedural knowledge, that is, information that students can integrate and apply to novel situations, appears to be relevant to future learning (Dochy et al. 2002; Hailikari et al. 2008). For instance, the General Models approach (Modell 2000) may promote the development of procedural knowledge by encouraging students to construct a generalized model that can be applied to multiple physiologic mechanisms. For instance, diffusion and tubular flow can both be explained by the general model of flow, in which flow directly correlates with gradient magnitude and inversely correlates with resistance.

While many instructors attempt to activate previous knowledge by reviewing material at the beginning of the course or topic, students tend to “tune out” because they overestimate their understanding of previous material (Willingham 2003). Numerous studies have supported the use of collaborative testing (Giuliodori et al. 2009, Rao et al. 2002) and peer discussion (Smith et al. 2009) for the promotion of conceptual understanding of course material. I have previously used the collaborative testing technique to review prerequisite material by administering a no-stakes two-stage review quiz, in which students complete the quiz first alone and subsequently in a group. However, the quiz did not appear to promote understanding and it also generated numerous negative comments (K. Hull, unpublished observations). Maxwell et al. (Maxwell et al. 2015) followed a similar procedure using instant feedback...
assessment technique (IF-AT) forms, in which student groups scratch off successive responses until they obtain the correct answer. An online answer key was made available. Student feedback revealed that they found the process helpful and that it promoted metacognitive strategies such as reviewing past exams.

The goals of the current study were as follows:

• To develop a collaborative review procedure that students perceived as both engaging and helpful.
• To analyze the impact of the collaborative activity itself on student perceptions of their own understanding.
• To track student understanding of selected concepts in the prerequisite course, throughout the activity, and in a subsequent exam question applying the concept to new material.

Methods
Student Population
The study population consisted of forty-four students in their third or fourth year of a BSc program, specializing in Biology, Neuroscience, or Biochemistry, enrolled in Biology 337 (Animal Physiology II). All students had credit for the prerequisite course, Biology 336 (Animal Physiology I), but fourteen of the forty-four students took the prerequisite course with a different instructor. The study was approved by the Research Ethics Board of Bishop’s University.

Procedure
The final exam of the first course (BIO 336) included ten questions addressing concepts particularly relevant for the second course (BIO 337). The concepts were placed in the context of the topics to come. See Table 1 (left-hand column) for sample questions. During the first week of the second course, students had 10 minutes to complete a paper quiz consisting of the same ten questions, and were asked to record their individual answer and confidence level (Table 2, first two answer columns). Students provided their name for tracking purposes, but were assured that the activity was not for marks. Students subsequently worked in self-selected groups of three or four students to come up with a first group consensus answer (Table 2, third column), and then used IF-AT scratch cards (Epstein Educational Enterprises; http://www.epsteineducation.com to discover the correct answer. Approximately 15 minutes was allocated to the group discussion. The activity was followed with an extensive instructor debriefing explaining the correct and incorrect responses to each activity, and students recorded when they

<table>
<thead>
<tr>
<th>Table 1. Sample Questions</th>
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<tbody>
<tr>
<td>Topic</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>General Model of Flow (Diffusion)</td>
</tr>
<tr>
<td>Homeostasis</td>
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<tr>
<td>Active Transport</td>
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first understood the concept on the Answer Sheet (Table 2, fourth column). Selected questions (or homologs) were included in a later summative exam (Table 1, right-hand column).

Evaluation

The percentage of students obtaining the correct answer was calculated at each stage of the activity: the prerequisite course final, the individual answer, the group answer, and, where relevant, the summative exam. In addition, to compare the effectiveness of the different stages of the activity, the responses to the question “When did you first understand the concept” were pooled for all questions and all students.

Student perceptions were evaluated using an anonymous paper survey. The survey was completed in the eighth week of term and addressed five different course activities; the two-stage review activity, three role-playing simulations, and peer instruction. Students indicated their agreement (1 = strongly disagree; 5 = strongly agree) with two statements: 1. The activity helped me understand the concept and 2. The activity was interesting and/or enjoyable. The survey also included a free response section. For comparative purposes, the survey results were compared with those of Peer Instruction (Smith et al. 2009), a well-validated technique that is generally appreciated by students, and with student perceptions of a similar two-stage review activity used in the previous year. In 2015, the two-stage activity differed in two respects: it did not use the scratch cards for the group answer portion, and the instructor feedback portion was not as extensive. Data for different activities in the same year was compared using Paired T tests, and data from different years was compared using Independent T-tests (Field 2013). Data are reported as means (M) and standard deviations (SD), including 95% confidence intervals (BCa 95% CI) in selected cases. Independent T test results were tested for equal variances using Levene’s test, and the effect size was estimated by calculating the r-value (Field 2013). All tests were reported as t (degrees of freedom) statistic and significance values. All analyses were performed using SPSS (version 21; IBM Corporation).

Results

The average score for the individual quiz was 6.3 (SD 1.78) out of 10, with individual scores ranging from 3 to 10. After completing the quiz individually, the students divided themselves into 12 groups of three or four students each to discuss the questions, come up with a consensus answer, and complete the scratch card to discover the correct answer. All students effectively engaged in the activity, and there was a considerable amount of lively discussion within groups.

Table 3 illustrates the percentage of students obtaining the correct answer in the prerequisite final exam, the individual response, the group response, and, when relevant, the summative exam. Comparing the results in the prerequisite final and the individual answer, the percentage of students selecting the correct answer stayed relatively constant (within 5%) for three questions, increased for two questions, and decreased for the remaining five questions. For all questions, individuals were more likely to select the correct answer after the group discussion than before it; the percentage of students selecting the correct answer on the first “scratch” of the IF-AT card ranged from 68% to 100%. Three questions were modified for inclusion in a summative exam (midterm or final). The percentage of students selecting the correct answer ranged from 65% to 78%.

After all groups had completed the scratch card, the instructor explained the answers to each question, and then students recorded when they first understood the concept (Table 2, right-hand column). Figure 1 illustrates the pooled responses from all students and all questions. Of the concepts that were

Table 2. The Answer Sheet (extract).

<table>
<thead>
<tr>
<th>YOUR Individual Answer</th>
<th>The FIRST group answer</th>
<th>When did you first understand the concept?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Write A, B, C, or D in the blank</td>
<td>Confidence 1: sure 2: pretty sure 3: a guess</td>
<td>Choose one option: 1. Before the activity began. 2. After the group discussion 3. After the instructor explanation. 4. I still don’t.</td>
</tr>
</tbody>
</table>
not understood prior to the activity, 56% were understood after the group discussion and 41% after the instructor explanation; only 3% were not understood after the activity.

Figure 2 illustrates data from anonymous, written student perception surveys from two subsequent years, in which students reported to which degree they found each activity: 1. increased their understanding of the topics; and 2. Was engaging (1= very little, 5= very much). In terms of utility, Peer Education (clickers) was perceived as slightly less useful in 2016 (M = 3.90, SD 1.04) than in 2015 (M = 4.41, SD 0.837). This difference, 0.504, BCa 95% CI [0.053, 0.943] was significant (t(71) = 2.23, p = 0.03) but is a relatively small effect (r = 0.26). Since the technique itself did not change, this difference likely reflects the student population. In contrast, the two-stage review activity was perceived as much more useful in 2016 (M = 3.51, SD 1.19) than in 2015 (M=2.56, SD 0.948). This difference, 0.95, BCa 95% CI [0.43, 1.46] was highly significant (t(71) = 2.23, p = 0.03) and is a medium sized effect (r = 0.4). As suggested by these results, the two-stage review activity was rated lower than Peer Instruction in both years, but the difference was much greater in 2015 (M=1.84 (SD 1.16); t (31) = 8.94, p<0.001) than in 2016 (M=0.39 (SD 1.14); t(40) = 2.2, p = 0.034).

In terms of engagement, Peer Education (clickers) was perceived as equally engaging in 2016 (M = 3.90, SD 0.96) as in 2015 (M = 3.97, SD 1.06); the difference (0.007) was not significant (t (70) =0.289, p = 0.774). In contrast, the two-stage review activity was perceived as much more enjoyable in 2016 (M = 3.73, SD 1.3) than in 2015 (M=2.31, SD 1.0). This difference, 1.41, BCa 95% CI [0.9, 1.97] was highly significant.

Table 3. The percentage of students selecting the correct answer in the prerequisite course final, the two components of the two-stage activity, and the summative exam.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Prerequisite Course Final* (n=28)</th>
<th>Activity: Individual Answer (n=40)</th>
<th>Activity: Group Answer (n=40)</th>
<th>Summative Exam (n=40)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homeostasis</td>
<td>71</td>
<td>70 (86)</td>
<td>98</td>
<td>78</td>
</tr>
<tr>
<td>Secondary active transport</td>
<td>68</td>
<td>38 (54)</td>
<td>78</td>
<td>75</td>
</tr>
<tr>
<td>General Model of Flow (Diffusion)</td>
<td>82</td>
<td>85 (89)</td>
<td>100</td>
<td>65</td>
</tr>
<tr>
<td>Feedback loops</td>
<td>54</td>
<td>45 (54)</td>
<td>70</td>
<td>N/A</td>
</tr>
<tr>
<td>General model of flow (Tubular Flow)</td>
<td>54</td>
<td>73 (71)</td>
<td>100</td>
<td>N/A</td>
</tr>
<tr>
<td>Signal transduction</td>
<td>57</td>
<td>55 (64)</td>
<td>93</td>
<td>N/A</td>
</tr>
<tr>
<td>Diffusion</td>
<td>50</td>
<td>35 (39)</td>
<td>68</td>
<td>N/A</td>
</tr>
<tr>
<td>Positive feedback</td>
<td>86</td>
<td>98 (100)</td>
<td>98</td>
<td>N/A</td>
</tr>
<tr>
<td>Steroid Synthesis</td>
<td>79</td>
<td>58 (61)</td>
<td>83</td>
<td>N/A</td>
</tr>
<tr>
<td>Bulk Flow</td>
<td>82</td>
<td>60 (71)</td>
<td>93</td>
<td>N/A</td>
</tr>
</tbody>
</table>

* Data in the Prerequisite Final column includes 28 students that continued on to the second course. The other columns also include data from 12 additional students that took the prerequisite course with a different instructor. In the Individual Answer column, the number in brackets excludes these 12 students.
In contrast, retention was lower for more detail-oriented questions addressing active transport and steroid synthesis, potentially indicating increased reliance on declarative knowledge.

After completion of the individual quiz, students divided into groups based on classroom proximity. As expected, the group scores for all questions were increased over the individual scores. While the potential learning gains were smaller for students with high individual quiz scores, these students may still benefit from the practice of elucidating explanations to others (Fonseca and Chi 2011). Indeed, one student noted that he/she “benefitted from explaining concepts to others, but did not learn much from the activity.” The questions with the lowest group scores investigated the determinants of diffusion and negative feedback. However, discussions with the students revealed that this difficulty likely reflected the increased difficulty level of the questions rather than the concepts as such.

Student perception scores of the activity were significantly improved over those for a similar activity used in the previous year. Since the scores for Peer Instruction were lower for this cohort than for the previous cohort, the improvement most likely reflects changes in the procedure rather than the different student population. The first change, using IF-AT cards for the group discussion, rendered the activity more fun; two of the ten student comments mentioned this aspect. Moreover, the cards provided immediate feedback, which has been shown to be significantly more effective than feedback delayed by even a day (Dihoff et al. 2004). The second change, increasing the time spent on the instructor’s debriefing, was also important, because students reported that they understood the concept only after the instructor debriefing approximately 20% of the time. Thus, time permitting, these findings support the use of an extensive in-person debriefing rather than the online debriefing used by Maxwell et al. (2015).

While students reported that they understood virtually all of the concepts after the activity, the success rate on related questions on the summative exams was not especially high. For instance, while 98% of students correctly answered the homeostasis question after the group discussion, only 78% of the students correctly answered a relatively straightforward, similar question on the midterm. This question was designed to address the common misconception that all regulated body parameters are maintained homeostatically; this result may simply indicate the “sticky” nature of the misconception (Modell et al. 2015). These data thus suggest that two-stage quizzes is not sufficient to repair difficult misconceptions. The activity can, however, identify students that would benefit from additional remediation.

In conclusion, two-stage collaborative quizzing, even when not for marks, effectively engages students in discussing prerequisite material. Using scratch cards increases student engagement, and a complete, in-person instructor debriefing minimizes student frustration.

(t (70) = 5.1, p < 0.001) and is a relatively large effect (r = 0.52). When the two activities were compared within a student cohort, the prerequisite activity was perceived as significantly less engaging than Peer Instruction in 2015. This difference, -1.66, BCa 95% CI [-2.14, -1.18] was highly significant (t(31) = 7.02, p < 0.001). In contrast, the mean difference between the two activities for 2016 was only 0.175, and was not significant (t (39) = 0.961; p = 0.343).

In the free response section, ten comments were relevant to the two-stage review activity:

- Fun to scratch
- We should have done more of this activity
- When discussing in the group, it helped to clarify the muddy quiz points
- Very good activity for discussing with your group
- It helped to understand and refresh basic concepts from last semester
- Got me to discuss more often
- Same as clicker questions, but the scratching is more fun
- I benefitted from explaining concepts to others, but did not learn much from the activity
- Activity isn’t very enjoyable but it’s always good to get a second guess/go at things
- Pretty much like the clicker questions without anonymity and a lot slower

**Discussion**

Collaborative testing is a well-validated technique that enhances knowledge retention, facilitates engagement, and promotes the development of a constructive classroom environment (Giuliodori et al. 2009, Jensen et al. 2002). The current study extends the work of Maxwell et al. (2015), showing that no-stakes collaborative quizzing can also be an effective introductory activity for courses with prerequisite requirements. It benefits students by activating their previous knowledge and preparing them for future collaborative learning activities. It benefits instructors by highlighting prerequisite concepts requiring remediation and identifying students needing extra help.

Identical questions were used in the prerequisite course final and in the collaborative quiz in order to track medium-term retention. Considering only those students who took the prerequisite course in Fall, 2015 (represented by the numbers in brackets in Table 1), the percentage of correct responses was similar or higher to that of the prerequisite final for five questions. Two of these questions asked students to apply the general model of flow to different situations, such as diffusion and tubular flow, while the remaining three questions addressed the general model of homeostasis and negative/positive feedback (Modell 2000). The relatively high degree of retention supports the use of the General Models approach for facilitating the development of procedural knowledge. In contrast, retention was lower for more detail-oriented
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**Literature cited**


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Bioengineered Skin Substitutes in the Treatment of Burns and Traumatic Skin Lesions

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Abstract
Skin grafting is the conventional method for treating burns and traumatic lesions of the skin. However, this procedure may one day become obsolete, as tissue engineers perfect the ability to construct synthetic tissue substitutes. This article examines the impact of stem cells, biomaterial scaffolds, and bioengineered skin substitutes on the treatment of traumatic wounds of the skin. The findings of two independent researchers, Shen et al. (2014) and Rodriguez et al. (2014), are examined to explore the effectiveness of a combination of stem cells and a biomaterial scaffold in the treatment of skin wounds using a mouse model. Shen et al. (2014) used epidermal stem cells paired with a chitin-collagen biomimetic membrane as a biomaterial and Rodriguez et al. (2014) used a combination of adipose derived stem cells with carboxymethylcellulose as a biomaterial. The results of these studies suggest that bioengineered skin substitutes hold great promise for the treatment of burns and traumatic lesions of the skin.

Key words: skin graft, biomaterial, scaffold, bioengineered skin substitute carboxymethylcellulose, chitin-collagen biomimetic membrane, autograft, allograft, stem cells

Introduction
In the United States alone, each year an estimated 70,000 people suffer from burns serious enough to require skin grafting. Venous ulcers affect another 600,000 to 1.5 million people, and 15 to 20% of diabetics will eventually become incapacitated to some degree with chronic foot ulcers (Eisenbud et al. 2004). In the US, the cost of materials just to dress these large open wounds is estimated to exceed $5 billion a year (Eisenbud et al. 2004). Clearly, the ability to effectively manage traumatic lesions of the skin is of significant concern.

Consider the Ant …
Primitive people may not have understood why, but they knew that penetration and opening of the skin often resulted in sickness and death. It seems logical to imagine that the earliest attempts at wound healing made use of things that were present in the environment and relatively easy to obtain. In this light, consider the lowly ant and its relatively large mouth area.

Study the mouthparts of ants and you will appreciate the significance of the evolutionary events that shaped the large, robust mandibles; form flowing seamlessly into targeted function. Composed of chitin, a complex polysaccharide reinforced with a protein matrix, the mandible is tough, resilient and very strong. It is one of nature’s precision surgical instruments; attached to adductor and abductor muscles for control, it is very sharp and can be used for cutting, tearing, crushing and chewing (Figure 1).

Figure 1. Head and jaws of an Eciton soldier ant, possibly the best candidate for an insect-clamp. Adapted from Majno (1975), illustrated by Kelly Paralis, Penumbra Design, Inc.
Sutures made from the heads of ants are mentioned frequently in descriptions of primitive medicine (Majno 1975). The mechanics described involve a process of bringing the wound edges together and holding them together with ant heads that cling in place by their mandibles after being severed from the body (Figure 2). The soldier ants of Eciton burchelli, a leaf cutting ant species that is widely distributed throughout Central and South America, are believed to be likely candidates for mandible suturing because of their large size and very sharp, fish-hooked shaped mandibles (Majno 1975). The mandibles of this species are known to latch onto skin and clothing so firmly that the heads often remain attached even if the rest of the ant is brushed off. The process is aided by the fact that the adductor muscles of this ant are noticeably stronger than the abductor muscles, a circumstance that tends to keep the mandibles in the closed position even after the body has been snipped off from the head (Majno 1975). The result is a primitive suturing device that remains intact until the mandibles are forcibly pried apart. It is likely that the science of wound healing was born of necessity and this rather primitive start. If so, we have indeed come a long way.

**Overview of skin grafting**

Skin grafting is the process of surgically removing a patch of skin tissue from an uninjured region of the body and transplanting it to cover an open wound using stitches, staples, or a padded dressing. Once the skin tissue is transplanted from the donor site to the wounded area, the donor site and the site of the transplant are typically covered for three to four weeks, though vascularization of the graft may begin to develop in as little as 48 hours after the surgery. Depending on the size of the graft, it can take up to twelve months for the site(s) to completely heal (Grande et al. 2015).

Skin grafts are classified based on the origin and thickness of the graft. Autografts come from the patient, whereas allografts or homeografts are usually cadaveric in origin (Pham et al. 2007). The recipient will reject an allograft after seven to twenty-one days, so allografts function only as a transitional stage before an autograft can be performed. Allografts can be expected to undergo some degree of revascularization, but most will be rejected within ten days because of the strong immune response of the skin. The exception occurs in immunocompromised patients, such as burn patients and transplant patients, in whom an allograft may last for several weeks (Pham et al. 2007). Pigskin grafts, known as xenografts or heterografts, are transplanted to an organism of a different species (Wood et al. 2016). Xenografts are typically rejected before the process of revascularization takes place.

Split-thickness skin grafts consist of the epidermis and part of the dermis, whereas full-thickness skin grafts consist of the epidermis and the entire dermis, including the muscles and blood vessels (Grande et al. 2015). Split-thickness skin grafts are most commonly used to cover large areas and are used on most burn wounds. Full-thickness skin grafts are used to cover small areas of the body that are exposed to the environment every day and require a good cosmetic result, such as regions of the hands or face (Maharloo et al. 2011).

The ultimate success of a skin graft depends on its nutrient uptake and the growth of blood vessels into the grafted tissue, conditions that constitute the “take” of the graft. The process takes place in three distinct phases (Beldon 2007, Wood et al. 2016). The first phase takes place within 24 to 48 hours after a skin graft is applied to the wound site. In this phase a network of fibrin is established between the graft and the wound surface that acts as an adhesive between the two layers. Leukocytes and fibroblasts then enter this network and convert it into a layer of fibrous tissue. Nutrients from the wound surface enter this layer by capillary action, a process known as plasmatic imbibition. In the second phase, inosculation, capillaries of the donor tissue and the recipient tissue are aligned and establish a vascular network within the graft. Phase three, which is typically complete four to seven days after grafting, occurs when the revascularization process is augmented by new vasculature that develops in and around the wound (Beldon 2007, Wood et al. 2016).

To reach mature functionality, reinnervation is necessary. Reinnervation of the graft occurs through growth of nerve fibers from the recipient site and the tissue surrounding the wound; a process that typically begins two to four weeks after the grafting surgery (Beldon 2007, Wood et al. 2016). Sensory function may be expected to return more quickly in full-thickness grafts than in split-thickness grafts because full-thickness grafts have a greater number of intact neurilemma sheaths. If hair follicles were present in the full-thickness donor tissue, they will be transferred intact to the recipient site. In contrast, split-thickness grafts are typically hairless (Beldon 2007, Wood et al. 2016).

Graft contraction occurs immediately after a graft is harvested from the donor site as well as after the placement of the graft into the recipient site and revascularization. The degree of graft contraction is directly proportional to the amount of dermal tissue that is present in the graft material continued on next page
et al. 2016). Harvested grafts undergo a process of immediate recoil, known as primary contraction, which is the result of the recoil of elastin fibers in the dermis. A full-thickness graft will contract more than a split-thickness graft because it contains more dermis. The contraction of a healed graft, known as secondary contraction, is thought to be the result of myofibroblast activity in the healed wound site. Secondary contraction is inversely related to graft thickness (Wood et al. 2016). It is for this reason that full-thickness grafts are preferred for areas such as the face that would be aesthetically impacted by extensive scarring or the contracture of scar tissue (Wood et al. 2016).

Limitations of Skin Grafting

Although it is not the only method of treating serious skin wounds such as burns and traumatic lesions, skin grafting is the most widely adopted method that is clinically practiced today. The earliest documented skin graft dates back to India 2000 years ago (Grande et al. 2015). Numerous attempts at skin grafting were made over the intervening centuries, but the current methods of skin grafting were not successfully developed until the early 1900s. All procedures prior to the early 1900s focused only on the use of epidermal grafts. In the 1920s, doctors found that inclusion of hair follicles and sebaceous gland epithelial cells located deeper in the dermis of the grafted tissue resulted in more rapid healing at the donor site. Researchers then began to take layers of skin from the epidermis and the dermis for grafting, a technique that yielded more successful results and which would become known as split grafting. Split grafting was practiced throughout the 20th century and ultimately developed into the effective and precise method of skin grafting that is practiced today. However, there is still debate as to whether or not this is the most efficient strategy for dealing with traumatic skin injuries (Grande et al. 2015).

Skin grafts, though efficient for treating a variety of skin lesions, are far from perfect. Complications related to skin grafting include wound infections, incomplete wound healing, graft rejection, reduced sensory function in grafted skin, severe scarring, an uneven skin surface, and skin discoloration (Pham et al. 2007). Incomplete wound healing can result in the necessity for re-grafting surgery, and graft rejection is a common occurrence associated with skin allografts. Graft rejection occurs when T cells of the recipient identify the major histocompatibility complex (MHC) molecules on the dendritic cells of the donor tissue as foreign, triggering an immune response that results in sloughing of the grafted tissue (Benichou et al. 2011).

Because autografts are derived from a patient’s own tissue, they are not rejected, but there may be other detrimental issues associated with autografts. Continuous harvesting of split-thickness skin autografts from a specific donor area takes a long time and may lead to excessive scarring and loss of dermal thickness at the donor site accompanied by increased pain for the patient (Chan et al. 2012). Autografts take a long time to heal, create scars on a patient at both the donor site and transplant site, and do not allow for the development of hair follicles and skin glands. If a patient has extensive, full-body burns, the availability of donor tissue may become a limiting factor (Chan et al. 2012). For these reasons, researchers have been actively seeking more efficient alternatives to skin grafts.

Today, skin grafting is routinely performed, despite its limitations and side effects. At the same time, research and technology have expanded the variety of sources from which donor tissue can be generated, including bioengineered skin substitutes and the use of adult stem cells. The vast capabilities of stem cells provide a huge potential for further research. For example, in 2008, researchers manipulated bone marrow derived stem cells to differentiate into epithelial cells of the liver, lungs, gastrointestinal tract, and skin (Peng et al. 2008). They did this by harnessing the power of transforming growth factor beta (TGF beta), a specific protein secreted by cells that controls cell growth, proliferation, differentiation, and apoptosis (Roelen and Dijke 2003). Recent findings such as these have opened up endless research possibilities in utilizing the many potential functions of adult stem cells.

Bioengineered Skin Substitutes

Bioengineered skin substitutes have been intensely studied and perfected since the 1980’s and today they represent the best of the advanced wound management technologies. Originally developed to cover large areas of the body in the treatment of burn patients who had exhausted their autologous skin supplies, they are widely used today for the treatment of large, open wounds such as those associated with chronic diabetic ulcers and chronic venous ulcers; wounds characteristic of diseases seen in an aging population. Possible applications for bioengineered skin substitutes continue to increase due to the ability of these products to accelerate the healing process (Pham et al. 2007).

Prior to the emergence of these new cell-based wound treatments, wound management was typically passive. Treatment consisted of attempting to remove the source of the problem, which was often uncontrolled diabetes mellitus, ischemia of the extremities, or chronic infection, and then allowing the body to heal itself. Bioengineered skin substitutes, along with technologies such as negative pressure bandages, electrical wound stimulation, hyperbaric oxygen, and the use of exogenous growth factors, have made it possible to improve upon the natural healing process (Eisenbud et al. 2004).

Skin substitutes must be engineered with certain basic characteristics in order to be useful. They must be nontoxic, elicit little to no immune response, be immunologically compatible with the human body, and be incapable of transmitting diseases to the recipient (Wood et al. 2016).
effect, bioengineered skin substitutes must mimic the gold standard for wound coverage, which remains the autologous split-thickness skin graft. Like natural skin, a bioengineered skin substitute must have antibacterial properties and the ability to minimize water, electrolyte, and protein loss from the body's external surface while facilitating the body's return to motion following traumatic injury and covering and protecting the most delicate tissues, such as blood vessels and nerves (Wood et al. 2016). Skin substitutes must have the ability to substitute for the epidermal and dermal layers of the skin, alone or in combination with each other, depending on the need.

**Cultured skin grafts**

In a cultured skin graft, the patient's own epithelial cells are used as an autograft after being harvested and cultured in the laboratory. This technique has been in use for over 20 years (Wood et al. 2016). One drawback to this procedure is that a cultured skin graft can only replace the epidermal layer of skin and the graft itself is very thin. Like natural epidermis, which lacks the underlying resiliency of connective tissue, it is incapable of stretch. A cultured epidermal autograft (CEA) consists of a thin sheet of autogenous keratinocytes. This sheet can be used to cover a large area of the body and, because many cells can be generated by the culturing procedure, the amount of donor tissue required is typically very small. However, these grafts are fragile, and they are associated with a high rate of infection and a high rate of graft loss, which is indicative of the importance of the underlying dermal layer in skin grafting (Wood et al. 2016). A cultured skin substitute (CSS) is composed of a cultured epidermal autograft combined with a cultured autologous dermal layer. A cultured skin substitute replaces both the dermis and the epidermis, and closely mimics the characteristics of natural skin (Pham et al. 2007, Wood et al. 2016).

**Dermal Substitutes**

Replacement of the dermal layer of the skin has historically been more challenging because natural dermal tissue is more complex than epidermal tissue. Acellular dermal allografts are made of cadaveric dermis, which functions as a scaffold for the growth of recipient tissue. These allografts are generally sturdy tissues that can be used in a variety of areas such as in abdominal wall reconstruction or in covering implantable prostheses (Pham et al. 2007, Wood et al. 2016).

The newest acellular dermal allografts are described as bilaminant membranes. They typically consist of a porous layer of collagen, which serves as a dermal analogue, bonded to a thin silicone layer that serves as a temporary epidermis. The dermal analogue layer undergoes revascularization and is populated with the patient's own underlying tissue over a seven to twenty-one day period. Upon completion of the revascularization process, the silicon layer is carefully stripped off and a very thin split-thickness skin graft or epidermal autograft is placed over the newly formed dermis. Grafts of this type produce skin elasticity and reduce transepidermal water loss nearly as well as the surrounding natural tissue. Dermal substitutes have the advantage of immediate availability, and they can be incorporated into the patient's newly forming skin layers without triggering an immune response (Pham et al. 2007, Wood et al. 2016).

**Biosynthetic dressings**

Biosynthetic dressings are designed to temporarily cover wounds in preparation for the application of permanent wound coverage. There are several types available. Biobrane (UDL Laboratories, Inc., Rockford, Ill) is an example of a biosynthetic dressing that is composed of a silicone membrane, which functions as an epidermal layer (Wood et al. 2016). The membrane is coated on one side with porcine collagen that is embedded in nylon mesh, which functions as a dermal layer. The mesh in the synthetic dermal layer adheres to the wound as healing progresses. Biobrane must be removed from any full-thickness wound before skin grafting can take place. It is used in the treatment of pediatric burns, in patients with toxic epidermal necrolysis (TEN), in various types of chronic wounds, and following cosmetic and other skin resurfacing procedures (Pham et al. 2007, Wood et al. 2016).

Cellular dermal allografts are composed of collagen or a polymer-based scaffold that is seeded with fibroblasts of cadaveric origin. They can be used in the treatment of partial or full-thickness wounds. Dressings such as these are designed only to temporarily cover wounds. They are not designed to provide full dermal scaffolding, so a standard split-thickness skin graft must be applied after about 2 weeks of healing (Pham et al. 2007).

**Stem Cell / Scaffold Combinations**

Tissue engineers have taken advantage of the major advancements in cell and molecular biology to acquire a deeper understanding of wound healing and the regenerative process. They have used this knowledge to develop artificial tissues by culturing stem cells in vitro and seeding them onto scaffolds made of biomaterials. Researchers have applied various stem cell/scaffold combinations to skin injuries using in vivo models and demonstrated that the combinations are capable of generating artificial skin. However, some stem cell/scaffold combinations produce skin that is more durable, thicker, better functioning, more vascularized, less discolored, and less scarred than others. The quality of the healing process depends on the specific type of stem cell/scaffold combination that is used. The goal of current research is to discover which stem cell/scaffold combination results in the formation of skin that most closely replicates the structure and function of natural skin (Pham et al. 2007).
The main role of the biomaterial in any stem cell/scaffold combination is to act as a scaffold to which stem cells can easily attach in order to begin differentiation. In this capacity, it acts as an artificial extracellular matrix (ECM). Cells adhere to the biomaterial scaffold and communicate with their surroundings via integrins, focal adhesions, and their innate ability to stimulate downstream signaling pathways (Metcalfe and Ferguson 2006). The scaffold must serve as a medium through which all these cell functions can be performed. This necessity creates very strict parameters for the selection of an appropriate biomaterial. The scaffold must have a porous internal architecture and an intricate shape in order for it to be able to direct tissue growth after the cells are seeded into it (Metcalfe and Ferguson 2006). Biomaterials can be either naturally or artificially derived, allowing for a wide range of potential sources.

Use of Carboxymethylcellulose and Mesenchymal Stem Cells

Rodriguez et al. (2014) focused on healing skin lesions in rats using artificially derived sodium carboxymethylcellulose (CMC) as a scaffold combined with human adipose tissue-derived stem cells (ADSC). The goal was to test the applicability of carboxymethylcellulose as a scaffold for ADSC (Rodriguez et al. 2014). Sixteen adult male Wistar rats were used in this experiment in order to avoid estrous-cycle-related hormonal changes in female rats that might interfere with the healing process (Rodriguez et al. 2014). Each rat was anesthetized and subjected to four circular lesions on its dorsal surface. Each lesion was 7 mm in diameter, and included both the dermis and epidermis. The rats were then left untreated, or treated with one of three different types of bandages: (i) 20 mg/mL CMC with ADSCs, (ii) 10 mg/mL...
CMC with ADSCs, or (iii) 20 mg/mL CMC without ADSCs. The results showed that groups with the combination of CMC and human adipose tissue derived stem cells produced a thicker epithelium and an increased amount of cytookeratin, a protein that forms intermediate filaments and provides mechanical support in epithelial cells (Figure 3) (Rodriguez et al. 2014).

In all of the groups, the human adipose tissue derived stem cells played their expected role, differentiating into adipocytes, which direct fibroblast function in wound healing at the site of the lesion (Fu et al. 2007). The groups that were treated with human adipose tissue derived stem cells showed an increase in cytookeratin expression, suggesting that the addition of human adipose tissue derived stem cells promotes a natural wound healing response (Rodriguez et al. 2014).

In this study, none of the treatments resulted in an increase in the number of collagen fibers, even in the groups with increased epithelial thickness and cytookeratin expression. It has been hypothesized that human adipose tissue derived stem cells regulate the synthesis of collagen by releasing anti-fibrogenic molecules, which would explain the consistency in collagen levels throughout the groups, but this has not been confirmed. A much deeper understanding of the exact mechanism and the fundamental role of human adipose tissue derived stem cells in tissue healing needs to be established.

The use of CMC in the formation of artificial skin presented a few complications in preliminary testing before being applied to the rats in the Rodriguez et al. (2014) study. Researchers found that CMC concentrations over 20 mg/L induced significant damage to DNA in the human adipose tissue derived stem cells. Prior to Rodriguez et al. examining the effect of CMC on human adipose tissue derived stem cell DNA, there was no available data assessing its potential risks or the safest concentrations to be used in treatment. More research needs to be done to ensure the safety of CMC, both in the short term and long term, before this type of research is advanced to any type of clinical testing.

The study performed by Rodriguez et al. (2014) demonstrated the ability of human adipose tissue derived stem cells embedded in a carboxymethylcellulose scaffold to develop into functioning and natural looking skin at the site of a wound. This eliminates many of the issues that traditionally accompany skin grafting such as scarring and the need for large donor sites. The stem cell/scaffold combination of human adipose tissue derived stem cells and CMC offers a great deal of promise for the future of wound healing (Rodriguez et al. 2014).

Use of Collagen-Chitin Biomimetic Membrane and Epidermal Stem Cells

Shen et al. (2014) focused on healing skin lesions in mice using naturally derived collagen-chitin biomimetic membrane (C-CBM) as a scaffold combined with epidermal stem cells (ESCs) derived from rat hair follicles. The goal was to test the efficiency of collagen-chitin biomimetic membrane as a scaffold rather than just chitin itself, which had been previously studied. A further goal was to demonstrate the proliferation and healing abilities of epidermal stem cells when seeded into this biomaterial. This set of experiments marked the first time that a chitin scaffold layered with type I collagen and epidermal stem cells had been applied to healing skin wounds.

Development of the Collagen-Chitin Biomimetic Membrane

Epidermal stem cells placed directly on the site of a skin lesion without any support would be quickly washed away by leaked tissue fluid and would not penetrate the wound surface. Preliminary testing performed by Shen et al. (2014) suggested that chitin would enhance the proliferation and differentiation of stem cells and promote re-epithelialization and accelerated wound healing. Since chitin has no immunogenicity there was no risk of rejection after implantation. Shen et al. tested this scaffold and found that chitin had good biocompatibility, but they encountered a few major shortcomings that rendered it useless for long-term skin implantation. The main issues were pore size too large (500-800 μm) to allow for the proper seeding of stem cells, an uneven grid, and poor compactness. To get around this they cross-linked the chitin membrane with collagen type 1, creating the collagen-chitin biomimetic membrane scaffold. This new “hybrid” biomaterial had small pore sizes (2-10 μm), which allowed for proper seeding of the epidermal stem cells (Shen et al. 2014).

Application of the Collagen-Chitin Biomimetic Membrane

Rat skin lesions were treated using three different therapies: (i) a collagen type I group, (ii) an ESCs/C-CBM group, and (iii) a C-CBM group without stem cells. This study found that the ESCs/C-CBM treatment resulted in a thicker and redder (i.e. healthy) epithelium, increased transcription of genes involved in the re-epithelialization process, more obvious hair follicle proliferation, and a faster rate of healing than the other groups. The red color indicated sufficient vascularization and the skin thickness was judged to be similar to that of the undamaged skin (Figure 4) (Shen et al. 2014).

Based on current research reviewed by Shen et al. (2014), epidermal stem cells appear to be the most efficient stem cells for the treatment of skin injuries. The skin that develops when epidermal stem cells are applied to the site of an injury is the closest match to natural skin in both function and appearance, with no scarring. Epidermal stem cells coupled with a collagen-chitin biomimetic membrane produced skin with an appearance and function that closely matched that...
of natural skin (Shen et al. 2014). Moreover, the collagen-chitin biomimetic membrane was totally degraded subcutaneously and the skin defects were fully repaired. Supplementary testing of the wound site found that the epidermal stem cells differentiated into epidermal cells to improve the wound healing. The combination of epidermal stem cells and collagen-chitin biomimetic membrane induced the proliferation of hair follicular stem cells (FSCs), which were the most abundant epidermal stem cells found at the site of the wound. Follicular stem cells fostered the development of all the appropriate sweat glands and hair follicles, resulting in a fully functioning layer of regenerated skin (Shen et al. 2014).

Conclusion

The results of the studies using human adipose tissue derived stem cells with carboxymethylcellulose and those using epidermal stem cells with a collagen-chitin biomimetic membrane demonstrate the ability of stem cells to protect a wound site and promote wound healing. The specific combination of epidermal stem cells in a collagen-chitin biomimetic membrane scaffold appears to promote the most successful results. Shen et al. (2014) were able to recreate a new layer of fully functioning skin without any visible scarring or deformations on the skin surface. When this new therapy is compared to traditional skin grafts, the benefits are apparent.

Skin grafting remains an important technique in the treatment of large open wounds like burns and traumatic skin lesions, as well as for the treatment of skin ulcers related to chronic disease processes. Important new technologies involving stem cell therapies and tissue engineering have made possible the production and use of bioengineered skin substitutes, which have significantly improved the functional and cosmetic outcomes of wound healing and offer great promise for the future.

Illustrations courtesy of:
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Figure 4. Figure recreated from Shen et al. (2014). Observation of nude mice full-thickness defect model. (A) Observation of nude mice full-thickness defect model dressed with type I collagen only, C-CBM, or ESCs-C-CBM at 1 day, 1 week, 4 weeks, and 10 weeks. Type I collagen group shows that wounds are much slower to heal. Group C-CMB shows the repaired wound skin in the control group was relatively thin and heliotrope with a tendency to bleed; Group ESCs-C-CMB shows the repaired wound in the experimental group was relatively thick and red with re-epithelialization. Scale bar = 1cm.

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Gender Differences Associated with greater Risk of Noncontact ACL Injury in Females

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Abstract

Females are more likely than males to suffer a noncontact injury to the anterior cruciate ligament (ACL). As a result, research on anterior cruciate injuries has expanded in order to find preventative strategies and improve anterior cruciate healing. Injury to this ligament is extremely common, especially in sports that involve jumping and lateral cutting. This article examines the common risk factors that have been found to contribute to injury of the anterior cruciate ligament and presents evidence that supports the hypothesis that females have an increased injury risk over males. Recent studies point to the effects of hormones, bone structure, and genes as possible sources of the gender differences seen in anterior cruciate ligament injuries. Female hormone fluctuations and tibial geometry are associated with an increased anterior cruciate ligament injury risk in female athletes and a novel finding from one study suggests that a specific gene variant was underrepresented in females who suffered an anterior cruciate ligament injury. The findings from these studies suggest that there are certain factors that increase female anterior cruciate ligament injury risk. These findings are a starting point for future research in identifying why females are affected differently with respect to anterior cruciate ligament injury so that improved preventative and healing strategies can be developed for this injury.

Key Words: Anterior cruciate ligament, hormones, knee, ligaments, prevention, noncontact, female athletes, sports, hamstring, injury

Introduction

The rate of noncontact injury to the anterior cruciate ligament is two to nine times greater in females with an average increased incidence of injury in the range of 3.5 to 4.0 times greater (Shephard et al. 2015, Voskanian 2013). Anterior cruciate injuries in female athletes are most likely to occur as a result of a noncontact injury; a sports injury that does not involve contact with another person and instead results from of an awkward movement performed by an individual (Voskanian 2013). Noncontact injuries of the anterior cruciate ligament are most likely to happen in fast moving, high risk sports such as basketball, soccer, handball, volleyball and football. In most cases, noncontact injuries occur when an individual is landing on a single foot from a jump, stopping rapidly, cutting or changing direction while one foot is fixed, and during planting maneuvers (Shephard et al. 2015). The common factor among these movements is an increased load on the anterior cruciate ligament, caused by a combination of outward rotation of the tibia, near or full extension of the knee, and femoral adduction while the foot is planted (Shephard et al. 2015).

Worldwide, 100,000 to 250,000 anterior cruciate injuries occur each year, making it the most common ligament injury (Siegel et al. 2012). However, the gender differences associated with anterior cruciate ligament injury are typically not observed until after the onset of puberty. After puberty, research has identified several areas, summarized below, where gender differences may affect the rate of post-pubertal anterior cruciate ligament injury.

(i) There are several gender specific differences in body structure that may have an effect on injury to the anterior cruciate ligament. Females have a wider pelvic girdle than males and a smaller anterior cruciate ligament. The size of the femoral notch, where the anterior cruciate ligament is located, is narrower in females. Females are also more likely to have internal rotation of the knee, a situation referred to as knock-knee or valgum (Shephard et al. 2015). These differences are believed to be most associated with anterior cruciate injury that results from landing after jumping. As a consequence of these differences, females tend to land from a jump in a more erect posture than males. They tend to exhibit insufficient flexion of the hip and knee and they have a tendency towards greater internal rotation.

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of the hip and greater hip adduction when they are decelerating or landing (Voskanian 2013).

(ii) There are gender specific differences in the body musculature itself that may have an effect on injury to the anterior cruciate ligament. Women have less overall muscle strength than men and they tend to use the quadriceps more for stability. Less overall muscle strength means that the hamstrings are not as strong in women as they are in men. As the primary flexor of the knee, the hamstrings provide most of the opposing force to the anterior displacement of the tibia. Additionally, it takes women longer to generate maximum muscle force at any given time. These factors may place the anterior cruciate ligament under stress in situations where muscle strength is demanded quickly. The anterior cruciate ligament is under greater stress when the knee is extended or minimally flexed (minimal flexion is in the 5 to 20 degree range and maximum flexion is in the 60 degree range) and when the knee is in the valgus position of internal rotation. Minimal extension of the knee and valgus stress are common compensatory mechanisms seen in females who have injured their anterior cruciate ligament (Shephard et al. 2015, Voskanian 2013).

(iii) There are gender-specific differences in laxity of ligaments and the range of motion of muscles that may have an effect on injury to the anterior cruciate ligament. Women have a greater range of motion in the knee and more knee laxity than men do. They are capable of greater hip internal rotation and knee hyperextension than men. Increased hyperextension results in a posterior curve of the knee when the leg is extended, making it harder for the hamstrings to protect the anterior cruciate ligament. Differences in ligament laxity may be related to hormone levels since ligament laxity has been shown by some studies to vary during the menstrual cycle. Several studies have suggested that women are at a greater risk of anterior cruciate ligament injury during certain stages of the menstrual cycle (Voskanian 2013).

General Risk Factors for Anterior Cruciate Injury

Differences in structure of the femur and tibial bones and the shape and structure of the knee cartilage and menisci can contribute to injury to the ligaments of the knee (Sturnick et al. 2014). Other risk factors include the size and strength of the musculature surrounding the knee, especially the hamstrings and quadriceps muscles, as well as the size and strength of the muscles of the torso and hip that play an important role in keeping the knee stable during dynamic movements. The biomechanics of the knee, such as valgus knees, and other movements that increase tensile load on the anterior cruciate ligament may also contribute to injury (Shephard et al. 2015.). Some factors such as genetics, hormones, and molecular composition of the anterior cruciate ligament are not as easily understood. Gene variations can affect the type and density of collagen and other components of the anterior cruciate ligament (Posthumus et al. 2009) and reproductive hormones can not only affect the ligament itself, but also directly bind to and influence muscles, which in turn can have an effect on the anterior cruciate ligament (Bell et al. 2012). Although these factors differ from person to person, research has shown a dichotomy between how these risk factors affect males and females (Shephard et al. 2015). There is an obvious difference between male and female anatomy and physiology, but what may not be obvious is how those differences affect the structure of the knee, and its response to dynamic movements, or how the anterior cruciate ligament can be injured due to a combination of these risk factors.

The Effect of Estrogen on the Anterior Cruciate Ligament

In 2012 Bell et al. studied the effect of hormones on muscles that are important in knee stability and the reduction of anterior cruciate loading. Estrogen and progesterone receptors have been identified on the anterior cruciate ligament and physiological levels of estrogen are known to decrease collagen synthesis (Bell et al. 2012). Bell et al. performed a study to test whether there is a relationship between reproductive hormones, estradiol-ß-17, progesterone and testosterone, and muscular neuromechanical variables (Bell et al. 2012). The muscles chosen for this study were the hamstrings since they are not only the primary dynamic stabilizer of the knee joint, but also capable of limiting the loading of the anterior cruciate ligament during natural movements. If this muscle group is affected by reproductive hormones, it may contribute to greater laxity and lesser strength of the anterior cruciate ligament (Bell et al. 2012).

This study measured the following four neuromechanical variables of the hamstrings: musculotendinous stiffness (MTS), rate of force production (RFP), time to 50% peak torque (T50%), and electromechanical delay (EMD) (Bell et al. 2012). These variables do not necessarily represent the strength of the hamstring, but rather how rapidly it can produce force, which may be more important than overall strength when it comes to stabilizing the knee (Bell et al. 2012). Researchers hypothesized that increased levels of estradiol-ß-17 and progesterone would have a negative effect on hamstring properties and an overall decrease in knee stability. Testosterone, however, was predicted to be associated with knee stability and to have a positive effect on the hamstrings (Bell et al. 2012).

This study involved 15 male and 15 female participants between the ages of 18 and 25, all with no history of anterior...
cruciate ligament injury, surgery, or neurological disorders. To reduce variability of hormone levels, females were eliminated from the study if they had been pregnant or taken oral contraceptives in the previous six months. Females were tested purposefully during the menstrual cycle because hormone levels fluctuate during each part of the cycle. The follicular phase was chosen as the part of the menstrual cycle to be tested based on previous research results suggesting that this phase is associated with the highest likelihood of suffering an anterior cruciate ligament injury (Bell et al. 2012). The hamstrings were tested for the four neuromechanical variables and blood levels of estradiol-β-17 in females and testosterone in males were measured. A test that elicited maximal isometric contraction of the hamstrings assessed electromechanical delay, rate of force production, and time to 50% peak torque. To test for musculotendinous stiffness, researchers used an apparatus that elicited oscillatory flexion/extension of the knee (Bell et al. 2012). The study found a positive correlation between free testosterone and hamstring muscle properties and a negative correlation for hamstring properties and estradiol-β-17 (Bell et al. 2012). No relationship was observed between tested hamstring properties and progesterone. The study suggests that female hormones may influence hamstring properties that are important in knee stability (Bell et al. 2012).

The Effect of Genes and Collagen Expression on the Anterior Cruciate Ligament

In 2009 Posthumus et al. carried out a study to determine if genes that encoded for collagen could be linked to sex-based anterior cruciate injury. Of the various types of collagen found in the body, types I and V are found specifically in ligaments (Posthumus et al. 2009). The two genes that encode for the components of type I and type V collagen, the COL1A1 and COL5A1 genes respectively, have become a focus of studies that sought to identify differences between male and female ligament injuries. Past studies have already identified an association between variants of the COL5A1 gene and ruptures of the Achilles tendon, which is another common soft tissue injury in sports. The COL5A1 gene, encodes for the α1 chain of type V collagen that is found not only in tendons, but also in ligaments and other tissues (Posthumus et al. 2009). Type V collagen only makes up about 10% of total collagen content of ligaments, but it plays an important role in supporting, organizing, and regulating type I collagen (Posthumus et al. 2009).

The study was conducted to determine if two sequence variants of the COL5A1, the DpnII and BstUI restriction fragment length polymorphisms (RFLPs), are associated with increased risk of anterior cruciate ligament ruptures. One hundred twenty nine participants with diagnosed anterior cruciate ligament ruptures (38 women and 91 men) and 216 participants with no history of anterior cruciate ligament injury (84 women and 132 men) took part in this study (Posthumus et al. 2009). Two alleles within the RFLP’s known as the C and T alleles were identified for use in this study. Blood samples of were taken from each participant and the DpnII and BstUI sequence variants of the COL5A1 gene were amplified with polymerase chain reaction (Posthumus et al. 2009).

The major finding of this study was that the CC genotype of the BstUI RFLP variant was underrepresented in female participants with history of anterior cruciate ligament rupture. This suggests that this CC BstUI genotype of the COL5A1 gene may be important for female anterior cruciate ligament stability (Posthumus et al. 2009). The second variant, the DpnII RFLP, was not associated with anterior cruciate ligament ruptures in males or females. The association between the CC BstUI genotype of the COL5A1 gene and decreased risk of ACL injury in females is a novel find, as it had not been presented before this study (Posthumus et al. 2009). These findings suggest that genetics can be a risk factor in female ACL injury, but the complexity of anterior cruciate ligament injuries makes it unlikely that this is the only genetic variant associated with the risk of ACL ruptures (Posthumus et al. 2009).

Increased Slope of the Lateral Tibial Plateau Subchondral Bone Associated with greater Risk of Anterior Cruciate Ligament Injury in Females

Beynnon et al. (2014) attempted to build on results of past studies that aimed to determine if the geometry of the subchondral bone of the tibial plateau had an effect on anterior cruciate ligament injury (Beynnon et al. 2014). Eighty-eight case-control pairs were used in this study, including 61 female case-control pairs and 27 male case-control pairs. Participants were accepted into the study after diagnosis by an orthopedic surgeon, confirmation by an MRI, and proof that it was their first anterior cruciate ligament injury. All injured participants were high school and collegiate athletes on a sports team from which a matched control, with no history of anterior cruciate ligament injury, was selected. Matched controls were as close to the injury participants in age, weight, level of risk, and activity levels as possible (Beynnon et al. 2014). Participants who were accepted underwent bilateral MRI’s of both knees. Geometry of the subchondral bone portion of the tibial plateau was determined using MATLAB hardware, which processed data from the MRI’s (Beynnon et al. 2014).

The tibial plateau is the weight-bearing area that constitutes the superior surface of the tibia. It is composed of the medial and lateral condyles, the intercondylar eminence, and the sloping areas that surround the eminence. The tibial plateau can be divided into three areas: the medial tibial plateau, which contains the medial condyle, the lateral tibial plateau, which contains the lateral condyle, and the central tibial
plateau, which contains the intercondylar eminence. The medial slope of the tibia is located in the area of the medial tibial plateau. The lateral slope is in the lateral tibial plateau and the coronal slope is the sloping area anterior to the tibial eminence. The depth of the tibial plateau is its anterior/posterior dimension (Beynnon et al. 2014).

Measurements of the subchondral bone included lateral (LTS), medial (MTS), coronal (CTS) slopes of the tibial plateau, and depth of the medial tibial plateau (MTD) (Figure 1). Due to the fact that past studies have suggested that anterior cruciate ligament injury can cause geometrical changes to the tibiofemoral articular cartilage and the underlying subchondral bone, the measurements for both knees of the injured participants were compared to determine if changes did occur (Beynnon et al. 2014). Comparisons revealed significant differences in the measurements of the lateral slope of the tibial plateau and the coronal slope of the tibial plateau between injured and uninjured knees of injured participants. This lead researchers to compare the uninjured knee of participants to the corresponding knee of their matched control. For example, if an injured participant tore their right anterior cruciate ligament, their left knee geometry was compared to the left knee geometry of their matched control (Beynnon et al. 2014).

The authors first compared controls with injured participants in a combined group of males and females. The only significant difference found in this combined group was that an increase in the lateral slope of the tibial plateau was associated with an increased risk for suffering an anterior cruciate ligament injury (Beynnon et al. 2014). When males and females were split and compared, males did not show a significant association between any measurements and an increase anterior cruciate ligament injury risk. Females, however, had the same association as both groups combined: an increase in the lateral slope of the tibial plateau was associated with an increased risk of anterior cruciate ligament injury. An increase in the lateral slope of the tibial plateau results in a greater posterior-inferior directed slope and anterior cruciate ligament injury (Beynnon et al. 2014). This study found no association in males between bone geometry and anterior cruciate ligament injury. Although this is not a novel finding, the results from this study provide a reliable and clear association between bone structure and anterior cruciate ligament injury that previously had been questioned for validity (Beynnon et al. 2014). These findings add greater understanding of the risk factors of the anterior cruciate ligament, and provide some evidence to show why females have a higher risk factor for anterior cruciate ligament injury.

**Conclusion**

The recent finding of estrogen and progesterone receptors on the anterior cruciate ligament opens up new and interesting areas for future research (Bell et al. 2012). Since the hamstrings are affected by specific female hormones, other muscles important in knee stability, such as the quadriceps and gastrocnemius, as well as muscles of the torso and hip that stabilize the knee, may become the focus of future studies to determine if hormones also have an effect on them. Due to the similar molecular composition of ligaments and tendons there is reason to believe that if receptors have been found on ligaments, they may also be found on tendons. Tendons are directly attached to muscles, which means that muscles, such as the hamstrings, which are affected negatively by certain hormones, might also exhibit changed muscle properties (Posthumus et al. 2009).

So far, only the association between the COL5A1 gene and its underrepresentation in females with anterior cruciate ligament injury has been identified (Posthumus et al. 2009), but there are many other genes that encode for other types of collagen that may also play a role in ligament injury. It would be interesting to determine why the COL5A1 gene is important in females for anterior cruciate ligament strength, but does not seem to play a similar role in males. It is possible that the molecular composition of anterior cruciate ligament may differ slightly in males and females, or that the anterior cruciate ligament in one sex could contain more of a certain type of collagen than the other. Additionally, it is extremely unlikely that the COL5A1 gene is the only one playing a role in the strength of the anterior cruciate ligament and there is

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no shortage of genes to study and test for associations with injury to ligaments.

With a definitive association found between bone geometry and ACL injury, future investigations might examine why bone structure differs between male and females, or why the knee is unstable with a certain type of geometry. Other risk factors, such as certain biomechanics of the knee, have not been researched extensively. For example, the valgus knee position has been linked to high stress on the anterior cruciate ligament (Siegel et al. 2012), but it is unclear in what ways valgus knee movements might be related to bone structure, muscle strength, or gender. Sex-related injury to the anterior cruciate ligament is an area of research with great potential for new findings. Much of the current research is outdated or neglects to compare injury between males and females. Although interest in gender specific differences in the rate of injury to the anterior cruciate ligament has increased, the future holds great promise for new relationships to be discovered in genetics, endocrinology, biomechanics and bone structure.

Appendix I Anterior cruciate ligament Reconstruction

To reconstruct the anterior cruciate ligament, the damaged ACL is removed, tunnels are drilled in the distal femur and the proximal tibia (Figure 1) and the new ACL graft is threaded through the tunnels. The new graft is commonly made from the central third of the patellar tendon or part of the hamstrings. Once correctly positioned, biodegradable screws are inserted into the femoral and tibial tunnels to hold the graft in place. The new ACL does not resemble the natural ACL but rather forms a rigid rope-like structure that stabilizes the knee joint.

Appendix I, Figure 1
Tunnels are drilled for ACL reconstruction surgery and the new ACL graft is threaded through. Adapted from Vivek Sharma, MD. ACL Reconstruction, illustrated by Kelly Paralis, Penumbra Design, Inc.

Illustrations courtesy of:
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References cited:


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A Model Idea: Round-Robin Student Review of Pre-Lab Exam Study Materials

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Abstract
The author has established a series of “round robin” in-lab study exercises in which small groups of students take turns identifying key structures and organ functions, while rotating through ten to twelve laboratory stations. The results indicate an upturn on lab exam scores, which seems to reflect a greater level of student comprehension and an easing of the need for rote memorization. Sample exercises for this activity are included in this article.

Key words: laboratory, pedagogy, best practices, engagement

*Robert Rawding presented a workshop on this topic at the 30th Annual HAPS Conference in Atlanta, Georgia in May 2016

Introduction
There is a massive amount of information that is typically presented to students who are majoring in nursing, sports and exercise science, biomedical engineering, and pre-pharmacy at Gannon University. Students who are just out of high school may be under-prepared for the intensity of the laboratory component of our human anatomy and physiology course. The first laboratory exam covers material from introductory terminology, the body planes, a survey of histology, the integumentary system, and the skeleton. The second laboratory exam covers only muscles and motions, but is rich in questions like ‘name four muscles that are involved in drinking a soft drink through a straw’ or ‘list at least four muscles you use in eating your dinner.’ The third and last encompasses the brain and spinal cord, cranial and spinal nerve organization and function, and the special senses.

We offer fifteen three-hour labs each semester to supplement the lecture coverage of topics such as learning muscle names, muscle actions, and the origin and insertion of muscles. To facilitate this process, we make use of an extensive model collection that we have built over the last fifteen years. We devote two full-labs to skeletal elements and bone markings. Students are told that two three-hour blocks are not sufficient to attain mastery of bone markings, recognition of differences between right and left bones, identification of sex differences in the pelvic girdles, and the differences among skull preparations. Learning all of this material is hardly a simple task and students are encouraged to set aside time outside of lab for further study. Student performance on the first lab exam is typically poor, with many F and D grades, and an inordinate number of C-minus scores. For nursing students, a C-minus in anatomy and physiology is not an acceptable grade.

The Problem Wanes
We present materials to learn in four phases:

1. Upon entering the lab, students receive a “structures and functions” (the ‘struxfuns’) packet that contains all of the elements of a system they are required to know such as key names, definitions, points of comparison, and unique differences from other systems.

2. The lab manual and the struxfuns packet accompany the hands-on small group exercises that follow. During these exercises, the lab instructor and a lab assistant, who has already taken the same lab course, casually ‘grill’ the students in each group with questions such as, “What is that structure called?”; “What does that ‘thingy’ do?”; “What is the importance of that element?”.

3. The students are strongly encouraged to attend one or more ‘Open Lab’ sessions prior to the ‘round robin’ sessions. An ‘Open Lab’ session is a scheduled, weekly resource time. The schedule for Open Lab time is posted on the outside of the lab entry door, emailed to every lab student, and posted as a retrievable electronic document on our learning management software, Blackboard Learn 9. Blackboard is also a repository for line drawings and unlabeled images that students can download and use as necessary.

4. The round robin review is described below.

round rob-in*

noun: round robin; plural noun: round robins; modifier noun: round-robin

1. a tournament in which each competitor plays in turn against every other, “a round-robin competition”
2. a series or sequence

* Sources: several online dictionaries

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THE ROUND-ROBIN REVIEW:  
How does all of this work?

You will need:

- An instruction sheet given to every student at the outset, explaining the process and procedures
- A group scoring sheet that includes each student’s name
- Tape, preferably masking tape, about ¾” wide, one or more fine-tipped permanent markers (e.g. Sharpie® pens), and a small pair of scissors for each station
- Any kind of lab resource that is suitable and available for group study. We use articulated and disarticulated skeletons, models of muscles, and microscopes and slides. If your lab incorporates dissections, you might want to include those specimens in this activity. The beauty of this exercise is that it relies on your creativity and resources. One of our lab instructors makes use of blank end-rolls from a newspaper company; paper large enough to be perfect for a “draw” problem or flowcharting a process. Perfect. Break out the Crayolas!
- Question sets for each station. I usually set up ten stations per session @ 5 points each, so that each student can earn up to 50 points that count as part of their final lab grade. The question sets go on cardstock, which is rugged and good for re-use, but 3 x 5 blank index cards are fine too. The cards can be hand-written so you can change things on the fly. It is not necessary to number each station, but numbering the stations makes it easier to reference them during the review.
- The first group at each station labels the model or bone found at that station with the structures that appear on the cardstock (3 x 5 card). Each label should be legibly written on the supplied tape and the tape should be cut to fit the model or bone. It is helpful if the end of the tape is trimmed to serve as a pointer.
- The lab instructor or assistant visits each station and checks that the labels are correct. If there are no errors, each person in the group earns five points. I tell them, if one synchronized swimmer drowns, then they all drown, highlighting the necessity for ‘group checks’ to ensure everyone in the group receives full credit. I also ask a random question about the labeled structure(s) at each group’s station. For example, “What is the action of this specific flexor?” There are an infinite number of possibilities for these questions.
- Once the lab instructor’s visit and the grading are complete for a station, all of the labels are removed and lightly attached to the model’s base or table edge. The group then moves to the next unoccupied station. A newly arriving group retrieves the labels from the model’s base or the table edge and attaches them to the resource that has just been vacated.
- Once everyone is finished at every station groups are directed to remove all tape from their specimen(s) and return the specimen or model to the proper shelf space.
- The average time spent at each station is six to eight minutes, depending on the complexities of the question sets, so a ten-station round robin laboratory will run from 60 to 80 minutes.

Results

We have seen an increase of a half-letter grade to two letter grades on scores on each of the three lab exams when compared to the grades of previous students who did not have access to the round robin activity. The best scores are typically seen in the second and third labs.

The prep time is short for this activity. It takes approximately thirty minutes to develop the question card for each station. The questions can be cut-and-pasted from the “struxfuns” packets. It takes another ten minutes to print the cards, and ten to fifteen minutes to set up the stations. There is no after-activity class discussion, except to ask each student his or her impression of what was accomplished e.g. “Did you learn anything today?”

At the end of the semester, I deploy a survey on Blackboard that consists of several short answer response boxes that students can complete in eight to ten minutes. What follows is a collection of responses from one of the Spring 2016 anatomy and physiology laboratory sections:

Comments:

These are representative, unedited End of Course Survey Responses to the Round-Robin lab activity obtained from 17 students who were surveyed in the Spring of 2016.

- I enjoyed the group work activities, especially the lab before the practical, as those were the most helpful to learning the information.
- (I enjoyed) the group work and round robins
- I really enjoyed the Round Robin activity before every practical- it really helped me to prepare for the lab exams. I enjoyed doing the labs as well, it helped reinforce what we were learning and gave a break from lectures. The handouts and power point slides were very helpful to take notes on as well.
- (Students need to) come to lab, study before the round robins and study more after them.
- Over all I really enjoyed the lab and thought everything was done pretty fairly. Round robins were very helpful.
• Great lab. (I) really enjoyed it and have already recommended it to others.
• I loved everything about this course. There was a lot of information to learn but in the end all the studying and learning pays off when you see how well you do on tests.

Discussion
Our jobs are more rewarding when we can draw students into an engaging activity and we realize that they demonstrate more depth of understanding and greater appreciation for our efforts. There are multidimensional challenges every day for a college teacher, but when we have facilitated an activity that is simple and rewarding for students, we can go home more fulfilled in our role as educator.

Note
All of the materials referenced in this article are available on my Google drive.
https://drive.google.com/open?id=0B4y6VHMMUJe3NzIzVjdPb01LNmM
On this site you will be able to download the introduction sheets for students, question sets for three round-robin activities, images of some of the class activities, the ‘struxfuns’ packets for each of the covered lab exercises and a PowerPoint file of the activity. If you have any difficulty with these materials, please email me or call me.
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An In-House Atlas Enhances Histology Learning

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Abstract

This study investigated whether the addition of an in-house printed histology atlas improved performance outcomes in the histology component of a first year anatomy and physiology course required for nursing students. The effectiveness of the printed atlas was analyzed by comparing histology test scores of the class of 2014 (atlas not available) to the class of 2015 (atlas provided). The class of 2014 outperformed the class of 2015 on all tests, with the exception of the histology focused test. Taken into consideration the in-between group performance differences, the class of 2015 significantly outperformed the class of 2014 on the histology-focused test. The addition of an in-house printed histology atlas enhanced students’ learning and improved histology test performance.

Key Words: Nursing, Histology, Anatomy, Physiology, Atlas

Introduction

Histology, the microscopic study of tissues is a challenging science at any educational level (Johnson et al. 2014, Shoepe et al. 2014, Zanetti 2013). The majority of baccalaureate nursing programs mandatory first year anatomy and physiology courses have a histological component, and a significant proportion of nursing students struggle with this material (Birks et al. 2013). Practical laboratory time incorporating kinesthetic, visual, auditory and oral learning is particularly important for optimizing first year student performances in this challenging domain (Johnston and McAllister 2008).

In recognition of the importance of these varied learning needs, in previous studies we projected real-time slide images incorporated into laboratory sessions of the anatomy and physiology course (LUSL 2105). These images were associated with significant improvements in histological performance outcomes among first year nursing students (Elbatarny 2014). Using similar technology, an in-house printed histology atlas was created, enabling students to view an exact copy of lab specimens outside of the lab setting facilitating increased visual and social learning opportunities (Elbatarny et al. 2015).

Methods

This study was conducted in the anatomy laboratory at St. Lawrence College, located in Kingston, Ontario. The class of 2015 students had access to all the same learning resources as the class of 2014. They additionally had access to the newly developed histology atlas; a resource that was not available to the class of 2014. Anonymized LUSL 2105 lab test scores from first year BScN students enrolled in 2014 (n = 60) and 2015 (n = 67) were examined. Using Student’s t-test the in-between class test scores were compared to analyze the effect of the atlas on student test performance. The overall mean difference in test scores between classes was calculated and added to histology test results in order to adjust for the difference between class performances in other tests.

Results

Comparison of overall lab test performance, excluding histology, revealed that the class of 2014 (72.6%) significantly outperformed the 2015 (63.6%) (p<0.05) (Figure 1). On average the performance of class of 2014 was 9.04% higher than the class of 2015 on all tests excluding histology. However, the class of 2015 had a higher mean score on the histology test (77.8%) compared to class of 2014 (76.7%). While the difference was not statistically significant and given the fact that class of 2014 was academically stronger than the one of 2015, we attempted to adjust histology results to reflect between group performance differences. This analysis revealed that the class of 2015 significantly outperformed the class of 2014 in the histology component of LUSL 2105 (86.8% vs. 76.7%) (p<0.05) (Figure 2).
Discussion

This study examined the impact of an in-house atlas on student learning of the histology component in a mandatory anatomy and physiology course for nursing students. The objective analysis of student performance in two successive years showed the class that had access to the histology atlas significantly outperformed the class that did not, based on a structured histology focused test.

There are inadequacies in the teaching of science content in nursing curricula (Birks et al. 2015). Research indicates that emphasis on anatomy and physiology in nursing education facilitates safe and effective point-of-care assessment (McVicar et al. 2010). Despite this, poor passing rates in this domain have generated an internationally documented reduction in content presentation resulting in many programs failing to meet industry required knowledge levels (McVicar et al. 2014). Our study suggests that offering students access to a histology atlas enriches the understanding of anatomy among first year nursing students. Facilitating this type of easy and repetitive interaction with anatomy and physiology content has also been linked to improved outcomes in first year anatomy courses with historically low pass rates (Johnston et al. 2015).

Our findings show that the addition of the histology atlas was associated with a significantly better performance on the histology test than was expected based on other test results. The potential exists to build on this pedagogical tool by incorporating an interactive online component. Lewis et al. (2014) showed that increasing laboratory interaction with specimens and facilitating social learning was associated with improved performance by first year nursing students taking anatomy and physiology. With evidence that anatomy and physiology test scores are significantly related to success in clinical nursing courses it is especially important that these learning modalities are further recognized by nursing schools (Griffiths et al. 1995, McVicar et al. 2015).

Beyond baccalaureate nursing education, advanced practice nursing programs are beginning to offer histopathological education to nurses in order to enhance multidisciplinary discussions and facilitate appropriate patient management decisions (Zanetto, 2015). By better preparing nurses at the undergraduate level, through resources like our histology atlas, it is possible that they will be better prepared for future specialized nursing practice.

References cited:


Elbatarny HS (2014) Pedagogical tools to enhance learning in microscopic anatomy laboratory. HAPS Educator. 18(3):47


**Jennifer Hutchinson** graduated with honors from Queen’s University in 2012 with a BS in Biology. She received her BScN degree from St. Laurence College/Laurentian University. Jennifer is the recipient of the St Lawrence College Dean’s List award for top academic achievement by an individual in the BScN program. While studying at St. Lawrence/ Laurentian University, she served as a peer tutor in human anatomy and physiology, microbiology, clinical chemistry and pathophysiology. Outside of her studies Jennifer is an accomplished soccer player having represented her home province of Newfoundland and Labrador on the national stage and earning CIS gold with Queen’s University in 2010, where she received first team all-Canadian honors.

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**Jennifer Hutchinson**

**Dr. Elbatarny**
Effective Teaching and Learning: Overview of Research and Tools to Use to Reach the Millennial Student

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Abstract

The Millennial generation is the first generation to have information overload and as a result, it is becoming increasingly obvious that the role of the professor in and out of the classroom is changing. With the evidence for various effective teaching methods increasing, it is becoming necessary to reexamine how instructors help the Millennial students achieve the desired course outcomes. This review will focus on three common themes within the literature: climate and rapport, practice with targeted feedback, and active learning. Within each theme, various activities will be explored in light of the Millennial student and evidenced-based teaching methods.

Key words: millennial generation, active learning, effective classroom practices, evidence-based teaching

Introduction

Today’s classroom is changing as our students change. With the inception of social media, Google, YouTube and mobile devices, the classroom is virtually everywhere all the time. Information is readily available on the Internet for students to find at a click of a button. In fact, the generation of traditional students entering our classrooms today is accustomed to having information when they want it and how they want it, often in small digestible bites. This generation, known as the Millennial Generation, is changing how we look at the process of instruction.

Some benefits of teaching strategies that can be incorporated into every class (traditional, flipped, hybrid, online) require an appreciation for the attributes of the average Millennial. The generation theory breaks the cohorts into Baby Boomers born 1946-1964; Generation X born 1965-1981; Millennial Generation “Gen Y” born 1982-2000; and Generation Z “iGen” born 2001 – present. Sources disagree on the exact birth year boundaries, possibly as a result of regional biases and differences in research design (Pew Research Center 2015, Strauss and Howe 2000). The Millennial Generation has grown up central to their parent’s lives. They have been constantly praised (everyone wins an award) and they are accustomed to parents that are involved in every aspect of their life (Howe and Strauss 2007, Price 2009). In fact, psychologist Jean Twenge (2006) has nicknamed the Millennial generation “Generation ME”, because they were raised to believe self-esteem is more important than achievement. No one is to blame for the change, it just a sign of the environment in which they were raised. The Millennials grew up with well-educated parents, generally in families where both parents were working. They were raised during a financial boom and in a climate where increases in technology tended to create information overload (Nicholas 2008).

Every year Beloit College (2015) puts out a summary of facts of students entering college. Freshmen entering college in 2015 were born in 1997. They have binge watched their favorite TV shows and gathered with friends on Skype, rather than meeting their friends in the local park. They have always been able to secure immediate approval and endorsement for ideas through ‘likes’ on their Facebook page and they are more likely to use online sources, rather than ads, to find new products and locations. By the time freshmen entering college in 2015 turned 10 years old the following things had occurred: Google started in 1997; portable MP3 players were available in 1998; Wikipedia hit the scene in 2001 followed by YouTube in 2005, Facebook and Twitter in 2006, and Dropbox and iPhones in 2007.

Understanding and appreciating the world these students grew up in, combined with evidenced-based research on how we learn, can lead to more effective teaching methods. Several research articles and books exist that examine evidence-based concepts for effective teaching. A few of the more common themes include: climate and rapport; goal-directed practice with targeted feedback; and active learning to maintain focus.

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Climate and Rapport

Research

Although educators must be concerned with ensuring that knowledge is gained by the students in their class, the fact that students are social and emotional beings cannot be ignored. Surprisingly, research shows that students grow more socially and emotionally than they do intellectually during a 4-year college span and their social, emotional and intellectual climates interact with their development (Ambrose et al. 2010, Astin 1993). There is a positive correlation with the climate instructors create in the classroom and the retention of knowledge by students (Astin 1993, Pascarella and Terenzini 1991, Price 2009). Think about a class or professor you loved and learned the most from. What was it about that professor or course that made you want to learn more? Certainly content was important (we all loved anatomy and physiology!) but what other attributes were there? Did the professor know your name? Was the professor engaging and able to pay attention to your needs? Different students can perceive climate differently and in some cases a series of smaller events can have a greater impact than one large event (Ambrose et al. 2010).

The tone set the first day of class can follow a student throughout the course. One study looked at student's perception of the approachability of the professor based on the language (punitive or encouraging) on the syllabus. Based on reading the syllabus alone, students perceived the professor who wrote a punitive syllabus (using bold type face, capital letters and harsh punishments) to be unapproachable (Harnish and Bridges 2011). This tone can be carried into the classroom as well. The more controlling or non-caring an instructor is perceived to be, the lower the intrinsic motivation of the student (Lowman 1990, Noels et al. 1999). These factors can lead to an environment that is not conducive to learning.

Activities

Here are some ideas you might want to incorporate into your next course. On the first day of class, try to set a tone that is encouraging and open. Since the Millennial generation grew up with their parents always explaining why, take a moment to provide rationale for why policies are in place (Price 2009). You might use phrasing like “I think you might find...” or “I’ll be interested in your impressions…” Express sincere compassion that ‘we are in this together’. This acknowledgement of fear can also be used throughout the course. When you know a concept will be more difficult, let the students know. However, be careful not to go to the other end of the spectrum and tell them things are easy. It might be easy for you, the expert, but for the novice it might be challenging. If you are knowledgeable of outside courses and stressful times in the curriculum, address these tensions in your class by stating that you are “aware this week maybe stressful”. You might provide some specific study tactics or, if possible, you might alleviate an assignment. Take time to learn the names of your students so that when they raise their hand or you call on them by name. Share some personal vignetters of yourself as they relate to the course content. These simple tactics can help student perceive you as approachable (Novotney 2010).

Make uncertainty safe in your class. Millennials believe that self-esteem is more important than achievement and what other people think is important to them (Howe and Strauss 2007). Thus, they are less likely to ask questions in an environment that does not praise them for trying or may leave them feeling less than their peers (Hattie and Timperley 2007). If you use assessments other than MCQ, consider using rubrics with a point scale or allowing for multiple attempts. Rubrics given prior to assignment deadlines can help guide learning and share expectations (Andrade 2001). If you use essays, consider having a draft that is reviewed by peers (or yourself if you have time). When answering student questions, take a moment to praise the student. You might try responses such as: “What a great question”, “I was hoping someone would ask that question”, “Great segue to my next topic”, “Good one”, “Let me think about that for a minute”, “Good application question”, and “Perfect time to review”. When students are answering a question, try to refrain from saying if they are right or wrong. Instead, ask them to articulate their answer before you volunteer yours. For instance, try saying “how do you know” or “what lead you to that answer”. Find something in their response to work with, especially if their initial answer was wrong. Gaining insight to how the student got the wrong answer will help you provide valuable feedback. If you know a question posed to the class is going to be more challenging, try using Think-Pair-Share. Have students individually think of the answer (or write it out) then pair up with a student next to them to help correct/finish the answer, and finally have someone share it with the class. Think-pair-share is a great activity if you want them to create a list (e.g. a list of all of the appendicular bones), a sequence (e.g. the process of muscle contraction), or complete a worksheet.

Practice Coupled with Feedback

Research

In a time where students are more technology savvy than ever and able to garner information anywhere, anytime, it is easier for instructors to provide practice opportunities (Nicholas 2008). Practice and feedback have always been essential in the learning process, but the effective combination of the two is what allows for the full learning potential to be reached. In her book, Ambrose (2010) talks about the cycle of practice and feedback being a necessary coupling to enhance the quality of students learning. The ideal practice includes three factors: it must be relevant to the outcome; it must have the appropriate level of challenge based on the students’ current performance; and it must be of sufficient frequency and quantity. Providing multiple

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assignments of shorter length results in more learning than a single assignment of greater length (Ambrose et al. 2010). Although a student may feel they mastered something after one correct attempt (e.g. one cycle of flashcards or one online quiz), we would all agree that nothing could be learned after one attempt. Taking anything you learned in life as an example: typing, driving a car, or recalling all the muscle names, etc. It was the repetitive practice that was essential to the learning process. Providing students with purposeful goal-oriented practice opportunities can enhance student comprehension (Fink 2013).

At the same time, to achieve the greatest gains in learning, students also need targeted feedback (Butler and Winne 1995, Hattie and Timperley 2007). The feedback should be constructive and specific about areas that need improvement. Feedback should be given in a timely fashion for maximum benefit and it should be positive and unbiased to assist the learner, not judgmental (Ambrose et al 2010, Butler and Winne 1995, Thurlings et al. 2013). The ability to obtain this combination of practice and timely targeted feedback has never been easier than in the world of mobile devices (Tutty and Martin 2014).

Activities

Consider providing online worksheets or quizzes that students can take at home to provide immediate feedback. Most learning management systems allow for creation and delivery of questions students can answer at their own pace along with feedback specific to the question and response. Although this might be a bit more upfront work for the instructor, it could be something used every time you teach the course and payoff in the long run. Many publishers have created online activities that students can utilize as an accompaniment to their textbooks. For an example, McGraw-Hill Education’s SmartBook® combines focused adaptive reading in the book with periodic stops to test comprehension of learning objectives. Each learning objective question/probe is accompanied by immediate feedback and links to sections in the text where students can learn more (McGraw-Hill Education 2016). Items like this allow the instructor to assign practice activities without increasing time spent grading.

Practice can also be obtained in the classroom. During a traditional lecture style class, stopping to ask questions of comprehension can be beneficial for both the student and instructor. Consider a classroom response system, which has been shown to have positive effects in the classroom from both an educational and a social point of view (Hoekstra 2008, Hunsu et al. 2016, Stowell and Nelson 2007). For a cheaper alternative, creating colored cardboard cards that students hold up on the count of 3 to show their answers (i.e. A on red, B on yellow, C on green, D on white) can also be quite effective. These quick questions can also be done at the beginning lecture, to assess student’s prior knowledge, or at the end of lecture, to allow for reflection and repetition.

Active Learning

Research

Active learning is most commonly thought of as introducing purposeful activities during lecture that encourage student engagement and help promote learning. Active learning activities do not need to take up a lot of time, but ought to be well thought out and purposeful to the learning objective (Astin 1993, Prince 2004). In addition, the activity should include student participation and critical thinking (Bonwell and Eison 1991). A meta-analysis of 225 studies comparing traditional lecturing versus active learning found a 6% increase in average examination with active learning. In addition, students were 1.5X more likely to fail in traditional lectures (Freeman et al. 2014).

The Millennial generation grew up with quickly changing and fast paced movies in addition to being able to get the answer to their question in a moment’s notice (Strauss and Howe 2000). Educational research supports the concept that the ideal environment has fewer lectures, with a purposeful use of multimedia and collaboration with peers (Ambrose et al. 2010, Price 2009, Sousa 2011, Svinicki 2004). Traditional 60-minute lectures are being replaced by lecturing in small chunks of ten to twenty minutes, followed by a two to five minute activity to test comprehension (Blumberg 2008, Carlson 2005, Prensky 2001). The exact amount of lecturing and the type of activity most effective varies widely (Bligh 2000). However, even just pausing to give students time to clarify notes with each other has shown promise in short-term retention and test scores (Ruhl et al. 1987).

Certainly taking some time out of class means shifting thinking of use of class time. If you cover all the content in class and it does not promote learning, is that the most effective use of your or your student’s time? Proponents of active learning and the learner-centered approach would argue that it is more important students learn the material than how it was covered (Ambrose et al. 2010, Freeman et al. 2007). It is the job of the instructor to help students make sense of the knowledge that they can readily obtain and to know which pedagogy will help the student achieve the objectives (Blumberg 2008, Bowen 2012, Lalley and Miller 2007, Nevid 2011).

Large class size may be a stumbling block to incorporating active learning into the classroom. Several studies have shown that the benefits of active learning can be obtained in classes with 100+ students (Day 2015, Foertsch 2002, Freeman et al. 2007, Hake 1998, McLaughlin et al. 2014). One such study compared a traditional lecture to a flipped classroom with a 100+ students, resulting in students in the flipped classroom having a 3% increase in course grades, 2% increase in retention of material seen in future courses and 12% increase in correctness of higher level questions (Day 2015). True, larger class sizes do limit the types of activities an instructor can choose, but there are numerous low-stakes classroom...
assessment techniques (CATs) that can be effectively used to maximize learning in the class (Angelo and Cross 1993).

**Activities**

Consider stopping after a difficult concept and having students pair up and explain it to each other (Ruhl et al. 1987). Then open up the floor for questions regarding the material. This activity is quick and does not require extra prep work on your part. For a more creative idea, try posting/showing a YouTube clip and asking students to critique what is right, wrong or missing. Critically thinking about content related videos can be an effective tool in student learning (Burkely and Burkley 2009). If you use online videos to deliver your content, try inserting a couple of MCQ throughout the short presentation. There is software available that allow you to do so, including Camtasia, Storyline and VoiceThread.

To get a better ‘read’ on the class, take the last minute of lecture to have students write down the muddiest point of the class on a piece of paper. You can either respond at that moment or in an online discussion. In contrast, if you teach a flipped or hybrid course, try starting the class session with a muddy point or by having students rank the major concepts of the previous class from least to most comfortable. These activities can provide insight into trouble areas. Purposefully adding technology to your teaching can be a good way to break up teaching moments. In lab you could leverage technology in the lab by having questions on note cards with a QR code for the answers or hints. There are many free sites to create QR codes and it is a great way to simulate your presence when you can’t get to every station of students. You can even leverage technology outside class by giving students a #hashtag to tweet a-ha moments.

**Conclusion**

Every instructor wants to see students be successful and work to their full potential. However, what worked in the past for some students, may not work for current students. Certain styles of teaching may be effective for some content but not for all content. It is the responsibility of a good instructor to know what pedagogy will best help the student and instructor reach their goals. Thankfully there is a wealth of information and research available to assist the novice and experienced instructor equally. Baby steps and constant feedback are important. Remember the ultimate goal, students need to learn the content and enjoy the process. Learning should be fun! I think Ramsden (2003) said it best, “The aim of teaching is simple: it is to make student learning possible.”

**Literature Cited**


Leslie Day is an Associate Clinical Professor in the Department of Physical Therapy, Movement and Rehabilitation Sciences at Northeastern University. Her current teaching responsibilities include Gross Anatomy and Neuroanatomy, but she has also taught many sections of Anatomy and Physiology. In 2009, she received the Excellence in Teaching Award, the highest honor at her institution. Her current research focus is in the scholarship of teaching, specifically on active learning and technology in the classroom and lab. She has also served on the HAPS Board and is currently the Chair of Membership Committee.
My First Attempt at Teaching Human Anatomy and Physiology in an Active Learning Classroom: Part 1 of a 3-part series

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Abstract
This article documents a troubled first attempt at teaching entry-level anatomy and physiology via inquiry in an active learning classroom. Both student and instructor frustrations are documented, as well as the need for strong administrative support. Specific lessons learned include the need for regular homework assignments and well-designed curriculum materials. Instructors need to be resilient as they try new teaching methods, and not expect immediate positive results.

Key words: active learning, cooperative quiz, cooperative group learning

Introduction
The unofficial first rule of teaching is “you teach the way you’ve been taught.” Like almost all anatomy and physiology educators, I was taught via listening to lectures. And so when I became a professor, I followed the first rule – I lectured to my students. And the teaching evaluations were good; students reported that they enjoyed the class.

However…

Research in science education consistently has shown the limitations of lecture and the benefits of active learning methods in promoting conceptual learning (Freeman et al. 2014). Students enjoy lecture because they are comfortable in that setting – there is not much to do but listen, take notes, and update their Facebook profiles every few minutes. And educators enjoy the lecture setting as well – it is comfortable, controlled, and predictable.

My switch to an active learning classroom was the result of two events: first, working with Roger and David Johnson and attending their cooperative learning workshops and second, the construction of a new building on the University of Minnesota campus designed specifically for active learning.

David and Roger Johnson (fraternal twins) were professors at the University of Minnesota and worked as a team for over 40 years studying cooperative learning, e.g. examining optimum group size, group composition strategies (homogenous vs. heterogeneous grouping), individual roles within groups (doubter, reader, etc.). They also explored the roles of administrators in supporting educators who are trying cooperative learning for the first time. David Johnson often spoke of the transition stage educators have to endure as they move from a “sage on the stage” (lecturer) to “guide on the side” (leader of an active learning classroom). “It is not easy – there will be very difficult days!” David would say. “But the key is to keep going. It will take a year, or maybe even several years, to get the hang of it. Just don’t give up.”

David would go on to cite research – lots of research – that supported cooperative learning, and constructivist learning theory (Vygotsky 1962) over traditional methods (e.g. lecture) of instruction (Johnson et al. 1991).

Despite the piles of research supporting cooperative group learning, professors at the University of Minnesota and around the world, resisted it. One of the many reasons it was resisted, or more accurately, ignored, was that implementing group learning in a traditional lecture hall was awkward – how do students work in groups when the chairs are bolted to the floor? To promote more active pedagogy, the University of Minnesota starting building classrooms specifically for cooperative group learning. In 2007, a small classroom was designed with four round tables that each accommodated nine students. Along with high-tech monitors and computer equipment, there were glass walls surrounding the room upon which students could write using dry-erase makers. The room was too small for my regular classes, but I was able to meet in there one day a week during a summer session. I ran cooperative quizzes (Jensen et al. 2002) in the room and also held classes in a traditional lecture hall. All was good. Student evaluations at the end of the semester were positive and students reported that they enjoyed their experience in the cooperative learning classroom.

In 2010, the University of Minnesota opened a new building entirely dedicated to cooperative learning / active learning classrooms. (These rooms are also called SCALE-UP classrooms, Student-Centered Active Learning Environment with Upside-down Pedagogies (Beichner et al. 2007)). The building had a few 36-student rooms, but featured several 127-student rooms with thirteen round tables and one instructional station in the middle (Image 1). I was one
of the first professors to move my class to the new building and I thought I was ready. I had attended workshops by Roger and David Johnson. I had good success meeting one-day a week in a cooperative room during a summer session. So, I thought I might as well jump in deep and put the whole course in there! This would be fun, and according to the research, students would really ramp-up their learning of human anatomy and physiology!

I was wrong.

My first year

The Fall of 2010 was my first immersion experience in an active learning room. About 120 students enrolled in my entry-level anatomy and physiology course that semester and only about 80 survived to the end. Going into the course I had in my possession one proven activity that I knew would work, the cooperative quiz. Once a week I would have students take short quizzes first as individuals, and then in groups of two or three. Those worked well. But what do you do with the other 120 minutes of time each week?

My first classroom activity was based on the Vitruvian Man. Students took measurements to see how Vitruvian they were, drew several graphs on the white boards that surrounded the room, and learned basic lessons in variation within our class and within the wider population. I sort of assigned homework; “Read and learn Chapters 1 – 4 in the text. Be sure to know your body regions, plans, etc.” Student performance on the first couple cooperative quizzes was fine as they were based on very small domains of information. The party was over, however, at test 1. Test 1 covered Chapters 1-4 as well as the activities we performed in class. Students bombed, and being students, they complained. Complained loudly!

“You never covered this in class.”

“You’re not teaching us anything.”

“How are we supposed to learn this stuff if you don’t teach it to us?”

After receiving all the complaints, I gave the students the usual pep talk. “You have to grow up! You have to read and learn from the textbook. This is college. It’s not high school anymore.”

But, I also started to get the feeling that I really did not know what I was doing. What should students be doing in an active learning classroom to learn the principles of human anatomy and physiology? Good question! And dang if I knew – and I’m in charge of the course. Ouch. Cooperative quizzes were fine, but they were more testing experiences and not so much “learning” experiences. How do you teach, for example, homeostasis, muscle contraction, and nerve signal propagation in an active learning room?

I tried the following: I asked each table of nine students split into three groups of three. I had each group learn a small bit of information (three or four paragraphs of from the textbook) and then I had them prepare a short lesson for the other two groups. This activity bombed. It created far more chaos than learning by inquiry. Test 2 came along and, well, … lets just say that I was required to schedule a meeting with my boss.

Students were mad, confused, and dropping out of the class. I was frustrated and needed to go into damage-control mode. And after test 2, approximately two-thirds of the way through the course, I made the decision to fall back into default mode, lecture. For the majority of the rest of the course, I went back to lecturing with Power Point slides and being the “sage on the stage.”

What’s odd about this situation, however, was that there is no stage in an active learning classroom. The instructor was located in the middle of the room and monitors are located on the walls on the outside of the room. As I talked and showed slides, several groups of seven or eight students would be seated at the perimeter of the room staring at the monitors (Image 2). But, they were happy! They were doing what they knew how to do which was to sit quietly and listen to a nice comfortable lecture about hormones, continued on next page
diabetes, and glucose metabolism.

Scores on the final exam showed improvement, but course evaluations were brutal. “(The instructor) does not know what he is doing,” “We had no idea what to study,” “No clue what’s going on.”

Ouch. And thank goodness for tenure. Fortunately I had a terrific boss. I told her ahead of time that this would be a difficult semester for my student evaluations and she fully supported me. “Hope you try it again!” she said, with just a bit of a cruel smile on her face.

Lessons Learned from the First Semester

I am now six years into teaching my anatomy and physiology course in the active learning rooms and will never go back to lecture. That first semester was indeed rough, but I kept David Johnson’s voice in my head: “The key is to keep going. It will take a year, or maybe even several years to get the hang of it. Just don’t give up.” I knew the research was on my side and students learn better in an active learning environment even though they enjoy the comfort of a lecture environment more. At this time (six years in), I tell colleagues that I am about 50% comfortable with what I’m doing in terms of pedagogy. I still have lessons to learn. However, I enjoy the struggle of figuring out the puzzle of how to best use an active learning classroom.

After that first semester I learned two very important lessons. First: The importance of regular homework assignments. During that first semester I, like many other professors, treated my students like adults and expected that they would read and learn from the textbook. “Be sure to read Chapter 3 for next time” I would say. Well, as many of us know, only a few entry-level students are mature enough to do that, and pre-class preparation is important, extremely important, for active learning lessons. I now assign extensive homework; ten to fifteen pages are turned in every session. Most of the homework assignments require labeling, fill in the blank, complete the sentence activities. Easy stuff. But I tell students that the easy stuff (like learning body regions and directional terms) will be done at home via their homework.

The difficult stuff, the concepts for example, is what we hit in class. And that brings up the second lesson.

Second: The need for strong curriculum materials. After that first semester I scrambled to web sites searching for teaching materials for entry-level anatomy and physiology. I looked for activities that could be completed in groups. I spent hours and hours hunting, finding, and revising curriculum materials. The second semester in the room went a little better but I still resorted to lecture to keep the peace. I knew there was a need for curriculum materials for the classroom but I just could not find them. Then towards the middle of the semester I ran into a Dean who asked me, “Have you ever heard of POGIL?”

Literature cited


Curriculum for the Active Learning Classroom – The POGIL Method: Part 2 of a 3-part series

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Abstract
In this article, the structure of a Process Orientated Guided Inquiry Learning (POGIL) activity is described and analyzed. A POGIL curriculum utilizes a series of questions that promote conceptual learning by following a highly researched teaching tool called a learning cycle. A POGIL activity, The Levels of Organization, is examined and explained as an example of an activity for classroom use.

Key words: active learning, inquiry, POGIL, curriculum, learning cycle

Introduction
Learning is maximized when students engage in small group discussions using the language of the discipline.
That’s easy to write, but getting students to actually do it?
Well ...
"OK, students. Today I would like you all to engage in small group discussions using the language of the discipline.
Ready…. GO!"

Part 1 of this series documented my difficult first semester in an active learning room. It was problematic in many ways but mostly I was lacking curriculum materials that would promote good student conversation. The summer after that first year I attended a Process Oriented Guided Inquiry Learning (POGIL) workshop and was able to begin to figure out how to design a curriculum that would be specific to the active learning classroom.

POGIL is a teaching and learning method that provides a template to develop curriculum. The POGIL project (https://pogil.org/) started with a series of grants from NSF, Toyota USA Foundation and others, to develop and evaluate an active learning curriculum for chemistry. The method is now used in several disciplines and academic levels, and works well with human anatomy and physiology (Brown 2010).

The goal of a POGIL lesson is two-fold: First, to promote traditional learning outcomes such as, "Students will learn the relationship between blood glucose and insulin levels" or "Students will be able take apart a medical term, identify prefixes, roots, and suffixes, and derive its meaning." The second goal of a POGIL lesson is to promote process skills such as the ability to work in groups and master oral and written communication skills (Brown 2010).

A few years back I was awarded an NSF grant (DUE-1044221) to write curriculum for an entry-level human anatomy and physiology. Ten college instructors and over 40 high school educators attended workshops to learn the POGIL method and then engaged in the laborious process of curriculum development. In this paper I will examine a couple of POGIL lessons that were developed through that project so as to introduce the method by which we promote student conversation using the language of human anatomy and physiology.

The Anatomy of a POGIL Lesson
All POGIL lessons are comprised of two components: first – a model, which can be an image, a graph, a data set, etc., and second – a series of questions which students answer using information found within the model.

Appendix 1 contains the Levels of Organization activity that closely follows the POGIL curriculum formula. Model 1, located at the top of page 1 of the activity, contains text, a graphic, and a table, all of which should look quite familiar in that it is information that can be found in most every textbook used in anatomy and physiology. The model is accompanied by questions for students to answer. Questions within a POGIL lesson are based on a long-standing and highly researched tool in education called the learning cycle (Karplus and Their 1967, Piaget 1964, Lawson et al. 1989). Several different styles of learning cycles exist (“what, so what, and now what?” and “see one, do one, teach one,” are both popular in health care education) and POGIL lessons are organized with a blend of two different forms (Figure 1). The idea behind a learning cycle is that in order to learn a concept a student should proceed through a series of well-organized questions that represent the steps of a learning cycle. During an activity, students do not see the names of the steps (e.g. a direct question), but an experienced POGIL instructor can look at a question and say, “That’s a direct question.” After working through the set learning cycle questions students should have a basic

continued on next page
understanding of a concept, which within a POGIL lesson should be communicated as content objectives, also called learning objectives or learning outcomes in the instructor’s guide (Figure 2).

Figure 1. Two Learning Cycles Used in Many POGIL Lessons

<table>
<thead>
<tr>
<th>Example 1</th>
<th>Example 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Direct question</td>
<td>1. Direct question</td>
</tr>
<tr>
<td>2. Convergent questions</td>
<td>2. Concept invention questions</td>
</tr>
<tr>
<td>3. Divergent questions</td>
<td>3. Application question</td>
</tr>
</tbody>
</table>

Figure 2. Learning Objectives for the Levels of Organization Activity

**Content Objectives**

Students will be able to list the levels of organization and provide examples of each.

Students will develop a working definition of tissues and organs.

**Direct Questions**

In all POGIL activities, the first couple of questions following the model should be direct questions. Direct questions can be answered simply by examining the model and should not be difficult for students to answer. In fact, if a student is having difficulty answering the first one or two questions on a good POGIL activity that is an indication that the student does not have the cognitive skills required to succeed in the course. If all students are having difficulty answering the first couple of questions, then the activity might be targeting students at a higher academic level or the questions may need revision. The purpose of direct questions is to familiarize students with the information found within model. The first two questions in the Level of Organization activity are examples of direct questions.

**Level of Organization**

<table>
<thead>
<tr>
<th>Level of Organization</th>
<th>Example</th>
</tr>
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<tr>
<td>Atom</td>
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</tr>
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<td>Digestive System</td>
</tr>
<tr>
<td>Organism</td>
<td>YOU</td>
</tr>
</tbody>
</table>

Direct Questions

1. Using the list above, identify two terms that describe components that are smaller than cells and four terms that describe components that are larger than cells.

2. What are two examples from the list above that can be found **inside** a cell?

**Convergent and Divergent Questions**

Following the direct questions are either convergent and divergent questions, or possibly concept invention and application questions, depending on which learning cycle is being used. The Levels of Organization activity uses convergent and divergent questions. Convergent and divergent questions require more thinking on the part of the students when compared to direct questions and should promote discussions within groups. Convergent questions should require students to think for a bit, and then after a discussion with group members, come to one best answer. Question 3 of The Levels of Organization activity provides an example of a convergent question. Not all students in an entry-level course will be able to identify every item in this question and discussion should ensue. After a couple of minutes, students should have most of the answers for the items shown in question 3.

3. Classify the following images and label each with the appropriate level of organization.
Students usually move through some of the above items quickly, for example, cell, skeletal system (organ system), heart (organ), but then there is the male figure - and that often generates a pause. What is that supposed to represent? Skin? Reproductive system? Organism? What does the teacher want us to put for that one? What’s the right answer?

Well, there is no one right answer.

The male figure in question 3 is a divergent question. Divergent questions require students to brainstorm, discuss, and sometimes even argue about possible correct answers. There is no one right answer for a good divergent question, but rather a collection of possible answers, each answer having strengths and weaknesses. In all cases, divergent questions should be good fodder for group discussion.

The role of the instructor will be the topic of Part 3 of this series, however, an important point needs to be made here. Many entry-level anatomy and physiology students believe that questions in science classes have one right answer and the ability to memorize those correct answers leads to student success. Experienced educators and research scientists know that the most interesting questions in science have several possible answers and often there is no single correct answer. By having students discuss, argue, and critique possible answers to divergent and convergent questions they begin to think like a scientist. They are beginning to be scientists. To generate a classroom environment where students can freely propose ideas and engage in open discussions, I frequently say a couple things over and over again to the whole class:

-- A good argument makes for a terrific learning experience.
-- It is OK to be wrong.
-- Throw your ideas out there, you might be right.
-- I want you to think like physiologists.
-- The best questions in science, and life, have many possible answers.

Hearing these coaching statements over and over again helps students begin to relax and become more engaged with conversations that have no single correct answer. It is important, extremely important, that students have the freedom to speculate and be wrong without penalty.

Question 7 in the Levels of Organization activity is another divergent question. The concept of shared organs will be new to most entry-level students, especially during the first week of class. Providing a clue in the body of the question (“For example, your mouth can be considered a part of both the digestive and the respiratory systems”) prompts students to think creatively and, after a few minutes, they will usually have at least one answer, the most common of which with my students in this exercise is “Penis - urinary and reproductive system.” Outside sources of information, such as textbooks or the Internet, are typically prohibited during a POGIL lesson. Students are encouraged to use their own thoughts and ideas to derive responses and thus they have a personal investment in their answers, as opposed to “This is what we found on the Internet”. Having a personal investment makes students more attentive during large-group discussions and more apt to pay attention while listening to an instructor’s critique of different answers, “Did we get this one right? Were we close?” as opposed to, “Well, that’s what we found on the web site.” Getting students to actually care about their answers is a big turning point in the active learning classroom. Students begin to think of themselves as thinkers and processors of science as opposed to simply retainers of factual information.

Question 7 is especially useful in that it can be brought up in almost every lesson during the semester to bridge body systems (e.g. the pancreas and the endocrine and digestive systems). Additionally, an entertaining question to ask on the last day of class is “Name an organ that is contained within only one body system?” This is the opposite of what was asked during the first week but the question is equally perplexing for good students. The difficulty in finding an answer provides evidence to students that “Wow, we learned something!”

Concept Invention and Application Questions

Along with divergent and convergent questions, concept invention and applications questions can be used within a POGIL lesson. The Glucose Metabolism activity (available to HAPS members at http://www.hapsweb.org/?page=GuidedInquiry) is an example activity that utilizes this type of learning cycle. After a series of direct questions students are asked a question that directly addresses a specific content objective for the lesson:

Content Objective: Students will be able to explain the relationship between insulin and glucose levels in the blood.

Question 10. On your own, write a grammatically correct sentence describing the relationship between blood glucose and blood insulin levels. After each individual is finished, compare sentences and as a group, decide on the most accurate sentence.

After the content invention question, a series of application questions are used to help students reinforce what they have learned. Question 11 is an example application question.

Question 11. Diabetics are often required to monitor their blood glucose levels to determine if/when they require a shot of insulin. Under what conditions should diabetic individuals give themselves a shot of insulin?

After a POGIL lesson focusing on glucose metabolism students should be able to explain the relationship between blood glucose and insulin levels. Understanding a relationship is a good example of conceptual understanding. Students know more than “just the facts” and are able to use their knowledge...
to predict and describe events. For example, question 17 in the activity asks:

**Question 17:** It is sometimes very dangerous to give someone a shot of insulin. Under what conditions should insulin never be administered?

Without a conceptual understanding students would probably Google this question and would likely come up with a correct answer. However, if they have followed the steps of the learning cycle and have indeed figured out the relationship between blood glucose and insulin they can then use their knowledge to answer this question, which is much more powerful than memorizing facts, and even more useful than Google.

**Selecting POGIL Curriculum for your Students: One Size Does Not Fit All**

“POGIL does not work with my students” is a phrase that I have heard many times and I totally understand the statement. There are two key elements for getting a POGIL lesson, or any lesson for that matter, to work with your students. First is the ability of the instructor to facilitate a POGIL lesson (Part 3 of this series), and second, the fit of the activity with the skills, background, and future goals of the students. Both Levels of Organization and the Blood Glucose Metabolism activities work well with most introductory students but they are far too easy to use with advanced students who would be bored. The divergent and convergent questions in those activities would become direct questions and little discussion would ensue. When selecting curriculum, the instructor must think of the students’ prior knowledge. Have they had chemistry? Organic chemistry? Gross anatomy? Pathophysiology? What do they know? What do they not know? The collection of POGIL activities developed by my group is intended for entry-level students. However, a couple of the activities in the collection do not work so well with my students because they are too difficult. Instead of promoting discussion within groups the questions produce frustration. Too difficult or too easy; it is the job of the instructor to dial in the level of difficulty and select the curriculum that best fits the students. At this time there are two collections of POGIL activities for anatomy and physiology, our group’s collection (Jensen et al. 2014) and Patrick Brown’s collection (Brown 2015). Reviewing the collections, an instructor might find ten, five, or maybe only one activity that might fit with their students. One size does not fit all. Some activities might work well to promote good conversation using the language of the discipline and other activities might bomb because they are either too easy or too difficult.

I am several years into using the active learning classroom now and unlike the very difficult first year (see Part 1 of this series), I have several activities that I know will work with the students. I have confidence that some days will go well. I tell fellow faculty members that I’m about 50% of the way to being comfortable with my curriculum materials. I still am looking for activities on, for example, the integumentary system, the autonomic nervous system, and several others. We have a good start, but I still have a long way to go.

**Conclusion**

Deciding what curriculum materials to use with students in an active learning classroom is indeed difficult. POGIL activities are just one of many different options for anatomy and physiology educators. Others include case studies, think-pair-share activities, one-minute essays, cooperative quizzes, and many more. The goal is always the same, to promote student conversations that utilize the language of the discipline. Sometimes just regular worksheets are enough, especially when they contain good convergent and divergent questions. Sometimes a single prompt by the instructor is enough to have five or ten minutes of productive work e.g. “Select one group member to draw a heart on the whiteboard and then have another member identify the path of blood through the heart.” For me, this quick and easy activity during our unit on the cardiovascular system works every time.

There is no single way to teach human anatomy and physiology. Many of us have been educated by means of traditional lectures. We have listened to hundreds and maybe thousands of hours of anatomy and physiology lectures. Lecture is indeed a good way to cover large amount of information. However, research in science education has shown the limitations of lecture. Unless the information learned via lecture is reinforced over and over again students tend to forget what they have learned. Additionally, many anatomy and physiology educators want to try out new ways to teach our students.

While the selection of curriculum materials for the active learning classroom is important, the materials need to be implemented in the classroom by skilled educators. Part 3 of this series will begin to look at the instructional skills needed to run a POGIL lesson.

**Literature cited**


continued on next page

Note: HAPS members have access to additional POGIL activities and class handouts here: https://hapsweb.site-ym.com/default.asp?page=GuidedInquiry

Levels of Organization

Model 1: Anatomy and Levels of Organization
An anatomist is a person who studies the structure of a living thing – how all the little things are organized into bigger things. The smallest living structures are cells, but there are things even smaller than a cell (such as atoms and molecules). Figure 1 shows the levels of organization used by anatomists. Table 1 names examples of each of the levels of organization shown in Figure 1.

Figure 1: Levels of Organization in the Human Body

<table>
<thead>
<tr>
<th>Level of Organization</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atom</td>
<td>Carbon</td>
</tr>
<tr>
<td>Molecule</td>
<td>Carbon Dioxide</td>
</tr>
<tr>
<td>Cell</td>
<td>Stomach Cell</td>
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<tr>
<td>Organ System</td>
<td>Digestive System</td>
</tr>
<tr>
<td>Organism</td>
<td>YOU</td>
</tr>
</tbody>
</table>

QUESTIONS:
1. Using the list above, identify two terms that describe components that are smaller than cells and four that are larger than cells.

<table>
<thead>
<tr>
<th>Smaller than a cell</th>
<th>Larger than a cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

2. What are two examples from the list above that can be found inside a cell?

3. Classify the following images and label with the appropriate level of organization.

4. Circle “TRUE” or “FALSE” for the following statements:
   a) Organs are composed of multiple tissues types. TRUE or FALSE
   b) Tissues are composed of multiple cell types. TRUE or FALSE
   c) Tissues are composed of multiple organ types. TRUE or FALSE

5. Spend 60 seconds working individually to write definitions for the two terms below. After 60 seconds, discuss your definitions with the group and decide who has the best definition.
   a) Tissue:
   b) Organ:

6. Without using books or the Internet, complete the chart by identifying the organ systems associated with the example organs listed: (the first row is completed as an example. If you cannot identify the organ system, leave the box blank)

<table>
<thead>
<tr>
<th>Organ</th>
<th>Organ System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Femur</td>
<td>Skeletal System</td>
</tr>
<tr>
<td>Heart</td>
<td></td>
</tr>
<tr>
<td>Brain</td>
<td></td>
</tr>
<tr>
<td>Skin</td>
<td></td>
</tr>
<tr>
<td>Pituitary Gland</td>
<td></td>
</tr>
<tr>
<td>Lungs</td>
<td></td>
</tr>
<tr>
<td>Stomach</td>
<td></td>
</tr>
<tr>
<td>Spleen and Appendix</td>
<td></td>
</tr>
<tr>
<td>Ovarus</td>
<td></td>
</tr>
<tr>
<td>Kidney</td>
<td></td>
</tr>
<tr>
<td>Biceps Brachii</td>
<td></td>
</tr>
</tbody>
</table>

CHALLENGE QUESTIONS:
7. Organs are sometimes shared by two or more systems - for example, your mouth can be considered a part of both the digestive and the respiratory systems. Without using your book or the Internet, try to name 3 organs that are shared by two or more body systems, and identify those body systems.

   Example: Organ: Mouth What two systems? Digestive & Respiratory Systems
   1: Organ: What two systems?
   2: Organ: What two systems?
   3: Organ: What two systems?

8. With your group, consider the following statements and determine if they are true or not. If they are NOT true, describe why (list exceptions that exist).
   a)Within the body, all atoms combine to form molecules.
   b)Within the body, all molecules in the body can be found inside cells.
Instructional Strategies for the Active Learning Classroom: Part 3 of a 3-part series

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Abstract

Inquiry-based instructional strategies require instructors to respond to student questions with hints and clues but not with answers. An introduction to questioning strategies, in relation to different settings and conditions is described and critiqued. Methods to familiarize students with inquiry-based teaching methods are also introduced.

Key words: instructional strategies, pedagogy, inquiry, questions, feedback.

Introduction

While riding in a subway a few years back, I sat across from a man and woman who were intently reading while their two young daughters were bouncing around the subway car the way kids do. Suddenly one of the daughters spoke to her dad, “Daddy! How many more stops until the museum?” The dad did not look up from his newspaper and simply said, “Look at the map. Figure it out.” The daughter immediately looked around the car for the subway map, ran over to it, and examined it for a moment. After a couple seconds of study, she shouted, “Three! No. Two!” She then spun back to her dad to look for some feedback. The dad’s response was ... well ... nothing. He did not even look up, he just continued reading. The daughter, satisfied with her dad’s response, and her own logic continued bouncing about the subway car.

What I had just witnessed was a perfect example of inquiry-based teaching. I wanted to hug the parents and say “Thank you from teachers everywhere” but I refrained.

“Look at the map, figure it out.”

The girl’s father did not ignore her question, nor tell her the answer, but rather said, “Look at the map” (a clue as to where to get an answer) and then “figure it out” (a clue as to how to derive an answer).

Responding to Questions with Questions

Good students have questions and they crave answers. Instructors love giving answers. We know the answers but “figure it out” is often the better response to a question than a direct answer.

Part Two of this series focuses on curriculum, and more specifically Process Oriented Guided Inquiry Learning (POGIL) materials. The intent of inquiry-based curriculum is to provide fodder for questions. In a POGIL lesson there is both a model, like the map in a subway car, and a series of guiding questions to help students “figure it out.”

An essential element of good curriculum materials is that the questions require students to think. As opposed to simple and quick recall, good questions require time for students to speculate, brainstorm, and contemplate. As part of the thinking process, students should be asking questions, lots and lots of questions. While working in small cooperative groups, many student questions are simply answered by other students when someone in the group knows the answer. However, there are times when hands go up and students are looking for help from the instructor.

In a traditional classroom, the one most of us remember well, a student question is responded to with an answer:

Student:  “What happens to blood glucose levels when a diabetic individual gets a shot of insulin?”

Instructor response:  “Blood glucose levels will fall.”

In an inquiry classroom, student questions are often answered with questions that specifically guide students with hints and clues for deriving the answer. Hints and clues that help students “figure it out.”

Student:  “What happens to blood glucose levels when a diabetic individual gets a shot of insulin?”

Possible instructor answers:

“Can you point to where in the activity you might find information about that question?”

“Instructor response: “Blood glucose levels will fall.”

In an inquiry classroom, student questions are often answered with questions that specifically guide students with hints and clues for deriving the answer. Hints and clues that help students “figure it out.”

Student:  “What happens to blood glucose levels when a diabetic individual gets a shot of insulin?”

Possible instructor answers:

“Can you point to where in the activity you might find information about that question?”

“Are there any data tables in the activity that can you help you answer that? “

“Can you tell me the function of insulin?”

“Can you tell a couple possible answers?”

“What do your group members think?”

continued on next page
Asking the right guiding questions can never be entirely scripted such that if student asks X, you respond with Y. Asking the right questions requires creativity and quick thinking and is largely dependent on a student’s intelligence and motivation. Some students need more help than others. Some students need stronger clues than others. If a student is smart, motivated, and has hopes for a career in health care you might want to give that student more indirect information and provide less guidance for the activity. For students who are non-majors and are having difficulty with the course you might want to provide more concrete clues and guidance.

Sometimes the following responses are appropriate:

Student: “What happens to blood glucose levels when a diabetic gets a shot of insulin?”
Possible instructor answers:
“Come on! Are you kidding me?”
“What? Look at the data and figure it out.”
“That’s too easy. You can do better.”

Or, you can respond by smiling at the students in the group and then simply walking away.

All of the above responses provide feedback and information to the student who asked the question. However, the instructor’s response has a negative tone and is indeed negative feedback (gasp!). The responses are cognitive kicks, as in “you have to do better” or “you can/should do better.” “Come on! Are you kidding me?” is indeed fitting when bright kids become lazy. Smiling and walking away is also a kick, but not as overt. Non-answers from an instructor in an inquiry classroom are a clear indication that the students have the information, materials, and cognitive skills to figure out the answer.

Determining the appropriate feedback to a student is difficult. The following is a partial list of the information needed:

How smart is the student?
What are goals of the student? Is the student a physiology major… a future engineer? … an English major? … a future lawyer?)
What does the student already know?
What does the student not know?
Is this the first time the student has spoken to the instructor?
Does this student have a good sense of humor?
Is this student shy? Extroverted? Obnoxious?
How motivated is the student?
Does the student do his/her homework?
How is the social chemistry within this student’s group?

How good are the curriculum materials?
What grade does this student want to get in this course?
Did this student just breakup with their boyfriend / girlfriend?
Some information that does not relate to the student is also needed. For example:
What week in the semester is it?
Is the student accustomed to an inquiry-based environment?
Do they know that thinking is a requirement in the class?

Dialing-in just the right response to a student question is a tremendous challenge. It requires a vast knowledge of both your subject, anatomy and physiology, and your students. The father in the subway car undoubtedly knew his daughter well. He knew how smart she was and what she was capable of doing. All that was needed from him was the directional instructions e.g. “Look at the map. Figure it out.” to send her on a quest to find the answer. And the daughter knew her father well enough to know that his non-response to her answer (“Three! No. Two!”) was indeed affirmative. She had indeed “figured it out.” This type of interaction could not have happened between strangers. But with time, skill, and good students, it can be replicated in an inquiry classroom.

Along with knowing your students, your students must learn about you and your teaching style. Do you have a sense of humor? Do you laugh funny? Are you easily embarrassed? Are you highly professional? Do you want to be called “Doctor?” Do you want to be called “Dude?” (I don’t recommend this one.) Are you comfortable when students are working in groups and are a bit loud? Do you walk around during class activities, or do you stay at your station until a hand goes up? Do you like to say, “I don’t know?” Or are you uncomfortable when you have to say, “I don’t know?”

It takes time to learn the personality of your students and it also takes time, years in some cases, to learn how to provide just the right feedback to student questions. Getting it right and creating the situation where a genuine “a-ha” moment arises … wow. You then get to see, hear, and even feel thinking. You see, hear, and feel inquiry. There is indeed a feel to inquiry. Some researchers call it cognitive tension or cognitive disequilibrium. If you are an educator whose goal it is to produce inquiry, that feeling is like a drug you learn to crave. “I want my students in that moment of inquiry! I want more of that!”

**Getting Started with Inquiry Teaching Strategies**

One of the easiest places to start practicing inquiry-teaching strategies e.g. learning to respond to questions with questions, learning to give good clues and hints, is during cooperative quizzes. A cooperative quiz involves two steps.
First, students take a quiz on an individual basis and upon completion, they turn in their answers. The second portion of the cooperative quiz involves the same questions as the individual portion of the quiz but now students work in small cooperative groups of two, three or four students. Students are now encouraged to talk and discuss questions and answers. Because it is a quiz, students are motivated to talk. Scoring is done by taking the average of the individual and group quiz scores (Jensen et al. 2002). During a quiz, students are typically more alert than during regular classroom activities because they are more eager to “figure things out” and they are more likely to listen closely to your clues. During the group portion of cooperative quizzes, I allow each group to ask for one clue to one question on the quiz. Students are not allowed to ask, “What’s the answer to #9?” Rather they must carefully script a question that will hopefully provide information to help them answer a question on the quiz.

The following are some clues that I have used when students have taken a cooperative quiz on the endocrine system.

Example 1

Student: “Where in the body can you find insulin?”
Instructor Response: “How do hormones move in the body?”

Example 2

Student: “Under what conditions should someone never receive an insulin shot?”
Instructor Response: “Does the brain need glucose?”

Example 3

Student: “What happens to blood glucose levels when a diabetic individual gets a shot of insulin?”
Instructor Response: “What is the action of insulin?”
Student: “I suppose we know that.”
Instructor Response: “Yes, indeed.”

But You’re Not Doing Your Job!

Students who are new to inquiry-based learning sometimes view instructor clues, hints, and non-answers as evidence that they have a bad instructor or that the instructor is not doing his/her job. It is vital to teach students the basics of inquiry-based learning and the reasons for your teaching methods. Helping students understand the philosophy (“this is how people learn”) and mechanics (“I will often respond to your questions with another question”) of an inquiry-based classroom prevents, or at least reduces, negative comments and poor classroom evaluations. “Come on, just tell us the answer” is sometimes heard at the beginning of the course but once students buy into the idea of inquiry they will figure out why you do what you do. “My goal is to make you think” is something I say over and over again during the first few weeks. Later in the course I sometimes say, “You are beginning to think like physiologists” if students have given an honest effort and provided reasonably intelligent answers to complex a physiological problem.

Instructors who are new to inquiry teaching will undoubtedly have experiences like those documented in Part 1 of this series. Administrators need to be told when you are implementing inquiry into your courses for first time because odds are good that they will be hearing complaints from students. It is also likely that there will be a drop in course evaluation scores. However, good administrators, those that support research-based teaching strategies such as POGIL, should support inquiry-based teaching and be willing to tolerate a temporary dip in course evaluations.

Start on the First Day of Class and Be Overt with Your Intentions

If inquiry-based teaching methods are going to be used in a course, it is imperative that students are informed during the first day of class. For example, an instructor might say, “When you ask me a question, I will probably respond with another question.” Tell them from the start that they will be required to speculate, guess, and, well, think during class sessions. Most students will accept inquiry if they are told the expectations on the first day.

And along with telling students about inquiry on the first day, it is also important to start using inquiry lessons on the first day (and never mid-course). After the first day, and maybe even the first few minutes, most students know what to expect from the course and the instructor. With that in mind, I try to get students going on the Levels of Organization activity (see Part 2 of this series) within the first five minutes of the very first class meeting. During the activity, I interrupt and state clearly and directly: “It is OK to guess. It is OK to express ideas and opinions. It is healthy to doubt each other and say, ‘Are you sure about that?’” In an inquiry classroom, students must be comfortable enough to be wrong; they must be given the academic freedom to speculate and brainstorm. It is also good to tell students that they will sometimes feel frustrated that they cannot quite figure out a question and that is fine - and in fact, it is good! It is evidence that they are on the verge of learning something. It might also help to remind students that research scientists spend their lives looking for answers, they live in a constant state of uncertainty and speculation.

In my freshman courses I rarely let students leave the room at the end of class without closure. That means giving students answers to questions on the day’s activity. The last 10 minutes of my classes I have whole-class discussions where students ask questions and I do indeed respond with answers. With more advanced students it is acceptable, even preferable, to go a few days, or even weeks, without closure.
What is important for entry-level students is that they get a taste of inquiry. They need to get acquainted with the feel of not knowing the answer but having enough data to derive a plausible answer. As students mature, they become more and more comfortable with the feeling of doubt and they will become more and more comfortable with less and less direction.

With time you might hear a student say....

“Don’t tell me the answer. Let me figure it out.”

**Literature cited**

Regional vs. Sequential Approach to Teaching Musculoskeletal Systems

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Abstract

This study examines the effectiveness of teaching skeletal and muscular system laboratory topics with a systemic vs. a regional approach. In group 1, the first and second assessments were administered after the skeletal system and muscular system unit, respectively. In group 2, the first assessment was administered after a unit on the skull, upper limb bones, shoulder girdle, and associated muscles while the second assessment focused on the remainder of the axial skeleton, lower limb bones, os coxae, and associated muscles. The format for all of the exams was a 50-question lab practical with the same questions used for group 1 and group 2. Results from a student’s t-test indicates students taught with a regional approach (group 2) scored higher on assessments than those taught with a sequential approach. Thus, instructors should consider revising their curriculum to teach a regional form of the muscular and skeletal systems.

Key words: muscles, bones, regional, systematic, lab

Introduction

In an article on the proper order in which to teach anatomy that appeared in Science in 1895, Frederich Gerrish stated:

“The active organs of locomotion are never learned unless there is a well-laid foundation of skeletal knowledge, upon which to build them; for, in absence of this basis, they are but impotent, flabby, almost shapeless masses of flesh, but little amenable to description, and quite elusive of comprehension.”

(Gerrish 1895).

Many textbooks, including the one used in our course, align with this thinking by presenting the skeletal system in its entirety before presenting each of the other body systems sequentially (Marieb and Hoehn 2013). However, this systematic approach to anatomy might hinder students who are trying to apply their knowledge in a clinical situation or envision an accurate 3-D image of a region (Pais and Moxham 2013). While some investigators have suggested teaching anatomy with a regional approach (Pais and Moxham 2013), few studies have examined the effect of this approach on student performance. This study examines the impact of teaching the skeletal and muscular systems with a regional vs. a systematic approach on the exam grades of introductory anatomy and physiology students.

Methods

During the academic years of 2014-2016, fifteen sections of Human Anatomy and Physiology I (BSC2085) were taught by the same instructor. Eleven of these sections (group 1, n = 265) were taught with a systematic approach where students were taught to identify the bones of the skeletal system and then assessed with a practical exam, then taught the muscles and similarly assessed with a practical exam.

Four of the fifteen sections were taught using a regional approach where the first assessment was administered after a unit that included the skull, upper limb bones, shoulder girdle, and associated muscles and the second assessment was administered after a unit that included the axial skeleton, lower limb bones, os coxae, and associated muscles. The format of all exams was a 50-question lab practical with the same questions used for group 1 and group 2. Lab exam scores were averaged for each student and the averaged scores for students taught sequentially and those taught using a regional approach were compared with a students’ t-test. The three most recently taught sections of group 1 and the three most recently taught sections of group 2 were surveyed to determine student attitudes toward the regional teaching approach. Evaluations were done after each of the lab exams. The evaluation consisted of two questions to which students responded using a four point Likert-type scale as follows: Strongly Agree, Agree, Disagree, and Strongly Disagree.
Results

Students in group 1 (n=265) who were taught with a sequential approach scored significantly lower than students in group 2 (n=88) who were taught bones and muscles together (Group 1: 70%, Group 2: 77%; p<0.05) (Figure 1).

A greater percentage of group 2 students (n = 62) selected strongly agree or agree with these two assessment statements: “I enjoyed how we learned the bones and muscles (89%) and “I can identify the major bones and muscles” (92%) (Table 1) than Group 1 students (76%, 87% respectively; n = 55; Table 2).

Discussion

While many textbooks present the skeletal and muscular systems in a sequential format, our study suggests that presenting this information with a regional approach leads to higher scores and improves student attitudes toward the course material. The authors encourage instructors to consider adopting this style for their labs.

References


Table 1. Regional group student satisfaction survey. Responses are % of students selecting strongly agree or agree to the statement (n=62).

<table>
<thead>
<tr>
<th>Statement</th>
<th>Percentage</th>
</tr>
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<tbody>
<tr>
<td>I enjoyed how we learned the bones and muscles.</td>
<td>89</td>
</tr>
<tr>
<td>I can identify the major bones and muscles.</td>
<td>92</td>
</tr>
</tbody>
</table>

Table 2. Sequential group student satisfaction survey. Responses are % of students selecting strongly agree or agree to the statement (n=55).

<table>
<thead>
<tr>
<th>Statement</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>I enjoyed how we learned the bones and muscles.</td>
<td>76</td>
</tr>
<tr>
<td>I can identify the major bones and muscles.</td>
<td>87</td>
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Re-inflation of the Subarachnoid Space as a Teaching Technique in a Gross Anatomy Course

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Abstract

Two novel techniques for re-inflation of the subarachnoid space in a cadaver-based dissection class are discussed. The first technique involves the passing of an 18-gauge needle through both the dura and arachnoid mater to inject tap water into the subarachnoid space. In the second technique, the dura mater is first carefully reflected so as not to damage the arachnoid mater. A 28-gauge needle is then inserted through the arachnoid mater and tap water again injected. Technical considerations and the learning benefits of the two techniques are discussed.

Introduction

It has been 140 years since histological studies first identified the three meningeal layers that envelop and protect the central nervous system (Key and Retzius 1876), which paved the way for decades of research into their morphology (Weed 1938). The outermost layer, termed the dura mater, is strong and dense (Weed 1938), providing a protective barrier to the spinal cord from external mechanical friction and abrasion during movement (Penning and Wilmink 1981). For teaching purposes, it can be likened to the protection that a pair of cargo pants provides the skin around the legs from external abrasions. Deep to the dura mater is the arachnoid mater, a delicate, translucent fibrous layer (Weed 1938) that lines the internal surface of the dura mater. The arachnoid mater sends cellular extensions to the surface of the brain and spinal cord that assist in maintaining a separation between the superficial meningeal layers and the pial lining of the brain and spinal cord, defining the subarachnoid space (Weed 1938). If the dura mater can be compared to the outer shell of a pair of cargo pants, the arachnoid mater would represent an inner lining, which would be much less abrasive to the underlying skin. The pia mater is the deepest of the 3 layers, in direct contact with the neurons and glial cells making up the brain and spinal cord (Weed 1938). For teaching purposes, it can be likened to a pair of comfortable leggings under the cargo pants, in direct contact with the skin.

Electron microscopy has led to the discovery of sub-regions within both the dura and arachnoid layers. These studies were first conducted in the cranial meninges (Ramsey 1965), with subsequent studies identifying subtle differences in the spinal meninges as well (Nicholas and Weller 1988, Vandenabeele et al. 1996). The dura mater can be divided into three distinct sub-regions. The most superficial is the outer dural border layer (Vandenabeele et al. 1996). Cytoplasmic extensions from the cells in this sublayer project and interdigitate along the long axis of the sheath. The middle portion of the dura is the thickest, composed of a highly vascularized collagen matrix with few fibroblasts (Vandenabeele et al. 1996). The inner dural border cell layer, or simply the dural border cell (DBC) layer is the deepest of the three sublayers, consisting of one or more layers of tightly packed fibroblasts (Vandenabeele et al. 1996).

The arachnoid mater can be divided into 2 separate sub-regions (Vandenabeele et al. 1996). The outer layer, referred to as the arachnoid barrier cell (ABC) layer, is composed of a collection of fibroblasts interlocked through an extensive series of tight junctions and supported internally by a basal lamina. As the name implies, it is thought that the absence of extracellular spaces creates a water-tight barrier preventing the leakage of CSF from the subarachnoid space to the epidural space (Nabeshima et al. 1975). Deep to the arachnoid barrier cell layer is the arachnoid reticular cell (ARC) layer, which contains a collection of loosely arranged fibroblasts (Nicholas and Weller 1988, Vandenabeele et al. 1996). Thick cytoplasmic extensions, the arachnoid trabeculae, project through the subarachnoid space, forming an anchor to the underlying pia mater. The web-like appearance of these trabeculae is responsible for the characteristic name of this middle meningeal layer.

In a living individual, the subarachnoid space is maintained by the positive pressure generated through production of the cerebrospinal fluid from the choroid plexus lining the ventricles (Weed 1938). Fluid passes through either the median aperture (foramen of Magendie) or lateral apertures (foramen of Luschka), where it circulates throughout the subarachnoid space and ultimately drains back into the dural sinuses via the arachnoid villi (Weed 1938). In addition, Vandenabeele and colleagues (1996) noted adhesions between the cells of the dural border cell layer and the arachnoid barrier cells that likely serve to fortify the

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association between these 2 sublayers. Following death and preparation of the cadaver for anatomical study, the positive pressure generated through production of cerebrospinal fluid ceases. Any remaining association between the dura and arachnoid layers is presumably due to the residual mixture of cerebrospinal fluid and embalming fluid, as well as the aforementioned junctions between the cells of the two layers. The association between intact dura and arachnoid meningeal layers does not typically survive the dissection process, particularly in the hands of inexperienced first year anatomy students. One or both layers can be easily torn by a deep penetrating chisel or saw during laminectomy. Even in instances where the meningeal layers are intact, the lack of positive pressure results in deflation of the subarachnoid space, as is evident by the sunken appearance of the dural sheath, particularly in the vicinity of the lumbar cistern. The residual support of the subarachnoid space results from the natural rigidity of the fibrous dura mater. This becomes evident following successful reflection of the dura mater, which disrupts the association between it and the underlying arachnoid mater. This dissociation has been noted in histological studies, in which tissue preparations of the central nervous system have been examined. Interestingly, this disruption, which has been traditionally described as occurring at the junction between the dura and arachnoid barriers, may actually occur within the dural border cell layer, itself (Haines 1991, Vandenabeele et al. 1996). Regardless of the specific location of the cleavage, without the support of the fibrous dura, the arachnoid mater has a tendency to collapse against the pia mater of the brain and spinal cord.

For the visual learner, it is difficult to fully appreciate the magnitude of the subarachnoid space when it can only be directly observed in its deflated state. To address this concern, a simple technique has been adopted in our teaching laboratory that allows a temporary re-inflation of the subarachnoid space, providing students with a visual sense of its magnitude and anatomical significance.

Materials and Methods

This technique was performed using cadavers prepared for medical student dissection in the Sanford School of Medicine of the University of South Dakota. Upon their arrival, bodies were prepared using a standardized embalming mixture (Baltimore formulation, Chemisphere Corporation) and stored for a minimum of 6 months to ensure adequate fixation of tissues. The vertebral column was dissected in accordance with the Grant method (Tank 2013). In previous dissection sessions, the integument had been removed and the extrinsic back muscles reflected from the vertebral column. At the beginning of lab, the erector spinae and transversospinalis muscles were removed bilaterally using a sharp scalpel and blunt finger dissection techniques. A chisel was then used to scrape soft tissue away from the vertebral arch, allowing a clear exposure of the lamina in the lower thoracic and lumbar regions. The laminectomy was performed with hammer and chisel between the levels of approximately T10 to L4 and the spinous processes were removed from the vertebrae to expose the epidural space. Students were told in advance of the possibility of re-inflating the subarachnoid space and advised to proceed cautiously to avoid damage to the dural sac during the laminectomy. Once the posterior arch was reflected, students consulted with the instructor to assess the dissection and the possibility of subarachnoid re-inflation. If the dural sac appeared intact and undamaged, the instructor attempted one of two approaches to re-inflate the subarachnoid space.

Approach 1 – Re-inflation without dural reflection

In some instances, the instructor attempted to pass an 18-gauge needle attached to a 20 cc syringe through both the dura and arachnoid mater. Once properly positioned, tap water was injected into the subarachnoid space.

Figure 1: Inflation of the subarachnoid space without dural reflection. In this instance, the needle was passed through a tear in the T7 nerve root sheath (not shown). The dural sac is shown prior to (upper image) and following (lower image) re-inflation.
Approach 2 – Re-inflation with dural reflection

In other instances, the dura mater was first carefully incised and reflected away from the arachnoid mater. To accomplish this, the dura was first grasped with forceps, forming a ridge along the sagittal plane. A pair of scissors was then used to make a cut along the transverse plane. The scissors were then inserted into the incision site and the dura was cut along the midsagittal plane. The cut edges of the dura was reflected bilaterally and held in place using either forceps or pins. A 28-gauge needle was then carefully passed through the arachnoid membrane and tap water was injected into the subarachnoid space.

Discussion

The present report describes a teaching method used to re-inflate the subarachnoid space in cadaveric specimens in a human dissection course. The concept of learning modalities (Barbe et al. 1979, Fleming and Mills 1992) identifies a number of different learning styles that students prefer on an individual basis. Students who prefer either an auditory and/or read/write style of learning are more likely to find a lecturer’s or textbook’s account of the inflated subarachnoid space adequate in grasping this concept. For the visual and/or kinesthetic learners, this narrative account is less likely to suffice. These students are more likely to recall graphical representations from their textbook images and, of critical importance, their experiences in the anatomy lab, when asked to recall the subarachnoid space. Two-dimensional images are notoriously limited in representing a three-dimensional view, and experiences from the lab risk leaving the student with a flaccid recollection of the subarachnoid space. For the budding anesthesiologist, this dissection represents a unique opportunity to visualize the anatomical structures that form the critical barrier between an epidural and spinal anesthetic. The potential to re-inflate the subarachnoid space should make a lasting impression on the visual learner that witnesses the technique firsthand. For the kinesthetic learner, having the opportunity to palpate the re-inflated dura and arachnoid mater will also provide a unique learning experience to help reinforce the anatomical concept being presented.

Before attempting either of the re-inflation techniques, it should be noted that the approach might not always be successful. Even with a cautious approach, the laminectomy procedure requires a great deal of blunt dissection that may inadvertently result in significant trauma to the dural sac, especially when performed by a novice dissector. The needle insertion, itself, may also result in additional trauma to the dural sac, resulting in fluid leaking from the puncture site. The instructor should not feel discouraged, however, as it provides an opportunity to discuss the clinical manifestations of a post-dural puncture headache. It is recommended that, whenever possible, photos and/or video should be taken to document each attempt. Ultimately a highly successful approach will be captured and recorded for posterity. While a video presentation may not prove to be as memorable as witnessing the technique firsthand (particularly for the kinesthetic learner), it can still be a useful resource, especially in smaller dissection classes where the odds of encountering a suitable body for demonstration diminishes.

In assessing the potential of subarachnoid re-inflation, the decision to attempt a re-inflation, and the approach to be taken, is decided on a case-by-case basis. From the author’s perspective an intact, moderately inflated subarachnoid space seems more conducive to re-inflation without dural reflection. In this instance, there is a greater possibility that the dura and arachnoid mater may still be adherent, which could result in disastrous consequences if a dural reflection is attempted. The presence of residual fluid in the subarachnoid space provides an easier target for needle placement. Generally, a lumbar cistern approach is recommended to avoid traversing the subarachnoid space and inadvertently embedding the needle into the substance of the spinal cord. In instances of minor trauma to the dura mater, in particular in the thoracic region, a re-inflation

Figure 2: Re-inflation of the subarachnoid space with dural reflection. Note the reflection of the dura mater and sunken arachnoid mater that no longer contacts the dura mater at its cut margin (top of upper image). In the bottom image, the arachnoid mater is re-inflated and once again opposes the cut edge of the dura mater (left of lower image)
without reflection may also be attempted if the needle is advanced inferiorly through the region of damage and the dural sac surrounding the lumbar cistern remains intact.

In contrast, an intact, highly deflated space appears more conducive to re-inflation with dural reflection. A substantial collapse of the subarachnoid space often leads to partial dissociation between the dura and arachnoid mater at the level of the dural border cell layer, making it possible to grasp the dura mater with forceps and make an incision without disturbing the underlying arachnoid layer. We have demonstrated on many occasions that it is possible to reflect the dura mater without damage to the arachnoid mater, using the technique described in the methodology section. This re-inflation approach is more challenging and less often successful, but allows for better visualization of the subarachnoid space through the translucent arachnoid mater, using the technique described in the methodology section. This re-inflation approach is more challenging and less often successful, but allows for better visualization of the subarachnoid space through the translucent arachnoid mater and the cauda equina within the lumbar cistern. This approach also allows the visual learner to see the approximation of the arachnoid mater relative to the cut margin of the dura mater to provide a better concept of the intact dural sac.

Another factor to consider is the length and diameter of the needle to be used. Often the choice is a matter of convenience, depending on what is readily available. In deciding on appropriate diameter there are advantages and disadvantages to both larger and smaller gauge needles. While there is less risk of tearing the arachnoid with a larger gauge needle, rapid expansion of the subarachnoid space provides a powerful visualization for the students. From personal experience, the author finds that an 18-gauge needle works well if the dura mater is not first reflected, as the dura resists tearing at the injection site and provides support to the underlying arachnoid mater. When piercing the arachnoid mater directly, a higher gauge is preferred to reduce the risk of damaging the delicate arachnoid mater through a slip of the hand. Another factor in needle selection is length. A longer needle provides the instructor with an opportunity to enter the subarachnoid space in the mid-thoracic region and advance the needle towards the lumbar cistern before injecting. While this approach increases the risk of piercing the spinal cord and clogging the needle lumen, successful advancement minimizes leaking at the injection site. As demonstrated in the present study, the needle may also be advanced through a preexisting tear from the laminectomy procedure, as long as there is minimal disturbance in the location of fluid accumulation. Again, a longer needle would be an asset for this approach.

Acknowledgements
The author wishes to thank individuals who donate their bodies and tissues for the advancement of education and research

Literature cited:


Stuart Inglis is a Professor of Basic Biomedical Sciences with the Sanford School of Medicine at the University of South Dakota and he serves as director of medical anatomy laboratories at the university. He received an undergraduate degree in kinesiology from McMaster University, a MSc in exercise physiology from the University of Western Ontario, and a PhD in Biological Sciences from Ohio University, with a research focus on morphological changes to skeletal muscle tissue in response to different forms of exercise. He is in a teaching faculty position at USD, teaching anatomy and musculoskeletal medicine to medical students, as well as OT, PT, PA, and undergraduate coursework. His research interests include teaching paradigms, exploring anatomical variants in the cadaver lab, and exercise physiology research with the Kinesiology and Sport Sciences program.
Tips for Humanizing your Online Course

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Abstract

Online courses may feel abstract and impersonal; this doesn’t need to be the case. Humanizing your online course shows students that they are learning from an experienced faculty member who cares about them rather than from a computer. This article presents a series of quick and easy tips for creating an online course that acknowledges and appreciates the human side of learning. It is based on a presentation at the 2016 HAPS conference in Atlanta, GA.

Abstract

Online courses may feel abstract and impersonal; this doesn’t need to be the case. Humanizing your online course shows students that they are learning from an experienced faculty member who cares about them rather than from a computer. This article presents a series of quick and easy tips for creating an online course that acknowledges and appreciates the human side of learning. It is based on a presentation at the 2016 HAPS conference in Atlanta, GA.

Key Words: online teaching, humanizing, pedagogy, syllabus

Introduction

Many faculty and students shy away from online courses, as they seem less personal and somehow less real than face-to-face courses. It is important to remember that online courses are not courses taught by a computer. The Internet and the devices we use are simply tools that help us teach and help our students learn over time and distance. When you humanize your course, you show students that someone cares. You show them that there is someone on the other side of the computer, and that the course is different with you than it would be with another instructor. You acknowledge that interesting people are taking your course, people who have things to contribute to the class and people who are different from those who took the course in the previous trimester. After teaching online for the past six years and consciously struggling with ways to humanize my courses, I offer the following advice.

Make the course inviting.

When students enter your course at the beginning of the term, the first thing they see is the syllabus. Does reading through your syllabus elicit excitement about the course? Does it demonstrate why students should care about the material? Many syllabi are legalistic and almost threatening, detailing the consequences for every infraction (“it is your responsibility to….”). Consider instead directing the students to a welcome video or letter that explains why studying anatomy and physiology matters, what you love about the course, and anything else to invite students into the course. There will be time to explore the course policies later. At the start of the course, focus on making a strong first impression.

Consider re-writing your syllabus to make it friendlier. I recommend Michele Pacansky-Brock’s work on creating a humanized syllabus. The following website is also a wonderful resource for writing syllabi that are accessible for students: https://accessiblesyllabus.tulane.edu/. I find that a friendly tone and avoiding the passive voice go a long way towards creating a welcoming environment rather than an intimidating one.

You can also make the course more inviting for students by adding “just in time” links to school or community resources. For example, when the drop deadline approaches you might schedule an announcement with information about the deadline, how to contact the registrar if students choose to drop, and how to assess your score in the course to determine the likelihood of passing. Similarly, you can add a link to the library’s research assistance as your first deadline approaches or a link to the Purdue OWL website in the instructions for your first assignment requiring citations.

While we may be quite comfortable with university infrastructure and resources, many students are not. They may not be aware of the resources that are available. It is easy to tune out a long list of resources when it is tucked away within the course. When resources are presented when and where they are likely to be needed, students will use them more often and get the impression that you care about their experience.

Show yourself.

You can humanize your online course by revealing your personality in the course materials and in your interactions with the students. In a face-to-face course, students quickly get a feel for your quirks as both an instructor and a person. This is trickier in an online setting. Students enjoy knowing a bit about your interests beyond the course, seeing a photo of your cat in the background, hearing about your latest research, or chatting about how you spend your weekends all signal to the student that you are a real person.

continued on next page
When recording lectures, consider including a video of yourself to accompany the slides or other visuals. Screencast-o-matic is an easy-to-use tool for screencasting with video inset, and the free Office Mix add-on for Powerpoint is another option. Students consistently remark that having my face in the lecture helps them to feel connected to me and engaged with the material.

Similarly, one of the easiest and most effective strategies I have adopted to humanize my online courses is a weekly check-in. I record a short introduction to the week every Monday. This informal “talking head” video includes reminders about upcoming work, a review of questions or concerns from the previous week and other administrative details. I also mention at least a few students in the course by name, and include at least one small detail about myself. For example, while attending the HAPS conference I mentioned that I was in Atlanta and what I was doing there.

You can also create a more personal connection with students by providing audio or video feedback rather than written feedback on assignments. Many LMSs offer built-in tools to do so; Vocaroo is a free audio-recording tool that serves the same purpose. Audio or video feedback has the added bonus of being faster to prepare than written feedback as well. Students are often surprised and grateful to receive such personal feedback, and it is easier to convey meaning when they can hear your voice and see your facial expressions.

Leave room for personalization.

The previous strategies have all centered on the course instructor. However, we also need to leave room for our students to be human. It can be tricky to see students as individuals in online setting, and we must design opportunities for students to show us who they are.

I always request that students add an image to their user profile in the LMS. Some students are not comfortable adding a photo of themselves, and in that case I encourage them to add an image of something that they feel represents them. Having an image associated with each student helps me to keep everyone straight and reminds me that there are people out there.

Leaving room for personalization can also mean giving the students choices in how they move through the course. For example, some instructors will require only ten of thirteen assignments in order to give students a bit of breathing room as they move through the semester. Others might provide three discussion topics from which to choose, or give students the option of completing an exam or a project as a final assessment. You can also create assignments that allow for personalization. When I am considering a new assignment, I ask myself whether it provides an opportunity for students to add a bit of themselves into the work. This may not always be possible, of course, but having some assignments that allow room for creativity can make the course more meaningful. Examples might include asking students to choose a project topic that is personally meaningful, having them create potential exam questions, or providing opportunities to illustrate physiological processes using items from their kitchens.

Many of the changes I suggest take only a few moments to implement. In my own courses, I have noticed that these practices strengthen connections between the students, the material and myself. I feel more as if I am teaching and less as if I am babysitting a course that runs whether or not I am present. For me, humanizing has led to a substantial increase in job satisfaction and the sense that I am making a difference. I hope that it does the same for you.

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You Say ba-NAN-a, I Say bah-NAH-nah: Surprising Pronunciations in Anatomy and Physiology

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Abstract

Faced with teaching many hundreds of biomedical terms in our anatomy and physiology courses, it seems likely that most of us pronounce them as we learned by oral tradition from our own teachers, or as we infer from the known sounds of other words with the same or similar syllables. But how do we know these pronunciations are correct? Are you really pronouncing mediastinum and apoptosis in the way the medical dictionaries prescribe? Who has time to look all of these up? This paper describes a perennial HAPS workshop in which we challenge our assumed pronunciations and many participants discover they have been teaching their students wrong for years. It includes a self-test of your pronunciation habits and reflections on some implications of the disparity between what we think is right and what the authorities in medical language say is right.

Key words: Medical pronunciation

Introduction

Probably the most daunting challenge for our students is the hundreds and hundreds of ten-dollar words in the vocabulary of anatomy and physiology. I am surely not alone among instructors in stressing to students the value of learning to pronounce terms correctly and to recognize familiar, recurring word roots. More often than explicitly telling them how to pronounce a term, or students asking me, I have simply tried to model good pronunciation in my lectures and labs. But when I began writing anatomy and physiology textbooks, I discovered I had often not been such a good role model after all.

The Pitfalls of Oral Tradition

As I embarked on my teaching career, how did I know what good pronunciation was? I certainly did not take the time, nor feel it warranted, to look up all these terms in the dictionary. I repeated what my teachers had taught me, from high school through graduate school. And, I feel sure, they taught what they had heard from their own teachers. And so it goes, academic generation after generation, teaching by oral tradition and perpetuating each other’s errors. We learn by oral tradition. For terms I had never encountered before, I relied on my two years of Latin education and on generalizing and extrapolating the sounds of common syllables from familiar words to unfamiliar ones.

Therein lie obvious hazards. I remember when, as an undergraduate in comparative anatomy, I encountered the word sutures in print before I had ever heard it spoken by my professor. Applying the principle that there are no silent vowels in Latin, I sounded it out in my mind as “soo-TOOR-eez” every time I saw it. When I first heard my professor pronounce it “SOO-churz,” I didn’t know at first what he was talking about. After a lecture or two, it dawned on me, and I had the epiphany of relating the word in skull anatomy to the homonym in surgical sutures.

Years later, as a professor, I was sometimes chagrined to discover that I had been mispronouncing a term to my students for ten or fifteen years. My wife Diane, a registered nurse, sometimes corrected me with gentle mockery when I mispronounced a term from work during our living room conversations. She enlightened me, with a smirk, that the term for inadequate perfusion of an organ, ischemia, is not pronounced “iss-SHE-mee-ah.” Like toppling dominoes, there too went my habitual mispronunciations of ischium, ischiocavernosus, and other ischy words. Relying on inference and oral tradition when we teach pronunciation is a rischy business.

The point was driven home with brute force when an acquisitions editor, Colin Wheatley, swayed me to write an anatomy and physiology textbook. Like many other authors, I included word origins and pronunciation guides beginning even in the manuscript of my first edition (Saladin 1998). Hundreds of my peers were engaged to review the manuscript during that book’s development, and perhaps a dozen of these enlightened me that some of my pronunciation guides were suspect. There is nothing like peer review to enlighten a writer. I cast aside many assumptions, hit the medical dictionaries hard, and changed my thinking and teaching on scores of pronunciations.
Feeling Less Alone

I was a decade into textbook publishing when our 22nd annual HAPS conference (2008) came up. Given the venue, I was in a New Orleans state of mind. By chance, I was listening late one night to Ella Fitzgerald and Louis Armstrong singing “Let’s Call the Whole Thing Off” (“You say toe-MAY-toe, I say toe-MAH-toe...”), and the idea hit me for my first HAPS workshop, “You Say ba-NAN-a, I Say bah-NAH-nah.” At risk of embarrassment, should I be the only one who had so long mispronounced much of our vocabulary, I wanted to see if many of my HAPS colleagues shared this experience.

Did they ever! The workshop packed the house at New Orleans standing room only, and in subsequent years I was asked to give repeat sessions for people who couldn’t get in the first day. I gave it for the fourth time in Atlanta (2016), but probably not the last. It has always generated much laughter, expressions of surprise, groaning, jaw dropping, and head banging as so many discovered that many of our classroom pronunciations were not at all what the medical and other dictionaries said they should be.

The format of the workshop (after a Fitzgerald–Armstrong musical prelude) revolves around a series of slides presenting a term and a multiple-choice list of correct and incorrect, but common or plausible, pronunciations. Participants vote, and then I show which pronunciations are sanctioned by any of three medical dictionaries—usually Taber’s (2001), Stedman’s (2006), and Dorland’s (1994), but occasionally resorting to others when none of these three was helpful.

I do not include eponyms such as nodes of Ranvier or crypts of Lieberkühn because dictionaries rarely give pronunciations for them (and, in any case, they are becoming obsolete). Pronunciations of muscle names are also hard to find in print, but audio files in such resources as McGraw-Hill Connect (Schneider et al. n.d.) are helpful. I do not include terms that have generally accepted alternative pronunciations and no likely incorrect ones, such as “doo-ODD-eh-num,” “DOO-oh-DEE-num.” I likewise omit British pronunciations, like the language of a physiologist who might study blood “ca-PILL-ahrees” in her “la-BORE-a-tree.” Some incredulous participants have asked whether any of the “correct” pronunciations I show might be British. All of these dictionaries, however, are published in the U.S. and thus germane to those of us who teach in North America.

Hardly a term comes up for which many and sometimes most participants are astonished that their habitual pronunciations are not found in any of these dictionaries. Many leave befuddled, rethinking their classroom teaching, and have perhaps found it as hard as I do to break some of their old habits.

What Do the Dictionaries Say?

Table 1 shows the 80 terms that I used most recently (Atlanta 2016). In the middle column are the pronunciations approved by one or more dictionaries. In the third column are some pronunciations I have fabricated (with an attempt at plausibility) and some that instructors often say they use (as have I), but which are not found in any dictionaries I consulted. For a self-test and taste of the fun had in the live workshops, cover the middle and right columns, pronounce the word in the left column, then uncover the answers and score yourself according to whether your customary pronunciation is found in the dictionaries or not.

In the pronunciation guides in my textbooks, and used here, I use as simple a format as possible. I avoid diacritical marks even as simple as the macron and breve, and such symbols as the schwa, not only because I have found my students do better without them, but also because dictionaries vary so much among themselves. I use capitals for the syllables to be accented, without distinguishing between primary and secondary accents. An unpaired vowel at the end of a syllable should be pronounced as a long vowel. For short terminal vowels that may otherwise be ambiguous, I add an h to suggest how the vowel should sound, as in “VUR-teh-bree” (vertebrae), “AZ-ih-gus” (azygos), and “aw-TOFF-uh-jee” (autophagy).

A dash in the third column indicates that all of the pronunciation options presented in the workshop were accepted by at least one dictionary; there was no incorrect foil, nor did I know of any common or likely mispronunciation.

Discussion

If the reader is like most workshop participants, he or she will find many surprises in Table 1. It has been a collective surprise to us all when we widely agree on a pronunciation that none of the dictionaries supports. It raises questions of the extent to which any dictionary is descriptive or prescriptive, and what defines correct usage. If most of us who teach this subject pronounce the terms one way but every dictionary prescribes a different pronunciation, which is right, and why? Where do the pronunciation editors of the dictionaries get their information? It is worth noting that even they differ among themselves; there is no single, unquestionable authority.

The possibility of regional dialects in medical pronunciation comes to mind, but does not seem a likely factor to me. Those of us who teach anatomy and physiology are a mobile lot. We may move away from home to attend college, move even farther away for graduate school and postdoctoral fellowships, and yet again for the job opportunities open to us. We attend conferences throughout the continent and the world. It is difficult to see any regional variations in the pronunciation of...
### Table 1: Dictionary-Sanctioned Pronunciations and Mispronunciations of 80 Terms from Human Anatomy and Physiology.

<table>
<thead>
<tr>
<th>Term</th>
<th>Dictionary pronunciations</th>
<th>Mispronunciations</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACETYLCHOLINE</td>
<td>ASS-eh-till-CO-leen, ASS-eh-teel-CO-leen</td>
<td>ah-SEET-ul-CO-leen</td>
</tr>
<tr>
<td>ACINUS</td>
<td>ASS-ih-nus</td>
<td>ah-SEE-nus, ah-SY-nus</td>
</tr>
<tr>
<td>APOPTOSIS</td>
<td>AP-oh-TOE-sis, AP-op-TOE-sis</td>
<td>ah-POP-tuh-sis</td>
</tr>
<tr>
<td>AMPULLA</td>
<td>am-PULL-uh</td>
<td>AM-pyu-luh, am-PYU-luh</td>
</tr>
<tr>
<td>ANGINA</td>
<td>an-JY-nuh, AN-jih-nuh</td>
<td>An-JEE-nuh</td>
</tr>
<tr>
<td>AREOLAR</td>
<td>ah-REE-o-lur</td>
<td>AIR-ee-OH-lur, ah-REEL-ur</td>
</tr>
<tr>
<td>AUTOPHAGY</td>
<td>aw-TOFF-uh-jee</td>
<td>AW-toe-FAY-jee</td>
</tr>
<tr>
<td>AZYGOS</td>
<td>AZ-ih-gus, AZ-ih-gose, AZ-eye-gose</td>
<td>ay-ZY-gus, ay-ZY-gose</td>
</tr>
<tr>
<td>BRADYKININ</td>
<td>BRAD-ee-KY-nin</td>
<td>BRAY-dee-KY-nin</td>
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<tr>
<td>BUCCAL</td>
<td>BUCK-ul</td>
<td>BYU-cul, BOO-cul</td>
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<td>CEREBRUM</td>
<td>seh-REE-brum, SAIR-eh-brum</td>
<td>—</td>
</tr>
<tr>
<td>CHONDROIOTIN</td>
<td>con-DRO-ih-tin</td>
<td>con-DROY-tin</td>
</tr>
<tr>
<td>CHORDAE TENDINEAE</td>
<td>COR-dee ten-DIN-ee-ee</td>
<td>COR-dee TEN-din-ee</td>
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<td>CLITORIS</td>
<td>clih-TOR-is, CLIT-or-is, CLY-tor-is</td>
<td>cly-TOR-is</td>
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<td>COCHLEA</td>
<td>COK-lee-uh, COKE-lee-uh</td>
<td>—</td>
</tr>
<tr>
<td>CONJUNCTIVA</td>
<td>con-JUNK-th-vah, CON-junk-TY-va</td>
<td>—</td>
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<tr>
<td>EPIPHYSIS</td>
<td>eh-PIFF-ih-sis</td>
<td>EP-ih-FY-sis</td>
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<tr>
<td>ESCHAR</td>
<td>ESS-car</td>
<td>ESS-kur, ESH-ur</td>
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<tr>
<td>FORAMEN</td>
<td>fo-RAY-men</td>
<td>fo-RAH-men, fo-RAM-en</td>
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<tr>
<td>FUNICULUS</td>
<td>foo-NIK-you-lus</td>
<td>fuh-NIK-you-lus, few-NIK-you-lus</td>
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<tr>
<td>GLIA</td>
<td>GLEE-uh, GLY-uh</td>
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<tr>
<td>GRACILE</td>
<td>GRASS-uh, GRASS-ile</td>
<td>GRAY-sile</td>
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<td>GRACILIS</td>
<td>GRASS-ill-is</td>
<td>gra-SILL-us, GRACE-ill-is</td>
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<td>GYRI</td>
<td>JY-rye</td>
<td>JY-ree, GUY-ree, GUY-rye</td>
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<td>HYALINE</td>
<td>HY-uh-lin, HY-uh-leen</td>
<td>HY-uh-line</td>
</tr>
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<td>ILIACUS</td>
<td>ill-LY-uh-cus</td>
<td>ILL-ee-AK-us</td>
</tr>
<tr>
<td>ILIOPSOAS</td>
<td>ILL-ee-oh-SO-us</td>
<td>ILL-ee-OP-so-us</td>
</tr>
<tr>
<td>IN SITU</td>
<td>in SY-too, in SIT-too</td>
<td>in SEE-to</td>
</tr>
<tr>
<td>ISCHEMIA</td>
<td>iss-KEE-me-uh</td>
<td>ish-EE-me-uh, ish-EM-ee-uh</td>
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<td>ISCHIOCAVERNOSUS</td>
<td>ISS-kee-o-CAV-ur-NO-sus</td>
<td>ISH-ee-o-CAV-ur-NO-sus</td>
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<td>ISCHIUM</td>
<td>ISS-kee-um</td>
<td>ISH-ee-um</td>
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<td>LACUNAE</td>
<td>la-COO-nee</td>
<td>la-COO-ny</td>
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<tr>
<td>LARYNGOPHARYNX</td>
<td>la-RIN-go-FAR-inks</td>
<td>la-RIN-go-FAIR-inks</td>
</tr>
<tr>
<td>LEVATOR (LABII)</td>
<td>lee-VAY-tur</td>
<td>leh-VAY-tur, LEV-a-tur</td>
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<tr>
<td>LIGAND</td>
<td>LIG-and, LY-gand</td>
<td>—</td>
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<tr>
<td>MASSESETER</td>
<td>ma-SEE-tur</td>
<td>MASS-eh-tur</td>
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<tr>
<td>MEDIASTINUM</td>
<td>MEE-dee-uh-STY-num</td>
<td>MEE-dee-ASS-tih-num</td>
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<td>MEDULLA</td>
<td>meh-DOO-luh, meh-DULL-uh</td>
<td>MED-you-la</td>
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<tr>
<td>MEGAKARYOCYTE</td>
<td>MEG-a-CAR-ee-oh-site</td>
<td>MEG-a-CARE-ee-oh-site</td>
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<td>METASTASIS</td>
<td>meh-TASS-tih-sis</td>
<td>MET-ah-STAY-sis</td>
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<td>MODIOLUS</td>
<td>mo-DY-oh-lus</td>
<td>MO-dee-OH-lus</td>
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<td>NASALIS</td>
<td>nay-ZAY-lis, nay-SAY-lis</td>
<td>nay-ZAL-is</td>
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<td>NEPHROPTOSIS</td>
<td>NEFF-rop-TOE-sis</td>
<td>neff-ROP-tuh-sis, NEFF-ro-TOE-sis</td>
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</table>
technical terms taking hold and surviving this mobility and commingling of professional postsecondary educators.

Some of the differences among us may arise from whether we were educated by biologists steeped in the language of taxonomy, comparative anatomy, and other such subjects, versus clinicians grounded in the language of medicine. I have asked my own doctors how they pronounce some of these words, and they more often respond than biologists do in the ways stipulated by medical dictionaries. We who were trained as biologists should bear in mind that we are teaching our students for clinical careers and defer to the pronunciations used by clinicians.

I have been occasionally dismayed by colleagues who discover their habitual pronunciations have been wrong but say, “I’m going to go on pronouncing it that way anyway.” There have been those who stick doggedly to “ISH-ee-um,” mispronouncing the consonant cluster “sch,” or to “COR-dye TEN-din-eye,” not only mispronouncing the diphthongs but also eliding an entire syllable from what should be “ten-DIN-ee-ee.” Should we continue to teach our students wrong just


<table>
<thead>
<tr>
<th>NEUROGLIA</th>
<th>nu-ROG-lee-uh</th>
<th>NOOR-oh-GLEE-uh</th>
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<td>OLECRANON</td>
<td>oh-LEK-ra-non, OH-lee-CRAY-non</td>
<td>OLE-eh-CRAY-non</td>
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<td>OS (COXAE)</td>
<td>OSS (from os, bone)</td>
<td>oz, ose</td>
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<tr>
<td>OS (UTERI)</td>
<td>OSE (from os, mouth)</td>
<td>oz, oss</td>
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<td>OVALE</td>
<td>Oh-VOL-ay, oh-VAIL-ee, oh-VOL-ee</td>
<td>oh-VAIL, oh-VOL</td>
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<td>PARENCHYMA</td>
<td>pa-REN-kh-ma</td>
<td>PAIR-en-KY-muh, PAIR-en-CHIME-uh</td>
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<td>PECK-toe-RAY-liss</td>
<td>PECK-toe-RAL-liss</td>
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<td>PERINEUM</td>
<td>PAIR-in-NEE-um</td>
<td>pa-RIN-ee-um</td>
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<td>FAIR-inks, FAR-inks</td>
<td>FAIR-nicks, FAR-nicks</td>
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<td>PHRENIC</td>
<td>FREN-ik</td>
<td>FREE-nik</td>
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<td>PEEL-ee, PEEL-eye</td>
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<td>PIN-ee-ul</td>
<td>pie-NEE-ul</td>
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<td>PLY-oh-TRO-pee, plee-OT-ro-pee</td>
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<td>POLYCYTHEMIA</td>
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<td>pop-LIT-ee-ul, pop-lih-TEE-ul</td>
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<td>PRO-teen, PRO-tee-in</td>
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<td>REN-in, REE-nin</td>
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<td>REE-tee</td>
<td>reet, RET-ee</td>
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<td>ROO-gee, ROO-gye, ROO-jye</td>
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<td>SAFF-eh-nus</td>
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<td>SKWAY-mus</td>
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<td>SUL-sigh, SUL-ky, SUL-kee</td>
<td>SUL-see</td>
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<td>SOO-pur-FISH-ie-AL-iss</td>
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<td>TACK-ip-NEE-uh</td>
<td>tack-IP-nee-uh, TACK-ee-NEE-uh</td>
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<td>TIB-ee-AY-iss</td>
<td>TIB-ee-AL-iss</td>
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<td>tin-EYE-tus, tin-IH-tus</td>
<td>TIN-ih-tus</td>
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<td>tri-KWET-rum, tri-KWEE-trum</td>
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<td>TRO-klee-uh</td>
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<td>VASA VASORUM</td>
<td>VAY-za vay-SOR-um, VAY-sa vay-SOR-um</td>
<td>VAH-za vah-SOR-um</td>
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<td>VERTEBRAE</td>
<td>VUR-teh-bre</td>
<td>vur-TEE-bre, VUR-te-bry, VUR-te-bray</td>
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<tr>
<td>XIPHOID</td>
<td>ZIFF-oid, ZY-foi</td>
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because we find it difficult to change our old ways? Shouldn’t we spare them the potential embarrassment of saying “ISH-ee-um” when they shadow or intern with a physical therapist or orthopedist? It is hard to change even when we know we are wrong, but to the extent that we care about our students’ professionalism and the reputation of the colleges where we have taught them, change we must.

**Literature Cited**


**Ken Saladin** has taught human anatomy and physiology for 39 years, along with histology, animal behavior, Galápagos natural history, and other subjects, at a public liberal arts four-year university in central Georgia. He has regularly attended HAPS conferences since 1994. Ken is the author of three anatomy and physiology textbooks with McGraw-Hill, now in a total of 13 English editions as well as Spanish, Italian, and Korean: *Anatomy & Physiology—The Unity of Form and Function, Human Anatomy*, and with Robin K. McFarland, *Essentials of Anatomy & Physiology*. 

Video Dissections to Determine the Usefulness of Synthetic Cadavers vs. Real Cadavers

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Abstract

Cadaver dissection is a staple of medical education and remains one of the most powerful tools for teaching anatomy, realistically pairing visual and haptic (kinesthetic communication) feedback. Cadaver dissection is used in many settings including undergraduate anatomy programs and specialized programs that train allied health professions. However, logistical difficulties encountered with the use of real cadavers, including the cost of cadavers, specialized facilities to house and store the cadavers, and access to instructors experienced in dissection, can be prohibitive and negatively impact student learning. Full-scale synthetic cadavers (SynDaver™ Labs http://syndaver.com/) with realistic tissue properties, offer an exciting possibility for expanding the scope of teaching gross anatomy. Synthetic cadavers are easy to store, do not require specialized facilities, and are accessible with minimal dissecting experience. We evaluated the use of synthetic cadavers and video dissections of synthetic vs. real cadavers using feedback from first year medical students at Campbell University Jerry M. Wallace School of Osteopathic Medicine.

Key words: cadaver, synthetic cadaver, SynDaver™, dissection, prosection

Introduction

Dissection of cadavers is a staple of medical education, and remains one of the most powerful tools for teaching anatomy as it realistically pairs visual and haptic feedback. While the utility of this technique transfers well to other settings, including programs that train undergraduates for the allied health professions, logistical difficulties including cost of cadavers, facilities, and access to instructors experienced in dissection can be prohibitive. Synthetic full-scale cadavers with realistic tissue properties offer an exciting possibility for expanding the scope of teaching gross anatomy. Here we evaluate the use of synthetic cadavers and video dissections of synthetic cadavers using feedback from first year medical students.

The study of anatomy has been traditionally looked upon as a rigorous learning experience as well as a rite of passage that every medical student experiences. Dissection of the human body is the principal method to directly observe and measure the tissues, muscles, organs and bones of the body. This fundamental aspect of medical training is based on the premise that physicians cannot treat disease without a thorough understanding of anatomy. This tradition dates back to the Greek Physician Herophilus, and to the dissections of Galen in 162 AD, which identified cranial nerves, described heart valves, and demonstrated arteries contain blood and not air. In 1315, Mondino de Liuzzi performed the first officially sanctioned public dissection in Bologna in the presence of medical students and other spectators, and this led to his publication of the first modern dissection manual, Anathomia Corporis Humani in 1316. Around 1490, Leonardo Da Vinci dissected specimens in the hospital of Santa Maria Nuova and broadened his anatomical work into a comprehensive study of the structure and function of the human body. Around the same time, Andreas Vesalius, a Belgian physician, published De Humani Corporis Fabrica. In 1761, Italian anatomist Giovanni Battisti Morgagni published The Seats and Causes of Diseases Investigated by Anatomy (De Sedibus et Causis Morborum per Anatomen Indagatis). The work contained records of 640 dissections (Ghosh 2015).

The Murder Act of 1752 in Great Britain allowed bodies of executed murderers to be dissected for anatomical research and education. In the mid-18th century, the Royal College of Physicians and the Company of Barber Surgeons were the only organizations permitted to carry out dissections in England. In 1832, the Anatomy Act in the United Kingdom allowed physicians and surgeons to have legal access to unclaimed corpses, particularly those of people who had died in prison. In 1858, Henry Gray and Henry Vandyke Carter published Anatomy: Descriptive and Surgical, a work covering 750 pages and containing 363 figures. The success of this book was largely due to its excellent illustrations and it subsequently became known simply as “Gray’s Anatomy”. The 41st edition of Gray’s Anatomy was published in 2016 (Ghosh 2015).

It was not until 1910 that dissection became an established requirement in medical school curricula. With the passage of time, laws were incorporated in the Uniform Anatomical Gift Act and this was followed by improved preservation techniques, such as plastination and latex injection (Anatomical Gift Association of Illinois).

continued on next page
MATERIALS AND METHODS

Dissections of the gluteal region in an embalmed (Figs. 1-6) and synthetic cadaver (SynDaver™ Labs) (Figs. 7-12) were prepared by faculty. Video presentations of the dissections were created to demonstrate the anatomy of the gluteal region. Students were allowed to interact with the synthetic cadaver in lab and view the narrated presentations. An optional questionnaire assessing the usefulness of the synthetic cadaver in lab and the video dissection was approved by Campbell University IRB (CUIRB-190) and delivered electronically to 162 medical students. A total of 54 students completed the questionnaire.
Figure 7. Title page of the video showing the dissection of the gluteal region on a synthetic cadaver.

Figure 8. Gluteal region and posterior thigh with skin and fascia removed. The tip of the probe is on the superior aspect of the gluteus maximus muscle at its origin from the iliac crest.

Figure 9. Parts of the “hamstring” muscles are revealed – the semitendinosus and long head of the biceps femoris muscles are in view.

Figure 10. The gluteus maximus muscle is labeled.

Figure 11. The gluteus maximus muscle has been reflected to reveal the labeled gluteus medius muscle. Inferior to the gluteus medius muscle are the deep muscles of the gluteal region; from superior to inferior, the piriformis, superior gemellus, tendon of internal oblique, inferior gemellus and quadratus femoris muscles are seen. The gluteus minimus is deep to the gluteus medius and cannot be seen.
RESULTS

Table 1 indicates students thought the synthetic cadaver in lab and review videos were helpful in understanding musculoskeletal relationships (Average Likert score of 3.98 and 3.91 respectively). However, neither the synthetic cadaver in lab nor review videos were helpful for understanding the gluteal neurovasculature (Average Likert score of 2.87 and 3.04 respectively). Overall students felt the synthetic cadaver was a useful adjunct (Average Likert score of 3.50), but would not serve as a replacement for cadaver-based anatomy in a medical school curriculum (Average Likert score of 1.50).

<table>
<thead>
<tr>
<th>Table 1: The Average Likert Response for the Cadaver vs. Syndaver Dissection Video Questionnaire (1=Strongly Disagree, 2=Disagree, 3=Neither, 4=Agree, 5 = Strongly Agree)</th>
<th>Average Likert score</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>The synthetic cadaver was helpful in understanding musculoskeletal relationships.</td>
<td>3.98</td>
<td>54</td>
</tr>
<tr>
<td>The synthetic cadaver was helpful in understanding neurovascular relationships.</td>
<td>2.87</td>
<td>54</td>
</tr>
<tr>
<td>The video prosection of the synthetic cadaver was helpful in understanding musculoskeletal relationships.</td>
<td>3.91</td>
<td>54</td>
</tr>
<tr>
<td>The video prosection of the synthetic cadaver was helpful in understanding neurovascular relationships.</td>
<td>3.04</td>
<td>54</td>
</tr>
<tr>
<td>Dissection of the synthetic cadaver would be a useful tool in addition to human cadaver dissection.</td>
<td>3.50</td>
<td>54</td>
</tr>
<tr>
<td>Dissection of the synthetic cadaver should replace human cadaver dissection.</td>
<td>1.50</td>
<td>54</td>
</tr>
</tbody>
</table>

Discussion

Synthetic cadavers are a useful adjunct to teaching gross anatomy in a medical curriculum and could be used in a variety of educational settings. They are easy to store, do not require specialized facilities, and are accessible with minimal dissecting experience. Instructors need to verify the level of anatomical detail that is appropriate for the course being taught since some structures may be absent in synthetic cadaver preparations. For example, the gluteal dissection of the synthetic cadaver we used for this study lacked neurovascular structures including the superior and inferior gluteal nerve, the accompanying artery and vein, and the pudendal structures. However, models can be augmented with additional structures and pathologies increasing the educational utility.

Literature cited


Acknowledgements

The authors express their sincere thanks to those individuals who donate their bodies for educational purposes.
EDU-Snippets: 2016 Conference Edition

Bariatric, Hormonal, Crucifying, and Term Paper Snippets

EDU-Snippets – A column that survives because you - the members - send in your Snippets

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EDU-Snippets is a column designed to let you, the members of HAPS, share your “ways to make sure your students get it.” Since EDU-Snippets began, our members have been continuously amazed at how many teaching and demonstration ideas pop up and are easily transferred from one instructor to another through Snippets. This edition is no exception. So, the eclectic topic for this issue is Bariatric, Hormonal, Crucifying, and Term Paper Snippets. Hopefully you will be able to utilize what our colleagues have submitted. Hopefully, too, some of the ideas presented here will spur you on so that you can either make alterations to fit your own needs or spark your imagination so that you can come up with your own Snippet ideas, which you can then submit for publication.

I. Bariatric Snippet

Krista L Rompolski (Drexel University, klr94@drexel.edu) had an idea that has never appeared in EDU-Snippets. It sounds like a very interesting approach to the digestive system.

Roux-En-What? Using the A&P of Bariatric Surgery to Learn Digestion

As obesity and its associated co-morbidities continue to rise in prevalence worldwide, more and more patients are pursuing bariatric surgery as an option to induce substantial weight loss and control metabolic syndrome. It is important for future health care practitioners to understand the changes that occur in the anatomy and physiology of the digestive system with these surgeries. Studying these procedures are excellent case studies for students, comparing normal digestion to altered digestion.

Who Undergoes Bariatric Surgery?

A thorough evaluation should be undertaken on any patient considering bariatric surgery, regardless of which method chosen. Higher risk surgeries should be reserved for the most seriously obese patients with immediate need for improvement of comorbid conditions, yet these also require the greatest commitment to permanent changes in nutrition, physical activity and overall lifestyle. Criteria varies from surgery to surgery, but generally, patients must have a BMI of >40 or >35 with at least 2 comorbid conditions and be historically unsuccessful at maintaining weight loss with diet and exercise. Months prior to surgery, patients must demonstrate the ability to lose weight, comply with regular appointments with their health care team and have the proper social support and psychological readiness for surgery.

Each surgical method carries varied degrees and types of risks. The choice of procedure depends on the severity of the obesity and the urgency of co-morbidities, cost, insurance coverage, physician expertise and the likelihood of patient compliance. As such, a thorough psychological evaluation is typically included in pre-operative planning. It is important to note that bariatric surgery is a tool, not a cure for obesity and associated conditions. Patients must adhere to small to drastic changes in their eating habits, choice of foods, and management of potential nutritional deficiencies and complications.

What Can Students Learn from Bariatric Surgery in A&P?

Many students enrolled in Anatomy and Physiology will encounter patients who have undergone or are planning to undergo bariatric surgery. Whether working in a physical therapy setting, inpatient environment, or fitness and wellness, it is imperative that they understand the physiological adaptations and limitations that bariatric patients must manage for the rest of their lives. Examining the physiologic changes of bariatric surgery throughout the entire body, not simply the digestive system, can reinforce “normal” anatomy and physiology and better prepare them to interact sensitively with patients. Case studies examining post-operative improvements continued on next page
in blood glucose, triglycerides, cholesterol, and blood pressure challenge students to think critically about how these changes would occur, given the anatomical changes. Furthermore, common complications such as nutrient deficiencies and gastrointestinal distress can accomplish the same task. Students can work with 3-D models of the gastrointestinal system to “build” normal and altered GI anatomy. Drawings of the digestive tract that illustrate which hormones and digestive enzymes are released from various sites, and how this would be altered in the various surgeries can challenge students to understand how weight loss is then achieved. Challenging students to evaluate the risk to benefit ratio with each of these surgeries develops critical thinking skills and prepares them for future patient evaluation.

**Case Studies and Activities in Bariatric Surgery**

“Ham and Cheese, Please!

**Step 1:** Draw the normal digestive system on a full sheet of paper. At each organ of the digestive system indicate which important hormones and enzymes are released, as well as where macronutrients and important vitamins and minerals are absorbed.

**Step 2:** Explain how Roux-en-Y surgery changes the digestive tract. Draw pictures. Now, draw the digestive system of someone who has undergone Roux-en-Y Gastric Bypass surgery. Most importantly, indicate which hormones and enzymes would be affected, and how absorption of the macronutrients, vitamins and minerals may be affected.

**Step 3:** Fill in the chart below, comparing mechanisms of digestion in a normal GI tract to Roux-en-Y. Indicate the role of each organ, what effect it has on each of the 3 macronutrients, and what hormones or enzymes it produces. How would these be altered by Roux-en-Y? You may use this chart to help you with your drawings above!

**Step 4:** Draw or write out how a ham and cheese sandwich would be digested and absorbed differently by a digestive system altered by Roux-En-Y gastric bypass.

<table>
<thead>
<tr>
<th>Organ</th>
<th>Normal</th>
<th>Roux-en-Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stomach</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duodenum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jejunum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large intestine</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**II. Endocrine Mapping Snippet**

Meanwhile, Jennifer Hillyer (Aultman College of Nursing and Heath Sciences, jennifer.hillyer@aultmancollege.edu) came with an interesting idea for teaching the endocrine system. Students struggle with the endocrine system, particularly with hypothalamo-pituitary-target organ relationships, which impact multiple systems. In lieu of this, I developed an in-class activity that introduces these relationships and builds upon them as we progress through the course. Students are assigned to watch a short online video and complete an out-of-class assignment structured around the hypothalamo-pituitary-target organ relationship prior to the in-class activity.
In class students are divided into small groups of 3-4 and provided an oversized sticky note paper. We work together as a class to develop a template based upon the example given in the video (hypothalamo-pituitary-thyroid axis):

**Hypothalamus:** TRH (thyrotropin-releasing hormone)

**Anterior Pituitary:** TSH (thyroid-stimulating hormone) secreted by thyrotropes

**Target Organ:** Thyroid gland

Follicular cells secrete TH (thyroid hormone) which includes T4 (thyroxine) + T3 (triiodothyronine)

**Effects:** Effects in the body are listed (increased metabolic rate, etc.)

After providing the above example we also discuss the concept of negative feedback as it relates to someone who might have a form of hyperthyroidism, such as Graves’ disease.

Though information for the template is presented in the textbook and through the video, the true purpose of the exercise is to have the groups map out other hypothalomo-pituitary-target organ relationships with a focus on tropic hormones. As we progress through the semester the endocrine maps will be pulled out and refined with more detail added as we delve into each system. This activity has proven to be especially helpful in the learning of gonadotropins, LH and FSH, which are discussed in detail in the reproductive system toward the end of the semester. As students draw upon their previous knowledge, they realize that they have the foundation needed to tackle more complex hormonal relationships inherent to the reproductive system.

### III. Crucifying Snippet

**And Kristen L. Hutchins (Howard Payne University, KHutchins@hputx.edu) also had an idea that EDU—Snippets has not published before.**

The method of death by crucifixion commonly used 2000 years ago was a slow, painful process affecting multiple organ systems of the body. The victims were nailed to a cross, often following other forms of torture, and left to die on their own. Death could take days. Scholars, including physicians and archaeologists, have argued over the actual cause of death for the victims. Which medical hypothesis is the best explanation—cardiac rupture, hypovolaemic shock, acidosis, asphyxia, or something else? This lack of a solid explanation presents an excellent learning opportunity for anatomy and physiology students.

This article presents an integrative project used at the end of a two-semester anatomy and physiology course series in which students revisit what they’ve learned about the human body to develop their own conclusion about the most likely cause of death. The product is a position paper explaining their conclusion and supporting their reasoning with sound, anatomical information. This expands the students’ minds to think about the body as a whole and consider the effects of trauma.

**INTRODUCTION**

The method of death by crucifixion has been used among various people groups over the years; however, it is most associated with the Roman Empire over 2000 years ago. It involves a person being “hanged, usually by their arms, from a cross or similar structure until dead” (p. 22, Hangel 1986). While there is little evidence of how crucifixions were conducted, there are details provided in biblical passages in the story of the crucifixion of Jesus Christ of Nazareth. In these writings, Jesus was tortured before he was hanged on a cross in the t-shaped position. Other biblical passages talk about crucifixion in an upside down position, with the victim’s feet nailed at the top of the cross. While it is obvious that being crucified causes extreme pain and eventually death, the stories often leave out the details about what the physical body experiences while on the cross and what actually causes death.

Maslen and Mitchell (2006) reviewed medical literature and identified several different hypotheses for the cause of death during crucifixion. Some of these included heart failure, acidosis, asphyxia, pulmonary embolism, hypovolaemic shock, and cardiac rupture (Maslen and Mitchell 2006). They did not, however, present one strong hypothesis over the others due to a lack of evidence and a lack of strength in the literature towards a single explanation.

Therefore, this topic presents an excellent learning opportunity for students to apply their knowledge of anatomy and physiology along with their research of the evidence available to decide for themselves what they believe is the best explanation for the cause of death by crucifixion. In the following sections, I will explain what students can learn from this process along with the parameters of the assignment.

**STUDENT LEARNING**

This is a writing assignment given at the end of a two-semester anatomy and physiology course series. Students are expected to have already learned about most of the body systems and can now build on that knowledge by connecting the systems into this whole body scenario. The application of this type of extreme physiological trauma can encourage students to think “outside of the box” and...
beyond the typical scenarios in these courses like exercise and diabetes. While almost every body system was likely to be affected during crucifixion, the most prominent systems include the cardiovascular system, respiratory system, nervous system, and muscular system.

**ASSIGNMENT**

1. The purpose of this assignment is to encourage students to investigate the method of death by crucifixion in order to understand how and why (physiologically) victims died. They are given five weeks towards the end of the second semester to conduct their research, considering aspects such as:
   - Exhaustion from torture before crucifixion
   - Nails through the hands and feet
   - Broken legs
   - Crucifixion posture
   - Dehydration

2. By the end of the 5 weeks, students must come to a conclusion and write a position paper defending what they feel is the best explanation for the cause of death. They must support their reasoning with sound anatomical information in order to demonstrate their understanding of the body.

3. This college-level assignment must be well-written (concise, meaningful) and be kept to a length of 2-3 pages. The following categories are used as part of a grading rubric:
   a. Original thought
   b. Quality of writing
   c. Quality of reasoning / Support for conclusion
   d. Grammar / Punctuation / Formatting
   e. References

4. All references must be from credible sources (limited internet-only sources), cited in text, and listed in a references section at the end of the paper.

**REFLECTION**

I have administered this assignment as both a required submission and as an extra credit opportunity. Either way, I find that students enjoy this train of thought and support their reasoning fairly well. They tend to lean towards asphyxia as the more common explanation for a cause of death. While we focused on the t-position during crucifixion and its effects on the body, other variations could include researching other positions on the cross and how the body might respond.

**Literature cited**


**IV. Term Paper Snippet**

Finally, David Evens (PennCollege, devans@pct.edu) submitted a very logical approach to the classic term paper assignment.

I’ve been requiring these papers/projects for a long time. So here are my ways to attempt sanity--futile as the attempt is in my case!

1. Make it idiosyncratic, killer (i.e., about 20% of the grade each) requirements. Some examples:
   - I require in-text citations and bibliographies using CSE guidelines.
   - Some people would use a citation style so far out in space that it makes it hard for anyone to cut-and-paste.

4. All references must be from credible sources (limited internet-only sources), cited in text, and listed in a references section at the end of the paper.

I also require at least one original, clearly labeled scientific illustration--also with the aim of cutting down on cut-and-paste.

All scientific terms must be defined either as stand-alone definitions or in context-cutting and pasting will introduce strange terms and students will better learn that stuff.

Everyone chooses their own, exclusive topic with my approval--tend to scatter out the papers better and the students will be more engaged: more engagement, better learning.

Of course, scientific accuracy is a must and I knock off 5 or 10% for each blunder whether it is in the text or the illustration. Some people go down in flames just on that basis.

2. Make the due date just before mid-term. Students will be less stressed than at the end and the experts in these things say less student stress = better student work and less cheating.

A plus: you will use that break to grade (good-bye Bahamas--they’ll be there when you retire!).

Some people might try giving a nominal prize or points for being earliest with their submissions--I never did but you could try that.

3. Check for any obvious signs of copying using a browser such as Google: just type the sentence into the search area or cut-and-paste. You have no idea how hard it used to be to go through the books and articles in our research library to nail someone--did it once and then I grew old.

continued on next page
4. The following will make me seem like a cream puff and not at all macho (DANG!). REQUIRE that the text be NO more than 500 words long. Be quite firm because some people just can’t control themselves: It is time to learn: their MD will throw a bedpan at them if they can’t be concise! Also, keep in mind that Watson and Crick’s original DNA article in Nature was around 750 text words long—they got the Nobel prize for this!

5. Don’t make the project/paper worth too much of their final grade: again one cuts down on student stress.

IV. And We Hope You Will....

Keep those cards and letters coming (right to our Edu-Snippets@Hapsconnect.org address)! Thank you all for your EDU-Snippet contributions. The influx of Snippets has been good! Please keep it up because more are always needed! Your ideas are tremendous! If you have thoughts or ideas, or any other interesting ways – any inspirations at all, great or small – to help our students understand anatomy and physiology, EDU-Snippets would love to hear from you! Once again, EDU-Snippets encourages new submitters to submit — and regulars to keep on contributing. If you’ve got some Snippets, please share them with us. You will also find a reminder on the HAPS-L list. But, plan ahead. You can even submit your ideas now and maybe next issue you too will see your EDU-Snippet in print! Perhaps you even have a suggestion for a Snippet theme! If that sparks a challenge, send in a Snippet!!

Dr. Roberta Meehan is a semi-retired science educator presently involved in tutoring and professional writing. Among other literary endeavors, she has written 17 science books and manuals and two non-science books. She has also written for, edited, copy edited, and done various types of analyses for most of the major publishing houses. She has been on the HAPS Editorial Board for 14 years and has been involved with EDU-Snippets for almost that long. Roberta lives with her dachshunds in Phoenix, Arizona.
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Click here to visit the HAPS committees webpage.
Tuesday, Session 1

101 (Room IC 109) - Improving Science Writing Skills through Calibrated Peer-Review - 90 Minutes
Chad Wayne, University of Houston, cwayne@uh.edu
Writing is one of the cornerstones of the sciences. A calibrated peer-review system coupled with a well-designed writing assignment teaches students to think critically, analyze data, organize, and appropriately analyze and critique the works of their peers while preparing them to enter into the scientific and health associated professions where they will need to use these skills. This talk will focus on how to design, create, and implement a calibrated peer-review writing assignment for use in the STEM classroom.

102 (Room IC 113) - I Know What Your Students Did Last Semester - 90 Minutes
Jason LaPres, Lone Star College - CyFair, texashapster@yahoo.com
Subject matter experts gain valuable insight from the feedback students provide when they report a problem with online homework. These comments tell us a lot about what type of students we have, how they learn, and how we can help them. This presentation will center around the student feedback and how it can impact your teaching and learning.

103 (Room IC 115) - Ultrasound in Teaching Anatomy and Physiology - 90 Minutes
Richard A. Hoppmann, University of South Carolina, Richard.Hoppmann@uscmed.sc.edu, Floyd E. Bell, III, University of South Carolina, Floyd.Bell@uscmed.sc.edu
The University of South Carolina has been using ultrasound to enhance Anatomy and Physiology education for medical students since 2006. We recently partnered with the College of Education in a program to teach middle and high school science teachers basic ultrasound to use in their classrooms. The first part (~30 minutes) of this workshop will be a didactic overview of the use of ultrasound in these settings. It will include an example of a case based learning activity. The second part (~60 minutes) will be a hands-on session where participants get to perform ultrasound scans.

104 (Room IC 209) - Reducing Cognitive Load in Multimedia Presentations - 90 Minutes
Jeff Hollar, Lord Fairfax Community College, jhollar@lfcc.edu
As an adjunct faculty member of the New York Chiropractic College (NYCC) Master of Science in Human Anatomy and Physiology Instruction (MSHAPI) Program teaching the Urinary System, Acid/Base Balance, Reproductive System, and Development/Inheritance course, I have become acutely aware that many instructors, even veteran ones, overload their multimedia presentations with content which inadvertently creates cognitive overload for the students. I will share what cognitive science and educational research tells us about how this impacts effective and meaningful learning, and then we will explore ways to incorporate methods to reduce the overload in your own multimedia teaching.

105 (Room IC 211) - Add Drama to Your Classroom - Great Kinesthetic Activities for Students - 90 Minutes
John Koch, jckoch45@verizon.net, Ewa Gorski, Community College of Baltimore County, egorski@ccbcmd.edu, Robin McFarland, Cabrillo College, romcfarl@cabrillo.edu, Javni Mody, Anne Arundel Community College, jmody@aacc.edu, Terry Thompson, Wor-Wic Community College, tthompson@worwic.edu, Carol Veil, Anne Arundel Community College, cveil@aacc.edu
Get your students up and out of their seats for an insider’s view of some challenging A&P content. Microscopic structures and molecular processes can be abstract and difficult for students to comprehend. In this workshop presenters will direct attendees (as “students”) in some creative kinesthetic activities to enhance understanding of a number of such structures and processes. Attendees will be provided with instructor’s notes, so they can direct their own students in these A&P performances. Attendees are sure to leave with fun and enlightening activities that will liven up the classroom and improve student learning.
106 (Room IC 213) - “Wait, how many genes?” HHMI BioInteractive Resources for Teaching Cancer Biology in the Era of Genomics - 90 Minutes
Javier Robalino, Howard Hughes Medical Institute, robalinoj@hhmi.org
*Sponsored by Howard Hughes Medical Institute*
Genomics is increasingly revealing the genetic complexity of cancer. This complexity challenges our ability as educators to help students grasp an accurate and relevant understanding of the biology of cancer. This workshop will showcase classroom activities for teaching the link between mutations, the cell cycle, and cancer. HHMI BioInteractive’s educational materials use real data from patients to help students appreciate the complex and heterogeneous nature of cancer. Participants will receive classroom-ready resources to teach this important concept using active learning strategies.

107 (Room IC 217) - So Much Digital... So Little Time. Choosing and Organizing Your Digital Learning Resources - 90 Minutes
Steve Sullivan, Bucks County Community College, stephen.sullivan@bucks.edu
*Sponsored by McGraw-Hill Education*
There is a wide array of digital learning resources available to A&P students today. Right at our fingertips, we have interactive adaptive reading assignments, tutor videos, lab prep, social media, lecture capture, high-level homework assignments, case studies, etc. etc. It overwhelms us, and especially our students. Let me show you how I’ve organized my use of these tools over the years for traditional, hybrid, and online courses.

108 (Room IC 219) - Civic/Service Engagement Learning Model for STEAM courses at an HBCU/HSI College - 90 Minutes
Solomon Nfor, St. Philip’s College, snfor@alamo.edu, Jo D. Duncan, St. Philip’s College, jduncan36@alamo.edu
Participants will be given an opportunity to design a community based project in STEAM. The proposal is one that has a two day training program design (BUT will be abbreviated for this workshop). By sharing the practices at this HBCU/HSI college, participants will have an idea of what has worked for this college and why it could be applicable in their institution.
Participant Outcomes: 1) Designing a substantial community-focused component white all students participate 2) Integrating learning assessment into engaged civic learning 3) Deal framework for critical reflection

109 (Room Clough 487) - Making the First Day Interactive and Engaging - 90 Minutes
Tom Lehman, Coconino Community College, tom.lehman@coconino.edu
First impressions set the tone for the entire course. Make the most of that first day. Come learn some simple techniques for the integration of group collaboration, terminology usage, and microscopy and model experience. Stations include “That’s a banana?”, “Where’s McBurney?”, “What color’s the nucleus?”, “Which way’s up?”, and “Build a Golgi.” Your students will leave that day with applicable knowledge, an idea of what to expect in the course, and the desire to come back for more.

110 (Room IC 105) - Anatomia Italiana: Art and Anatomy in the Italian Renaissance - 90 Minutes
Kevin Petti, San Diego Miramar College, kpetti@sdccd.edu
Italy’s medieval universities established the study of human anatomy for physicians. To heighten their art, Renaissance masters clandestinely examined anatomy through human dissection. The profound connection between art and science is best demonstrated by the genius of Michelangelo. Indeed, the wooden crucifix he carved in gratitude for secret access to corpses from a convent’s hospital still hangs in the Basilica of Santo Spirito in Florence. This talk will examine the nexus between art and science, and the history of anatomy education in the university. Participants in this workshop are invited to also enroll in a workshop immediately following that will present a curriculum you can use in international programs you wish to develop.
111 (Room IC 211) - Use Drawing to Improve Learning Engagement! - 60 Minutes
Adam Fisch, Draw it to Know it - Medical Sciences, fisch@drawittoknowit.com, Amy Harris, Draw it to Know it - Medical Sciences, harris@drawittoknowit.com
*Sponsored by Draw It to Know It*
In the PowerPoint era, memorization has trumped true learning. See how, with Draw it to Know it, your students master core subject matter prior to class and show up primed and ready to learn -- no matter what your teaching style. Draw it to Know it takes the classic approach to anatomy and physiology education and revitalizes it for the modern classroom with efficient and effective drawing-based tutorials, quizzes, and state-of-the-art analytics. Create study plans and track students’ performance so you know, before stepping into the classroom, what they struggled with so you can use class time effectively.

Tuesday, Session 2

201 (Room IC 109) - You say ba-NAN-ah, I say bah-NAH-na - 90 Minutes
Ken Saladin, Georgia College, ksaladin2@windstream.net
How do YOU pronounce“mediastinum,” “apoptosis,” or “conjunctiva”—as you were taught orally, or as a dictionary says they “should” be pronounced? Are you sure you’ve been teaching your students correctly? What defines correct pronunciation, anyway? The presenter will show slides of alternative, correct and incorrect pronunciations of common A&P terms. Participants will vote on how you think each word should be pronounced, then dictionary-sanctioned pronunciations will be revealed. Revealing differences of opinion will serve as a springboard for discussion of variations in pronunciation, how we learn pronunciation, oral tradition in A&P, and disparities between common practice and dictionary recommendations.

202 (Room IC 111) - Focus Group on HAPS Student Learning Outcomes: Come Share Your Insights - 90 Minutes
C&I Committee (Kathy Burleson, Christie Canady, Hiranya S. Roychowdhury)
*Sponsored by HAPS*
The Curriculum and Instruction Committee is in the process of reviewing and updating the HAPS Learning Outcomes for two-semester undergraduate Human Anatomy and Physiology courses. If you teach, plan to teach, or have ever taught this course sequence, this session is for you. If you use or are interested in using the HAPS Comprehensive Exam, it is directly related to the HAPS Learning Outcomes. How do you use the HAPS Learning Outcomes in your course design and syllabus? Regardless of the extent to which you use them, your input will be extremely valuable. Come find out what others are getting out of the HAPS Learning Outcomes, share your thoughts with fellow HAPSters, and guide us in this important review process.

203 (Room IC 113) - Got Pre-Load? (Exploring the Challenges of Teaching CV Physiology) - 90 Minutes
Heiko (Gary) Heisermann, Winona State University, gheikoHAPSter@gmail.com
The Cardiovascular System involves many subtle interactions of blood, blood vessels, and the heart. Student often struggle to appreciate the details of the physiology of this system, while at the same time learning it’s anatomy. In this interactive, discussion-focused workshop we will explore different strategies for organizing and presenting the cardiovascular system to A&P students. After a short introduction, participants in small groups will discuss the major concepts and themes associated with this system, and compare various approaches to helping students’ master cardiovascular physiology. Bring your questions, ideas, teaching strategies, and/or student activities to share.
204 (Room IC 209) - Using Our Brains to Facilitate Lab Teams: Recognizing Strengths in Ourselves and Our Students to Understand Group Dynamics and Inspire Successful Team Work - 90 Minutes
Cheryl Purvis, Nova Southeastern University, cpurvis@nova.edu, Yuri Zagvazdin, Nova Southeastern University, yuri@nova.edu
Creating a working team in the lab is an integral component in education and can be the key to success in life. As part of their training, we expect students to be able to work in groups. However, personality clashes often undermine the learning environment. To be effective facilitators and foster healthy group dynamics, we must learn to appreciate and evaluate different personality types. Participants will identify their own strengths, assess their individual characteristics and discuss how to create a positive environment for teamwork. This workshop will help us inspire our students to become leaders in their own unique way.

205 (Room IC 211) - The Good, the Bad, and the Ugly for Multiple Choice Question Writing and Item Analysis - 90 Minutes
Jennifer Marie Burgoon, The Ohio State University, jennifer.burgoon@osumc.edu, Melissa Marie Quinn, The Ohio State University, melissa.quinn@osumc.edu
With increasing class sizes and the need to quickly return exam scores, more instructors are utilizing some form of multiple choice exams in their courses. Composing effective multiple choice questions is not an easy task and requires some time and effort. Poorly written multiple choice questions can be confusing and frustrating for students. Therefore it is important to learn guidelines to improve the quality of and to practice composing appropriate multiple choice questions. This workshop is designed to help identify the guidelines for constructing effective multiple choice questions, evaluating existing multiple choice questions, and modifying flaws.

206 (Room IC 213) - The Many Roles of Skin - 60 Minutes
Melissa Csikari, Howard Hughes Medical Institute, csikarim@hhmi.org
*Sponsored by Howard Hughes Medical Institute*
Skin is the largest organ of the human body, but it is often unappreciated by students. This workshop will highlight several free activities on the biology of skin color to answer that ever-present question, “Why should I care?” These materials will translate students’ general knowledge from introductory biology to the content covered in Anatomy and Physiology courses. The resources presented will introduce why so many skin colors exist, the role of skin in the synthesis of Vitamin D and the protection of folate, skin cancer, and homeostasis.

207 (Room Clough 487) - Inexpensive Hands-On Activities to Reinforce Basic Physiological Principles - 90 Minutes
Vicki Abrams Motz, Ohio Northern University, v-motz@onu.edu, Rema Suniga, Ohio Northern University, r-suniga@onu.edu, Jacqueline Connour, Ohio Northern University, j-connour@onu.edu
For many reasons, physiological aspects of A&P labs are often presented as simulations. While simulations effectively convey concepts, hands-on activities promote more active student engagement. Recycled soda bottles supplemented with other inexpensive readily available supplies are used to create working models illustrating concepts such as filtration at the glomerulus with reabsorption at the PCT, flow regulation by heart valves, negative pressure of inhalation, and fluid conduction of sound waves in the inner ear. Activities demonstrate basic properties, then allow for deeper student exploration. Participants will be guided through model construction and provided with handouts.
**208 (Room IC 105) - Anatomia Italiana: A Curriculum Guide to Connecting Art and Anatomy in Italy - 90 Minutes**
Kevin Petti, San Diego Miramar College, kpetti@sdc.edu, Wes Colgan, ADInstruments Inc., w.colgan@adinstruments.com
*Sponsored by ADInstruments*

Since 2012 I have taught courses Connecting Art and Anatomy in Italy for HAPS-I, and San Diego State University. Many HAPS members want to develop their own international programs, but struggle with curriculum development. In this workshop I will demonstrate the online curriculum I’ve developed on the ADInstruments Lt platform. This highly interactive curriculum is available for adoption, and will dramatically reduce the course development workload. This curriculum is also suitable for interdisciplinary art/science courses that do not require international travel, perhaps as an honors component of an anatomy course. Ideally, participants in this workshop will also attend my preceding workshop Anatomia Italiana: Art and Anatomy in the Italian Renaissance.

**209 (Room IC 107) - Yoga Anatomy Workshops for Kinesthetic Learners - 90 Minutes**
Megan Sugrue, Indiana University, mksugrue@indiana.edu, Barbie Klein, Indiana University, barbklei@indiana.edu, Mackenzie Loyet, Midwestern University, mloyet@midwestern.edu

Integrating lecture and laboratory material from a human anatomy course can be difficult for kinesthetic learners. In this hands-on session, we will lead you through the creation and evolution of yoga anatomy workshops where yoga poses (asanas) and pose sequences (vinyasas) are used to review anatomical structures and system functions. We will guide you into basic yoga poses as we demonstrate the instructional dialogue used in our workshops. Participants are encouraged to wear loose-fitting clothing or active wear to the workshop.

**210 (Room Clough 475) - Austin Community College’s Modularized Flipped Curriculum - 90 Minutes**
Meg Flemming, Austin Community College, mflemmin@austincc.edu, Felix Villarreal, Austin Community College, fvillarr@austincc.edu, Florence Oxley, Austin Community College, foxley1@austincc.edu, Aglaia Chandler, Austin Community College, achandle@austincc.edu

The STEM pre-requisite courses for health science programs have long been a barrier to student success. In response, the Biology Innovation Lab at Austin Community College used a Department of Labor grant to redesign BIOL 1308, Biology Fundamentals, BIOL 2101/2304 Human Anatomy and BIOL 2404, Introduction to Anatomy & Physiology. The modularized course material creates a “flipped” approach with extensive in-class active learning opportunities. We will present examples of the modules, the hands-on activities and the data showing improved student success. Your tax dollars at work! The modules will be free of charge to any school wanting to adopt them starting in August 2016!

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**Tuesday, Session 3**

**301 (Room IC 109) - Best Practices for Conducting a Lab with the Biopac Student Lab - 60 Minutes**
William McMullin, BIOPAC Systems, Inc., brentopp@biopac.com, Ken Graap, BIOPAC Systems, Inc., keng@biopac.com
*Sponsored by BIOPAC Systems, Inc.*

This workshop will provide attendees with hands-on instruction in conducting a lesson with the Biopac Student Lab (BSL) from beginning to end— including available pre-lesson activities and resources, equipment setup, lesson procedures, hints and techniques, and post-lesson processing. New BSL features such as customization using system preferences, the Curriculum Management System licensed feature, and several others will be illustrated. The workshop is ideal for current BSL users and for those contemplating future use of the Biopac Student Lab system. Light refreshments will be served.
302 (Room IC 111) - If I Only Had A Brain - 60 Minutes
Brandee Gillham, Morgan Community College/Sheridan College, Alyssa@anatomyinclay.com
*Sponsored by ANATOMY IN CLAY® Learning System,*
In this fun workshop you will discuss function and design of the intricate parts of the human brain and spinal cord and build it with the Anatomy in Clay® Learning Systems. Learn how this engaging method of learning can help you students retain what they have learned about the human body. AND...you will get to keep the brain you create!

303 (Room IC 113) - Visible Body 3D Human Anatomy Apps: Solutions for your Lecture and Lab - 60 Minutes
Robb Kneebone, Visible Body, robb.kneebone@visiblebody.com
*Sponsored by Visible Body*
Join Robb Kneebone as he takes you on a tour of our award-winning apps, Anatomy & Physiology and Human Anatomy Atlas, and get some great ideas for your flipped classroom and your lab! Visible Body’s 3D models, illustrations, and animations provide accurate, engaging solutions to help you teach human anatomy and physiology. Visible Body apps are robust and simple to use, based on a collection of more than 150 stunning animations and illustrations and more than 5,000 human body structures in real 3D. We provide site licenses and mobile access for educational institutions across the globe.

304 (Room IC115) - Increase Active Learning in the Anatomy Lab by using Mobile Devices with Histology and Anatomy Apps - 60 Minutes
Zvi Ostrin, Hostos Community College, zostrin@hostos.cuny.edu, Vyacheslav Dushenkov, Hostos Community College, vdushenkov@hostos.cuny.edu
The use of mobile devices in the Anatomy & Physiology Laboratory promotes active learning, increases student enthusiasm and engagement, and augments the retention of material. Mobile technology is highly effective as a pedagogical tool for individualized active learning because of the ease with which students can access information, visualize anatomical structures in 3-D, and clearly see histological specimens. This workshop will explore options, tips and best practices to integrate iPads into the Anatomy & Physiology Laboratory. The presenters will engage participants in a discussion about the criteria for selecting appropriate applications.

305 (Room IC 209) - Effective Teaching and Learning: Overview of Research and Tools to Use to Reach the Millennial - 60 Minutes
Leslie Day, Northeastern University, l.day@neu.edu
*Sponsored by McGraw-Hill Education*
Do you wish your students were more motivated or came to class more prepared? Do you feel like you have tried everything, but they just don’t listen? Understanding the millennial generation of learners can help you improve student outcomes in your course. This presentation will discuss evidence-based research on the principles of learning and help you apply these principles in your class. Application of these principles into McGraw-Hill’s Smartbook will also be explored.

306 (Room IC 213) - Membrane Transport and Membrane Potential to Get your Students Active in Lab - 60 Minutes
Candi K. Heimgartner, University of Idaho, cheim@uidaho.edu, Shannon Gill, Indiana University, gillshan@umail.iu.edu
Do your kinesthetic and visual learners struggle with the aspects of basic membrane transport and how excitatory cell membranes work with resting membrane potential? This hands on lab will outline how to get your students “excited” for membrane transport and potential by setting up visual cells using readily available candy pieces as models as well as provide an outline for building an interactive model. See how to get your students actively participating in lab and understanding what goes on behind the “cell scene”.
307 (Room IC 217) - An E-learning Approach to Spinal Cord Cross-Sectional Anatomy - 60 Minutes

Allison A. Foster, The Ohio State University, foster.941@osu.edu, Jennifer M. Burgoon, The Ohio State University, jennifer.burgoon@osumc.edu, Melissa M. Quinn, The Ohio State University, melissa.quinn@osumc.edu

A cross-sectional approach to human anatomy provides three potential benefits to students: an appreciation for anatomical organization, an insight to the complementary nature of anatomy and physiology, and the ability to apply these principles to medical imaging techniques. E-learning provides anatomy and physiology educators the opportunity to extend the learning environment past the classroom setting and reach students with different learning styles. Taking an e-learning and cross-sectional approach to spinal cord anatomy provides undergraduate students with easy access to fundamental principles underlying basic anatomical concepts and supports skills necessary for interpreting medical imaging modalities during professional school and beyond.

308 (Room IC 219) - A Model Idea: Round-Robin Student Review of Pre-Lab Exam Study Materials - 60 Minutes

Robert S. Rawding, Gannon University, rawding001@gannon.edu

We have established a series of “round robin” in-lab study exercises, in which students in small groups take turns identifying key structures, organ functions, etc. They rotate through 10-12 stations. We have seen an upturn on our lab exam scores, which seems to reflect a greater level of comprehension and ease the torment of rote memorization. Sample exercises will be part of the attendee handouts for this workshop.

309 (Room IC 105) - Teaching Central Nervous System Concepts Using Diagnostic Radiology and Case Studies - 60 Minutes

Carmen Eilertson, Georgia State University, ceilertson@gsu.edu

Interested in adding clinical case studies to your anatomy and/or physiology course? If so, then join us for a hands-on workshop that explores the nervous system through diagnostic radiology and case-based instruction. Those attending the workshop will learn how to integrate clinical data and radiology cases with course content. This workshop will also serve as a kick-start session for a new HAPS-I course. Those enrolling in the HAPS-I course will develop a portfolio of in-class activities, exam questions, and case studies. Join us to gain the tools and confidence you need to incorporate radiology cases into your course.

310 (Room IC 205) - Best Practices for Getting Started with MasteringA&P - 60 Minutes

Terry Austin, Temple College, taaustin@templejc.edu

*Sponsored by Pearson*

Are you just getting started with MasteringA&P? This session will introduce best practices for using MasteringA&P to help reinforce the content you cover in class. MasteringA&P is a continuously adaptive system, designed to give students a personalized learning experience from before students come to class to after they complete the homework assignment. Plus, MasteringA&P provides instructors with detailed individual and collective student work, allowing one-click insight into students’ learning. Professor Terry Austin from Temple College will share best practices for how to get started using MasteringA&P to complement course content.
311 (Room Clough 475) - ECG: Using LabTutor to Develop and Implement an Inquiry-Based ECG Experiment - 60 Minutes
Eileen Bush, Mohawk Valley Community College, ebush@mvcc.edu, Shannon Crocker, Mohawk Valley Community College, scrocker@mvcc.edu, Donald Kelly, Mohawk Valley Community College, dkelly@mvcc.edu, Wes Colgan, ADInstruments, w.colgan@adinstruments.com
*Sponsored by ADInstruments*
This is a demonstration of a customized laboratory exercise used at MVCC that demonstrates ECG data collection and cardiac electrophysiology. Using an ADInstruments data acquisition system, participants will participate in a guided inquiry oriented around collecting and analyzing human ECG data. In small groups participants will actively predict and test their hypotheses about ECG variables during a variety of changes in position and activities. This demonstration will also show the steps in planning, customization, developing, and deploying the ECG exercise using ADInstruments data acquisition software and Lab Author.

Tuesday, Session 4

401 (Room IC 109) - Giant Bodies — A History of Pituitary Giants and their Glands - 60 Minutes
Jon Jackson, Institute of Philosophy in Public Life, jcksn@mac.com
This workshop reviews our changing understanding of the endocrine system through the lens of the pituitary gland, and pituitary giants in particular. It examines stories of physicians and the earliest documented giants they studied. We’ll examine how society gawks at and even exhibits giant bodies after their deaths, on a historical romp that includes everything from rooster testes to PT Barnum to The Princess Bride. Lastly, we’ll will challenge one another to place our natural curiosity of the unusual in context with reverence and respect for the history and humanity of the really big people among us.

402 (Room IC 111) - Comparative Study of Anatomy and Physiology Courses Taught by Fulltime and Affiliate Instructors - 60 Minutes
Nahel Awadallah, Johnston Community College, nwawadallah@johnstoncc.edu
*Sponsored by eScience Labs LLC*
The study will compare success rates of students who took traditional, hybrid and online anatomy and physiology courses. In addition, many strategies to combat grade inflation by affiliate instructors will be presented. Data offered will illustrate the effectiveness of these strategies. Experiences with standardization efforts and associated challenges are part of the topic.

403 (Room IC 113) - Students Master a Normal or Pathologic Process by Building a 3D Model - 60 Minutes
Deborah J. Merritt, University of Hawaii at Manoa, dmerritt@hawaii.edu
This alternative to written extra credit projects allows students, individually or in groups of 2, to produced 3D models, sans labels, on topic of their choice to educate fellow students. This opportunity uses both the “artistic” and the “critical and analytical” cerebral cortex. The rubric and logistics that have evolved over the years to ensure project originality, depth of understanding, appropriate choice of media, and avoidance of procrastination and plagiarism from the internet will be shared as will pictures and videos of successful and some (surviving) unsuccessful student projects.
404 (Room IC 115) - An In-House Atlas Enhances Histology Learning - 60 Minutes  
Dr. Hisham S. Elbatarny, St. Lawrence College & Queen's University, HElbatarny@sl.on.ca  
In a recent study, we demonstrated that the projection of real-time slide images, using a light microscope with built-in camera, significantly improved histology learning. We expanded on this technology and developed an in-house histology atlas, enabling students to view specimens outside the lab. In this current study, we evaluated the effectiveness of this atlas by comparing students’ scores on histology quiz in year 2014 (no atlas), with those of 2015 (atlas provided). We found students in 2015 achieved significantly higher scores on this quiz. We conclude the independent review facilitated by the take home atlas enhances students’ understanding of histology.

405 (Room IC 209) - Metacognition - Getting Students Involved In Their Own Learning Process - 60 Minutes  
Kerry Hull, Bishop's University, khull@ubishops.ca, Rachel Hopp, Bellamine University, rhopp@hapsconnect.org  
Metacognition, or thinking about thinking, involves conscious monitoring of one’s knowledge and skills. Students engaged in metacognition are able to figure out what they already know and devise strategies to learn what they need to know. This session will discuss in-class and out-of-class metacognitive strategies that can help students maximize their learning. Since these strategies require more cognitive effort than the traditional “reread and review” study techniques, we will also discuss methods to promote student buy-in. Participants will leave the session with a toolkit of ideas for promoting metacognition in the classroom and in faculty development seminars.

406 (Room IC 211) - Simulation as a Pedagogical Approach in Pre-Professional Physiology - 60 Minutes  
Ann Massey, Emory University, ann.massey@emory.edu, Kate Moore, Emory University, kmmoor4@emory.edu, Kelly Fullwood, Emory University, kelly.m.fullwood@emory.edu  
Medical and healthcare professions education is changing rapidly in an attempt to provide greater numbers of practitioners to meet increasing demand. Simulation, in a variety of forms, provides a safe, effective and cost-efficient means for students to gain clinical experience and insight. Pre-professional students can also benefit from real-world scenarios that allow them to experience physiological principles in a clinical setting. In this workshop, we’ll explore various types of simulators and their uses in professional nursing education. We’ll demonstrate a scenario developed for first- or second-semester Anatomy and Physiology students using a high-fidelity manikin.

407 (Room IC 213) - Draw to Learn in the Anatomy Laboratory - 60 Minutes  
Michael Wood, Del Mar College, mwood@delmar.edu  
Professor Michael G. Wood has been getting his students to draw in the A&P lab for over 30 years. In this workshop, he will share strategies for incorporating drawing in the A&P lab as a way to engage students in the learning process and promote a deeper understanding of anatomical structures and physiological processes. Anyone can draw - no artistic abilities required!
408 (Room IC 217) - The Use of Flow Charts as an Ancillary Teaching Tool for Physiological Mechanisms - 60 Minutes
Adrian Isaza, Galen College of Nursing, aisaza@galencollege.edu
In 1988, Meursing, et al. conducted a study in which general nurses without previous training in psychiatry were instructed, over a period of thirteen hours, in the use of eight flow-charts for the identification and management of mental health conditions. Seventy-eight of the 105 patients (74%) were identified and treated correctly by the nurses. A total of 32 mistakes were made, 17 of which were due to the nurses and 15 to defects in the flow-charts. In 2014, Conway, et al, conducted a study in which a flowchart was designed to help students select the appropriate base for an ointment. Prior to implementation of the flowchart, 51 of 101 students selected the correct base. After implementation, 169 of 212 students selected the correct base. This study concluded that use of a flowchart to select an ointment base improved student performance when used in the context of a dry laboratory assignment.

409 (Room IC 219) - Engineering Simple Laboratory Devices to Help Introductory Students Learn Core Concepts of Physiology - 60 Minutes
Murray Jensen, University of Minnesota, msjensen@umn.edu
Providing entry-level human anatomy and physiology students with suitable hands-on and engaging lab activities is often restricted by cost and complexity. At the University of Minnesota, we collaborated with undergraduate engineering students to develop simple and inexpensive mechanical models for use in the physiology classroom and laboratory. To date, the engineering students have constructed devices that model the concepts of homeostasis, active transport, blood flow through systemic and pulmonary circuits, and the cardiac conduction system. During the development and design process, engineering students were restricted to using only inexpensive and common materials that could be from local hardware stores.

410 (Room IC 105) - It's Time to Start Using the HAPS A&P Comprehensive Exam: The 2016 Update - 60 Minutes
Jennifer Marie Burgoon, The Ohio State University, jennifer.burgoon@osumc.edu, Valerie Dean O'Loughlin, Indiana University, vdean@indiana.edu
*Sponsored by HAPS*
Have you wondered if the HAPS A&P Comprehensive Exam is a good measure of student A&P knowledge and if it would work for your institution? Wonder no more! This secure, online exam has been analyzed by psychometricians and exam questions were refined by A&P content experts. The current exams have demonstrated excellent reliability and validity, and we have data from multiple institutions to compare to your school. At our workshop, we will discuss psychometric analyses of the exam, how schools may utilize the exam, how you can order the exam, and development plans for future exams (e.g., anatomy-only, physiology-only).

411 (Room IC 205) - Histopathology: for Undergraduates? - 60 Minutes
Nina Zanetti, Siena College, zanetti@siena.edu
Can histopathology be used to help students learn topics taught in undergraduate A & P courses? To explore this question, we’ll examine photomicrographs of actual pathological specimens and will see how they provide easily understood correlations between histopathology and basic topics such as mitosis, histology, organelles, and embryology. We’ll consider how histopathological correlations can aid in visual learning and understanding of material. Participants will also have an opportunity to explore resources available through the HAPS Histology Challenge and to design classroom activities that use these resources (micrographs and case studies).
412 (Room IC 107) - Incorporating a Modified “Interteaching” Methodology into Anatomy & Physiology Lecture Settings - 60 Minutes
David Mercer, Salem State University, dmercer@salemstate.edu
Interteaching is a technique developed by behavioral analysts to promote deeper student learning by encouraging student teaching. Several studies demonstrate improved student test scores when compared to traditional lecture methods in diverse fields of study. This workshop will describe interteaching in its original format, its use in an Anatomy and Physiology course, the improvement in test scores compared to lecture only classes, and the limitations when used in its original form. In addition, the workshop will introduce modifications made to the interteaching technique to make it more engaging and acceptable for students in learning the complex concepts of human physiology.

413 (Room Clough 475) - JustPhysiology: an Online Simulation of Human Physiology for Experiential Learning - 60 Minutes
Robert L. Hester, HC Simulation, LLC, robert@justphysiology.com, David Julian, University of Florida, djulian@ufl.edu
*Sponsored by HC Simulation*
Understanding the integrative aspects of human physiology can be challenging for undergraduate, graduate and medical students. Justphysiology.com is a browser-driven, cloud-based human physiology simulation developed over 45 years to address precisely that problem. JustPhysiology provides over 30 simulation exercises, spanning cardiovascular, respiratory, renal, metabolic, and integrative physiology. Students can control the simulations to observe a variety of physiological responses over different time scales, and to explore relationships between physiological variables. Workshop participants will learn to use JustPhysiology and see how it has been used with undergraduates in classroom and online learning environments at the University of Florida.

Wednesday, Session 5

501 (Room IC 109) - Managing Incivility in Your Classroom - 60 Minutes
John R Waters, Penn State University, johnwaters@psu.edu
Educators must sometimes deal with students who are rude, disruptive, or even dangerous. These situations challenge teachers to address the issue promptly and professionally. Using case studies based on real world situations, we will discuss student behaviors that range from annoying to threatening, how one might address these behaviors inside and outside the classroom, and the resources available to faculty at different institutions.

502 (Room IC 111) - Using Whiteboards to Facilitate Critical Thinking and Deep Learning in Small Groups - 60 Minutes
Louis (“Tres”) Kutcher, Univ. of Cincinnati, Blue Ash College, louis.kutcher@uc.edu
Students often find Anatomy & Physiology courses conceptually challenging. Teaching A&P using an organ-systems approach provides a logical organization for the body, but individual systems remain complex, with many interrelated parts. Using low-tech whiteboards in a group learning environment makes visible the student’s conceptions, and misconceptions, of physiological processes. A survey of student perceptions on this technique indicates they were motivated to prepare for class and they appreciated learning from their group’s (and other group’s) presentations. This hands-on workshop will explore the mechanics of directing group work using small whiteboards and discuss the pedagogical underpinnings of this technique.
503 (Room IC 113) - Online Science Courses Without Sacrificing the “Hands-On” Component - 60 Minutes
Stephanie Songer, Carolina Biological Supply Company, ashley.faucette@carolina.com
*Sponsored by Carolina Biological Supply*
Science education has been challenged by the rapid growth of online instruction. Using lab kits as part of a hands-on approach to online science avoids the sacrifice of student engagement. We will explore ideas to adopt and adapt a hands-on, inquiry model for online science labs that achieve essential lab skills and learning outcomes. Participants will actively take part in hands-on lab investigations developed for online science courses. These investigations have been designed for the off-campus setting while maintaining the college-level rigor.

504 (Room IC 209) - The Biology of Sex: Myths and Facts - 60 Minutes
Nanette J. Tomicek, Penn State, njt128@psu.edu
Think you know it all? Or heard it all? Come to explore common misconceptions regarding the biology of sex. Student inspired questions will include: Can Mountain Dew serve as an effective birth control? What is the best aphrodisiac? Will hormone replacement therapy kill me? We will also take a look at some dated topics commonly appearing in text books. Faculty, are you still teaching the body fat and fertility hypothesis? Do you classify heart disease as a man’s disease? Are condoms and vasectomy the only types of male birth control? Lecture based workshop with opportunity for discussion.

505 (Room IC 211) - Classroom Assessment Techniques (CATs) Made Simple: How You Can Quickly Assess Student Understanding and Inspire Active Learning in the Classroom - 60 Minutes
Valerie Dean O’Loughlin, Indiana University, vdean@indiana.edu
CATs are not just cute, furry animals. Classroom Assessment Techniques (CATs), first compiled and presented by Angelo and Cross, are formative assessment tools that will allow you to assess student learning and understanding prior to the exam. In this workshop, I will introduce you to different examples of CATs, how you can use them in any size classroom, and provide you with data about how CATs transformed learning in a large undergraduate anatomy class. We will brainstorm how you can develop and utilize CATs in your own classroom. Come join the fun!

506 (Room IC 213) - Understanding Alzheimer’s Disease through Virtual Exploration - 60 minutes
Melissa Csikari, Howard Hughes Medical Institute, csikarim@hhmi.org
*Sponsored by Howard Hughes Medical Institute*
It is estimated that 5.3 million Americans currently have Alzheimer’s disease. Use HHMI BioInteractive’s new engaging interactive to help students understand the complexity of this disease, improve their scientific thinking, and see how medicine and basic research are working together to treat Alzheimer’s. Students will analyze and interpret evidence from studies on Alzheimer’s disease to formulate a hypothesis regarding 1) the cause of the disease and 2) the target for a treatment. Throughout the exploration, students will investigate data collected from a variety of sources, including: pathology, biochemistry, genetics, DNA sequencing, and cell biology. After gaining an understanding of the mechanism of disease, they will explore treatment options based on data from clinical trials.

507 (Room IC 217) - Journaling in Classroom - 60 Minutes
Hiranya S. Roychowdhury, NMSU-Dona Ana Community College, hrroychow@nms.edu
Journaling is a powerful tool in organising thoughts and reflecting on events of the day. I use journals as a part of “writing across the curriculum” strategy that has yielded some interestingly encouraging results in my A&P classroom. This provides a platform to scaffold ideas even as the students listen and take notes. Used as a reflective exercise following class discussion, formative tests, and lectures, this process has proved to be very effective in augmenting their thinking skills. This workshop will show how we can use it in every class.
508 (Room IC 219) - Potential Pandemic H5N1 Influenza Virus Update, with an Immunological Twist - 60 Minutes
Sandy Lewis, Pierce College, WA, profilewis55@comcast.net

Abstract: Use this highly relevant topic to enhance your immunology unit! The presentation will focus on the H5N1 influenza virus; virus subtypes; characteristics; potential as a pandemic virus; current global movement; the history of pandemics with a focus on the Great Influenza Pandemic of 1918-19; comparison between a pandemic influenza virus and the annual influenza viruses; and progress in vaccine preparation and stockpiling for this particular virus. Video clips of the 1918-19 pandemic will be included. This presentation topic was well received at the Melbourne HAPS Regional Conference in December.

509 (Room Clough 487) - Animal Bones Challenge - 60 Minutes
John Koch, retired from John Tyler Community College, jckoch45@verizon.net

Enjoy some hands-on anatomical sleuthing and gain a little insight too. Using only your knowledge of human skeletal anatomy and the similarities between human and animal skeletons, see how many animal bones and their features you can name. Attendees will rotate through lab practical stations composed of a variety of actual bones from turkeys, pigs, cows, elk, bison and humans. Upon completion answer keys will be available and questions/comments welcomed.

510 (Room IC 105) - Conscience in Crisis: the Nazi Academics - 60 Minutes
Aaron Fried, Mohawk Valley Community College, afried@mvcc.edu

Anatomists benefited from the Nazis. Universities accepted bodies from political prisons. Prisoners executed for espionage were being used for teaching and research. Academics were flourishing with a large supply of cadaver materials for research and teaching. After World War II, most who worked the Nazi camps were tried as war criminals while the academics kept working without rebuke, often using the source materials gained unethically. This workshop will examine the history of academic anatomists under the Nazis. How should these specimens have been dealt with? What do you do with the knowledge gained from experiments and work with these tissues?

511 (Room IC 205) - Weird and Wacky Methods to Torture A&P Students - Ideas for Active Learning - 60 Minutes
Nichole Warwick, Clatsop Community College, nwarwick@clatsopcc.edu

Active learning strategies may be good for our students, but students can feel uncomfortable or even that they are being tortured. Additionally, active learning can press the limits of classroom time forcing the instructor to choose between formal lecture and hands on activities. Do the student’s need us to explain the text book to them, or do they benefit from activities? What is best? I plan to share some of the things I developed and use to facilitate active learning allowing me to move away from traditional lecture and improve student comprehension.

512 (Room IC 103) - Best Practices for Teaching Effectiveness, Student Inspiration and Classroom Joy! - 60 Minutes
Mary Tracy-Bee, University of Detroit Mercy, tracyma@udmercy.edu

*Sponsored by the HAPS-Thieme Excellence in Teaching Award*

As experienced educators, we have learned first hand the importance of creating a teaching style that engages our students. Gone are the days of the classroom where facts were simply stated. Now is the time where we aim to inspire and teach critical thinking and compassion. Many of us accomplish this through service learning, peer-feedback, educational games and crafts, Thieme atlases, and discussing clinical vignettes. This presentation will focus on activities that help form inspired, smart students who want to be in our classroom. Come to hear about some tried-and-true activities and be prepared to share some of your own.
Students with low social and cultural support are already disadvantaged so they are more likely to be helped by active learning techniques. Since Anatomy and Physiology courses are the gateway for students to enter Allied Health professions, four lectures of a one semester combined A&P II course were flipped. These lectures were replaced by two NSF case studies and two diagnostic games. This study used pre- and post-class surveys to compare student engagement, grit, social-belonging, and more. Students were separated into high and low cultural support groups from survey responses based on Wells 2008 segregation of social and cultural capital.

**Wednesday, Session 6**

601 (Room IC 109) - The Transformation of Cadaver Dissection Using Video Prosections of a Cadaver and a Synthetic Cadaver - 60 Minutes  
Terence Mitchell, Campbell University School of Osteopathic Medicine, tmitchell@campbell.edu, Mark Xavier VanCura, Campbell University School of Osteopathic Medicine, vancura@campbell.edu  
*Sponsored by Syndaver Labs*  
To ascertain the value in utilizing Syndaver, a synthetic cadaver, to teach gross anatomy, a dissection of the gluteal region was filmed on a Syndaver and a donor cadaver. Video dissections of the Syndaver and donor cadaver were shown to first year medical students the week prior to a gross anatomy examination. After the exam, a questionnaire was given electronically to each student assessing their subjective value of the utilization of this tool for study purposes. We will discuss the results as they highlight the value of incorporating a new technology as an adjunct to traditional donor cadaver dissection.

602 (Room IC 111) - Stop Testing in the Stone Age: Exam App for Anatomy Labs, Classroom Flipping and Student Engagement - 60 Minutes  
David Vogelsang, EducationHive LLC “AnatomyHive”, david@anatomyhive.com  
*Sponsored by AnatomyHive*  
Stop grading handwritten, fill-in-the-blank practical exams. Get out of the A through E, bubble sheet box. Flip your classroom and engage your students in lecture. AnatomyHive is an exam app created for anatomy labs, but can solve any of your testing needs. Pin your practical exam like you normally would, and students can use any WIFI enabled device to take your exam in the lab. Exams are graded instantly and actionable statistics are generated. Flip your classroom and spice up your lecture using embedded YouTube videos and high quality images. For more information, visit www.anatomyhive.com.

603 (Room IC 113) - Fostering Authentic Anatomy and Physiology Laboratory Experiences for Online Learners - 60 Minutes  
Caitlin Runne-Janczy, eScience Labs LLC, esalvidrez@esciencelabs.com  
*Sponsored by eScience Labs LLC*  
Online education is becoming increasingly commonplace, particularly the transition to online science courses with a lab component. For anatomy and physiology instructors considering teaching online, questions such as, “What do students experience in an online laboratory course?” and “How do I effectively teach the scientific method and retain a hands-on approach in a home environment?” may seem daunting. However, it is possible to effectively teach anatomy and physiology online. In this seminar, the eScience Labs team will discuss their hands-on anatomy and physiology kit and curriculum, with a focus on maintaining a rigorous and safe laboratory experience at home.
604 (Room IC 115) - Full STEAM Ahead: All Aboard - 60 Minutes
Mia Ray, Trinity Washington University, raym@trinitydc.edu
Can the integration of Arts into an Anatomy and Physiology (AP) curriculum increase student learning and information retention? See how the humanities, film, sculpture and 3D design, integrated into the AP curriculum ignites students’ imagination through hands-on STEM projects. This technique allows the application of creative thinking, thereby unleashing innovation and reinforcing key concepts to improve understanding and information retention.

605 (Room IC 209) - MasteringA&P and MyReadinessTest: A First-Timer’s Guide - 60 Minutes
Shawn Macauley, Muskegon Community College, Shawn.Macauley@muskegoncc.edu
*Sponsored by Pearson*
This session will introduce participants to MasteringA&P and MyReadinessTest. MasteringA&P is an advanced online science tutorial and homework system that allows instructors to give students personalized attention outside of office hours. MyReadinessTest is a powerful online system designed to assess pre-A&P students’ proficiency in the foundational concepts needed for success in A&P courses and efficiently remediate gaps in targeted topics. Dr. Shawn Macauley will share results from using MyReadinessTest and MasteringA&P in his course, which will include an overview of creating homework assignments, reviewing student work, and exploring available teaching diagnostics to increase student success.

606 (Room IC 211) - Learning How to Learn in A&P - 60 Minutes
Da’Quan Craven, Georgia State University, dcraven2@student.gsu.edu, Emily O’Connell, Georgia State University, eoconnell2@student.gsu.edu, Brian Reid, Georgia State University, breid4@student.gsu.edu
Tired of poor student performance in A&P? If so, then come to this hands-on interactive workshop designed to explore techniques to improve student success. Many A&P students are new to college or science and struggle with learning large amounts of material. We will explore methods that students can use to organize and condense material while improving study techniques. We will use concept mapping, both on paper and with technology, through the use of apps and word processing programs. We will examine the importance of eye-catching color and visual schematics as a means of learning optimization. Join us to gain the tools required to be proficient in optimizing student success in A&P.

607 (Room IC 213) - Using Repeated Low Stakes (Formative) Assessment to Maximize Student Learning in your Course - 60 Minutes
Jon Jackson, Institute for Philosophy in Public Life, jcksn@mac.com
Several lines of research have indicated that for some subjects at least, low-stakes assessment with its emphasis on information retrieval and usage, can promote effective learning, even in strange and unfamiliar topic areas. This seminar will review the science behind such claims, and report on using these techniques to teach radiological anatomy in a one-semester Human Gross Anatomy course in an allied health setting. The workshop will conclude with an open discussion of the necessary logistics for adapting such practice into the variety of A&P courses in which HAPSters are involved.

608 (Room IC 217) - Incorporating 21st Century Skills Into A Human Physiology Course - 60 Minutes
Ann Caplea, Walsh University, acaplea@walsh.edu
Historically, biomedical sciences education has primarily focused on learning content. However, healthcare professions are now demanding higher levels of thinking, communicating and lifelong learning. The skills at the heart of being a lifelong learner include 21st century skills (http://www.21stcenturyskills.org). Learning to learn includes critical thinking and problem solving, communication and collaboration, and creativity and innovation. This workshop will introduce participants to my Human Physiology course that uses problem-based learning (PBL) and team-based learning (TBL) strategies in the classroom. The use of directed case studies, individual and group readiness assurance tests (IRAT/GRAT), and a peer evaluation process will be presented.
609 (Room IC 219) - Lab Assessment Techniques - 60 Minutes
Stephanie Wallace, Texas Christian University, stephanie.wallace@tcu.edu, Molli Crenshaw, Texas Christian University, molli.crenshaw@tcu.edu
There are many different methods for assessing knowledge in the lab, and it can be difficult to determine which is the best for achieving learning outcomes. We will discuss the methods we have used and how effective they were at determining knowledge of lab material. We will also open the floor for discussion of other techniques.

610 (Room IC 105) - Taking the Lab to the Cloud: Using Lt as a Learning Platform for Large Enrollment Lab Courses - 60 Minutes
Aura Grandidge, University of Rhode Island, afgrandidge@uri.edu, Wes Colgan, ADInstruments, w.colgan@adinstruments.com
*Sponsored by ADInstruments*
In today’s teaching environment where many Universities rely heavily on graduate teaching assistants (or adjuncts) to staff large enrollment multi-section laboratories, having access to a tool that provides pre-lab uniformity across sections, while giving students opportunities to learn before, during and after laboratories is invaluable. During this workshop, we will discuss our experience using Lt in our Intro to Human Physiology labs (400 students, 17 lab sections). Participants will have the opportunity to run one of URI’s custom exercises using ADInstruments’ cloud based learning system, while experiencing the ease of authoring and deployment of pre, post and wet lab materials.

611 (Room IC 205) - Ok, I’ve Flipped, but it Doesn’t Always Look Pretty - The Mechanics of Classroom Management - 60 Minutes
Nichole Warwick, Clatsop Community College, nwarwick@clatsopcc.edu
Effort has been put forth recently to convince us to “flip” or use active learning strategies, but the individual class personality can create problems with implementation. One year an intuitive group will be your dream class, another may find us grid locked with concrete learners that have little buy in. I’d like to invite beginner, intermediate and experienced flippers to engage in round table discussion to address the challenges of classroom management.

612 (Room IC 107) - Students with Blindness and Visual Impairments in the College Biology - 60 Minutes
Barbara R. Heard, Atlantic Cape Community College, bheard@atlantic.edu
Students with blindness and visual impairments (BVI) often encounter obstacles participating in laboratory activities. Specific accommodations, such as audible equipment, projections of microscopic images, and Braille-labeled models, are being provided for students with BVI in the college biology laboratory. This workshop will examine the effectiveness of those specific accommodations based on data from a recent study that gathered the perceptions of students with BVI who have completed a college biology course, and of college biology instructors who have taught students with BVI.

Wednesday, Session 7

701 (Room IC 109) - Four Years Flippin’: The Good, the Bad, and the Ugly - 60 Minutes
Wendy Riggs, College of the Redwoods, wendy-riggs@redwoods.edu
There is a lot of chatter about the value of the flipped classroom in the biological sciences. After four years of using video lectures to completely flip the three courses I regularly teach (Human Anatomy, Human Physiology, and General Biology), I have a lot to say. This workshop will facilitate a conversation about the pros, cons, and CRAZIES of the flip.
702 (Room IC 111) - Move into Success - 60 Minutes
Brandee Gillham, Morgan Community College/Sheridan College, Alyssa@anatomyinclay.com
*Sponsored by ANATOMY IN CLAY® Learning System*
Build on our MANIKEN® models and learn how other amazing instructors are using this innovative and creative system to increase student success. In this fun, hands on workshop you will learn how to build the rotator cuff and muscles of facial expression out of clay. Building different types of muscles, muscle fibers and attachment sites with the Anatomy in Clay ® Learning systems will help your students create lifelong retention of the importance and function of muscles in the human body. Come build with us!

703 (Room IC 113) - Anatomy and Physiology and Glitter: Open-Ended Creative Assignments Amp Up Student Learning & Engagement - 60 Minutes
Kristen M. Platt, University of Kentucky, platt.kristen@uky.edu
Glitter, glue, and glitz are not words typically associated with anatomy and physiology, but when creativity and science combine, exciting products can result. Undergraduate anatomy and physiology students were provided the opportunity to complete an open-ended assignment in the medium of their choice regarding the respiratory system. Students were given specific instructions to create a one page product discussing a clinically relevant topic; results will be discussed. In this workshop, participants will actively develop ideas for creative assignments in their own classroom using mixed media. In addition, participants will brainstorm and share alternative ways to add pizzazz to their pedagogy.

704 (Room IC 115) - A “Less is More” Approach to Technology in the Classroom - 60 Minutes
Benjamin Miller, Texas Wesleyan University, brmiller@txwes.edu, Robert (Bob) Eckstein, Warren Wilson College, eckstein@warren-wilson.edu
There is pressure to incorporate technology into the curriculum, aiming to achieve educational objectives, including the Anatomy and Physiology course competencies. The concept “less is more” minimizes one component and results in a greater final product. In this workshop, we will explore this idea through technology-free face-to-face delivery. Rather than inundating students with myriad technologies, we must remember the value of a genuine one-on-one relationship with our students. Our goal for this workshop is to present several approaches that we have used in the lecture and laboratory which have been shown to increase course competencies using more face-to-face content.

705 (Room IC 209) - The One-Semester A&P Student: Overcoming the Challenge of Being Underprepared - 60 Minutes
Suzanne Keller, Indian Hills Community College, Suzanne.Keller@indianhills.edu
The majority of one-semester A&P students are underprepared, and A&P will be the first college-level science class for many of these students. Study skills are often lacking. How do we prepare this student population to learn new vocabulary, understand tough A&P topics, and link concepts between systems all without sacrificing the material? Dr. Suzanne Keller has taught the one-semester A&P course for eight years and will share how she tackles these challenges. Attendees will get hands on so that everyone leaves with new ideas to implement.
706 (Room IC 211) - Building Community and Creating Authentic Learning Opportunities - 60 Minutes
Jacqlyn King, University of Oregon, jhyler@uoregon.edu
Student learning, persistence and retention improve when students have personal relationships within their academic community and opportunities for authentic learning. Given the physical design of classrooms and reality of larger class sizes, one might assume that a teacher-centered approach, where the instructor is viewed as the content expert and students assume the role of passive and invisible participants, is inevitable. During this workshop, we will share techniques to help you transform your classroom into an engaging experience where students have the opportunity to apply knowledge from their preparatory assignments and interact with their team of instructors and peers. You will leave this workshop with a new outlook on the community and engagement that can be established in a large (or small) classroom setting through the use of authentic preparatory assignments.

707 (Room IC 213) - Thinking about thinking: How Does Metacognition Impact Student’s Performance and Perception of their Learning Experience - 60 Minutes
April Richardson Hatcher, University of Kentucky, arich3@uky.edu
This workshop will characterize students’ learning techniques and perception of their learning experiences in a large undergraduate anatomy course. The course is divided into four units of systems-based anatomy. For each unit, students worked on a series of “Blue Book Assignments”, including reflections on how they studied (e.g., how many hours, methods) each module, drawings of key anatomical structures before/after class to reinforce the foundational content, and clinical applications of the material. Participants will follow the journey of 260 students throughout their semester of anatomy. We will actively discuss ways to encourage metacognitive practices in the classroom.

708 (Room IC 217) - When a Picture is NOT Worth a Thousand Words - 60 Minutes
Lori Garrett, Parkland College, LGarrett@parkland.edu
Research shows that images can promote deeper learning. However, research also shows that students often ignore images presented in their textbooks or in class, they undervalue the artwork, or they simply don’t understand it, which all translates into lost learning opportunities. What challenges do our students face when studying from images? Why are some images more effective than others? In this session, we will explore the questions and discuss ways to effectively incorporate images in our classes to promote visual literacy and increase learning.

709 (Room IC 219) - Design, Implementation, and Assessment of a High Structure Graduate Human Anatomy Course - 60 Minutes
Justin Shaffer, University of California, Irvine, j.shaffer@uci.edu
High structure courses that include pre-class content acquisition and assessments, in-class active learning exercises, and weekly review assignments have been shown to improve learning in biology courses, but are they suitable for teaching human anatomy? The goal of this study was to design, implement, and assess a high structure undergraduate human anatomy course at a large research university. This workshop will describe the teaching materials for this course, explore quantitative and qualitative assessment results, and suggest ways to implement high structure human anatomy courses at other institutions.
710 (Room IC 105) - Don’t be Passive - Activate your Lessons! - 60 Minutes
Ellen Miller, ADInstruments, e.miller@adinstruments.com, Wes Colgan, ADInstruments, w.colgan@adinstruments.com
*Sponsored by ADInstruments*

Interested in turning passive studying material into an active learning experience for your students? Increasingly, assessment researchers conclude that reading wordy documents is one of the lowest-value study techniques. In this workshop, we will build engaging and interactive lessons using ADInstruments Lt learning system. We’ll also discuss free resources available for you to makeover your materials into compelling content that has a positive impact on your students. Get tips and best practices for incorporating active learning approaches into your lessons, and explore how integrating study questions with immediate feedback enhances student learning outcomes.

711 (Room IC 205) - A Simple Tool to Encourage Effective and Voluntary Student Use of Learning Outcomes - 60 Minutes
Tynan Becker, University of Alaska Fairbanks, tabecker@alaska.edu

The use of Backwards Design has been established as an effective method for developing a course. A key component of the Backwards Design concept is the use of learning outcomes. In my classroom, I have observed that students are reluctant to use learning outcomes as a study guide. To remedy this, I created a simple tool that encouraged the voluntary and effective application of learning outcomes by students as a way to focus their learning. I will share my method and facilitate a discussion among participants that wish to share their efforts in encouraging students to use the learning outcomes.

712 (Room Clough 475) - PowerPoint Beyond the Basics - 60 Minutes
J. Ellen Lathrop-Davis, Community College of Baltimore County, elathrop@ccbcmd.edu

Ever consider spicing up your lecture PowerPoint presentations with animation? Ever wonder how to make videos for your online students using PowerPoint? Ever wonder how to decrease file size when your PowerPoint is huge? PowerPoint can do a lot while not causing the motion sickness some associate with other programs. Bring your own presentation to work on and learn how to add animation, transitions, videos, and sound and more to your presentations.

Wednesday, Session 8

801 (Room IC 109) - Using Fun Activities to Learn About the Function of the Organelles - 60 Minutes
Julia Schmitz, Piedmont College, jschmitz@piedmont.edu

Looking for fun and new ways to help your students learn about organelles’ functions? This workshop will engage the audience in different activities to teach about the organelles to their students. Participants in this workshop will partake in determining which object is representing which function and coming up with their own analogies. Activities include having the students come up with analogies of organelles to a city, finding objects to represent the functions of the organelles, and researching diseases that result in a malfunction of specific organelles. Interactive discussions will provide your students with an understanding of the interworkings of organelles.
802 (Room IC 111) - Game-Based Learning and Student Motivation - 60 Minutes
Alice Khin, University of Alberta, alice.khin@ualberta.ca, Upinder Singh, University of Alberta
I have been teaching physiology and pathophysiology to undergraduate nursing students for years. The class sizes are large and it is challenging to get students engaged with the course material. Recently, I changed my teaching from a traditional format to a blended learning design format. The blended format requires students to participate in an online game-based learning platform called 3D GameLab. This is a tool that enables instructors to design and share personalized learning paths for students. Quests vary in complexity from simple recall to higher level synthesis activities. Students are engaged and highly motivated and the failure rate is almost zero.

803 (Room IC 113) - From Student to Text: How Data is Changing Content Development - 60 Minutes
Michael Windelspecht, Appalachian State, michael@ricochetprod.com
*Sponsored by McGraw-Hill Education*
Students don’t know what they don’t know. This has implications across the entire learning ecosystem. From the classroom to the content developers, a considerable amount of time is dedicated to development of resources that anticipate the needs of the learner. Adaptive learning technologies are now providing the data that allows us to understand specific knowledge deficiencies. We will explore how data enhances the personalization of the remediation process, assists in the revision of content, and allows for the development of specific micro-learning resources that target the actual needs of the learner.

804 (Room IC 115) - Strategies for Teaching A&P to Best Meet the Needs of Nursing Education - 60 Minutes
Sally Aboelela, Columbia University School of Nursing, sa2242@columbia.edu
Many of us who teach anatomy and physiology are embedded within nursing departments or schools of nursing. Trained as basic scientist ourselves, we are presented with the challenge of making our courses approachable to students of diverse educational backgrounds, teaching our content effectively, and engaging student interest. Yet another challenge is how best to use the context of nursing education as a guide for course design, teaching approach, goal setting, and course evaluation. Through this workshop we’ll explore the particular nursing competencies our courses serve to develop, a specific approach to teaching anatomy & physiology I’ve developed over many years aimed at best meeting the needs of nursing students, and we’ll discuss how this approach can be applied to the courses you teach.

805 (Room IC 209) - Understanding Tubes - 60 Minutes
Mark Nielsen, University of Utah, marknielsen@bioscience.utah.edu
Tubular anatomy is a ubiquitous structural feature of the human body. In fact, early in the evolution of multicellular organisms tubes became essential features to connect the external environment, with its rich nutrient supply, to the internal milieu. With the evolution of the vertebrate body, tubes have taken on numerous functional roles related to this theme of environmental exchange, yet all tubes have the same basic structure. Our goal as teachers is to help our students see this basic tubular plan and understand how various modifications logically account for the structure-function interplay that is unique to each specific tube.

806 (Room IC 211) - From the A&P Lab to the Museum: The Art of Damien Hirst - 60 Minutes
John Robertson, Westminster College, robertjc@westminster.edu
Damien Hirst is a popular and polarizing artist who, over the past 25 years, has re-contextualized materials very familiar to A&P students and instructors in creative and provocative ways. A retrospective of Hirst’s work will be presented, focusing on his use of anatomical models and biological specimens to challenge some basic conceptions of art. His success as an artist and rise as a popular culture icon will be contrasted with criticism that has become increasingly associated with Hirst and his art. Uses of Hirst’s art in an A&P course, and student reactions to his work, will also be presented.
807 (Room IC 213) - Changing Traditional Face-to-Face A&P I and II into Blended Online (Hybrid) Classes - 60 Minutes
Brenda del Moral, Edgewood College, bdelmoral@edgewood.edu

Four years after changing face-to-face A&P classes to a hybrid online class structure, what has been the benefit to students and student learning? In this workshop, the presenter will explain how a traditional class was changed into a hybrid online course, which included keeping the 2-hour laboratory session, adding a 50-minute discussion, and removing the three, 50-minute weekly lectures. Most A&P content was moved online to Blackboard 9.1 with the use of Blackboard-embedded discussions, wikis, and blogs, as well as MasteringAP.com and free Web 2.0 tools and interactive videos. This is an example of blending curricula – no online lectures, only using instructor-created online assignments, case studies, and portfolios, as well as the plethora of freely available online A&P content. Analysis of grades and exam scores between these hybrid and traditional classrooms reveals an interesting picture of performance among different student populations and some surprising anecdotal results. Participants will be encouraged to share their feedback and interpretation of the assessment analysis.

808 (Room IC 217) - I Don't Think They Hear What I Am Saying! How to Help Students Conceptualize Difficult Material - 60 Minutes
Jennifer Regan, University of Southern Mississippi, Jennifer.Regan@usm.edu, Cinnamon VanPutte, Southwestern Illinois College, Cinnamon.VanPutte@swic.edu

How many times have you read answers on an exam and exclaimed “I never said THAT!”? Over our years of teaching Human Anatomy and Physiology we both share the feeling that our students are just not hearing what we are saying. However, what we have found is that it is not for their lack of trying, many of our students just do not have the framework for understanding difficult concepts. We will present several active learning exercises that we have found are useful in improving student learning, resulting in some learning opportunities for ourselves as well.

809 (Room IC 219) - A History of Women in Anatomy: Nuns, Criminals, and Midwives - 60 Minutes
Danielle C. Hanson, Indiana University, dchanson@indiana.edu

The stories of women in the history of anatomical exploration are often overshadowed by the well documented stories of male anatomists such as da Vinci and Vesalius. Nuns were dissected to look for holy signs imprinted within them, midwives held “secret knowledge” of the female anatomy, wax models were made to reveal the anatomy of the female body and pregnancy, and the anatomization of executed female criminals drew enormous crowds. Though often conducted outside of traditional medical contexts or not recorded in typical scientific or anatomical materials, these female contributions to anatomy are integral to understanding its complete history.

810 (Room IC 105) - Five Simple Ways to Humanize Your Online Course - 60 minutes
Camille Freeman, Maryland University of Integrative Health, cfreeman@muih.edu

Are you and/or your students worried that online courses feel impersonal and robotic? “Humanizing” your course can improve student learning and lead to a better experience for everyone involved. In this session, I’ll share my experiences humanizing two online physiology courses over the past two years. We’ll cover five quick and easy suggestions for those who would like to modify their own courses, with a few advanced strategies thrown in for good measure. Please plan to share your own experiences and ideas during this interactive session.
811 (Room IC 205) - 3D Printing of Anatomical Models to Increase Student Engagement in Education - 60 Minutes
Laura Sweet, Eastern Michigan University, Lsweet1@emich.edu, James J. Sweet, Eastern Michigan University, jsweet@emich.edu
3D printing is a new technology being utilized for students to be more hands on in learning A&P concepts, while also developing clinical skills. The authors of this proposal have utilized 3D printing in the classroom to support the unique learning styles of students. The significance of this proposal is to increase the awareness of educational technologies in the classroom and clinic. Additionally, the idea of using 3D printing in education allows for fiscal responsibility and also an increase in student engagement. It provides the educator an ability to develop a number of anatomical and related models inexpensively to help students with understanding.

812 (Room IC 103) - What We Teach in High School A&P - 60 Minutes
Carolyn Hess, School of Health Professions, DISD, cahess@dallasisd.org
The HAPS blog has often contained threads where frustrated post-secondary A&P instructors wonder, “why don’t these students have ANY background if they’ve taken “A & P” in high school?” This session is presented by a 20-year A&P high school teacher with a background in 3 school districts. I’ve seen the range of what is presented by different teachers, and I will offer some information about what may be taught in high school, what may not, and some explanation.

813 (Room IC 107) - DaVinci to Teach Anatomy - 60 Minutes
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The general background of the arts in anatomy and medicine are the basis for this lecture and workshop. Using the principles and drawing strategies of Leonardo DaVinci, we developed a course, workbook, and exercises that take full advantage of a student’s inherent often underdeveloped and underrated ability to draw. Focusing on transparency, rotation, and transverse section, and applying DaVinci’s universal appreciation of patterns in nature, we teach anatomy from a wholistic, whole brain pedagogy. The methods used in this book rely on the concept of the human body in context with all of nature. The story of human anatomy is presented as narrative. We invite educators to develop skills that allow them to better utilize anatomical models, complex and “fuzzy” topics in anatomy, physiology, and medicine, and to create a theatrical component to the lecture experience. Dr. Mangione is an expert on Leonardo, his life, and his anatomical notes and drawings. The lecture is interactive and involves drawing and visualizing.