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Cover art: Stephanie Makualu, wife, mother of three, honor student, and currently a junior majoring in biology at the University of Tulsa, plans to attend medical school to be a physician and researcher in the field of pediatric endocrinology. Her step-daughter, a Type-I diabetic, is her inspiration for pursuing the combined DO/PhD degree. HAPS member Karen McMahon knows Stephanie through her role as advisor to the Pi Alpha chapter of Tri-Beta biological honor society.
Greetings from Your President

Hello HAPS members!

It seems like the Baltimore meeting just ended and now fall semester is already over! Thank you Ellen Lathrop-Davis (Community College of Baltimore County) for a wonderful week in Baltimore; the 2009 conference was a huge success!

It is a privilege today to be writing the first President’s letter in the first completely on-line issue of the HAPS-EDucator. Thank you to Marsha Sousa and the HAPS-ED committee for implementing this vision. I can remember years ago when we were debating the pros and cons of switching to an electronic version of the membership directory, and this seems like a natural progression that will both serve the membership and help us to responsibly manage our Society’s resources. This summer, the Board and Steering Committee have continued the work we discussed during the annual meeting last May, so I want to give you a brief update.

The members attending the business meeting in Baltimore were nearly unanimous in their decision to hire an Executive Director for HAPS. The position was posted in June, and as of the beginning of August, we have twenty-four applications to review. The search committee, with input from other HAPS leaders, will now narrow that list to the three or four individuals whom we wish to interview. That process has begun and we hope to be interviewing in September and have someone hired this fall. This is an exciting step in HAPS’ development as an organization, and the Board appreciates your suggestions and support.

At the business meeting, we also voted to create the HAPS Foundation, which will provide oversight for charitable gifts made to HAPS. At the meeting, the membership ratified new bylaws which outline how we will be responsible stewards of such gifts, and the Board has appointed Judi Nath (Lourdes College) to chair the HAPS Foundation Oversight Committee. We are confident that Judi and her committee will do a wonderful job implementing this new facet of our Society. Thank you also to Joe Griswold (President Emeritus), Judi Nath, Mike Nath (legal consultant), Kevin Patton (President Emeritus, St. Charles Community College), Phil Tate (President Emeritus) and everyone else who consulted prior to the annual meeting to establish the framework for the HAPS Foundation!

There are many other new faces on the Steering Committee this year. The committee chairs collectively form the HAPS Steering Committee. Leslie Day (Northeastern University) has stepped up as chair of the Cadaver Use Committee to replace Wanda Hargroder (Louisiana State University) who is now serving on the Board of Directors as Secretary. Ron Gerrits (Milwaukee School of Engineering) is leading the Curriculum and Instruction Committee and continuing the outstanding work of outgoing chair, Carol Veil (Anne Arundel Community College). Michael Kopenits (Amarillo College) will lead the Grants and Scholarship Committee, after serving on the committee with Rich Faircloth (Anne Arundel Community College), who is retiring. Ellen Arnestad (Southern Alberta Institute of Technology) was appointed director of the HAPS Institute earlier this spring, and has been working closely with outgoing director Kevin Patton (St. Charles Community College) to ensure a smooth transition. Elizabeth Hodgson (York College of Pennsylvania) is now chair of the Membership Committee, allowing Jon Jackson (University of North Dakota School of Medicine) and Valerie O’Loughlin (Indiana University) to rotate off of that committee, and hopefully take on new positions! Margaret Weck (St. Louis College of Pharmacy), steps in as chair of the Presidents Emeriti allowing Joe Griswold (President Emeritus) to finally take a little break. Karen McMahon (University of Tulsa) and Linda Nichols (Santa Fe Community College) will co-chair the safety committee, and Curtis DeFriez (Weber State University) joins Eric Sun (Macon State College) to co-chair the testing committee. We are fortunate to have so many talented members stepping into leadership positions!

Thank you also to our other continuing chairs: Don Kelly (Mohawk Valley Community College) of the Animal Use Committee; Izak Paul (Mount Royal College) who leads the Annual Conference Committee; Marsha Sousa

(Continued on next page)
(University of Alaska), editor of HAPS Educator; Javni Mody (Anne Arundel Community College), our wonderful Marketing Manager; Betsy Ott (Tyler Junior College), chair of the Partner Associations Committee; David Evans (Pennsylvania College of Technology), Public Affairs Chair; Ewa Gorski (Community College of Baltimore County), Regional Conference Chair; Terry Harrison (Arapahoe Community College), coordinator of the 2010 annual conference in Denver; Tom Lehman (Coconino Community College), Steering Committee Chair; Tom Lancraft (St. Petersburg College), Web Committee Chair, and of course the omnipresent and omnipotent Carl Shuster (Madison Area Technical College), our web editor. Committee chairs love hearing from people wishing to make a contribution and the strength of our society lies in the talent and energy of our members! If you are interested in getting involved with any of these committees, please contact the committee chair (http://www.hapsweb.org/displayboard.cfm).

I know I mentioned this in an earlier email, but on behalf of the entire organization, Kevin Petti and I also wish to acknowledge the hard work and dedication of the outgoing Board members for 2009. Thank you Past President Margaret Weck (St. Louis College of Pharmacy), Secretary Mark Bolke (Clark College), Southern Regional Director Mary Lou Percy (Navarro College), and Central Regional Director Judi Nath (Lourdes College). Your dedication to the Society is exemplary.

This year, the Board of Directors and Steering Committee will meet in Minneapolis during October for our mid-year meeting rather than during the winter as has been the tradition. We felt that meeting five months after the annual meeting, rather than five months before, will help all of us maintain the momentum from the annual meeting throughout the academic year. It also lessens the chances of getting stranded in an airport during a snow storm! We look forward to updates from Terry Harrison (Arapahoe Community College) and his committee on the plans for the 2010 annual conference in Denver, as well as working with members of the Steering Committee. We will be discussing possible updates to some of our position statements, ways to recruit new members, publishing and copyright policies for HAPS documents, strategies to continue developing the HAPS Institute, progress on integrating the Executive Director into the organization, as well as other initiatives submitted by Board members, the Steering Committee, and members-at-large. If you have something you think needs to be addressed, please contact your Regional Director or me. Contact information is available on the HAPS website (http://www.hapsweb.org/displayboard.cfm).

I will keep you updated on the Society’s progress and please don’t hesitate to contact me with questions or concerns.

Best wishes to you all,
John Waters
President, Human Anatomy and Physiology Society
johnwaters@psu.edu  814-863-1154

——

**Annual Conference**

**2010 Denver**
May 29th - June 3rd

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May 28th - June 2nd

For more Info: Phone 800-448-4277
website: www.hapsweb.org
At this year’s conference in Baltimore, I had many people approach me with different ideas that they wanted to see in the HAPS-Institute. Some had ideas for courses that they really wanted to take, others had ideas of how we could deliver the courses that would be more convenient for themselves and their colleagues, and still more told me what they needed for their colleges to recognize and reimburse them for taking the courses we offer. And all of these people approached me in the wonderful HAPS way -- with respect for the project and constructive ideas of how to make things better. It made me feel very honored to be in the position of HAPS-Institute director.

The sheer number of people that I talked to told me that we have definitely gotten the word out about the HAPS-Institute. The passion with which people spoke told me that we have hit upon an idea that is really valuable for our members. Then there was the fact that all of our new courses were full this year to let us know that we really have a needed commodity on our hands.

The trick now is to make it sustainable. To do that we need to make sure that the instructors we contract continue to develop quality courses. We need to start to get the word out to more than just HAPS members and let all high school, college, and university biology and A&P instructors know about the type and quality of courses that we provide. We have to make sure that we provide blended learning courses around the continent and at different times of year so that it is convenient for everyone. We need to figure out new and better ways to provide complete online courses that have value. We are also considering creating either a certificate or a masters program from some core and option courses within the HAPS-Institute. There is so much to do.

In trying to do all of this, we have had to make some changes. Fortunately, being a relatively small organization at present we have the flexibility to do this. We have expanded our leadership to spread some of the work around (as we all have full time jobs as instructors) and to have a pool of ideas to draw from. Let me take this time to introduce the leadership team: Mark Terrell (associate director), Jennifer Lundmark (academic affairs coordinator), Tom Lancraft (instructional design coordinator), Christine Martin (academic assessment coordinator), Luis Martinez (marketing and communications coordinator) and Joe Griswold, Kevin Patton, and Christine Martin (development team) who are looking into and applying for grants for our programs, and finally myself, Ellen Arnestad, as the working director. This working group has become a team over the last few months and has put in a lot of work to bring HAPS-I from its small start to a robust and thriving program.

Alongside the leadership team we also have a group of friends and advisors. These are people from both inside and outside of HAPS who are interested in the program and want to help to see it survive and contribute to the scientific community. We also have you, the people within HAPS, who want to see a valuable professional development program that can sustain needed credentials for our members, give people an opportunity to share their specialties by teaching courses to a group of highly motivated scholars, and provide opportunities for participating in some educational research within HAPS. All of these people are so important to what we do and we have learned so much from everyone. I truly believe that we will continue to create a valuable program by having this core group of ‘directors’ while cultivating all possible advisors. This will give us many ideas of ways around the challenges of creating a unique program like HAPS-Institute while at the same time preventing the scenario of ‘too many cooks, spoiling the broth’.

Please take this as an open invitation to let myself or others on the team know about any ideas that you see for improving HAPS-Institute. If you have an idea for a course you would like to teach, or a course you would like to take, let us know. If you see some things within a course that you think should be changed or amended, let us know. If you see an opportunity, in a grant, in a research project, in collaboration with another organization that would be beneficial to HAPS-Institute, let us know. We want HAPS-Institute to be useful to our members, valuable to HAPS, and a recognized body within the scientific community. If you have any ideas to share, please feel free to contact any of the people on the leadership team at HAPS-Institute@hapsweb.org or join the Google group ‘HAPS-I Update’ by searching for us at: http://groups.google.com/.
Dr. Kathryn Jones of the Loyola University Chicago Stritch School of Medicine delivered the final update seminar on neuronal regeneration and the therapeutic role of gonadal steroids. The seminar provided an overview of the structural and functional changes that occur upon neuronal injury and during neuronal regeneration, as well as evidence for the role of gonadal steroids in the process of neuronal regeneration. The goal of studies performed in her laboratory is to better understand the actions of gonadal steroids on successful neuronal regeneration and to apply these findings to neurons unable to regenerate for the treatment of human neurological disorders, diseases, or injuries.

The seminar began with an overview of the structural and functional changes that occur in response to neuronal injury and during the regeneration process. Upon axonal injury, degenerative changes begin immediately in both the proximal axon segment connected to the cell body and the isolated distal segment of axon. These degenerative changes also will impact neurons with synaptic connections to the injured neuron, potentially leading to transneural changes that reflect a reorganization of connectivity among neurons.

Simple, yet striking, photomicrographs illustrated the structural differences between a normal neuronal cell body and a neuronal cell body immediately following trauma to the axon. Following damage, the neuronal cell body, nucleus, and nucleolus swell and the nuclear envelope develops an uncharacteristic smooth appearance. The rough endoplasmic reticulum degrades and the remaining Nissl substance appears near the plasma membrane, away from the nucleus of the cell body. There is an increased number of free ribosomes to support enhanced protein synthesis. The increased protein synthesis reflects production of proteins necessary for axonal regeneration rather than normal cellular functions, such as standard repair processes.

The segment of axon distal to the injury also degenerates. This process, termed Wallerian degeneration, leads to the destruction of the entire distal axon segment. Wallerian degeneration occurs regardless of neuron survival and, actually, is necessary for recovery. In the peripheral nervous system, Schwann cells become phagocytic, acting to degrade the axon as well as to engulf debris. The axon can then regrow to reestablish its connection with the target tissue. During the regeneration process, the axon will sprout neurofibrils and begin to elongate via the growth cone.

Neuronal regeneration requires axon elongation and reinnervation of target tissue. Various factors, as Dr. Jones explained, influence the ability of neurons to regenerate. She noted that, based on differences in the extracellular environments, neurons of the peripheral nervous system are more likely to regenerate than those of the central nervous system. Additionally, the severity and the location of the neuronal injury will affect a neuron’s regenerative capacity. Neurons can typically recover when axonal damage leaves the connective tissue of the nerve sheath intact (which helps guide the elongating axon). Injuries proximal to the cell body are more damaging than those distal and less likely to result in recovery. Age also impacts regeneration and, interestingly, immature neurons are more likely to die. Finally, it also was noted that local damage affecting regeneration may result from immune cell activity rather than from the injured neuron itself.

Gonadal steroids and their role as neurotrophic factors in the nervous system were introduced with regard to their potential role in neuronal regeneration. Androgens, estrogens, and progesterone have widespread receptor distribution in the nervous system. Research has demonstrated that gonadal steroids affect neural growth and survival, neurotransmission, and synaptogenesis under normal conditions as well as play a neuroprotective role during cell stress. These effects appear to be receptor-mediated, as application of androgen leads to a rapid increase in mRNA transcripts. To emphasize the potential importance of gonadal steroids on neural function, Dr. Jones mentioned that her laboratory has observed increased mRNA transcripts one minute following androgen application.

Dr. Jones presented several animal studies used to evaluate the therapeutic potential of gonadal steroids in neuronal regeneration.

(Continued on next page)
The hamster crush facial motor neuron injury model is an extremely useful animal model to study neuronal regeneration. One reason for its usefulness is the ability to damage the facial nerve at three locations to mimic various clinical scenarios. For example, peripheral nerve regeneration following axonal injury can be modeled and studied by easily damaging the facial nerve at its location exterior to the stylomastoid foramen. This is advantageous because the site is outside the blood-brain barrier and prevents damage to the cell body within the facial motor nucleus found in the central nervous system. The crush injury model damages the axon, but does not disrupt the neural sheath, so regeneration and complete recovery occurs within three weeks. Evidence of functional recovery, specifically, the return of motor movements of facial muscles responsible for eye blinks and whisker movements, is easily observed. Additionally, the uninjured paired facial nerve can be used as an internal control.

Notably, Dr. Jones showed data that the administration of androgen (testosterone propionate) at supraphysiological, but not normal levels, enhanced the recovery from facial paralysis and the rate of axonal regeneration following crush injury. The administration of cortisol had no effect. The neuroprotective effects of androgen occur immediately (within six hours post-injury) and are mediated via the androgen receptor. It appears that androgens enhance molecular events, such as increased protein synthesis, that typically occur following injury. Another study that was presented showed data that simultaneous androgen administration and electrical stimulation had an additive effect compared to either treatment used alone. The treatments had different effects, each targeting distinct steps of the regeneration process. Specifically, electrical stimulation decreased the time to sprout formation whereas androgen therapy increased the peripheral axon regeneration rate. This combinatorial treatment also resulted in faster functional recovery compared to treatments alone. Finally, it was mentioned that their laboratory is currently investigating the role of androgens in treatment of facial nerve paralysis caused by acoustic neuroma formation (intracranial tumors).

Overall Dr. Jones provided us with a thorough understanding of neural regeneration and evidence that androgens play a neuroprotective role in the process of successful axonal regeneration of a peripheral nerve following crush injury. ■

2010 HAPS Annual Conference –
Set Your Sights High, Breath Easy and Inspire Yourself

The 24th annual HAPS Conference will be held in beautiful Denver Colorado from May 29th through June 3rd 2010. Participants will be staying at the Hyatt Regency Denver Hotel at the Colorado Convention Center. This stunning hotel, built in 2005, stands 37 stories above the city skyline and is conveniently located downtown, within walking distance to much of what Denver has to offer.

We have an exciting conference planned, with update talks on Sunday and Monday and a full slate of workshops on Tuesday and Wednesday. Come in early and take advantage of a Colorado Rockies baseball game or a Saturday afternoon tour. Stay late and choose a bus ride that will take you high in to the Colorado Rocky Mountain National Park to the town of Estes at 7,522 feet above sea level where you can take a stroll through the city on your own or continue the ride up Trail Ridge Road to an elevation over 11,000 feet. There is plenty for all ages to do while in Colorado and the Mile High City.

Saturday May 29th
Fly into Denver International Airport and you will know you’re in Colorado when you see the famous airport roof designed to resemble the snowcapped Rocky Mountains. Conveniently located in the center of the United States, DIA is a natural hub in the aviation industry. HAPS registration begins in the early afternoon where you’ll receive all of your information for the days ahead. Once safe and sound in your hotel room, you can choose between attending a Colorado Rockies baseball game, walking the 16th street mall or lounging by the pool or hot tub high above the city with panoramic mountain views. There is sometimes a welcome reception that night where you can meet and greet old and new friends (see the conference brochure for details).

Sunday May 30th
The conference begins with a continental breakfast in the exhibit hall or a welcome breakfast for those attending a HAPS conference for the first time. The day is filled with update talks, poster sessions, and time to visit the exhibits. On Sunday night, we will have dinner at the Denver Museum of Nature and Science. There you will be able to interact with the new exhibit, Exhibition Health, and start your own personal health expedition while taking in one of the best views of City Park, the Denver skyline and the Rock Mountains. This evening event requires a ticket (see conference brochure and registration).

(Continued on page 9)
Dr. Dean Wong gave a fascinating talk on PET imaging and its use in medical diagnoses and treatments. He began by explaining the mechanisms by which PET, positron emission tomography, is able to image the metabolism of glucose in the brain.

PET works by measuring the emission of positrons in the brain tissue. A positron acts like an electron, but it has a much shorter lifespan. The positron will interact with positive or negative molecules and then a particle is emitted as energy. Specifically, this occurs as the positron is able to travel 1-4 nanometers across a tissue until it comes into contact with an electron. Once the two meet, they combine and are reduced to two photons of light. A positron-containing tracer is administered intravenously to a patient usually 60-90 minutes prior to the scan. The tracer, often C-N-methylspiperone or 2-fluoro-2-deoxy-D-glucose will become trapped in cells that try to metabolize the molecule and its concentration will be in proportion to the rate of glucose metabolism. The release of light photons is then measured by the PET and brain activity can be measured. Tracers such as [11C] raclopride are also used to measure uptake by D₂ dopamine receptors in the brain, a focus of Dr. Wong’s early research.

Dr. Wong engaged the audience with his description of the first time D₂ dopamine receptors were studied using C-N-methylspiperone as a radiotracer (Wagner et al. 1983). We could all imagine Dr. Wong’s graduate advisor threatening the young scientist and his hopes of a prosperous career if Dr. Wong did not inject the dye into his advisor’s arm. While the results are now considered priceless, the fear evoked by graduate advisors on many levels added a jovial and intriguing atmosphere to the talk.

Using the PET to image D₂ dopamine receptors, Dr. Wong and colleagues have found that these receptors decrease in number with age. This decrease in abundance is also more rapid in males than in females (Wong et al. 1984). Nordstrom et al. (1998) have also used PET to examine the fluctuation of D₂ dopamine receptors during the menstrual cycle. These small differences are presumed to be caused by hormonal variation during monthly cycling.

Currently, PET studies are a starting point with most psychiatric drugs. This technology enables investigators to determine if the drugs are actually working in the brain prior to the initiation of a trial. For example, schizophrenia, a chronic disease that impacts 1.1% of the U.S. adult population (Schizophrenia 2009) is believed to be caused by a lack of resting time for neurons. PET scans are now being used to visualize dopamine and glutamine uptake in the brains of schizophrenics during the administration of drugs in order to find the most effective treatment regime.

Dr. Wong also recapped the work of Koepp et al. (1998) that used PET to study the role of dopaminergic transmitters in learning and reinforcement of behaviors. This study analyzed the brain chemistry of young males while playing a video game. For each level in the video game that the test subject completed, he was awarded a monetary gain. [11C] raclopride was used to measure changes in extracellular dopamine levels in the brain during the task. The study found decreased binding to [11C] raclopride during video game play when compared to baseline uptake. This indicated that larger quantities of dopamine were being released and binding to the receptors instead of the [11C] raclopride. This groundbreaking study was the first to show in vivo behavioral conditions causing the release of dopamine and was only possible through the use of PET.

Additionally, this same technique has been employed by Dr. Wong and colleagues (Oswald et al. 2005) to study the interrelationship of stress, cortisol release, dopamine release, and addiction to drugs and alcohol. Using PET technology, patients were interviewed about their feelings and state of anxiety while undergoing a brain scan. This, like the video game study, allowed scientists to measure mesolimbic dopamine (DA) during administration of intravenous amphetamine (AMPH) as well as a placebo. This study found increased levels of cortisol release were

(Continued on next page)
linked with increased AMPH-induced DA release in the brain as well as more positive subjective effects described by the subjects. Also, the use of PET linked highly positive subjective interviews with the release of greater DA in many subregions of the brain including the left ventral stratum, left and right dorsal putamen, and the left and right dorsal caudate nuclei. The findings of this study can be used in future pharmacotherapy development for drug and alcohol dependence.

Dr. Wong's current research involves the use of PET and single photon emission computed tomography (SPECT) to study the comorbidity of Tourette's syndrome and obsessive-compulsive disorder (OCD). He has measured dysfunction of dopamine and serotonin metabolism as well as an increase of amphetamine-induced dopamine release in patients with both Tourette's syndrome and OCD (Wong 2008).

The work of Dr. Wong provides a link between the cognition, neurochemistry, and behavior. The talk spanned the work of the past twenty-five years that has been accomplished through the use of PET. The audience came away with a better understanding of the equipment and an appreciation of the great advances in medicine and physiology that have been gained since its introduction.

References


The interest in teaching Anatomy or Anatomy and Physiology online is increasing due to several factors. Colleges are not increasing the numbers of lab rooms or the budgets, but increasing numbers of students are enrolling in these courses.

In Betsy’s case, a need arose to offer additional anatomy lab sections to meet the needs of students from a local university. There was no space available on her campus for such a lab, so she developed an online version of an anatomy lab. Her course runs eight weeks and includes online testing in a secure, proctored testing center. She currently uses A&P Revealed from McGraw Hill Higher Education as a visual simulation tool in her course. She likes the detail of the images and the ability to manipulate images to create lessons and exams. Betsy listed other suitable programs including Practice Anatomy Lab (Pearson), Real Anatomy (Wiley), ADAM, VH Dissector and Online Netter (Elsevier) as possible alternatives.

Lansing Community College currently uses the ANGEL course management system. Betsy pointed out the importance of being highly organized and giving very clear instructions to online students. The lab guide she has created for her course is embedded within the lessons. Students must work with the lab guide before completing assignments or assessments.

An excellent discussion occurred among those attending the workshop. Some pointed out the need to compress files uploaded to any online course site to assist students who might be downloading course materials using slower internet connections. Others described the effectiveness of Respondus, a software program that can be used in conjunction with course management systems in order to increase exam security. Still others brought up the service provided by Lab Paq (see workshops 205 and 604), which allows students to purchase specimens for dissection and kits for other experiments related to A&P. One person pointed out the need to specify which browser(s) work best with a given software program. For example, Anatomy and Physiology Revealed does not work with Safari (for MacIntosh) but does work with Firefox.

The group was interested in the performance of online students vs. on campus students. Betsy reported that the online students did as well or better than the on campus group.

Betsy’s workshop gave us useful information and helped us formulate more questions for the other workshops re: distance learning at HAPS 09.

If you are teaching anatomy or anatomy & physiology as a fully online course and would like to collaborate on teaching methods, assessment issues, comparison of online to face-to-face sections, etc., please feel free to contact Betsy at brantlb2@lcc.edu.
Students Perform better on Anatomy Laboratory Assessments with the Opportunity to Attend an Additional Unstructured Review Lab

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and

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Minneapolis, MN 55455

Introduction
The Human Anatomy laboratory is a critical supplement to the lecture.

This study was undertaken to examine the impact of unstructured review time – in addition to the structured lab time - on performance in the lab practical exam.

Significant Learning Opportunities in Unstructured Laboratory:

- “Time-on-Task”
- Problem-solving (discovery)
- Team work/Consultation (small group activities)
- Integrating and finding interactions of structures
- Proficiency using the language called Anatomy (“language lab”)
- Development of psycho-motor skills
- Using peer-teaching to learn
- Working with the cadavers develops motor skills
- Assume the tenets of professionalism
- Promotion of active (self-directed) learning over passive learning
- Select the appropriate supplement materials
- Develop a system of learning that works for them
- Learning How-to-Learn
- Obtaining critical-self-assessment

Hypothesis
Students who attend OPEN LAB (additional unstructured review lab) perform better on exams, despite the lack of formal instruction. There are many learning opportunities – all of which are important and lead to better learning in Anatomy.

Research Question
Do students who attend additional, unstructured, lab sessions perform better on practical exams than students who do not?

(Continued on next page)
Methods

- Our Human Anatomy is a one-semester undergraduate course offered by the Program in Human Anatomy Education.
- The Laboratory course is highly recommended, but not required.
- The course is taught as systems-based, not regional.
- The lab meets once per week for 2 hours.
- The lab consists of tutored (formal instruction) investigation of 18-20 prospected human cadavers and excised organs.
- OPEN LAB = an additional 4 hours per week as a review lab, or non-structured review (Tutors are available, but there is no formal instruction. Students have the opportunity to come and go as they wish.)
- Lab registration = 445 students:
  - 43% seniors;
  - 26% juniors;
  - 17% sophomores;
  - 0% freshmen; and
  - 14% other.
  (Note: Many of the sophomores are advanced placement freshmen).
- Attendance in OPEN LAB:
  - 368 students did not attend;
  - 77 students attended:
    - 37.7% seniors;
    - 16.9% juniors;
    - 23.4% sophomores; and
    - 22.1% other.
  - This suggests that the OPEN (review) LAB has the same distribution as the course as a whole and did not select for students by academic class.

- All laboratory students in the course also had unlimited access to our password protected course website (WebCT/ Blackboard).
- Laboratory Practical Exam:
  - 80% multiple-choice
  - 20% short-answer
  - 8% (extra-credit) second-order
- Performance on the laboratory practical exam was analyzed
  - Students who attend OPEN LAB versus
  - Students who do not attend OPEN LAB.

(Continued on next page)
Results

Multiple Choice Questions

- **9.2% increase, P < 0.0001**

Short Answer

- **22.8% increase, P < 0.0001**

Second Order Question

- **37.0% increase, P < 0.0024**

Total Score

- **12.0% increase, P < 0.0001**

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Difference in Performance

<table>
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<tr>
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P < 0.0201

(Continued on next page)

**A TAXONOMY OF SIGNIFICANT LEARNING**

1. **Foundational Knowledge**
   - "Understand and remember" learning
     - For example: facts, terms, formulae, concepts, principles, etc.

2. **Application**
   - Thinking: critical, creative, practical (problem-solving, decision-making)
   - Other skills
     - For example: communication, technology, foreign language
   - Managing complex projects

3. **Integration**
   - Making "connections" (i.e., finding similarities or interactions)...
     - Among ideas, subjects, people

4. **Human Dimensions**
   - Learning about and changing one's SELF
   - Understanding and interacting with OTHERS

5. **Caring**
   - Identifying/changing one's feelings, interests, values

6. **Learning How to Learn**
   - Becoming a better student
   - Learning how to ask and answer questions
   - Becoming a self-directed learner

(Continued on next page)
Conclusions

Students who attended OPEN LAB (additional unstructured review lab) performed better on exams.

Despite the lack of formal instruction in the unstructured lab, there are many learning opportunities – all of which are important and lead to better learning in Anatomy.

These include:

1. Foundational Knowledge (cognitive domain)
   ✓ “Time-on-Task” used to identify, name and remember.

2. Application (cognitive domain)
   ✓ Solves problems to identify structures from textual figures.
   ✓ Distinguishes, compares, and understands structures.
   ✓ Evaluates, discriminates, and deduces the correct identification.
   ✓ Employs team work/consultation to accomplish these tasks.

3. Integration (cognitive and psychomotor domains)
   ✓ Integrates and finds interactions of structures.
   ✓ Proficiency using the language called Anatomy (“language lab”).
   ✓ Develops psycho-motor skills.
     ➢ Imitates Teaching Assistant to locate and identify structures.
   ✓ Uses peer-teaching to understand, organize, and demonstrate.
     ➢ Becomes precise, accurate, and exact.
     ➢ Becomes articulate with Anatomy language.
     ➢ Becomes natural – easily identifies and describes structures.
     ➢ Develops creative ways to teach anatomy to peers.

4. Human Dimensions, and

5. Caring (affective domain)
   ✓ Internalizes a value system to control behavior, actions, and practices.
   ✓ Assumes the tenets of professionalism.

6. Learning how to learn (cognitive and affective domains)
   ✓ Promotes active (self-directed) learning over passive learning.
     ➢ Actively participates by discussing and presenting.
     ➢ Organizes, develops a system, and is able to verify.
   ✓ Selects appropriate supplemental materials.
     ➢ Evaluates and compares productivity with success in lab activities.
   ✓ Develops a personal system of learning.
     ✓ Obtaining critical-self-assessment.
     ➢ Able to make judgments and comparisons based upon success in lab activities.

(Continued on next page)
LEARNING DOMAINS or BLOOM’S TAXONOMY (BH Butler, 2002)

(I) Cognitive domain (Anderson and Krathwohl, 2001):

<table>
<thead>
<tr>
<th>Learner’s Behavior</th>
<th>Key Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remember:</td>
<td>Defines, describes, identifies, lists, names, recalls, recognize states</td>
</tr>
<tr>
<td>Understand:</td>
<td>Distinguishes, compares, understands, classifies, explains, infers</td>
</tr>
<tr>
<td>Apply:</td>
<td>Applies, demonstrates, predicts, prepares, shows, solves, uses</td>
</tr>
<tr>
<td>Analyze:</td>
<td>Analyzes, compares, differentiates, distinguishes, infers</td>
</tr>
<tr>
<td>Evaluate:</td>
<td>Evaluates, compares, discriminates, deduces, justifies, explains, interprets</td>
</tr>
<tr>
<td>Create:</td>
<td>Integrates, creates, develops, compiles, designs, reorganizes</td>
</tr>
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</table>

(II) Psychomotor domain (RH Dave, 1970):

<table>
<thead>
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<th>Learner’s Behavior</th>
<th>Key Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imitation:</td>
<td>Imitates, copies, follows, reproduces</td>
</tr>
<tr>
<td>Manipulation:</td>
<td>Adjusts, calibrates, connects, focuses, builds</td>
</tr>
<tr>
<td>Develop Precision:</td>
<td>Assembles, calculates, sets-up, precise, accurate</td>
</tr>
<tr>
<td>Articulation:</td>
<td>Integrates, coordinates, combines, regulates, shapes</td>
</tr>
<tr>
<td>Naturalization:</td>
<td>Creates, formulates, designs, invents, constructs, develops</td>
</tr>
</tbody>
</table>

(III) Affective domain (Krathwohl, Bloom, Masia, 1964):

<table>
<thead>
<tr>
<th>Learner’s Behavior</th>
<th>Key Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receiving:</td>
<td>Asks, acknowledges, responds, retains, processes</td>
</tr>
<tr>
<td>Responding:</td>
<td>Participates, discusses, presents, performs, assists, practices</td>
</tr>
<tr>
<td>Valuing:</td>
<td>Completes, commits to, differentiates, explains, initiates, justifies</td>
</tr>
<tr>
<td>Organizing values:</td>
<td>Organizes, alters, combines, defends, explains, synthesizes</td>
</tr>
<tr>
<td>Internalizing values:</td>
<td>Internalizes, assumes, acts, discriminates, influences, proposes</td>
</tr>
</tbody>
</table>

This article was presented as a poster at the HAPS Annual Conference in Baltimore, MD, May 2009.

Additional Sources of Information


Overbaugh RC, Schultz L. Old Dominion University.
As educators of students who are entering the health care fields, we have a responsibility to explore scientifically contentious matters. Many of our students hold science to have “proven” nostrums such as fat is bad for you, or salt is dangerous, or even early detection of cancers (such as prostate cancer) is always beneficial. While many scientific findings, and their associated popular acceptance, will stand the test of time, many do not hold up. The value of using the cholesterol question as a “case study” for our students is that it can engender a certain healthy skepticism towards new ‘findings’, towards their textbooks, towards our pronouncements in the classroom.

Research conclusions of the last few decades concerning diet and cholesterol and their effect on cardiovascular health have been based on contradictory and/or misinterpreted findings. Unfortunately, popular perceptions and practical applications in this area are not based on scientific results. Our students and many others are only cursorily aware of this contradiction and they often follow the ‘settled wisdom’ in their daily lives. Furthermore, our A&P textbooks and other scientific writings do not reflect this controversy, but instead accept and re-enforce the settled wisdom. We, as members of the science/health community, should examine these data and lead the population in a re-evaluation of the accepted perceptions. It is up to us, as educators of the future generation of health-care practitioners, to provide this “case study” of the controversy that exists on the cholesterol question. The social and medical confusion on the (misleading) importance of both dietary and blood cholesterol translates into unsubstantiated and possible harmful decisions on diet and medication, and needless worry for the population.

Following are data that should lead to questions on this topic, and help persuade us that science is an ongoing endeavor that provides new, and often contradictory, findings that can alter or overturn current truths.

Where did it begin? One of the starting points for the idea that cholesterol, and meat, and saturated fats, are highly deleterious to our nation’s health came from studies of Ancel Keys. Let us examine one of his publications that, although refuted many times, nonetheless still retains the aura of fact. The “wisdom” of low-fat diets was championed by Ancel Keys in a 1953 publication (Keys 1953). His graph, shown here in Figure 1A, is very convincing, showing us that as per capita fat consumption rises, so does coronary heart disease. What he did not show were total data available at that time which, as shown in Figure 1B (from Ravnskov 2000, p19-20), tell a very different story. Figure 1A is certainly compelling; one easily assumes that increasing dietary fat consumption correlates so perfectly to increasing coronary heart disease that it might well be assumed to show a causative relationship, and not just a correlative one. But Keys left out other data that did not fit his “fats are unhealthy” hypothesis; these data are shown in Figure1B. Here we see, at best, a weak correlation, so weak that the question of causation could never be raised convincingly.

(Continued on next page)
But these findings are about dietary fats. What about levels of cholesterol in the blood and coronary heart disease (CHD)? One argument often put forth is that coronary atherosclerosis (the thickening of the walls of the arteries that supply the heart) is due to buildup of cholesterol on these artery walls and, therefore, the higher the blood cholesterol, the more the buildup. This is certainly a valid starting point for scientific study but does not serve us well as proving a causative relationship.

Figure 2 (from Ravnskov 2000, p116) graphically shows data from a study that addressed this question. The data shown here are measurements of individuals' arterial wall thickness and their blood cholesterol levels. Does Figure 2 show causation, or even a correlation, between blood cholesterol levels and coronary atherosclerosis? These data, as plotted, show virtually no relationship between atherosclerosis and cholesterol.

But there seem to be so many studies that show higher blood cholesterol levels increase overall mortality risk and cardiovascular risk. Examining the data, from the so-called definitive Framingham study and from numerous other studies, indicates that this is not the case. Looking at Figures 3A-B (Taubes 2008, p82) we can ask if blood cholesterol levels provide us with an accurate picture of risk of cardiovascular mortality or of overall mortality.

In Figure 3A we see that for total mortality in females there is an inverse relationship (that is, the lower the blood cholesterol levels, the higher the total mortality rate, the exact opposite of the usual assertions.) For males the picture is a little less clear. In Figure 3A we see that low blood cholesterol (below 160 mg/dl) and high blood cholesterol (above 240 mg/dl) show equal and slightly higher total mortality risk than the normal and moderately elevated blood cholesterol levels. Clearly, it cannot be said that blood cholesterol levels correlate consistently with mortality rates. As far as cardiovascular risk for females, Figure 3B indicates that cardiovascular mortality rates are similar at all blood cholesterol levels. For males, the rates of mortality due to cardiovascular disease show a positive
correlation with blood cholesterol levels above 200mg/dl, but note that the relative risk for a fatal cardiovascular event also increases with blood cholesterol levels below 160mg/dl (which contradicts the frequent assertion that “there is no such thing as a cholesterol level that is too low”). These data indicate that the link between blood cholesterol levels and human health is tenuous (and actually probably non-existent) and do not provide us with the rationale to use blood cholesterol levels for public health measures, nutritional advice, or medical interventions.

Another study examining this cholesterol/cardiovascular disease (CVD) relationship concerns the age factor. We have seen that there is virtually no increase with either CVD mortality rates or total mortality rates associated with cholesterol in women. For males, the picture is less clear. It should be pointed out here that the overwhelming amount of CVD is found in individuals over 50. CHD deaths below 50 years old account for 3% of total CHD deaths, and over 50% of CHD events occurring in the 5% of the population that is over 74 years old. The Framingham Study looked at cholesterol levels for males over 48 years old and found that they do not correlate with survival rates.

Figure 4 (data from Anderson et al, 1987) is a plot of the data obtained for a cohort of males aged 48, where their blood cholesterol levels were determined and plotted against the time they remained alive. Here we see that after the age of 48, while those men with the highest cholesterol levels died the earliest, the second group with the shortest survival time had levels lower than the group with the third longest survival times. This argues that overall survival rates for men are not causally linked to blood cholesterol levels. If it were causally linked, for each cholesterol grouping, going from lowest cholesterol levels to highest, there should be a decreasing time of survival. This is clearly not so.

It still might be argued that there is a relationship between blood cholesterol levels and CVD mortality for males as indicated by the data for the males in Figure 3B. Again, although higher blood cholesterol levels do increase male CVD mortality, they do not increase overall mortality, which indicates that there are confounding issues at play here. It is beyond the scope of this paper to explore this.

Figure 5. The distribution of the participants in the Framingham project according to their blood cholesterol. The solid line represents 1378 individuals without coronary disease; the broken line represents 193 patients with coronary disease. Data from Kennel, Castelli and Gordon.

The Framingham Study is an epidemiological study that has been ongoing since 1948. It has been used to examine numerous factors associated with health and disease questions in the U.S. population, and is
often credited with findings that show cholesterol to be a societal problem. Figure 5 is a graph from those findings and is usually presented as indicating that blood cholesterol levels are definitively associated with CHD (coronary heart disease) mortality. This graph represents an interesting prospective study. The data were obtained from 1571 individuals who had their blood cholesterol levels determined at the start of the study and were followed for the next 16 years and their health outcomes tabulated. It should be noted that rather than presenting the raw data, the study’s authors normalized the results before graphing, thus presenting a more convincing, albeit distorted, “proof” of their hypothesis. Also, included in the results for those suffering the CHD outcomes are individuals with blood cholesterol levels over 350. These individuals are usually those with the genetic disorder familial hypercholesterolemia, and should be considered outliers in studies of this kind. Including these individuals distorts the graph and improperly strengthens the “proof” offered by the authors. In this study, out of the original group, 1378 did not suffer CHD events, while 193 did. What Figure 5 is purported to show is that increasing cholesterol levels are detrimental and can be used as predictors of future CHD. Actually, it is clear that the majority of those stricken had “good” cholesterol levels. If we looked at the actual numbers, and not the normalized figures, we would see that at any level of cholesterol the number of those stricken was less than those who did not show adverse events. The great overlap of the presented curves demonstrates that cholesterol levels provide no predictive value for CHD events. And speculating here, what might be the correlation of the cholesterol levels with resulting deaths due to all causes? (Smith 1991, p140, after Kannel et al 1979.)

Out of the original group, 1378 did not suffer CHD events, while 193 did. What Figure 5 is purported to show is that increasing cholesterol levels are detrimental and can be used as predictors of future CHD. Actually, it is clear that the majority of those stricken had “good” cholesterol levels. If we looked at the actual numbers, and not the normalized figures, we would see that at any level of cholesterol the number of those stricken was less than those who did not show adverse events. The great overlap of the curves demonstrates that cholesterol levels provide no predictive value for CHD events. And speculating here, what might be the correlation of the cholesterol levels with resulting deaths due to all causes? (Smith 1991, p140, after Kannel et al 1979.)

The findings discussed provide contradicting data to the usual ‘cholesterol is bad’ dogma. But these results have not been accepted, or have been “explained” away, by members of the medical/health/nutritional fields, and many medical practitioners have persisted in advocating lowered cholesterol for the general population. Unfortunately the textbooks found in our classrooms do the same. Instead of presenting the science, they present the current wisdom as though it were as factual as that the femur is the largest bone in our body. We are educators of health science and would better serve our students by presenting the controversy and not just repeating the dogma.

In addition to the overall anxiety associated with the constant concern about our blood cholesterol levels and our diet, the expense for physician visits, lab tests, special diets, and medications (pharmaceutical as well as alternative) is huge. These factors lead to two questions: 1) Can we lower our blood cholesterol by diet, or are medications necessary? and 2) Does lowering blood cholesterol protect against CHD and CVD? Regarding the first question, the basic principal of homeostasis comes into play. Six out of seven individuals do not experience a decrease in blood cholesterol in response to diet to a clinically-significant degree. This failure is often associated with guilt, self-deprecation, and even a scolding by the physician -- even though homeostatic mechanisms are normal physiological phenomena, and homeostasis is what we teach! Then come medications, usually statins. These are expensive, and worse, often have side-effects that can range from annoying to dangerous.

But the push for lowered blood cholesterol goes on, so that the second question, Does lowering blood cholesterol protect against CHD and CVD?, becomes more important. Chart 1 (Ravnskov 1992) answers this, and it does not support these prescribed attempts. Yes, reducing blood cholesterol does protect against non-fatal heart attacks, but no, definitively not, for fatal heart attacks. What is worse is that the data indicate that lowered blood cholesterol even leads to an increase in overall mortality.

Associated with the question of CVD and cholesterol and diet is the ongoing demonization of eating red meat and its associated saturated fat. But, is saturated fat a problem? If so, then an increase in consumption should lead to an increase in CHD mortality. Chart 2 shows that this is not the case. (Ravnskov 2000, p43)

And these data are not the only ones weighing in on this controversy. For instance, it was concluded that a recent study showed: “At eight years of follow-up, a fat-reduced diet was not associated with reduced risk for breast or colon cancer, heart disease, stroke, or cardiovascular disease…” (Beresford et al 2006; Howard et al 2006). Where do we go from here? Even if you remain unconvinced by the data and arguments presented above, this article will have served its purpose if it has caused you think about how you present this and related material when you teach nutrition, or to pause the next time you are in the food market or at your physician’s office. The value of using the cholesterol question, and other similar research findings, in the classroom is that it prompts a critical thinking and a healthy curiosity in our students. An open, questioning mind will keep the soon-to-be practitioner alert to possible new findings that challenge or even change current practices. If this does happen then we will have done our jobs well.

(Continued on next page)
Chart 1: Overall results of 26 controlled cholesterol-lowering trials. The number of individuals in the three calculations is not identical because a few trials did not give the number for all end points.

<table>
<thead>
<tr>
<th></th>
<th>Treatment Groups</th>
<th>Control Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Individuals</td>
<td>59,514</td>
<td>53,251</td>
</tr>
<tr>
<td>Nonfatal Heart Attacks</td>
<td>2.8%</td>
<td>3.1%</td>
</tr>
<tr>
<td>Number of Individuals</td>
<td>60,824</td>
<td>54,403</td>
</tr>
<tr>
<td>Fatal Heart Attacks</td>
<td>2.9%</td>
<td>2.9%</td>
</tr>
<tr>
<td>Number of Individuals</td>
<td>60,456</td>
<td>53,958</td>
</tr>
<tr>
<td>Total Number of Deaths</td>
<td>6.1%</td>
<td>5.8%</td>
</tr>
</tbody>
</table>

After Ravnskov 2008.

Chart 2: These figures show that Mediterranean people ate much more saturated fat in 1991-92 than 25 years earlier, but during the same period (with 5-6 years displacement) the number of heart attack deaths increased a little in only two of the countries; in the other three it decreased, and to a marked degree.

<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Italy</td>
<td>+69</td>
<td>-61</td>
</tr>
<tr>
<td>Greece</td>
<td>+65</td>
<td>+13</td>
</tr>
<tr>
<td>Spain</td>
<td>+43</td>
<td>+10</td>
</tr>
<tr>
<td>Portugal</td>
<td>+10</td>
<td>-46</td>
</tr>
<tr>
<td>France</td>
<td>+28</td>
<td>-20</td>
</tr>
</tbody>
</table>

Data from 1986 FAO Production Yearbook 40, 1987; and World Health Statistics Annual, 1983

References


Howard BV et al. 2006. Low-Fat Dietary Pattern and Risk of Cardiovascular Disease: The Women’s Health Initiative Randomized Controlled Dietary Modification Trial. JAMA 295(6):655-666


Yerushalmy J, Hilleboe HE. 1957. Fat in the diet and mortality from heart disease; a methodologic note. NY State J of Med. 57(14):2343-2354

Richard Pollak, Ph.D. June 30, 2009
Abstract
Traditionally, clinical skills are taught in the graduate medical setting. At the undergraduate level they are occasionally introduced in premedical society workshops. Teaching undergraduate students basic suturing in the anatomy and physiology laboratory creates a unique opportunity for students to reinforce their basic understanding of body tissue organization and to apply their understanding clinically as they perform psychomotor skills. The equipment and supplies are relatively inexpensive and easily obtained. Suturing can be taught concurrently with or after the integumentary system lab session. Although pigs’ feet are commonly used for this wet-lab, most dissection specimens already utilized can be substituted. Furthermore, this concept has great versatility and can be modified to meet the needs of any current A&P laboratory curriculum.

Background
It is difficult for most undergraduate students in the anatomy and physiology (A&P) laboratory to do more than just identify and memorize the names of anatomical structures as they are usually doing “cookbook” lab exercises that have little problem-solving or critical thinking components. Using an inquiry approach can lead to more active participation by the students that requires higher-order thinking skills (Meuler 2008). This technique is common at the undergraduate medical level (Gogainiceanu et al 2008; Weyrich et al 2008; Shabbir 2008) with the students developing three-dimensional orientation, dexterity, and team-working skills. For safety reasons, the shift has been for students to learn procedural skills in the laboratory instead of first practicing them on patients (Dubrowski and Macrae 2006). Basic suturing is recognized as an essential psychomotor skill (O’Connor et al 1998) and the effectiveness of laboratory training of undergraduates in suturing has been tested using porcine skin successfully (Lamawansa and Perera 2007). A free online suture manual is available at http://www.scribd.com/doc/7248940/Wound-Closure-Manual as a reference.

Equipment & Supplies
Most of the tools required for this activity can be found in most anatomy and physiology laboratories (Fig 1) with the exception of needle drivers and suture material. Besides purchasing, it may be possible to obtain these items from local hospitals and outpatient surgery centers. Surgery departments often contain outdated sutures or open, non-sterile packages of sutures. Pig’s feet are commonly used to train students in suturing, however current organisms such as cats or fetal pigs or individual organs can be used.

Fig 1. Various materials needed for suturing.
Objectives & Timing
Students in A&P I, A&P II, and Human A&P can all take part in this lab exercise. The three primary objectives (Fig 2) will assist the instructor in planning the best time to present the training. The major objectives incorporate specific competencies. All three groups will develop manual dexterity, the ability to identify neurovascular structures, and the ability to navigate body layers. A&P II and Human A&P students will be able to relate wound physiology and specific clinical applications.

Fig 2. Primary objectives of a suturing lab and options.

Methodology
In the summer of 2008, students enrolled in A&P I, A&P II, and Human A&P were given separate suture exposures based upon the objectives and timing listed above. A&P I students were trained early in the semester concurrent with the integumentary system. A&P II students were trained midway in the semester after covering the lymphatic system. Human A&P students were trained near the end of the semester. All students received the same suture training consisting of a 10 minute demonstration by the instructor followed by students in teams of two performing the basic technique known as simple interrupted suturing. Students then took turns making incisions and closing the wounds for the next 50 minutes. At the conclusion of the session, students were asked to answer questions related to the objectives along with a brief survey.

Technique
The simple interrupted suture technique is very useful to close most wounds. As diagrammed in Figure 3, it is a basic stitch that forms a rectangle pattern to close down the center of the wound. The ‘rule of halves’ will then be followed until the wound is reapproximated.

Fig 3. Simple interrupted suture pattern.

(Continued on next page)
**Training**

Teamwork is vital in today’s healthcare workplace, so have your students pair up during the training session (Fig 4). One student takes on the role of surgeon and the second student takes on the role of assistant. They then switch roles.

![Fig 4. Teamwork in suturing.](image)

**Discussion**

The equipment, materials, and supplies needed to perform this lab are readily available in most A&P labs that do dissection. Although not ideal, a hemostat can be used in place of a needle driver. Although pig’s feet are used in this presentation, other dissections such as fetal pigs, cats, organs, or synthetics can be usable replacements. The greatest financial cost will be the suture materials. Students can sometimes obtain outdated supplies from hospitals and medical offices. A primary consideration will be the trainer. If the instructor is not versed in suturing, then a suitable stand-in such as a medical student, physician, dentist, etc. can be recruited from the community. The students demonstrated a normal distribution of dexterity. They were stimulated by the multi-tasking required to perform a manual task early in their career development. The student surveys suggest that the benefits of this training to the student include motivation, self-esteem, teamwork, communication skills, and safety.

**Conclusion**

Suturing is a clinical skill that is currently not taught in the undergraduate anatomy and physiology laboratory. Taking an hour out of the anatomy and physiology schedule for a suture session can have tremendous value. A single session of formalized teaching in procedural skills introduced early in the undergraduate medical curriculum was seen to lead to long-term effectiveness in basic skills competence (Liddell et al 2002). Student feedback will provide evidence if this holds true for college undergraduates as well. Future assessment of the impact of this lab should consider pretest and posttests and incorporate computer simulations.

**References**


Abstract
Computer-based data acquisition systems provide students the opportunity to use sophisticated technology to acquire data on human physiology. The ability to acquire, display, store, and analyze data using technology-enhanced learning experiences provides hands-on experiences that students may later use in research laboratories and medical institutions. This paper describes a guided inquiry lab activity that uses a computer-based data acquisition system to measure electroencephalograms (EEGs). Guided inquiry lab activities complement the step by step lab formats that are provided with the system. Results showed that students found the inquiry based EEG lab to be an interesting and effective way to learn about the nervous system.

Introduction
There exists a lack of guided inquiry labs for computer-based data acquisition systems. The software that is often included with the system directs the student through a number of steps to obtain data. (Biopac Systems 2002) Students follow step by step instructions in a manner that has been described as cookbook format. Those students who are comfortable with interactive computer programs find the cookbook format easy to follow but they may collect data without understanding its meaning. In contrast, guided inquiry labs empower students to critically think about the physiology that is being measured and to apply those physiological principles to real life situations. Inquiry labs have been demonstrated to improve student learning. (Bybec 2002; Ertepmar and Geban 1996; Meuler 2008; Wilke and Straiis 2007)

I use a computer-based data acquisition system in my undergraduate Human Biology class, a one semester course for non-science majors. Although experiments involving the muscular, nervous, cardiovascular, and respiratory systems frequently utilize these systems, I chose to focus on the nervous system. Without instrumentation for data acquisition, measuring quantitative neurological parameters is more limited than measuring other body systems such as the muscular or cardiovascular systems. The ability to measure EEGs adds depth and creates hands-on learning directly related to the nervous system.

Methods
The experiment described here used the Biopac data acquisition system, but can also be done with similar systems on the market. The EEG test procedure described here eliminates the need for shaving the head and allows quick application of electrodes. EEG measurements are made by placing three electrodes on strategic locations on one side of the head. The black lead is the ground connection at zero volts. Thus, it acts as the baseline for the red and white electrode measurements. The black electrode is placed on the lower ear lobe, the white electrode on the temple, and the red electrode behind the ear lobe. Voltage measurements are taken at regions marked by the red and white electrodes, and the voltage difference between these two points represents the magnitude of the raw EEG. Application of electrodes in this manner is simple and allows students to gather data quickly.

Experimental Procedures
Guided inquiry labs can be done with all levels of students as demonstrated here with a majority of students who have little background in science. The most common major in my Human Biology class is Psychology, and those students tend to be most interested in the nervous system. Prior to lab, we discuss the various types of brain waves and their functions as a method of engaging students to question their own brain functions. The lecture meets twice weekly for one hour and fifteen minutes.
and the lab meets once per week for one hour and fifty minutes. A pre-lab assignment is given for each student to identify and explore conditions that cause changes in brain waves. (Figure 1) Students may refer to reference books for descriptions of the basic EEG wave forms.

**Figure 1: Pre-lab Assignment for Brain Waves**

<table>
<thead>
<tr>
<th>For each scenario, what type of brain waves would you expect to be most prevalent?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Driving a car.</td>
</tr>
<tr>
<td>2. Meditation with your eyes closed.</td>
</tr>
<tr>
<td>4. Dosing off during class.</td>
</tr>
<tr>
<td>5. Arguing with your roommates.</td>
</tr>
<tr>
<td>6. Sunbathing on a beach (not sleeping).</td>
</tr>
<tr>
<td>7. Under hypnosis.</td>
</tr>
</tbody>
</table>

Why might brain wave patterns vary among different individuals? Think of three reasons.

The EEG Lab begins with students working in groups of three or four. Our labs have a maximum of 15 students each with one instructor and one data acquisition system per lab. The resulting 4 or 5 groups discuss their pre-lab assignment findings regarding conditions that cause changes in brain waves and take notes for their lab report introduction section. Students are asked to explore their differences and to hypothesize about potential wave differences among the members of the lab group. For example, personality types such as introvert versus extrovert affect alpha waves (Jausovec and Jausovec 2007; Konareva 2006). The amplitude of alpha waves is indicative of the level of alpha activity in the subject. Variables such as gender, state of relaxation, and level of concentration affect alpha wave activity (Jausovec and Jausovec 2007; Gunterik and Basar 2007). Subjects performing memory tests tend to have higher frequency alpha waves. Beta waves are accentuated when the subject opens the eyes or undergoes other sensory stimulation and with the performance of mental tasks (Tortora and Derrickson 2009). Emotional stress or frustration may stimulate theta waves (Tortora and Derrickson 2009; Gordeev 2007). It is doubtful that delta waves will be elicited unless a subject is able to engage in deep sleep (Tortora and Derrickson 2009).

Each group generates a list of possible hypotheses for an EEG experiment. As a class, students share their lists of hypotheses, ultimately choosing one hypothesis to test. Consideration should be given to the ease of data collection and data analysis. Identification of an experimental hypothesis is followed by an explanation of the specific methods to be utilized for their experiment.

General methods are a combination of instructions following the system's software program and the methods described below. Specific methods refer to the protocol that the group will be using to test their hypothesis. As the groups collect their data, it is displayed on the board at the front of the room for all to analyze.

**Materials and Methods**

**Required materials:**
- BioPac® Unit (MP30)
- BioPac® electrodes, 3 electrodes per subject, wash and use gel on each electrode
- BioPac® Electrode Lead Set
- BioPac® Pro Software
- Computer – Mac or PC
- Cloth "headband", ace wrap, or rubber cap to hold electrodes in place

1. Open up BSL (Biopac Student Lessons) Lessons 3.7 in the Start menu. Choose Lesson 3 (LO3-EEG-1). Type in your file name. Click OK.
2. Position the subject supine on the lab bench lying on blankets or towels.
3. Affix the 3 electrodes on the right side of the subject's head: one posterior to the lower ear lobe on the mastoid process, the second one on the temple next to the eyebrow (adjacent to the hairline), and the third behind the ear (in the triangle formed by the ear and hairline).
4. On your subject, connect the leads to the electrodes (black on the lower ear, white on the temple, and red superiorly behind the ear) and have the subject lie on the blanket on the lab bench. Electrodes should be held in place by tying a cloth headband (cut a piece of cloth roughly two inches by twenty four inches) or using an ace wrap around the head covering the electrodes. Alternately, a bathing cap or other hat may hold them in place.
5. Subject should relax and close his/her eyes.
6. Click on Calibrate. An error message will appear if the BioPac accessories are not plugged into the proper channels. If no error message, click on OK. Check your calibration data. Look for even, flat line, no spikes. If it contains erratic "static," recheck to secure electrode placement or add more conducting gel and repeat calibration.
7. When subject is completely relaxed, the data recorder should start the Biopac program by clicking on "Record." The program will then begin recording data. Record a baseline relaxed value for 10 seconds then have the data recorder press "Stop".
8. Determine whether your subject will be alert, engaged in mental activity, or relaxed for the duration of your experiment. One must avoid both eye movement and blinking when the eyes are open, as any movement will have a huge impact on results. Ignore computer generated instructions to open and close the eyes.

(Continued on next page)
9. Click on the frequency buttons in the top row in the following sequence: alpha, beta, delta, theta and print your results. Use the I-beam cursor to select and then measure amplitude and frequency of each wave type. Finally click “done”. Measurements of amplitude and frequency will be used to determine the type of waves generated. It may be useful to plot mean amplitude measurements for comparison of wave forms.

Results and Discussion
Each group saves data on the Biopac and prints their results to submit with their lab reports. During the analysis phase of the lab, students will be exposed to various brain waves and will utilize critical thinking skills to identify differences between individuals and changes within each subject’s EEG. The ultimate analysis is whether or not their hypothesis was proven according to the data they collected. Groups summarize their results and explain expected and unexpected outcomes. Data is shared with the whole class in order to draw conclusions from a larger population. A written lab report using sections for introduction, methods, results, and conclusions is due one week after completion of the lab.

After the lab, students were asked to fill out a questionnaire that was determined by the Endicott College Institutional Review Board to be exempt from approval process since it did not require students to identify themselves or their lab results. The three questions were: Was your hypothesis correct and if not, why do you think your data did not support your original hypothesis? What is your impression of using the Biopac to learn about the brain? How could the Biopac EEG lab be improved? Of the 27 students who performed the lab, 20 students returned the questionnaire.

Most students (85%) were successful in obtaining data that supported their hypotheses. The major areas for improvement were a better environment for their subjects, that the electrodes adhered better, and that the sample size was too small to accurately determine if their hypothesis was correct. Forty percent of the surveys noted that it was difficult to keep the electrodes in place. Purchasing new self stick electrodes rather than reusing electrodes with gel and headbands would solve this issue. Twenty percent of the surveys noted that it was difficult for the subjects to relax while lying on a blanket on a lab bench. Moving this activity from the laboratory to an unoccupied student lounge would improve the environment in the future. Fifteen percent were uncomfortable drawing conclusions about their hypotheses from a small sample size. Combining data from several labs would increase future sample size. Ten percent of students wanted more instruction on how to interpret the data they obtained. Lab instructors could work individually with the small number of students who need assistance in data analysis.

Ninety percent of students reported that they either found the lab to be a useful way to learn about the brain or they were interested in the lab. The two students who did not find the lab interesting or useful to learning noted that there were problems in obtaining data and that the data did not support the hypothesis. The majority of students who found the lab interesting showed enthusiasm in their exclamatory remarks.

Acknowledgments
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References
This is a true story, attested to by several witnesses.

My mom and dad managed a ranch in Northwestern Colorado before WW II. It was near Steamboat Springs in the Yampa Valley, a high mountain valley. The last winter before the war was particularly brutal for even that high elevation, but the fence lines still had to be checked. A man we will call Shorty had the turn on one awful January morning and left the bunkhouse to check the fences.

Noon came and went with no Shorty. Serious concern arose when Shorty had not come in by 3 PM or so. Some of the other “hands” went off in the pickup to see what had happened to him. They found poor Shorty’s body tangled in the barbed wire about three miles from the ranch house; he had to have been immobile for most of the day. Clearly he was dead since none of the cowboys could find a pulse, movement, or ventilation and his skin was pale.

The local physician was called as soon as they got Shorty’s body back to the ranch house. Since it was quite dark and cold by then and a wind had come up, the physician was not going to go out on a night like that just to declare someone dead. Therefore, the doc told my father to put the unfortunate man into the woodshed. Woodsheds in those days leaned up against a kitchen wall and usually had a door from the kitchen (the kitchen stove was a wood-burner) going into them, saving a trip out into the freezing wind.

All of the hands and even the owner gathered in my mom’s kitchen for a sort of wake that night. Mom put the coffee pot on; the escaping steam wafted about the kitchen. The wind whistled and the snow and ice blew, but it was nice and warm in that kitchen and some of that steamy warm air probably leaked into the woodshed. Suddenly around 9 PM the door to the woodshed creaked open slowly into the kitchen. Everyone was immediately quiet and fearful for there was only one person in that wood shed: Shorty.

Sure enough old Shorty walked slowly into the kitchen, looked around, blinked his eyes at the sudden light and said: “It was cold out there.”

Shorty survived the experience well enough to be drafted into the US Navy and was killed at sea in the Pacific.

Questions

1. Why would Shorty have been immobile but alive?

2. What vital signs of life would you have looked for if you had been one of the cowhands?

3. Why was it important that Shorty was not warmed up externally first?

4. In what type of operation might you induce hypothermia in a patient?

Answers

1. These are signs of severe hypothermia: Shorty’s peripheral skeletal muscles were unresponsive. The heart and respiratory muscles were moving very slowly since he had so little cellular respiration. The skin was pale because of peripheral vasoconstriction.¹

2. If you were a cowhand you would know something about palpating pulse either near the wrist or at the carotid. The latter is actually more likely since you might have had to do this with some cattle at some point. You might have also realized that you could hold a cold mirror up to the person’s mouth to look for breath condensation on the cold surface. You might check on the temperature of the skin under the clothes. We can assume Shorty would have been wearing many layers of wool and cotton clothes, hat, scarf, as well as heavy gloves for the day’s work. Finally, you might have checked for pupil fixation as a way of determining the cranial reflexes. The cranial reflexes are those that are due to brain activity and are still a good set of things to check for when you wonder about a patient’s brain death.

3. Heating only the outside of the body first may cause the warming blood to be shunted away from the vital internal organs. Since Shorty still had his winter clothes on when he was placed in the wood shed and out of the wind, he retained his radiant heat which helped to keep his temperature from falling even further. The warm air from the kitchen appears to have heated Shorty’s pulmonary circulation which then warmed the heart and finally the brain. Those two factors (the continued warm clothing and the warm moist air leaking) appear to be the main things the cowboys did in accordance with modern guidelines.² Hospitals now use heated, humidified oxygen along with warmed intravenous saline (centrally administered) and warm saline in the peritoneal cavity. Without any special equipment (absolutely lacking in an isolated ranch in the early 1940s), raising the core body temperature by leaving the patient in warm moist air seems to be the best idea in moderate or severe hypothermia. If you are interested in reviving a hypothermic patient, the Journal of the American Medical Association published some guidelines now available from a website.

4. Patients are cooled down during open-heart surgery and the heart...
slows. The body needs less oxygen if it is cool; therefore, the circulation need not be as efficient.

References


Enhance Student Retention and Understanding of Physiological System Integration: A Disease Assignment

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One-semester Human Physiology courses and two-semester Human Anatomy and Physiology courses cover a lot of information. In the process of learning the intricacies of each physiological system, students may lose focus of the human body as an integrative whole. Additionally, knowledge may only be relegated to short-term memory, where it is quickly forgotten after a quiz or an exam. Assumedly, these situations are not goals that we as physiology instructors have for our students. We desire students to study specific systems, maintain an integrative view of the body, and remember concepts long-term. This article explains and gives an example of an assignment designed (1) to help students relate each physiological system into an integrative whole and (2) to foster longer-term memory of physiological information.

The assignment:
To write, either individually or with a partner, a paper on how each physiological system (integumentary, musculoskeletal, nervous, endocrine, cardiovascular, lymphatic or immune, respiratory, renal/urinary, gastrointestinal, and reproductive) is directly or indirectly affected by a certain disease or pathology. One approach for this assignment would be to identify and expound upon the 1-3 key systems that are directly affected by the disease/pathology, and communicate ways in which the other systems would be indirectly affected as a result of alterations to the 1-3 primary systems.

In the field of educational theory, informational processing is accepted as the means by which people gather, store, and use or retrieve information (Woolfolk 2007). Organization and pattern formation, repetition, association of new information with known information, and feelings of control over the learning situation are important keys to students remembering information long-term (Woolfolk 2007). The assignment described here focuses on several of these keys. First, students choose a disease or pathology; often, the choice is one that has affected a family member or friend, which gives the students a vested interest in the assignment, fosters association, and gives them a sense of control over the assignment. Second, students are advised to order the systems within their paper in a logical format, beginning with systems most affected by the disease. Students find it helpful to draw a flow-chart or concept map. These activities organize the information into helpful visual patterns, promote systematic and sequential thinking, and create opportunities for students to review a particular concept of a certain system. Third, students are instructed to write to an audience of their peers, students who do not necessarily know technical medical terms. This insures that students do not pull words or phrases from a source and use them without understanding the underlying meaning. By writing in their own words, students are forced to process information on a deeper level, which increases understanding and enhances memory.

This writing assignment is assessed using a grading rubric that is handed out to the students at least one week before the assignment is due. (Specific (Continued on next page)
instructions are provided in the syllabus handed out on the first day of class.) Students seem more comfortable knowing the point values and criteria on which their grade will be based. Items on the rubric may include the following:

- **Appearance.** Appropriate title, headings, and figure or table labels; correct font, length, and page setup
- **Grammar and spelling.** Proper sentence structure and punctuation; clear and concise sentences; no spelling errors
- **Content.** Satisfactory coverage of each physiological system; integration present, correct, and sensible
- **Bibliography.** Source selection; citations and references in proper format

Most of the grade depends on the content. However, this instructor believes that students should also be held accountable for the way in which they convey the content. Therefore, approximately 15% of the grade is impacted by the writing itself. Each instructor may modify this as best suited to the class.

**Other assignment modifications** that may be made:

- Periodically, have the students turn in a brief outline of how their disease impacts the physiological systems covered so far in the course. This will encourage students to begin system integration and to review previously-learned material, and will discourage them from procrastinating.
- Limit the number of systems students are required to address. This may alleviate intimidation that some students may feel when confronted with the assignment. Practically for the instructor and depending on the class size, this would reduce the amount of time spent grading.
- Have students give a presentation of a few key systems affected by their disease-of-choice. Limiting the presentation to a few key systems avoids information-overload. Oral presentations encourage the presenters to understand the information, give public speaking practice, and allow classmates to benefit from hearing physiological information presented by their classmates. Presentations also give the presenters some creative license and more control over the assignments.
- Give students a choice of how to present the information - orally (PowerPoint, skit, or class activity such as completing a handout) or written.

**Potential problems**

- Students may skim the text to look for an article or textbook page that supports everything they write or present. Encourage students to have confidence in what they have learned.
- Some information reported on by students may be documented in literature; other information may be based on lecture information or an educated inference made by the student. Students should clearly delineate between their own inferences and information obtained from another source.
- Students may think, “This source states exactly what I want to say; I will quote the sentence(s).” Encourage students to put information in their own words. If grade points are a motivating factor for students, perhaps a line item on the rubric could read, “Direct quotes kept to a minimum”. Each instructor would have to determine whether or not this would promote plagiarism.
- Students may be overwhelmed by the assignment. Consider one of the modifications listed above.

Student responses to this assignment over the years have been overwhelmingly positive. What follows is an example of a sample written assignment (shortened considerably from the original) and associated flow-chart (Fig 1).

**Plasmodium falciparum Malaria**

Malaria, a disease caused by a single-celled parasite of the Plasmodium genus, affects as many as 250 million people a year (WHO 2008). The parasite relies on mosquito and vertebrate hosts to complete its complex life cycle. While the mosquito feeds on blood, sporozoites (infective stage of the parasite) enter the bloodstream...
of the vertebrate host, which is often a human. Upon entering the bloodstream, sporozoites invade liver cells and produce thousands of motile merozoites. Within 9-16 days, merozoites are released into the blood, invade erythrocytes, and produce additional merozoites (Tuteja 2007). This proliferation induces erythrocytic lysis (Ghosh 2007). Some merozoites develop into macrogametocytes and microgametocytes (the sexual stage), which reenter the mosquito while its feeds: the cycle repeats. Although malaria can be considered a blood disease, it has indirect debilitating repercussions on every system of the body. This paper highlights these wide ranging effects of Plasmodium (Fig 1).

**Immune System**

Cell-mediated immunity is the body’s primary line of defense against the Plasmodium parasite (Medana et al 2001). Cytotoxic (CD8) T-cells bind to antigen-presenting MHC I proteins on the surface of infected erythrocytes. MHC II proteins on macrophages present the Plasmodium antigen to CD4 helper T cells and cause swift activation of CD8 T cells via messengers called cytokines. Cytokines attract phagocytic cells such as macrophages to the site of antigen detection and cause inflammation. Many malaria-related complications are linked to the overproduction of inflammatory cytokines such as TNF-α and IFN-γ (Medana et al 2001, Awandare and Goka 2006). These chemicals activate monocytes, macrophages, natural killer (NK) cells, and neutrophils, which subsequently release toxins. While effective in destroying the parasites, these toxins contribute to many clinical manifestations of the disease. Normally the immune system remembers the invader allowing the body to respond more efficiently to a future infection. However, malaria boasts a variety of strains, and each strain presents numerous antigens. Therefore, the effectiveness of acquired immunity is often tenuous and short-lived due to the diverse and constantly mutating nature of malarial antigens (CDC database). Parasite antigens displayed on red blood cells initiate the humoral response. Antibodies produced by B cells subsequently bind to the infected erythrocytes and mark them for destruction. However, “autoantibodies” are also produced (Jhaveri et al. 1997) and have excessive debilitating effects on the body’s RBC levels and the cardiovascular system’s ability to transport oxygen.

**Cardiovascular and Endocrine Systems**

Anemia (a deficiency of hemoglobin) is a common cardiovascular symptom of severe malaria. Anemia results from the destruction of red blood cells, inefficient erythropoiesis (production of red blood cells), and hypoferrremia (low iron) (Ghosh 2007). Erythropoietin, a glycoprotein produced mainly by the kidneys, stimulates red blood cell production. Although malaria patients have elevated erythropoietin levels, the body’s ability to respond to these levels is thought to be impaired by the abundant cytokines and toxins (Casals-Pascual and Roberts 2006; Ghosh 2007; Xie and Wolin 1996; Fink 2001). Hypoferrremia results from the sequestration of iron in macrophages following RBC phagocytosis and because iron is hoarded by Plasmodium (Oppenheimer 1989).

**Respiratory System**

Pulmonary blood vessels fill with Plasmodium-infected RBCs, which adhere to vascular walls and reduce blood flow to the alveoli. Inflammatory microvascular dilation and RBC occlusion increase endothelial permeability, constrict pulmonary airways, and reduce the rate of alveolar ventilation (Anstey et al 2002). Increased endothelial permeability causes pulmonary edema (Maguire et al 2005; Anstey et al 2001), which increases diffusion distances between the blood and alveoli and reduces O₂ and CO₂ diffusion between the alveoli and capillaries. Hypoxia, respiratory acidosis, and acute respiratory distress syndrome (ARDS) may result. Hyperventilation might ensue to compensate for these imbalances.

**Nervous System**

Malarial parasites may move through the circulatory system to the brain and activate an immune response that damages astrocytes (Medana et al. 2001). Astrocytes form the blood brain barrier (BBB), which protects neurons from toxins in the blood and prevents peripheral changes in blood concentration from affecting brain function. Astrocytes also maintain local electrolyte and pH levels and repair neurons (Seeley 2008). This BBB breakdown and subsequent invasion of Plasmodium into neural tissue are thought to be primary causes of the high fatality rate of cerebral malaria.

**Renal System**

Renal dysfunction is common in severe malaria cases. Pro-inflammatory cytokines increase systemic capillary permeability resulting in low blood pressure. Adhesion of parasitized RBCs to renal microvasculature decreases blood flow. Together, these effects may cause tubular necrosis (Rajapurkar 1994). Inflammation of the glomerulus (glomerular nephritis) affects glomerular filtration; plasma proteins enter Bowman’s capsule (Rajapurkar 1994, Sinniah et al 1998), and creatinine and urea clearance is reduced (Nand et al 2001).

**Liver, Digestive, and Integumentary Systems**

The liver serves as the body’s main blood filter, removing unhealthy cells and toxins. While clearing Plasmodium-infected RBCs from the blood, the liver comes in direct contact with the parasite. In response, inflammatory cells invade the liver tissue and compromise liver function. In healthy livers, damaged or infected RBCs are lysed, hemoglobin’s heme goups are broken down to iron and bilirubin, iron is reused for erythropoiesis, and bilirubin is eventually deposited in the bile, emptied into the small intestine, and excreted in feces. However, the liver of malaria patients is often unable to dispose of the large amounts of bilirubin produced by the unnaturally rapid hemolysis. The resulting buildup of this protein leads to yellowing especially evident in pale skin, the eye sclera, and nail beds (Seeley 2008).

**Musculoskeletal System**

Skeletal muscle appears to be an important site for Plasmodium storage, reproduction, and maturation (Davis et al 1996). However, Plasmodium attracts leukocytes, and the resultant inflammatory response damages...
Muscle tissue and releases myoglobin, an oxygen-binding protein, into the bloodstream. Myoglobin is toxic to renal tubule epithelium, and in the case of severe muscular degeneration may contribute to renal failure (Naka et al 2005, Davis et al 1996). Muscular tissue typically relies on oxidative phosphorylation to meet its energy needs. However, malarial anemia necessitates anaerobic glycolysis. This results in lactic acid build-up, muscle fatigue and soreness. As anaerobic glycolysis uses up glucose, glycogenolysis depletes muscle glycogen stores (Davis et al 1996).

**Reproductive System**

Malarial infection is clinically associated with premature labor, fetal growth retardation, and a low birth rate (Fisayo 2007). Many of the complications experienced by the fetus parallel those experienced by the mother. Parasitized RBCs adhere to the placental membrane and cause coagulation that may result in placental tissue death. Fetal anemia is present, though to a lower extent than is found in adults (Davison et al 2006). Up-regulation of inflammatory cytokines also complicates pregnancies: detectible traces of TNF-α are associated with premature birth or fetal death, possibly because TNF plays a role in inducing labor via progesterone release (Davison et al 2006).

**References**


Snippets – from Chemistry to Analogy

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.” During these past few years of putting together your ideas into our EDU-Snippets column, we have been continuously amazed at how many teaching and demonstration ideas pop up and are easily transferred from one instructor to another through Snippets. The following Snippets came in as a result of a desperate call for more Snippets. The members of HAPS came through with flying colors! Please keep your wonderful ideas coming.

I. Chemical Snippets

Chemical concepts often present a real challenge to students. We have all probably struggled along with our students as they work to grasp the world of chemistry.

Ken Malachowsky (Florence-Darlington Technical College, ken.malachowsky@fdtc.edu) sent in three snippets to help us help our students visualize chemistry.

A. Polar Compounds

Students usually have difficulty understanding the concept of partial charges as found in polar compounds. I use my own gross analogy to help them understand this vital point. I tell the students I am 5’9”. I then tell them that I cut my ankles off and place them on top of my head. I ask them what happened to the length from my hips to the blood stump (goes down). Then I ask them how about the length from my hips to the top of the bloody ankles (goes up). Finally I ask for the overall length from the bottom of my stump to the top of the ankles (over length stays the same). Thus, part of me is shorter, part of me is longer, but overall I am the same length. I correlate this with the polar molecule. Part of the molecule is partially positive and part is partially negative, but overall...no overall charge such as would be found in an ionization event.

B. Monomers vs. polymers

This second one is not as gross! In discussing monomers vs. polymers, I warm up the students by asking them to think about different types of homes and to visualize the building blocks of each. Brick homes are made of bricks, log cabins are made of logs, straw huts are made of straw, and glass houses are made of glass. I tie those facts into a chemical context when discussing proteins/amino acids, polysaccharides/nucleotides, nucleic acids/nucleotides, and triglycerides/fatty acids + glycerol. I show how the building blocks (the monomers) of each type of home join together to make the whole (the polymer).

C. Protein Synthesis

Here is how I do one on protein synthesis. I have the students brainstorm materials needed to build a brick home. I tell them that there are many correct materials but I am fishing for certain items. I usually elicit bricks pretty quickly and mortar follows soon after that. I tell them I don't have time to build the house since I am busy instructing them. Students will then tell me that workers are needed. I ask how the workers know how to put the materials together to form the house. Blue prints! Lastly, I ask how the materials get to the construction site. Trucks!

I then mention each item and have the students connect those items with the concept of building a protein. The bricks represent amino acids; the mortar, peptide bonds; the workers, the ribosomes; the trucks, the tRNA; the blueprint… Instead of mRNA, they usually say DNA and I stop them at that point. I ask them if the blueprints they receive in the mail and use out in the field with potential for being destroyed must be??? mRNA. The original blueprints, kept nice and safe (a la nucleus), must be DNA. We review this point so that everyone understands the analogy and by then, it definitely makes sense.

II. Noisy Snippets

We all know that sometimes our lectures seem to induce a restful repose during class. We know our every word is a nugget of pure gold.
and we certainly do not want anyone to miss anything vital. Well, here is how a couple of our HAPS members solve the problem of periodic estivation.

A. Amplification

Jon Jackson (University of North Dakota, jackson@medicine.nodak.edu) sent us this magnified idea for use in a large lecture hall when people are falling asleep during the respiratory system.

I use a wireless clip/on microphone. (I teach my anatomy class in the largest classroom on our campus, mostly to save my voice – as those who know me realize I could talk loud enough to be heard just about anywhere.)

Anyway — I saw some students who must have been out late the night before. They were sleeping near the back, so I warned the non-comatose students to brace themselves. Then, into the microphone, I performed a loud and sudden demonstration of respiratory stridor, which sounded not unlike a marine air-horn going off in the room. Many, many students shot up in their seats, even those who had been warned.

B. iPod Solution

Meanwhile, Michael Pollock (Mount Royal College, mpollock@mroyal.ca) came up with this ingenious suggestion – in a somewhat joking way. (Maybe....)

If you are able to plug an iPod into your classroom sound system, there’s a terrific item from the Apps Store called “Sound Grenade.”

III. Muscular Snippets

In addition to his earlier contributions, Ken Malachowsky (Florence-Darlington Technical College, ken.malachowsky@fdtc.edu) sent in still another set of snippets. These are on muscles.

This first snippet demonstrates the basic sarcomere. I have two students stand on either side of me with their arms outward. My arms overlie their arms. I ask the students questions so they can visualize that their bodies represent the Z Lines. Their arms represent the thin filaments. One hand of mine to the other hand of mine represents the A band. The part of their arm not overlying my arm is the I band. My hands represent the myosin heads. I usually pick small students because I then use my hands to power stroke and bring the two students closer to me and I then ask them questions about the length of the I bands, A bands, sarcomere.

I do a variation of this experiment later with two large students (football players are great) in which I do the same thing but the students do NOT move when I power stroke. Students hopefully realize this is an isometric contraction. I ask them if they feel tension (some say no and they laugh) but they realize tension is produced but the muscle contraction can not overcome the load. Lastly I repeat this and have one student hold onto the door knob of an open door and the other student hold onto a stationary object. I power stroke and the door opens. I use this to demonstrate the origin vs. the insertion of the muscle proper.

IV. Assembly Line Snippet

Scott Smidt (Laramie County Community College, ssmidt@lccc.wy.edu) sent in a novel analogy for helping students understand tubuloglomerular feedback.

For several years, I had used an analogy of workers on an assembly line to help students understand tubuloglomerular feedback. However, it soon occurred to me that most of my students had no direct experience performing this kind of work. As a result, the analogy was not as helpful as I had hoped.

To improve the analogy’s effectiveness and give students a concrete example of how an assembly line works, I now begin by briefly explaining the basics of tubuloglomerular feedback. I then show the students a clip from a classic “I Love Lucy” episode. The video (www.youtube.com/watch?v=nXN5s8fQvHY) is approximately three minutes long and depicts Lucy and Ethel wrapping chocolates as the candies pass by on a conveyor belt. As the belt speeds up, the two have trouble keeping pace.

After the students watch the video, I draw a schematic of the process (Figure 1) that incorporates two groups of workers whose existence is implied but not explicitly shown in the video: a belt operator (who controls the speed of the conveyor belt) and a packager (who boxes the wrapped chocolates).

Figure 1 – below:
Next, I make a list of relevant features (and the functions they perform, where necessary) from the assembly line example (the analog concept) and ask students to match each one with a corresponding feature related to tubuloglomerular feedback (the target concept). In effect, students complete the right side of Table 1. It might be necessary to help students get started by pointing out that the filtrate corresponds to the conveyor belt in the analogy. If time permits, finer points and flaws in the analogy can be addressed (e.g., on an assembly line the rate of chocolates passing can vary either by changing the speed of the belt or placing the chocolates closer together on the belt; for tubuloglomerular feedback, we are only interested in the first of these possibilities).

The whole process (including the video) takes about 15 minutes

Table 1 – **Mapping the similarities between features of the analog and target concepts.**

<table>
<thead>
<tr>
<th>Assembly Line</th>
<th>Tubuloglomerular Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conveyor belt&lt;br&gt; - carries chocolates</td>
<td>tubular fluid</td>
</tr>
<tr>
<td>Chocolate</td>
<td>Ions and other solutes</td>
</tr>
<tr>
<td>Speed of conveyor belt</td>
<td>Glomerular filtration rate</td>
</tr>
<tr>
<td>Lucy &amp; Ethel&lt;br&gt; - wrap chocolates</td>
<td>Cells of the tubular epithelium&lt;br&gt;- remove solutes (and water) from tubular fluid</td>
</tr>
<tr>
<td>Packager&lt;br&gt; - boxes chocolates, detects unwrapped&lt;br&gt; chocolates, signals status to belt operator</td>
<td>Macula densa&lt;br&gt;- Detects amounts of Na⁺ and Cl⁻ in tubular fluid,&lt;br&gt; signals status to juxtaglomerular cells</td>
</tr>
<tr>
<td>Belt operator&lt;br&gt; - Controls speed of belt</td>
<td>Juxtaglomerular cells&lt;br&gt;- Causes constriction of afferent arteriole</td>
</tr>
</tbody>
</table>

V. And We Hope You Will....

Keep those cards and letters coming! We thank you all for your EDU-Snippet contributions. The influx of Snippets after my plea was great! Please keep it up! Your ideas are tremendous! For the next issue of the *HAPS-Educator*, send your EDU-Snippet experiences and ideas to biology@ctos.com as soon as possible. You will also find a reminder on the HAPS-L list. Plan ahead. You can even submit your ideas now and maybe next issue you too will see your EDU-Snippet in print!
This is the second in a series of notes about issues in nursing, designed to help A&P teachers make the connections between nursing and A&P (A&P and nursing) clearer to nursing majors. They are being written in response to HAPSters’ complaints of nursing majors who are not invested in their A&P courses, or even feel that those courses are unnecessary.

Some of you may have noticed the headline in April of 2008: “Little-known ‘failure to rescue’ is most common hospital safety mistake” (Aleccia 2008). The article, based on the 2008 HealthGrades study of American hospitals, reported that more than 188,000 hospital patients had died because of failure to rescue (FTR) between 2004 and 2006. This year’s report (HealthGrades 2009) is not much more encouraging; FTR remains the most common problem, occurring in over 96 of every 1000 patients. This problem is obviously serious, but what exactly is it, and is it relevant to our nursing students?

In hospital evaluation, ‘Failure to rescue’ is defined as “death following the occurrence of an adverse event during hospitalization” (Hughes and Mark 2004). It is also described as a ‘nurse-sensitive outcome,’ meaning that it is one nurses can affect. It seems obvious that the nurse, who sees the patient far more often than the doctor does, is most likely to notice changes that may indicate a potential medical catastrophe. Even in hospitals which have set up rapid response teams to deal with crises, the nurse is the one most likely to have to decide when to call the rapid response team.

If nurses are properly trained to identify variances from the patient’s norm/usual/customary findings early, before they become emergencies, they can have a tremendous impact on their patients’ survival. HealthGrades’ 2009 evaluation of American hospitals reported that patients treated in a ‘5-star’ hospital have an over 40% lower chance of dying in procedures that usually have low mortality than patients in a ‘1-star’ hospital (HealthGrades 2009; appendix F). All your students would rather be part of the 5-star team!

Does this mean nurses who aren’t working in hospitals don’t need to worry about FTR? Not necessarily. While nurses are more directly responsible for hospitalized patients, FTR can be generalized to any health care context as not noticing initial changes from normal for a patient, allowing the patient to develop an avoidable complication. Even in clinics, this can fall into the nurses’ hands if they do primary evaluation of the patient. It may also fall to family members or other people familiar with the individual, or the patient him/herself. This means that nurses not only may bear the major burden of early identification of significant changes, but also of educating the patient and family to identify them.

This is a tall order for nurses, but a great opportunity for the physiology teacher. This column is about using FTR as the ‘hook’ to grab the interest of nursing students when studying systems that often do not excite them, like the liver.

To begin with, Hughes and Mark (2004) identified a set of skills nurses need to avoid FTR. These include:

• Monitor appropriately (measure the right things often enough)
• Recognize relevant clinical cues
• Interpret clinical cues to identify that something potentially dangerous is happening
• Obtain an appropriate physician response (often by concisely describing the situation over the telephone) in the time period needed.

What do your students think they need to know to develop these skills? The liver, with its many functions, is a perfect system with which to tie FTR to the A&P class. For example:

1. A client has long-standing liver disease, yet the nurse is seeing her for the first time in a clinic. During the assessment, which of these findings might the nurse expect to see because of the liver disease, and which might represent a new problem that needs immediate investigation? When reporting to the doctor, how will the nurse explain why this is a concern?

   a. Yellowish sclera
   b. Mild generalized edema
   c. Spider nevi (broken capillaries)
   d. Cyanosis

(Continued on next page)
This question can lead into several liver functions. Everybody knows about jaundice (a). The edema from long-standing liver disease (b) will be generalized because it is at least partially caused by decreased synthesis of plasma proteins leading to decreased blood osmolarity; osmosis will move water into tissues all over the body (Porth 2002). Failure to synthesize clotting proteins or absorb the fat-soluble Vitamin K will contribute to the spider nevi (c). All of these, while superficially 'abnormal,' may be long-standing conditions in this client.

Cyanosis, however (d), is not related to liver functions and may indicate a new problem with the circulatory or respiratory systems. By identifying that, your student may 'rescue' the patient from developing a serious new illness.

2. In discussions with the client, the nurse asks whether she has noticed any changes lately. The client complains about weight gain and that her slacks are too tight. She says 'They told me this disease would interfere with my digesting fat, so I thought I'd lose weight!' How many possible reasons for the weight gain can your students come up with, and what tests might they anticipate being ordered to distinguish them?

Your students may come up with many problems, but edema is a major possibility, for several reasons: either because fewer plasma proteins are being synthesized, or because the liver is not breaking down aldosterone, leading to an edema secondary to sodium retention. The fact that the slacks have become tight may indicate an increase in abdominal girth due to ascites development resulting from decreasing protein levels that have caused leakage of fluid into the abdominal cavity.

A rapid increase in edema is a concern; cerebral edema can be a serious risk in patients with liver failure. Plasma proteins will probably be measured, as will SGOT, SGPT, AST (liver enzymes measured in liver function studies). If the doctor is worried about aldosterone levels, plasma potassium might be tested. An increase in aldosterone causes the kidneys to retain Na+ and water and excrete K+, which can lead to low K+ levels.

If students are really on the ball, they might even look back at the cyanosis and think about edema due to right-sided heart failure.

3. Is the patient correct that she will have trouble digesting fat?

Often students know about bile and jaundice, but don't really remember that bile is important for emulsifying fats in the small intestine, allowing their digestion and absorption. Where do they think the fat will go, if it is not digested? What might the client experience? They may not know the term 'steatorrhea,' but they should be able to infer that the undigested fat will go out in the stools and that the client will probably lose weight due to malabsorption. They may even predict deficiencies in the fat-soluble vitamins A, D, E, and K.

Do we have to provide answers or provide them with potential signs and symptoms and causes?

4. The nurse identified cyanosis as a new problem for this client and was correct! The client was diagnosed with early heart failure and referred to a cardiac specialist. Now she is back for her next yearly checkup with her liver specialist. The doctor asks the nurse, 'Where is the list of her meds? Didn't the cardiologist put her on anything?' Why is the liver doctor worried about cardiac meds?

The liver's role in detoxifying or activating medications is key here. Mentioning that the liver is involved in elimination of routine drugs such as aspirin or antiepileptics may catch students' interest: an impressive list of medications detoxified by just one family of liver enzymes is available from Indiana University School of Medicine (2009). The fact that genetic variability in liver enzymes can determine whether standard drug dosages are effective, ineffective, or even toxic for their patients (Lynch and Price 2007) is another topic that interests nursing students. Also, the impact of drug accumulation in ascitic fluid on the ability of the blood to deliver medications, and the rebound that may occur when ascites is decreased, may grab their attention.

5. The patient's liver failure is becoming more serious, and she has moved in with her daughter's family. The daughter has asked what she should watch for so she can catch any signs of a potential crisis. What can your students come up with? How will they explain them?

This is a good chance to assign special topics to student groups and have them teach. Another good way to summarize liver functions is to have the students create a one-sheet concept map of possible complications of liver failure (Fig 1). The physiology behind this is usually presented in a table in A&P or pathophysiology texts, but my students always have trouble going the next step and predicting how they might observe these complications in the patient. That is what will matter when they are nursing, though!

Your nursing students will be able to prevent FTR when they can:

- Predict what might go wrong with a patient and recognize that it is happening
- Identify unexpected occurrences/variances from normal for this patient
- Be taken seriously by the physician by showing they know what they are talking about and have done some critical thinking
- Teach the patient and caregivers what to watch for

Practicing nurses I have interviewed agree that all these skills depend on knowing and being able to explain what they learned in their physiology classes. But they did not know that at the time they took physiology. Perhaps our nursing students can benefit from others' hindsight!

(Continued on next page)
DECREASED PROTEIN SYNTHESIS
- Decreased albumin (hypoalbuminemia)
- Decreased clotting factors

WATER ENTERS TISSUES
- EDEMA

DECREASED PLASMA OSMOLARITY
- Purpura (hemorrhage in skin)
- Bruises
- Increased menstrual bleeding
- Anemia

DECREASED ALBUMIN (hypoalbuminemia)
- Decreased bile synthesis
- Fat not absorbed

DEFICIENCIES IN FAT-SOLUBLE VITAMINS (e.g. Vit K)
- Decreased clotting factors
- Purpura (hemorrhage in skin)
- Bruises
- Increased menstrual bleeding
- Anemia

BILIRUBIN STAYS IN BLOOD (hyperbilirubinemia)
- Jaundice
- Icterus (yellow sclera)

DECREASED CLOTTING FACTORS

FAT LOST IN STOOL
- Pale, floating stools (steatorrhea)

DECREASED BILE SYNTHESIS

SEX HORMONES
- Decreased libido
- Infertility or impotence
- Amenorrhea or testicular atrophy
- Males may have breast growth (gynecomastia)

ALDOSTERONE IS NOT DESTROYED

KIDNEYS REABSORB Na+ AND WATER, SECRETE K+
- EDEMA
- Decreased K+ levels

Drug interactions [Internet]. [updated 2009 May 19]. Indiana University School of Medicine, Division of Clinical Pharmacology. [cited 2009 Jun 19] Available from http://medicine.iupui.edu/clinpharm/ddis/


Drug interactions [Internet]. [updated 2009 May 19]. Indiana University School of Medicine, Division of Clinical Pharmacology. [cited 2009 Jun 19] Available from http://medicine.iupui.edu/clinpharm/ddis/


Background and Introduction
The study of histology and cell structure is an integral part of every comprehensive anatomy course. Our feelings, which we believe are shared by most anatomy instructors, are that the study of microanatomy not only helps correlate structure and function, it also provides a glimpse into a microscopic world that often sparks the imagination of students and teachers alike. Unfortunately, providing microscopic laboratory experience can be time consuming and expensive. Optical microscopes and glass slides are obviously fragile and expensive, and with novice students, accidents are an unfortunate and frequent reality. Fortunately, recent advancements in digital imagery have led to the development of virtual microscopy. In this article, we report our experiences on the introduction of virtual microscopy into the laboratory curriculum of a large undergraduate anatomy course at Indiana University.

Virtual microscopy takes advantage of image scanning and streaming technology to render an entire microscopic slide as a series of indexed images that can be delivered to a viewer’s computer via an internet connection. The indexing system allows the streamed images to be assembled on the client’s computer screen as a full-field microscopic view. As the user moves the cursor, additional images are streamed, thus allowing the client to change the microscopic field and even the magnification power. With virtual microscopy, the computer can now serve as an optical microscope, and with several distinct advantages. First, and most obvious, the microscopic view is the size of a computer’s screen. A byproduct of this feature is that several students and instructors can gather around one monitor to discuss and compare observations. Second, the digital nature of the images allows projection of microscopic specimens via a digital projector, thus permitting classroom and large group viewing. Finally, screen capture and printing of microscopic fields allows students to have immediate access to images that can be labeled and reviewed at a later date. This feature means that images can also be captured and incorporated into exams and quizzes.

How we started
Our experience with virtual microscopy began at Indiana University in the fall of 2005. At that time, the medical school pathology course, taught at the Bloomington branch of the Indiana University School of Medicine, began the process of scanning its study slide set for virtual microscopy delivery. As virtual microscopy was incrementally introduced to the medical students, it became obvious that they enthusiastically embraced the new technology. Aggregate grade comparisons with previous years showed no decrease in content mastery. Not only were the medical students accessing the virtual microscopy website when it fit schedules best, it became obvious the technology was also contributing to cooperative learning. As the advantages of virtual microscopy became clear to us, we decided to expand its use to our medical school histology course and to our undergraduate anatomy course. In the summer of 2008, virtual microscopy was introduced into the laboratory curriculum of our 200-level undergraduate anatomy course. This course hosts over four hundred students per semester and includes laboratories with demonstration models and prosected cadavers as well as a major histology component.

Creating the digitally scanned microscopic slides
To create the digital microscopic scans the Indiana University School of Medicine uses equipment and technology developed by Bacus Laboratories, now a subsidiary of Olympus America (Olympus, 2008). Olympus is not the only company providing this technology; other sources of virtual microscopy include Aperio Technologies (Vista, California), Carl Zeiss Microimaging (Thornwood, New York), and DMetrix Inc. (Tucson, Arizona). All of these companies will provide technical help in establishing the program and designing the web interface. In many cases, scanned slides of normal and diseased tissues are available. Because of the size of the scanned slide (Continued on next page)
files, we chose to use a dedicated server to store the image folders, although a separate server is not a necessity. One of the authors (MB) was involved with the development of the pathology virtual microscopy website, so it was a simple matter for him to retool the pathology HTML templates to meet the needs of the undergraduate anatomy course.

The development of a digital slide library is only part of the requirement for a successful virtual microscope program. Proprietary software for the hosting server is necessary for streaming and assembling the finished virtual microscopic image on the client’s computer. This required software must be leased on a yearly basis from the web browser, with a freely available java add-in, is all that is needed.

Notes on our experience
With almost one academic year behind us, we are glad we made the switch from optical microscopes. Here are some of the features reported by students or observed by laboratory instructors.

- Students and instructors can quickly and easily access slides during lab time and outside of class.
- Students are able to master the use of the virtual microscope after minimal use, thus allowing more efficient use of class time.
- Students frequently work in pairs or groups when reviewing for an exam. Students can also quiz each other over multiple structures within one slide.
- During introductions of class material, instructors can display the virtual slides on projector screens and demonstrate important histological features, while students follow along at their own computers.
- Because students already have the virtual microscope opened they will often continue using it after the introduction is complete.
- Slide images can be captured in snapshots and then printed. One student commented: “I was able to create a study slide show for myself by taking the screen image and pasting it into a PowerPoint.”
- Snapshots also work well for instructors when setting up quizzes or for use in review sessions.
- The ability to have more than one active browser window open at once allows for comparison of different tissues.
- Virtual microscopic slide images are clear to students, thus eliminating problems resulting from inconsistent and poor quality glass slides. One student commented: “We know we are viewing the right thing, not just a crack or spec on a slide.”
- Virtual microscopy eliminates, or greatly reduces, motion sickness while viewing the microscopic sections on a screen. Although a minor issue, at least as judged from the numbers affected, motion sickness will all but preclude microscopic study for some students.

One of the authors (AS) has been an instructor in this undergraduate anatomy course for several years and has experience with both optical and virtual microscopes in the teaching of the histological component. This author feels the transition from optical microscopes has been smooth for instructors and students alike. Students learned to use the virtual microscope quickly and only rarely experienced problems. One initial concern of instructors was that students would use computers for non-class related activities, such as web surfing, checking email and updating their Facebook pages. However, after one year of students having internet access during class time, non-sanctioned use has not been a problem. When students use the computers they are almost always utilizing course materials. Interestingly, on several occasions, students were discovered using an Internet browser for purposes other than looking at the virtual microscopic slides. To the instructor’s relief, and elation, the students were doing a web search to find information about, and additional pictures of, the microscopic structure being studied.

Printing snapshots of the slides has been advantageous for students and instructors. Students often use print-outs to label and study from, while instructors can use them for practice quizzes and review sessions. Previously, it was cumbersome to include a histology question in a practice quiz. Instructors would have to dedicate at least one of the student optical microscopes for the demonstration, thus it was not available at that time for general student use. Now questions of histology can be included in practice quizzes and demonstrations without limiting study resources. To capture the slide images in our PC computer equipped laboratory, students simply press the print screen button on their keyboard. Then the copied image can be pasted into a photo editing program, such as Paint, Photoshop, Powerpoint or for that matter directly into a Word document. Although our experience has been

![Figure 1: A typical virtual microscopic screen capture, labeled and ready for incorporation into study materials. Students are encouraged to find their own example, print and add their own labels.](Continued on next page)
primarily with PCs, we know the virtual microscope works well with Macs and the copy and paste image procedure is just as easy.

An example of a pre-labeled, screen captured image is seen in figure 1. This motor neuron was captured directly from a virtual microscopy view screen. The labels were added and the image was used in class and the laboratory manual to highlight the important histological features. Students are encouraged to find their own example, print and label it. Figures 2 and 3 are examples of two different virtual microscopy views that illustrate the potential of side-by-side viewing. One image is of cerebellum, the other cerebrum. Side-by-side projection of tissue sections allows the instructor to highlight differences and similarities, while encouraging students to following along at their own computers.

While the virtual microscope has been embraced by instructors and students, one problem related to its ease of access has come up. Because it is available online, the virtual microscope can be used to study from home. Obviously, this wonderful feature is not lost on the students and we encourage them to use it in this way. This convenience, however, leads some students to put off looking at the virtual microscopic slides during class. “If I can review the slides from home, why do it now?” They leave with good intentions of looking at the slides out of class, however, for some the opportunity does not come until just before exams. The result being that they cram the night before a test without supervision or assistance. To remediate this problem, we have found it helpful to incorporate the virtual microscopic slides into lectures, and remind students to spend time examining slides during class time. Another proven technique involves quizzing students before they leave class, emphasizing the important concepts revealed in the microscopic slides. These approaches have value beyond emphasizing the importance of the microscopy review. These techniques build on prior knowledge and encourage application while improving utilization of class time.

Interestingly, some students have expressed the desire to gain experience with optical microscopes. We have

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found it valuable to keep a few optical scopes, and microscopic slides, for students with this interest. The optical scopes can be set up at the side of the room, thus allowing students the opportunity to try their hands at the technology the rest of us learned from.

Infrastructure considerations for optical and virtual microscopy

Clearly the development of virtual microscopy has the potential to revolutionize the teaching of histology. But for web delivered microscopy to be useful, there must be adequate infrastructure. High-speed internet connection for the client is a must, and because of the size of the image folders, a committed server is helpful. Constructing the HTML pages for displaying the virtual microscope interface is not difficult and companies supplying the technology will freely provide templates and assistance. Even so, minimal proficiency with web design is needed. And there is the cost of the yearly software lease. We have found, however, that these expenses are less than the expense of maintaining a large number of student microscopes and glass slides.

Summary

In conclusion, our experience for the teaching and learning of histology at the undergraduate level is that virtual microscopy is effective, cost-efficient, and enthusiastically embraced by the students. We believe the virtual microscope offers a number of important advantages, not least being the ability to provide concurrent and immediate feedback to the students. Reduced cost and maintenance of slide collections and student microscopes has proved an important factor as we adapt to tighter budgets. Most importantly, students appreciate and avail themselves of the convenience of when and where to use the resource. Students in our course feel their efficiency of learning has been improved by the use of the virtual microscope, and that it increases their opportunities for learning collaboration. In addition to these factors, the important element of search and discovery is maintained with the virtual microscope. Students must still explore the slide and identify the pertinent histological features, rather than simply memorize a series of fixed images in a laboratory manual.

We acknowledge that there are start-up costs of both money and time to initiate a virtual microscopy program, but the efforts will begin paying dividends almost immediately. Please feel welcome to visit the our website, and let us know what you think: http://medsci.indiana.edu/a215/virtualscope/start.htm

Additional resources dealing with this topic

Blake CA, Lavoie HA, Millette CF. 2003. Teaching medical histology at the University of South Carolina School of Medicine: Transition to virtual slides and virtual microscopes. Anatomical Record 57B:196-206.


Learning and retaining anatomy and physiology of the human body is critical for student nurses’ success in future theory and clinical courses and eventual safe practice as a registered professional nurse. However, educators are faced with student nurses’ perceptions that anatomy and physiology content can be taught during their nursing classes and students who do not see the relevance or value of taking a separate anatomy and physiology course. This article will explore the issues surrounding this perception and discuss strategies to assist students with their learning of anatomy and physiology.

**Nursing Education’s Perspective**

Nursing education is a dynamic and ever evolving entity that prepares student nurses for the practice profession of nursing. The knowledge, technical skills, attitudes and critical thinking expectations for the new graduate in the healthcare environment have expanded exponentially. The American Association of Colleges of Nursing (AACN) has “reaffirmed its position that baccalaureate education is the minimum level for entry into professional nursing practice in today’s complex healthcare environment” (AACN 2008, p 7).

The liberal arts (humanities, fine and performing) and sciences (physical, life, mathematical and social) form the cornerstone “for the development of intellectual and innovative capacities for current and emergent generalist nursing practice [and] provides the foundation for understanding health as well as disease processes, and forms the basis for clinical reasoning” (AACN 2008, p 11).

The Institute of Medicine (2000) report, _To Err is Human: Building a Safer Health System_, estimated medical-errors-related deaths were between 44,000 and 98,000 deaths per year and the eighth leading cause of death in the United States (AACN 2008). Considering what is at risk, a human life, a solid knowledge base of anatomy and physiology enhances nursing practice and improves patient outcomes. Although educators see the importance and relevance of a liberal arts education in nursing education, the student may not. It is within this clash of perceptions that student discontent with taking anatomy and physiology may occur.

**Nursing Students’ Perceptions**

Three distinct themes emerged from this literature review as factors contributing to student nurses’ perceptions of the need to take an anatomy and physiology course: relevance, requirement to take a separate course, and students’ characteristic profile and life experiences. In the first theme, students’ perceived relevance of course content to nursing practice was identified (Clancy et al. 2000; Gresty and Cotton 2003; Johnston and McAllister 2008; Thornton 1997; Trnobranski 1993). This is commonly referred to as the Theory to Practice Gap -- the difference between the idealized theories taught in the classroom and actual clinical practice (Friedel and Treagust 2005; Trnobranski 1993; Wynne et al. 1997). "Concerns that the standard and competence of patient care have been compromised were expressed by Gould (1984) who, after reviewing a number clinical studies highlighting limitations in physical care concluded that a lack in biological knowledge or failure to apply knowledge had placed clients at risk" (Wynne et al. 1997, p 473).

Contributing to the Theory to Practice Gap is the timing of when students take anatomy and physiology. Students may be unable to link anatomy and physiology concepts to patient care because they have no prior clinical experience (e.g., Certified Nursing Assistant) or due to the time lapse experienced between completing anatomy and physiology and actual nursing courses and clinical experiences (Friedel and Treagust 2005; Jordan et al. 1999; Parfitt 1989; Thornton 1997; Trnobranski 1993; Wynne et al. 1997). All of these experiences may lead to student dissatisfaction and impatience with an anatomy and physiology course.

Nursing students judge the value and relevance of course content by relating it to their personal beliefs and definitions of nursing (Jordan et al. 1999; Manninen 1998; Thornton 1997). Bridges’ (1990) research attributed perceptions of a nurse and nursing to the images portrayed by the media, especially television. The stereotypical view of the nurse is female and a ‘Doctor’s Handmaiden’ who is “subordinate to physicians and as executors of doctors’ orders” (Manninen 1998, p 390). “The

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perception of beginning students often focused on images portrayed by the media, where nursing practice equated with acute care settings facing skilful practice with technical equipment and administration of drugs” (Thornton 1997, p 182).

With nursing students, consciously or unconsciously, holding this image of nursing, it is no wonder why students experience the Theory to Practice Gap dichotomy and “demonstrate impatience with anything which appears extraneous to their perception of professional practice” (Thornton 1997, p 181). Students assess their learning needs for their role as a professional nurse “from their perspective on the reality of nursing practice, and subsequently discounted information seen as irrelevant to the perception of reality” (Thornton 1997, p 184). This narrow perspective obscures the nursing students’ understanding of the symbiotic relationship between their liberal arts education and professional nursing courses which provide the framework for their future practice.

The second emergent theme was that nursing students questioned and perceived irrelevant the requirement of a separate anatomy and physiology course as part of their nursing curricula. Generally, an anatomy and physiology course is completed early in the nursing program while taking other support courses. Carrying a heavy course load over-burdens the student which competes with their time to study anatomy and physiology (Jordan et al. 1999; Thornton 1997). Nursing students go into a ‘survival mode’ in order to complete complex assignments and assessments for all of their classes. “The placement, format and assessment of supporting sciences content will often direct the level of application of content to practice and can contribute to the superficiality of learning approaches used” (Thornton 1997, p 181); students do not have time to learn!

In regards to the anatomy and physiology course, there is an ongoing debate as to: “the absence of a definition of the required level of knowledge of the biological sciences to practice; the absence of national guidelines and minimum standards for curricula; and shifting role boundaries” (Jordan and Reid 1997, p 169). The instructor’s educational background and understanding of the nursing profession, as a scientist or nurse educator, affects the delivery of content and assessment of knowledge (Jordan et al. 1999; Clancy et al. 2000; Friedel and Treagust 2005; Larcombe and Dick 2003; Trnobranski 1993). These factors impact the current delivery of anatomy and physiology course content to nursing students and must be defined and aligned.

The final theme extrapolated from the literature as influencing the nursing students’ perceptions of anatomy and physiology was the characteristic profile of the student and their life experiences. Billings and Halstead (2009) identified the traditional student (Millennials, born between 1981 and 2003) as a self-confident social learner who is digitally savvy and able to multitask. These authors classified the nontraditional student (Gen Xers, born between 1961 and 1981) as an independent task-oriented learner who is digitally naïve and prefers to work alone. The latter group may have additional responsibilities and financial concerns related to family and work commitments and “often felt anxious about competing with younger students ‘fresh from school’” (Montgomery et al. 2009, p 36). Understanding the students’ characteristic profile allows educators to use effective pedagogical strategies when presenting course content.

Both types of learners, traditional and nontraditional, express other factors that impact their learning of anatomy and physiology. Students perceive this course as difficult to learn (Clancy et al. 2000; Friedel and Treagust 2005; Gresty and Cotton 2003) because of abstract physiological concepts and endless rote memorization of anatomical structures (Johnston and McAllister 2008) with unfamiliar vocabulary (Larcombe and Dick 2003). Additional concerns expressed by these learners include the volume and difficulty of the textbook readings, time consumption, pace of the course, and poor study habits and test performance (Gresty and Cotton 2003; Larcombe and Dick 2003; Thornton, 1997). How can nursing students recognize the importance of anatomy and physiology when presented with so many perceived or actual barriers to learning?

The problem is further compounded by prior life experiences of the student. Several studies have indicated that students lacked the fundamental science knowledge expected from high school or other academic institutions needed for the rigors of higher education (Courtney 1991; Friedel and Treagust 2005; Gresty and Cotton 2003; Thornton 1997; Trnobranski; 1993), thereby making it difficult for educators to meet the learning needs of the nursing student. These findings also discussed students’ perceptions of their preparation for college level science courses as weak or negative, and that they lacked knowledge upon which to build. This caused anxiety and low self-confidence within the course (Courtenay 1991; Gresty and Cotton 2003; Thornton 1997; Trnobranski 1993).

As students progressed through the nursing program, their negative perceptions of the need for a separate anatomy and physiology class changed. In Thornton’s (1997) qualitative study (n =120), first year students “were less convinced of the value of supporting sciences… [as] essential knowledge for practicing nurses” (Thornton 1997, p 183); however, students expressed a “greater awareness [of the need for anatomy and physiology]…as they progressed to their second year and were exposed to the reality of clinical practice in a hospital setting the value of these areas became more recognized” (Thornton 1997, p.183-184). Other researchers noted similar positive perceptions towards the relevance of anatomy and physiology by student nurses during their nursing education (Table 1).

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<table>
<thead>
<tr>
<th>Number of Nursing Students</th>
<th>Results of the Study</th>
<th>Comments</th>
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| **Clancy et al. 2000**    | • 92.1% expressed that the biological sciences (e.g., anatomy and physiology) were important to nursing practice.  
• 97.6% reported that more education in the biological sciences would benefit them in future practice. Students wanted more study days (37.9%) or seminars (53.4%). | • Quantitative study.  
• One time study; not longitudinal. |
| **Courtenay 1991**       | • 51% reported anatomy as a most critical course in their preparation for nursing. Physiology was rated second (25%) in importance.  
• 50% stated that their understanding and knowledge of anatomy and physiology increased as they progressed through the program. | • Quantitative study.  
• One time study; not longitudinal. |
| **Friedel and Treagust 2005** | • 97% perceived a good knowledge base in anatomy and physiology is important to nursing practice.  
• 81% perceived anatomy and physiology forms the framework of nursing practice.  
• 88% desired better knowledge in anatomy and physiology.  
• 73% see the relevance of anatomy and physiology to their nursing practice.  
• Anatomy and physiology is not stressed enough in the program.  
• Prior preparation for the course impacted their perceptions of difficulty with the content. | • Mixed study.  
• Conducted the focus groups and questionnaire to same participants, but at different times.  
• One time study; not longitudinal. |
| **Manninen 1999**        | • 90% felt anatomy and physiology was the most useful subject in nursing education for nursing practice.  
• The preference for biomedical (anatomy and physiology) knowledge; Likert-type 5-point scale used as measurement; mean average for all participants in this study:  
1989 (n = 283; mean = 3.99)  
1990 (n = 239; mean = 4.05)  
1991 (n = 201; mean = 4.01)  
1992 (n = 158; mean = 3.96) | • Quantitative longitudinal study; Data collected after 6 months, 1.5, 2.5 and 3.5 years of education. |

Table 1: Nursing Students’ Perceptions towards the Relevance of Anatomy and Physiology during Their Education

**Nurse Educator’s Perspective**

At Alverno College, the writer teaches a physical assessment course which includes individual assessment skills. Anatomy and physiology is a prerequisite for this course and definitely referred to in every class. All systems are covered in theory and demonstrated by the instructor in class. Students validate individually on the assessment skill (e.g., cardiovascular, respiratory, abdominal) in the skill lab. Anatomy and physiology is reviewed in the readings for the system presented in each class and optional on-line review materials are available for the student.

An example of the importance of understanding anatomy and physiology is made clear by the cardiac assessment and skill validation. The neck vessels are first assessed including bilateral inspection for jugular venous pulsations, bilateral palpation of carotid arteries for contour and strength and bilateral auscultation for burit. Normal and abnormal findings (Continued on next page)
are discussed. The precordium assessment consists of the following: inspecting the apical impulse, palpating the apical impulse, palpating for thrills, and auscultation of heart sounds. Anatomical locations for stethoscope placement are noted and related to the location of the heart valves. Various normal and abnormal heart sounds are then made audible at every area. The cardiac assessment is then demonstrated by the instructor and students perform a demonstration on each other. How could a presentation of this important magnitude be absorbed by the learner in a 3 hour presentation and demonstration, if they are still trying to figure out structure and function?

**Adult Learning Theory Applied**

The main word underpinning this article’s analysis of nursing students’ perceptions of anatomy and physiology is relevance. It was discovered that the students’ perception of the relevance of anatomy and physiology was dependent upon their belief in the transference of knowledge to practice. Knowles (1980) Adult Learning Theory is applicable to the teaching and learning partnership that occurs between the student nurse and their undergraduate education; especially in their anatomy and physiology course (Billings and Halstead 2009). “Adults make a commitment to learning when the learning goals are perceived as immediately useful and realistic and as important and relevant to their personal, professional, and career needs” (Billings and Halstead 2009, p 207). Therefore, to enhance the learning experience of theoretical concepts for the student nurse, “the ideas must become personalized” (Wilkes and Batts 1998, p 125) as relevant knowledge for future practice as a registered professional nurse.

In order to heighten the students’ perceived relevance of taking an anatomy and physiology course, their new knowledge of anatomy and physiology content must be constructed, organized, and sequenced into a meaningful higher level of understanding and linked to various nursing course content and practice settings. Understanding and applying The Adult Learning Theory (Knowles 1980) to student learning will assist educators with planning and designing course content and learning activities.

**Learning Style of Nursing Students**

Meehan-Andrews (2009) research brought out another factor that needs to be considered when designing and teaching an anatomy and physiology course; the students’ preferred style of learning (e.g., visual, aural, read/write, kinesthetic) for assimilating new knowledge. In the first part of the Meehan-Andrew study, anatomy and physiology nursing students (n = 86) and post graduate medical students (n = 166), responded to a survey on their experiences with lectures, tutorials, and practical sessions (labs) using a 5-point Likert scale. Comparatively, practical sessions were ranked 40% more beneficial than tutorials and 21% more beneficial than lectures. Additionally, students believed lectures were 15% more beneficial to learning than tutorials. When an integration of teaching strategies was used, students still favored the practical sessions over lectures and tutorials.

In the second part of the study, nursing and medical students took the VARK test online questionnaire (http://www.vark-learn.com/english/index.asp). “The VARK test, visual, aural, reading/writing, kinesthetic sensory modalities determines the different ways of receiving information” (Meehan-Andrews 2009, p 26) and has been completed by the population at large (n = 65,358) since 1995. The findings indicated that 54% of student nurses “prefer a single mode [teaching strategy] of information presentation.” Of the students that preferred a single mode of information presentation, more than two thirds, 68%, preferred kinesthetic methods, 17% preferred the read/write approach, 11% preferred visual, while only 4% of the students preferred the aural or lecturing presentation mode” (p. 27). Comparatively, 18% of medical students and 21% of other VARK website participants preferred the kinesthetic information presentation (Meehan-Andrews 2009). These findings suggest that educators of anatomy and physiology for nursing students need to use a wide variety of teaching strategies, especially kinesthetic, in order to better engage the students in their learning. Another finding was that upper class nursing students “may develop or mature in their learning to prefer visual, aural or read/write modes as they tackle more challenging manual skills projects in clinical placements” (p. 30).

Courtenay (1991) compared perceptions of effective teaching methods used in anatomy, physiology, and other health sciences between 3rd year nursing students (n = 140) and teachers of bioscience (n = 43). The results were widely varied between both students and teachers. Students ranked the most effective teaching methods as experiential learning (40%), lectures (36%), projects (35%), debates (26%), seminars (22%), quizzes (19%), and self-directed learning (18%). In contrast, teachers ranked self-directed learning (36%) as the most effective teaching method followed by lectures (35%), seminars (19%), quizzes and debates (8% each), and experiential learning (4%). Projects were not even ranked as a teaching method by these teachers. Both studies, Meehan-Andrews and Courtenay, emphasize the importance of using experiential (kinesthetic) teaching methods when teaching anatomy and physiology to nursing students. This is important knowledge for educators to be aware of and use when teaching nursing students.

**Teaching Strategies Used In Anatomy and Physiology**

Relevance of anatomy and physiology to real clinical practice is the key that engages student nurses in learning content. The literature review revealed numerous teaching strategies used in anatomy and physiology courses with nursing students over the last 10 years (Table 2). Technology is (Continued on next page)
an emerging trend in teaching; especially simulation in nursing education (Jeffries 2005). It can address the diverse learning needs of the traditional and nontraditional student and promote learning. This positive teaching strategy has been used in teaching anatomy and physiology, but needs to be developed more for use in the classroom. It is important to note, no ‘live’ interactive gaming strategies to deliver anatomy and physiology course content were reported in the literature review.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Teaching Strategy</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green et al. 2006</td>
<td>-- Virtual learning environment using Blackboard 5</td>
<td>Online module resources (lecture PowerPoint’s/notes, learning enrichment activities, discussion rooms, projects, and other learning resources) available for students that augmented lectures; no correlation with performance on examinations.</td>
</tr>
<tr>
<td>Gresty and Cotton 2003</td>
<td>-- Headstart Package-‘students needs analysis’ was conducted</td>
<td>Online resources available for identified students; “level-up” knowledge base and improve their confidence prior to or early in their coursework.</td>
</tr>
<tr>
<td>Harris et al. 2004</td>
<td>-- Multiple review sessions -- Homework</td>
<td>Prior preparation in math/ science in high school and college; course load; work; and family significantly impacted student’s success in anatomy and physiology.</td>
</tr>
<tr>
<td>Johnston and Moore 2008</td>
<td>-- Lecture and laboratory -- Optional help-sessions -- Extra-credit assignments -- Homework</td>
<td>Student’s academic perceptions, motivation, and behaviors impacted their success in the course.</td>
</tr>
<tr>
<td>Larcombe and Dick 2003</td>
<td>-- Collaborative teaching between bioscientist and nurse educator in laboratory sessions</td>
<td>Experiments were presented by the bioscientist with lecture content and nurse educator transferred them to clinical relevance. Students were satisfied and perceived benefits from using this teaching approach. No performance scores reported.</td>
</tr>
<tr>
<td>Raynor and Iggulden 2008</td>
<td>-- Virtual learning environment using E-book literature (WileyPLUS)</td>
<td>Online resource that supplemented (self-test questions, animations and online note-taking) the lectures. Student satisfaction noted. No performance scores reported.</td>
</tr>
<tr>
<td>Stein et al. 2006</td>
<td>-- Audience response system -- Teachable moments</td>
<td>Jeopardy®-style formatted anatomy and physiology game used for examination review. No significant improvement in test scores when compared to control group; students were satisfied and perceived benefits in learning.</td>
</tr>
<tr>
<td>Woody et al. 1999</td>
<td>-- Case Studies in problem-based learning format -- Small group work and discussion</td>
<td>Student satisfaction noted. Rated as “moderately to very helpful in learning concepts of anatomy/physiology and applying them to a clinical situation.” No performance scores reported.</td>
</tr>
</tbody>
</table>

Table 2: Teaching Strategies Used in Anatomy and Physiology Courses with Nursing Students

Many studies have identified collaborative teaching between scientists and nurse educators as a strategy of narrowing the Theory to Practice Gap (Friedel and Treagust 2005; Thornton 1997; Wynne 1997). Larcombe and Dick (2003) developed a collaborative ‘Teaching in Partnership’ approach for teaching anatomy and physiology to nursing and midwifery students. The specific anatomy and physiology instructor develops the core course content and experiments for each system and the nurse/midwife instructor links the content to relevant clinical practice. Scenario example cards are designed collaboratively merging each instructor’s cognitive schema.
An example of this approach is seen in the experiment of respiratory blood gases analysis. The anatomy and physiology instructor presents the role of carbon dioxide in stimulating respiration and the physiological mechanism involved in maintaining homeostasis. The nursing instructor reads “more into the value of the experiment in terms of transferable clinical relevance” (Larcombe and Dick 2003, p 40) by adding health and safety concerns, infection control, ethics, documentation, oxygen administration and nursing observations. This approach directly transfers theoretical concept to nursing practice in the lab. Future research is needed to see if students perceive this approach as valuable during their nursing school clinical practicum.

**Conclusion**

There is a domino effect when a student nurse does not see the relevance or value to taking an anatomy and physiology course. “If bioscience is not perceived as relevant to nursing, this may engender a downward spiral of de-motivation, disinterest in study and increasing difficulty with the subject” (Jordan et al. 1999, p 221). This spiraling will impact the student nurse’s ability to perform successfully on anatomy and physiology examinations (Gresty and Cotton 2003). Poor self-efficacy and perceptions are not only linked to low assessment scores (examination), but also poor clinical performance (Friedel and Tregast 2005; Gresty and Cotton 2003; Jordan et al. 1999).

The literature identified that current evidence-based practice brought to the anatomy and physiology class will engage student learning and promote the critical thinking needed in providing patient care. Understanding our diverse learners and addressing their relevance concerns of taking a separate anatomy and physiology class, will only assist them in their learning and future professional practice.

Without an understanding of anatomy and physiology, new content in nursing classes provides a greater challenge to learning because of the wider area of information needing to be covered. Anatomy and physiology scattered throughout the nursing curriculum does not allow the student to see the patient as a whole; only its parts and systems. When this happens, patient safety is at risk!

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**References**


(Continued on next page)


Introduction

Every year a large number of students take courses in anatomy and physiology (A&P). These are important gateway courses for coveted careers in the health sciences. A&P is a challenging subject that requires a serious commitment of time and effort by the students in order for them to achieve mastery of the topics and academic success. Many of today’s students have large course loads, some have part-time or even full-time jobs, and some have families to care for and financially support. As a result, many students have extremely limited time to meet with tutors or peer-study groups and to use other resources outside of class time that are available at the colleges. Students are frequently ill-prepared for A&P courses and there is often a high drop-out and failure rate. At many colleges there are now no biology or chemistry prerequisite courses required before taking A&P. Many students have little or no background in science and have not developed good language and study skills. Furthermore, many students enter A&P courses with little or no prior experience using microscopes and handling microscope slides, and consequently considerable laboratory class time can be spent helping students use microscopes properly. A&P courses often have large enrollments and class sizes. It is not uncommon for laboratories to have more than 20 students with a single instructor. These facts combined with budget limitations and other problems encountered at educational institutions can cause logistical and pedagogical difficulties for instructors, course coordinators, departmental and college administrators, and for students.

Histology is often considered one of the most difficult topics in A&P. Typically, histology is covered in A&P 1 after the study of cells. Students need to master basic histology and retain that information throughout the remainder of their study of A&P. If a student fails to master basic histology they will have great difficulty understanding how organs and organ systems are structured and how they function. Many students have difficulty conceptualizing and intellectually accepting that their bodies are composed of microscopic components and that some of those components are living and some are non-living material. Furthermore, it is not uncommon for some students to emotionally reject the fact that our bodies harbor a huge number of symbiotic bacteria. Various authors in the HAPS-EDucator and in other publications have given valuable suggestions and described useful individual techniques and strategies for teaching histology. (See list of additional resources at end of article.)

In introducing students to histology it is important to include a discussion about biological stains (how and why they are used) and to briefly review cells and their basic structure. Instructors should explain to the class which cellular structures (plasma membranes, nuclei, and cytoplasm) the students will see while examining tissue slides at magnifications available on typical A&P student laboratory microscopes. Students frequently think that they will be able to see all of the different organelles that they learned about while studying cells. Drawing for the class a basic illustration of simple columnar epithelial tissue with the plasma membranes, nuclei, cytoplasm, free surface, basement membrane, and the underlying connective tissue all shown and labeled is a good way to review aspects of basic cytology and introduce to the class the structural complexities of tissues. We suggest that instructors discuss with their classes the anatomical and physiological diversity of tissues, explain that there are four principal categories of tissues (epithelial, connective, muscular, and nervous tissue), and explain that the individual types of tissues that are classified into these four categories have some important characteristics in common but also possess some distinguishing and important structural and functional differences. For students to understand A&P their instructors need to help them understand the essential connections between structure and function.

Examining tissues in the laboratory is often confusing for students and poses special problems for the instructor. An excellent laboratory exercise that helps to introduce students to histology is the preparation by each student of a cheek cell slide made by scraping cells from the stratified squamous epithelial tissue lining the inside of their cheeks. This exercise allows students to make their own slide using biological stain, to have the experience of examining cells that they themselves removed from their own body tissue, to see the primary structural components of the cells, and to have the opportunity to practice using microscopes.

We explain briefly ten different pedagogical methods for teaching histology in courses in anatomy and physiology.
Pedagogical Methods for Teaching Histology

1. Self-Guided Learning. This is the traditional method of teaching histology in the laboratory. The instructor tells the students to get out their individual microscopes, slide boxes, laboratory manuals, and notebooks. The students are then instructed to study on their own a specific group of tissues (such as epithelial tissues) within a specified period of time. Instructors can suggest to the students that they view tissues at more than one magnification, compare what they see with the information in their course book(s), and make notes and drawings of the tissues that they examine. The instructors can either walk around the laboratory visiting the students’ individual work stations or position themselves in a location in the room where they are accessible to the students.

Advantages of this method include the students’ hands-on learning with microscopes, slides, individual observation, and biological illustration. Tactile learners may benefit from the instructors suggestion that they draw what they see. Disadvantages include the lack of direct guidance from the instructor, the need for student self-motivation, the time that this method requires when all of the students conscientiously do the necessary work on their own, the likelihood of students lacking sufficient knowledge of microscopy, and the possibility that students will spend time studying the wrong slides and the wrong areas on the required slides. With self-guided learning it is not uncommon to see students mistake various things (such as cracks in the slide and coverslip, the adhesive that affixes the coverslip to the slide, dust particles on the slide, and even parts of the manufacturer’s slide label) for tissues. Also, the lack of direct guidance from the instructor increases the likelihood of students clandestinely text messaging and engaging in other nonproductive behavior.

2. Learning with Preset Microscopes. Microscopes are set up in the laboratory with slides in place each showing a good field of view, at an appropriate magnification, of the tissues to be studied. This can be done by the instructors or laboratory technicians before the laboratory class. Supplemental information can be provided at each microscope, such as illustrations, photomicrographs, and brief written descriptions of the important physical characteristics of the tissues. During the laboratory each student is expected to visit each preset microscope to study the slides along with any supplemental material present. The students need to be instructed how to use the fine focus adjustment on the microscopes and told not to move the slide and not to change the magnification.

Advantages of this method include the time saved from not having the students setting up and putting away their individual microscopes and slides, reducing the likelihood of students studying the wrong slides and the wrong areas on the slides, the ability to have multiple activities occurring in the classroom simultaneously, and the ability to provide the instructor’s choice of supplemental material for each microscope. Disadvantages include the students not having the experience of setting up the microscopes and slides themselves (i.e., not having to go through the entire process of focusing the microscope and hunting for and finding the correct tissue and proper field of view), the possibility of students accidently moving the preset field of view, and the problem that sometimes students either have to wait while others are at the microscopes or they feel pressure to rush through their work when they are using the microscopes because other students are waiting.

3. Learning with Image Projection. Histological images in the form of transparencies, PowerPoint slides, microscope projector images, video images, or internet images are projected on a screen (e.g., projector screen, video monitor screen, or computer screens) in the classroom. The instructor guides all the students at the same time through a series of images of the tissues to be studied, pointing out on the images the primary and distinguishing anatomical features of each tissue. This is an excellent opportunity for the instructor to explain the physiological purposes of the anatomical features, the etymologies of the names of the tissues, the locations in the body where the tissues are found, and the roles that each tissue plays in bodily functions. The instructor can also ask the students to follow along with this presentation by referring to images in the students’ lecture textbook, laboratory manual, and/or in supplemental course material provided to the students. The instructor can ask the students questions and involve them in classroom discussions about the tissues that they are seeing projected on the screen.

Advantages of this method include saving time (and money) by not having the students use microscopes and slides, focusing the students’ attention on a single classroom activity guided by the instructor, providing the opportunity for students to see and hear the instructor’s explanations of the tissues, having structured classroom time in which students can ask questions and there can be classroom dialogue, eliminating the likelihood of students studying the wrong slides and the wrong areas on their slides, and the fact that practical examinations can be conducted using image projection instead of setting up a series of individual microscopes with slides. Disadvantages include losing the valuable opportunity for students to have hands-on experience with microscopy and not being directly involved in the discovery process.

4. Learning with Digitized Imaging. Students are encouraged or required to make digital images of the tissues that they examine by microscopy. This can be accomplished with microscopes coupled to a digital camera or now with the students own digital cameras and with cell phones that possess built-in digital cameras. The students can then digitally label their images and post the images on the course website and into their own digital...
sites (such as ePortfolio). They can also send by email their images to the instructor and to their classmates. The instructor can have the entire class work together to make a course digital histology atlas, or the students can be divided into groups and instructed to assemble unique group digital atlases, or the students can be told to create their own personal digital atlases. The students would have the ability to make computer printouts of their labeled and unlabeled histological images. The labeled and unlabeled digital images and the printed copies can conveniently be used by the students for review and self-testing.

Advantages of this method include involving students with the production of course material (many students feel motivated to try to produce good quality digital images to share with their classmates and to post on the course website and their personal sites) and having the students experience identifying tissues and structures by digitally labeling their images prior to their classroom examinations. Disadvantages include the possibility that the students will spend more of their time involved in the technology (making, electronically distributing, and posting the digital images) than actually learning about histology, the likelihood that students will mislabel their digital images and that these mislabeled images will then be posted to the course website and distributed by email to classmates without being factually correct, and the concern that email attachments may contain harmful computer viruses.

5. Cooperative Learning. The students are divided into cooperative-learning groups, usually composed of 2–5 individuals. The groups are instructed to carry out specific cooperative-learning exercises. These exercises can be unique for each group or all groups can be given the same exercises to perform. The instructor can either limit the cooperative learning to the members within each group or can require different groups to engage with each other in intergroup cooperative-learning exercises. Each group can be required to hand in to the instructor some specified form of group work. The instructor can also require each group to give a brief presentation of the results of their group exercises to the entire class or this information can be shared in some other way. An example of a type of cooperative-learning laboratory exercise is to have all members of a group examine a specified tissue and then the students within the group discuss between themselves the characteristics of the tissue that they examined.

Advantages of this method include providing the students the opportunity to formulate their thoughts in order to verbally communicate their ideas to their classmates. Some students feel motivated in cooperative learning environments. The instructor can also incorporate into this pedagogical method aspects of Methods 2, 4, 6, 7, 9, and 10. Disadvantages include quality control because students at this level usually lack the knowledge to provide quality information to their classmates about the tissues that they examined. They frequently describe the tissues incorrectly, omit valuable information, and describe the tissues based on the colors resulting from the biological stains. Some students are shy or uncomfortable during cooperative learning and recede from group interactions. Often one student will dominate the group and from our experience these dominant individuals are often the most gregarious people and not necessarily the better students.

6. Problem-Based Learning. The instructor devises problems that are appropriate for their classes and help to achieve the course learning objectives. The students can be instructed to work on the problems individually or in cooperative-learning groups. There are many different possible problems and techniques that instructors can use, and the problems can be presented to the students in a variety of different ways. Students can be given written and verbal problems to solve and case studies of various complexities. In the laboratory the instructor can use microscope slides that lack written labels or that have their labels securely covered. These slides need to be easily identifiable by the instructor and for this purpose we suggest that each slide receives an identification number. The students can be asked to identify the tissues and/or to classify them (e.g., into the four principal categories of tissues; or as either simple or stratified epithelial tissues; or into connective tissue proper, cartilage, osseous tissue, and blood). These types of problem-based exercises can be done with preset microscopes, or with each student working individually with a microscope, or as cooperative-learning exercises. Similar exercises can also be accomplished without microscopes by projecting unlabeled histological images on a screen or by furnishing the students with handouts of unlabeled histological illustrations and photomicrographs. Additionally, when illustrations and photomicrographs are used the students can label the different parts of the tissues directly on the handouts.

The principal advantages of this method are involving students in critical thinking and problem solving. Instructors can also use Methods 1–5 and 8–10 in conjunction with this method. The disadvantages in A&P are that many students find this method difficult and frustrating because they have little or no prior experience with this teaching method and often lack sufficient scientific knowledge to draw reasonable conclusions and solve on their own many types of problems.

7. Motor-Based Learning. Students are encouraged or required to draw the tissues that they need to know for the class and to correctly label the structures illustrated in their drawings. This is usually done while the students are examining tissues on their individual microscopes or on a series of preset microscopes. The students should be encouraged to consult their course books but discouraged from copying the figures that are in those books. The instructor should draw and label at least one illustration (such as a field of view of elastic cartilage with the lacunae, chondrocytes, plasma membranes, cytoplasm, nuclei, elastic fibers, ground substance, and possibly the perichondrium shown and labeled) for the

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class as a demonstration of the level of quality that the students are expected to strive to achieve in their own drawings. An effective technique is to simultaneously project on a screen the image of the same field of view that is being drawn by the instructor. The students are then able to watch the process of the instructor drawing and labeling the tissue while at the same time directly comparing the instructor’s illustration with the actual field of view projected on a screen. This technique enables the instructor to point out and explain any differences between the illustration and the actual field of view, and it provides the opportunity for an exchange of questions and answers between the instructor and the students. Instructors can have their students work individually or in cooperative-learning groups and can require the students to create individual or group learning portfolios that include the illustrated and labeled drawings, along with short written descriptions of each tissue. When this method is used as a cooperative-learning exercise each student within a group should be given the responsibility for drawing and labeling a specified number of tissues. This attempts to ensure that each student in the class is directly involved in the motor-based learning. After students have completed their assigned drawings the labeled illustrations are shared, discussed, and edited by the group members. The illustrations can then be assembled into the group’s learning portfolio. These learning portfolios can be turned in to the instructor and/or shared between the group members after photocopying or digitally scanning the included material.

The advantages of this method are not limited to tactile learners and students with artistic talents. An advantage of this method is that students need to closely observe the tissues to draw them properly. When the drawings are done properly, this method often helps students retain mental images of the tissues and learn their distinguishing anatomical features. Disadvantages include the large amount of time needed by most conscientious students to draw the tissues and the likelihood that students will mislabel their illustrations and that some students will simply copy figures from a book or from a classmate instead of making their own drawings. An additional common problem is that many students make very fast, poorly done drawings that do not resemble the tissues they examined and are therefore of little or no value to them.

8. Instructor-Guided Learning. In this method the instructor guides the students in a step-by-step fashion as they examine individually or in small groups the tissues to be studied. This method is similar to Method 1 except that the instructor directs the class step-by-step in the process of examining the tissue slides. The instructor tells the students exactly what slide to examine, tells them to find a specific tissue on the slide (many slides contain more than one tissue), and tells them to then find and place the ocular pointer on a specific structure (such as a nucleus, collagenous fiber bundle, chondrocyte, etc.) while using a specified magnification. The students are instructed to raise their hands when they believe they have the required structure in position on their microscopes. The instructor then goes to the students’ work stations to check the accuracy of the students’ work. If a student fails to find the correct structure, as is frequently the case, the instructor has the option to: (1) guide the student by various pedagogical techniques to locate the proper structure, (2) simply tell the student that they did not place the ocular pointer on the correct structure and to try again to locate and identify the structure, or (3) as is sometimes necessary, to place the ocular pointer on the structure for the student. After all of the students have correctly found the required structure (or have had the structure found for them by the instructor) the instructor can tell the class to find a different structure on the same slide or to remove the slide and put a slide of the next specified tissue on their microscope stage. From there the above outlined procedure is repeated.

Advantages of this method include the fact the students receive the instructor’s direct supervision and guidance at each step in the discovery process, the instructor and each student have a one-on-one interaction with each other and the instructor can therefore easily identify students who are having difficulties with the subject and difficulties using a microscope, the instructor can engage the students with individually tailored questions to access each student’s progress and comprehension on the material, and the instructor can incorporate into this pedagogical method aspects of Methods 3–7 and 9–10. Disadvantages include the fact that this method is very time consuming, requires the instructor to be continually moving from one student’s work station to another and therefore requires good mobility and endurance on the part of the instructor, and even a single student if not managed properly can disrupt and hold back the forward progress of the entire class. We have found that with some students it is necessary for the instructor to find the tissues and structures for them; otherwise, the class progress comes to a halt (it is usually quickly apparent which students need this type of help).

9. Organ-Based Learning. This method is best employed after the students have concluded their primary study of the different individual types of tissues and as part of learning about specific organs. In this method the students are asked to identify the individual tissues that compose bodily organs and, depending on their level of knowledge, to either hypothesize or explain the likely function or functions of each of the tissues in those organs. To accomplish this the students will need to examine carefully the microanatomy of organs on microscope slides, or on histological images projected on a screen, or on printed histological photomicrographs (in books, on handouts, and on computer printouts). The availability of well-drawn illustrations for the students to review can be an excellent supplement to slides and histological images and photomicrographs. The instructor can devise a variety of different projects and assignments

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for their classes and can have the students work individually or in cooperative-learning groups. As part of this method some instructors may want their students to have the hands-on experience of making their own microscope slides.

The advantage of this method is that it integrates the students’ knowledge of histology into their experience of learning about the structural organization and physiology of the body’s organs. This method can be used with a variety of different strategies, techniques, and teaching styles. The first eight methods described above can be easily and productively incorporated into this method. Disadvantages include that some students become confused and often frustrated trying to decipher the structural complexities of organs and attempting to differentiate and identify the individual tissues.

10. Organ System-Based Learning. This method is best used when the students are studying the body’s organ systems. In this method the students, working either independently or in cooperative-learning groups, are required to analyze the histological structure, macroanatomy, and functions of the major organs of one or more of the body’s organ systems. The instructor should tell the students to consider in their analyses the overall functions of the organ systems and the functional roles played by the different individual types of tissues and by the organs. As in Method 9, the students will be required to examine carefully the microanatomy of the organs. Many of the strategies and techniques that instructors can employ in Method 9 can be incorporated successfully into this method. Instructors can require that each student or cooperative-learning group prepare a written or verbal report or a PowerPoint presentation giving the results of their integrative analyses.

Advantages of this method are that it stimulates the students to use a variety of important skills; to analyze tissues, organs, and organ systems; and to think about and discuss the functional roles that tissues and organs perform in our body’s organ systems. This method helps students to better understand the anatomy and physiology of the organ systems and their constituent parts, while simultaneously using, reinforcing, and expanding their knowledge and understanding of histology. Instructors can use Methods 1–8 in conjunction with this method. Disadvantages include the fact that this method often requires a considerable amount of time and that some students may not be able to carry out the necessary integrative analyses.

Conclusions

There is no single method that works best for all students. The outcomes of these different pedagogical methods depend on the unique setting of each individual classroom. The decisions of each instructor as to which method or methods to try depends on a variety of factors such as whether or not there are biology prerequisite courses required before taking the A&P course, class size, the amount of available time dedicated in the course to histology, the availability of equipment and other materials in the classroom, institutional budgetary constraints, and the instructor’s mobility and preferences. Each instructor may employ one or more of these different methods to supplement their own teaching styles, enhancing the learning experience and comprehension of the students.

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Additional Resources


(Continued on next page)


Have any of your students told you that Anatomy and Physiology I (A&P I) is the hardest class they have ever taken? This kind of comment totally confused me at first, since I surely did not think it was the hardest class, considering that I also teach a few senior level courses. However, looking over my gradebook after a few quarters of teaching A&P I, I began to see that the passing rate was indeed not great. I compared my grades with those of the two other A&P instructors at Houston Baptist University (HBU) from Fall 1999 – Winter 2005 and determined that 72.1% of our students who took the final exam earned an A, B, or C in the course (308 of 427 students). Moreover, when the withdrawal rate was factored in, 43.6% of our students (n=546) were getting a W, D, or F at the end of the term. Students who take the course have a broad range in prior coursework and life experiences. Since there is not a pre-requisite course for A&P I at HBU, I hypothesized that any science class would probably be considered “the hardest class” if it were taken first. Further, if an A&P I student had previously been successful in another science class they would struggle less with A&P I and have a higher grade in A&P I compared to a student who had no previous college level science experience. This study examines the effect that prior science courses have on success in A&P I and summarizes a related survey posed to HAPS members during the fall of 2006. The overall findings indicate that prior success in college level science, particularly Chemistry, correlates with success in A&P I.

HBU A&P I Students: Success When Chemistry Comes First

The electronic transcripts of 546 A&P I students from the Fall Quarter 1999-Winter Quarter 2005/06 were analyzed to determine if the students had taken and passed any previous college level science courses (Biology, Chemistry, or Physics). Some students had taken A&P I more than once but, in this case, only their first attempt at A&P I was considered. The initial studies deal with the demographics of our first-time takers of A&P I.

At HBU, A&P I is a required course for Pre-Nursing majors and Kinesiology majors; the majority of the students are from the former major. A&P I is also taken as an elective by Biology majors and other students to fulfill the requirements for various pre-health programs like Optometry. During the study period, HBU had a mandatory double major system, where all students except Nursing majors and few other programs required two majors. For example, a student with the majors Biology and Chemistry would be labeled Sci/Sci in Figure 1. The students with greater science background (Kine/Sci, Sci/Sci, and Sci/ Other majors) performed better in the A&P I course than students without a science major. Many of these students had taken multiple science courses before A&P I. This result supports the hypothesis that prior science improves success in A&P I. To further evaluate the hypothesis, a more in depth study of the students’ transcripts was performed.

Before discussing the data it should be noted that students who withdrew from A&P I (n=119) did not receive a numerical GPA score and were not considered further. Of the 427 remaining students, 9 did not have complete academic records on file, so 418 students were considered for the subsequent analyses. All data presented are means ± one standard error. All data was analyzed with SPSS using independent t-Tests.

Analysis of the transcripts of the 418 A&P I students revealed that more than half of these students had passed a science course before taking A&P I (n=259). However, less than half of A&P I students had passed Chemistry prior to taking A&P I (n=186). The analysis of these cohorts is presented in Figures 2 and 3. While both of the tested conditions increased success rates significantly, the students with prior Chemistry had the highest mean GPA, 2.64. Of greatest concern was that the mean GPA of the students without any prior science or prior Chemistry was not passing, 1.79 and 1.88 respectively. Similarly, a previous study found that prior Chemistry correlated with success in A&P I (Homgren and Schoondyke 1991).
An online survey regarding pre-requisites and success in A&P I was administered to 185 HAPS members logged into www.hapsweb.org, September-November 2006. The majority of the respondents were from 2-year institutions (61.1%). When asked the length of their A&P curriculum, most HAPS members said their course was taught over two semesters (82.7%). Most instructors said their A&P I course consisted of a mixture of Anatomy and Physiology topics in A&P I (76.2%) as opposed to Anatomy only or Physiology only. One hundred-eleven survey responders said, yes, there was a pre-requisite and 84.37% (SD=14.43%) of their students passed the course. Although 64.3% of respondents said their institution had a pre-requisite in place for A&P I, there was not a clear common pre-requisite among the variety of types of pre-requisites queried. Refer to the data in the survey form for more details.

Several questions were then answered by using SPSS to analyze the survey data. Does a pre-requisite for A&P I lead to higher success rates? Sixty-one survey responders said there was no pre-requisite for A&P I and 80.73% (SD = 13.00%) of their students passed the course. This was

(Continued on next page)
An online survey regarding prerequisites and student success in A&P I was posed. Twenty-eight survey responders cited college level Chemistry as a pre-requisite for A&P I and 89.27% (SD = 9.39%) of their students passed A&P I. One hundred-two survey responders said that Chemistry was not a pre-requisite and 82.26% (SD = 13.032%) of their students passed A&P I. Although the standard deviations were substantial, the p = 0.009 indicated a statistically significant difference. When a similar analysis was done regarding college level Biology as a pre-requisite, the results were similar. Fifty-seven survey responders said Biology was a pre-requisite and 86.61% (SD=11.91%) of their students passed A&P I, while 77 survey responders said Biology is not a pre-requisite and 81.61% (SD=12.80%) of their students passed. The standard deviations were again substantial and this time p=0.023, which was also statistically significant, but less than in the case of the Chemistry pre-requisite. None of the other pre-requisites were found to have significant differences in success rates in A&P I (data not shown).

The data collected on passage rates was based on the students who took the final exam to eliminate students who withdrew from the course from the analysis as was done in the HBU study. The survey passage rates of >80% were higher than HBU’s 72.1%, but still within the range of the standard deviations reported. It should be noted the survey does not address the same question about prior courses that the transcript based study at HBU did. For example, students in the “no Chemistry pre-requisite” cohort in the survey may in fact have taken Chemistry (although not required) prior to A&P I. As with any study there are limitations to the interpretations that can be made. Nonetheless, the trends for the importance of prior coursework in Chemistry and possibly Biology are evident in the survey results.

Rather than to call for a mandate on pre-requisites for A&P I, the purpose of publishing these results is to remind us of the importance of good advising when working with students who may be weak in Chemistry. Most A&P textbooks begin with a cursory overview of chemistry topics and then apply them immediately in chapters relating to basic molecular and cellular processes. The chemical concepts then extend to additional topics regarding membrane potential, excitation-contraction coupling in muscles, and calcium homeostasis in the skeleton, to name a few. At least three arguments could be made to explain the correlation between success in Chemistry and A&P I, (A) understanding chemistry in its pure form makes it easier to understand it in its applied form in A&P, (B) the rigor of a prior Chemistry course helps students hone their study skills, or (C) students who score high on the first test, which is heaviest on chemistry, have an early win that increases their morale for the remainder of what truly is a hard course after all. While this paper does not determine how knowledge of chemistry increases the success rate in A&P I, it presents evidence that mastery of basic chemistry is important for students seeking to achieve their highest possible grade in A&P I.

Acknowledgments

Thank you to my colleagues, Dr. Avin Brownlee and Dr. Curtis Henderson, for their thoughtful reviews of this manuscript.

References


Hopp RMP. 2006. Identifying Factors which Lead to Success in Anatomy and Physiology I. Human Anatomy and Physiology Society Meeting, Austin, TX.
Survey Questions
1. Do you teach at a 2-year, 4-year, or other institution?
   - 2-year (61.1%)
   - 4-year (30.3%)
   - high school (2.7%)
   - other (4.3%)
   - 1.1% did not respond to this question.
2. Do you teach A&P as a one semester or two semester course?
   - one semester (8.1%)
   - two semesters (82.7%)
   - three semesters/quarters (4.3%)
   - other (4.3%)
   - 0.5% did not respond to this question.
3. Is your A&P two semester course taught as a mixture of anatomy and physiology during both semesters or as separate anatomy only and physiology only courses?
   - Mixture of A & P components (76.2%)
   - Separate A & P components (16.8%)
   - 7.0% did not respond to this question.
4. Does your institution have a pre-requisite for A&P I?
   - Yes (64.3%)
   - No (35.1%)
   - 0.5% did not respond to this question.
5. Which of the following describes the pre-requisite? Mark more than one if necessary.
   - College Level Biology Course (33.5% yes, 43.8% no, 22.7% blank)
   - College Level Chemistry Course (17.3% yes, 57.8% no, 24.9% blank)
   - High School Level Biology Course (23.8% yes, 48.1% no, 28.1% blank)
   - High School Level Chemistry (18.9% yes, 55.1% no, 25.9% blank)
   - Math Level/Proficiency Test Score (20.0% yes, 53.5% no, 26.5% blank)
   - Reading Level/Proficiency Test Score (32.4% yes, 44.9% no, 22.7% blank)
   - Recent High School Science Course (ex. last 5 yrs or similar) (9.7% yes, 59.5% no, 30.8% blank)
   - Recent College Science Course (ex. last 5 yrs or similar) (12.4% yes, 55.1% no, 32.4% blank)
   - Other. Please explain ___________________________________
6. Please provide some specific data on the success rate of the students in your A&P I class. The simplest assessment would be to look at one semester (or quarter) of grades. Choose a semester where there would be the highest percentage of “new” A&P I students (those who have never taken A&P I), such as Fall 2005. You can include data from all sections of A&P I if you taught multiple sections. Determine the total number of students who took the A&P I final exam (as to exclude students who dropped or withdrew prior to the final). Then determine the number of students who passed and failed the course as determined by your college’s standards. For example, I would count A, B, and C’s as passing at my university, because those students do not need to retake the course to get credit for it. D and F’s would be failing. Please report raw numbers, because percentages (% passed and % failed) will be calculated later. Please take the time to answer this question as accurately as possible, so that all HAPS members can benefit from this data.
   - Number of students taking the final exam in A&P I = ___________
   - Number of students, who took the final exam and passed A&P I = _________
   - Number of students, who took the final exam and failed A&P I = _________
   - The data entered for question 6. a-c was converted to percentages and analyzed.
Non-surgical endodontic therapy or root canal treatment is a dental procedure that remains so shrouded in myths and misconceptions that the American Association of Endodontists (AAE) launched a public and professional awareness campaign known as Root Canal Awareness Week in 2005. Generally falling at the end of March, its purpose is to dispel the myths and misconceptions associated with endodontic treatment. Even in this age where access to local anesthesia is ubiquitous, the fear of pain associated with dental procedures remains the top reason adults avoid going to the dentist and the most feared dental procedure is root canal treatment. According to the AAE, adults fear getting a root canal (54%) as much as they fear flying in an airplane during a thunderstorm (57%) or speaking in public (42%). More than 16 million teeth receive endodontic treatment each year in an effort to restore and save natural teeth. Such treatment boasts an extremely high tooth retention rate of 95-97% after eight years. Competitive therapies, such as dental implants, lag behind with a tooth retention rate of 85-90% (AAE 2009; Spangberg 2008).

Endodontics is the branch of dentistry that deals with prevention, diagnosis and treatment of diseases of the pulp, root, periodontal membrane and alveolar bone. As a result of an 84% increase in the number of endodontists in the past 20 years, there are currently approximately 4,000 active endodontists practicing in the US. Newly certified endodontists outnumber new general practice dentists and all other dental specialists and it is expected that there will be continued growth in this area over the coming decades. While the most common procedure done by endodontists is root canal therapy, endodontists are also experts in repairing cracked teeth, dividing a tooth in half, repairing injured roots, removing one or more roots, and replacing teeth knocked out by injury. The American Board of Endodontics requires that endodontists be certified through a two-year postgraduate program that generally includes thesis based research in clinical endodontics or a related basic science. There are currently 50 postgraduate training programs for endodontic education in the US populated by approximately 400 dental students (AAE 2009).

Teeth typically consist of three primary regions (Fig. 1). The crown is the part of the tooth that can be seen above the gum line. The roots anchor the teeth in the alveolar processes of the maxillae and mandible, and the neck of the tooth is the area at the gum line where the crown and the root meet. Dentin, a calcified connective tissue that is harder than bone due to its high concentration of calcium salts, is the most abundant material in teeth and gives shape and rigidity to tooth structure. Dentin encloses a cavity known as the pulp cavity which houses connective tissue containing blood vessels, nerves, and lymphatic vessels. Root canals are narrow extensions of the pulp cavity that run through the interior of the roots. Each root canal ends at the apical foramen, an opening at the base of the root canal. Blood vessels, nerves, and lymphatic vessels enter and leave the tooth by way of the apical foramen. Dentin in the crown of the tooth is covered by enamel, a substance that is also harder than bone. Cementum, another bone-like material, covers the dentin of roots and anchors the root to the periodontal membrane. The anterior and posterior superior alveolar branches of the maxillary artery and the incisive and dental branches of the inferior alveolar artery feed teeth with oxygen and nutrients. Teeth are innervated by sensory fibers of the trigeminal nerve (Ryan and Ray 2004).

Endodontic treatment may become necessary as a result of pulp inflammation or infection secondary to deep decay, cracks or chips in teeth, or extensive dental procedures. At the start of treatment, a “dental dam” of latex is placed around the tooth to prevent contamination from saliva and a local anesthetic such as lidocaine is administered. The pulp of the tooth is then removed and the root canal is carefully cleaned and shaped (Fig. 2). The root canal spaces are filled with a rubber-like biocompatible material such as “gutta-percha” before being permanently sealed. Gutta-percha is a natural thermoplastic polymer of isoprene that can be melted and injected into the root canals or cemented pre-formed into the root canal space. Barium is added to gutta-percha to make it opaque so that root canals can be easily observed on X-ray to determine if they have been completely filled (Fig. 3). If the patient’s tooth was abscessed, the endodontist may prescribe antibiotics for a period of time after treatment. After receiving root canal treatment the patient is instructed...
to return to his/her regular dentist to have a permanent filling put into the tooth or to have a crown placed on the tooth to protect it. Very often, successful endodontic treatment can be completed in only one office visit, often in less than 40 minutes (AAE 2009; Kirsch 2009).

Fig. 2. Root canal process: including removing the pulp, measuring the pulp cavity, and filling the pulp cavity with polymer.

Although it has a high success rate, endodontic treatment occasionally fails. In some cases there may have been new trauma to the tooth, progressive deep decay, or a cracked or broken filling that resulted in a new infection. In other cases, there may have been very narrow or curved root canals that were not located and treated during the first endodontic procedure. Most endodontists believe that the success of root canal treatment depends on identifying all of the canals so that they can be cleaned, shaped and filled. Some teeth are more predictable than others in terms of the number and location of their root canals. For instance, while most maxillary molars have three or four root canals, the presence of five, six or even seven root canals has been reported in the literature. Additionally, sometimes the roots themselves are oddly shaped, more oval than round, making it difficult to detect additional canals on X-ray. Many clinicians today are using operating microscopes to better illuminate the visual field and the inner structure of teeth. Research indicates that when endodontists are well-trained and experienced in the use of operating microscopes, the rate of detection of additional and abnormal root canals reaches 93%. Cone beam computerized tomography (CBCT), originally developed for the evaluation of hard tissue in oral and maxillofacial surgery, is now available to endodontists and is used to identify the anatomical features and root canal variations of teeth requiring endodontic treatment. Since CBCT is a three-dimensional imaging system, it can be used as a complement to two-dimensional X-ray systems to facilitate endodontic diagnosis and treatment (Filho et al. 2009; Kirsch 2009).

Fig. 3. Radiograph of completed root canal surgery.

Over the years the high incidence of certain bacteria in filled root canals has interested researchers. A bacterium known as Enterococcus faecalis has been of particular interest since it is not believed to be a regular colonizer of the oral cavity and is rarely found in the dental decay that may necessitate root canal treatment, yet it is often found in filled root canals associated with root canal failure (Zehnder and Guggenheim 2008). Enterococcus faecalis is a non-motile, gram-positive, spherical bacteria and its natural home is thought to be the intestine of humans. It is a facultative anaerobe which is listed as the first to the third leading cause of nosocomial infections following abdominal surgery or puncture trauma linked to IVs and cathers. One of the most antibiotic-resistant bacteria known, existing alone or in conjunction with other bacteria, it can be responsible for urinary tract infections, bacteremia, endocarditis, meningitis and wound infections following surgery (Ryan and Ray 2004). How does it find its way into filled root canals? In theory there are two possibilities worth exploring: (i) enterococci colonize the root canal system as it becomes necrotic and survive endodontic treatment and the filling of the root canal, and (ii) enterococci enter the root canal during or after treatment via improperly sealed root canal systems. The former is considered unlikely since enterococcus is rarely found in dental caries or primary root canal infections and the likelihood of bacteria reaching the tooth pulp by way of the blood stream is believed to be very small. The latter, although data is scarce, has some degree of support since recent research points to the fact that the most likely source of enterococcus that can be found in the oral cavity is food (Zehnder and Guggenheim 2008).

Enterococcus faecalis is an indicator for contamination of food and water from human sources and it is ubiquitous in food products for raw consumption such as milk products like cheese and meat products like fermented sausage, vegetables, and olives. Surprisingly, very few health problems appear to be related to this fact. Enterococci are commonly added as food supplements to veterinary products and they are used as probiotics for human consumption in the treatment of diarrhea. Enterococci are known to add to the taste of Mediterranean cheeses and they are routinely used in starter cultures to ferment olives and cheese. However, recent research, using artificial oral environments, has shown that viable enterococci can leak through the calcium sulfate temporary fillings that are used to cover new root canals prior to the placement of permanent fillings if the temporary filling is less than 4 mm in thickness. The current hypothesis with respect to colonization of filled root canals with enterococci is that they may enter the root canal at any point during or after treatment if the crown of the tooth is improperly sealed. Though the most likely source of these bacteria is food, enterococci do not colonize the oral

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cavity of healthy people with good oral hygiene habits but they appear to enter improperly sealed root canal systems and are exceptionally well adapted to grow and survive in these systems (Zehnder and Guggenheim 2008).

When root canals fail, teeth can often be saved by endodontic surgery. The most common type of endodontic surgery is called apicoectomy or root-end resection. This procedure is performed when an infection persists in the bony area around the end of a tooth after the original root canal treatment. In this procedure, the endodontist makes a small cut in the gum at the tooth site and creates a flap of gum tissue that can be gently pushed to the side, exposing the underlying bone so that inflamed or infected tissue can be removed. The very end of the root is also removed and a small filling is placed at the end of the root canal to seal it. The gum is put back in its normal position and held in place with a few stitches. The bone will heal around the end of the root over a period of several months. Today, it is even possible under certain circumstances for a tooth to be extracted, treated with an endodontic procedure while it is out of the mouth, and repositioned in its tooth socket for healing. The only alternative to endodontic surgery is tooth extraction. Since an implant, a bridge, or a removable partial denture must replace teeth lost by extraction in order to maintain proper chewing function and to prevent teeth from shifting out of proper alignment, the total cost of tooth extraction can exceed that of endodontic treatment (AAE 2009; Kirsch 2009).

The goal of endodontic therapy is to save natural teeth. As a result of the high success rate of endodontic treatment, millions of endodontically treated teeth are serving patients all over the world today, enabling the vast majority of these patients to keep their natural teeth for a lifetime. With the advent of constantly evolving technology that has revolutionized magnification, illumination, and three-dimensional scanning equipment, endodontic therapy has become a fast, pain-free, and cost effective way to treat teeth that would otherwise be lost. As technology and pain management techniques continue to improve, the American Association of Endodontists is hopeful that the old comedian’s line “I’d rather have a root canal….” will take on new meaning and fear of this particular dental procedure will be replaced by the realization that no matter how effective modern tooth replacements like dental implants are, and they can be very effective, nothing is as good as a healthy, natural tooth.

References
Faculty and Student grants announced

At the annual business meeting during the HAPS 2009 annual meeting in Baltimore, the winners of the faculty grant and student grant were announced. Dr. Dennis Delfert, Professor of Biology at Lewis and Clark Community College, received the faculty grant for his project “Building a low cost neurobiology unit for measuring action potentials and muscle potentials in anatomy & physiology and physics courses: Integrating biology and physics to enhance higher order critical thinking skill.”

Michael Jones, who studies in the Department of Kinesiology & Nutrition at the University of Illinois at Chicago, received the student grant for his project “The Effects of Therapeutic Massage and Kinesio® Tape on Scapular Posture and Upper Shoulder Chronic Musculoskeletal Pain.” HAPS member Mary Lou Bareither is his supervisor.

Call for proposals

Do you have a project in mind? You could be the next grant recipient! Check out the Call for Proposals on the HAPS website (www.hapsweb.org) or contact Michael Kopenits, Grants and Scholarships Committee Chair at kopenits-ms@actx.edu. The deadline for the next round of Faculty and Student Grants is February 1, 2010. Be sure to check out the Web site for details.

Robert Anthony and Adjunct Faculty Travel Awards

Do you know someone who fits this description?

- HAPS member in good standing
- Full-time faculty member
- In their first three years of teaching anatomy and/or physiology
- Has a teaching load that includes at least one section of Human Anatomy and Physiology
- Wants to attend the Annual meeting 2010

Or maybe you know someone who fits this description?

- HAPS member in good standing
- Adjunct or part-time faculty member
- In the first three years of teaching anatomy and/or physiology
- Has a teaching load that includes at least one section of Human Anatomy and Physiology
- Wants to attend the Annual meeting 2010

If you do, please encourage them to apply for either the Robert Anthony Scholarship or the Adjunct Faculty Scholarship. The deadline for both is November 15, 2009. Full details can be found on the HAPS website (www.hapsweb.org).

HAPS-I Scholarships available

Would you like to have financial assistance to be able to participating in the continuing education opportunities offered by the HAPS-Institute? If so, go to the HAPS website (www.hapsweb.org) and check out the HAPS-I call for applications.

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Reflections of the 2009 Robert Anthony and Adjunct Faculty Grant Recipients

The following are comments that were received from scholarship recipients after the annual meeting in Baltimore.

Tom Keenan
SUNY-Onondaga Community College

My experience regarding the 2009 HAPS national conference was extremely positive starting from the award of my Robert B. Anthony scholarship and continuing right through the last teaching workshop I attended Wednesday afternoon. I enjoyed the warm welcomes offered at the first-timers breakfast and the conversations I engaged in during the impressive banquet ceremony (and food of course). I have to say that Frank the Body Snatcher and the tie-in to Poe in Baltimore were quite memorable events as well. Great planning done by the HAPS conference committee for sure!! In addition to the exhibitor’s financial generosity, their display of teaching-enhancing products piqued my curiosity. I will have to convince my college to send me off to my next HAPS conference with a blank check!!! I did enjoy the neurological-based update seminars and found them to be ‘neurologically stimulating’ as well. The workshops, in which novel teaching techniques and strategies were presented by other A and P professors, were by far the most valuable of my experiences. I will be bringing a few of these into my classrooms and laboratories over the next year. I thank HAPS for my scholarship and all of the time and energy put into organizing and delivering this conference by HAPS members, exhibitors, and staff.

Bill Karkow
University of Dubuque

It was a pleasure to go and to share a room (sight-unseen) with Tom Lancraft with whom I’d had email correspondence but never met. I told several people that the level of initial presentations the first two days surprised me by being at a more sophisticated level than I had expected, and reminiscent of several medical conferences for surgeons I have attended - presenting basic research at the edge of their fields. The last two days were fun, partly in hearing the interesting ways others teach, but also simply getting to meet and talk with folks that share similar situations, students, and challenges. There was good humor and a more relaxed, less competitive atmosphere than most other professional conferences I have attended. Among other particular things I learned was that astrocytes harbor latent HIV, the implication being that HIV is very unlikely to ever be “cured” in the sense of viral elimination. The first speaker privately confirmed this to me after his talk. Why didn’t he say so to the entire audience? He must fear losing funding for further research in his field - but that’s just the cynic in me. HAPS members are like physicians or engineers -- interested in science but with a practical bent, not pie-in-the-sky abstractions. At least that’s my take so far.

Howard K. Motoike
LaGuardia Community College

The 2009 Annual HAPS Meeting held in Baltimore was a very positive experience for me. I thank the Grants and Scholarship Committee for allowing me the opportunity to attend the meeting. I was able to present a poster on our study using clay modeling to learn the human musculature and had the opportunity to meet many individuals in person for the very first time. I had engaging discussions regarding the difficulties and issues that face A&P programs. I was also impressed with the caliber of the invited speakers at the meeting. I am looking forward to future HAPS meetings.

Tony Chennault
Clark College

First, the Grants and Scholarships process was very easy to do. I was alerted by a colleague that I should apply for a Robert Anthony Grant, and I easily found the relevant information and application on the HAPS website, which I completed and submitted without a problem. I am very grateful to have been awarded a RA Grant, and I’m very glad to have had the opportunity to attend my first national HAPS conference in Baltimore.

I enjoyed all aspects of the conference, but my favorite parts were the educational opportunities: I learned a lot of valuable information and teaching tips at the update seminars and workshops. It was also really neat to be able to “vent” some of the issues I’ve had as a community college A&P instructor to my peers, and receive a ton of support and valuable advice in return.

Please let me know if you’d like anything further, and thanks again for your contributions to making HAPS such a successful organization.

Karen L. Keller
Frostburg State University

I would like to thank the HAPS Grants and Scholarships Committee for the opportunity to attend my first HAPS conference as a Robert Anthony Scholarship recipient. My experience at the HAPS annual meeting was very enriching and rewarding. The conference was extremely well-organized and informative. I was particularly impressed with the quality of the presentations and the willingness of participants to share ideas and comments. Also, the convenience of the Renaissance Hotel to all of the wonderful attractions at the Inner Harbor was a great...

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It was an excellent opportunity to explore new software, meet with my sales representatives, and simply interact with fellow A&P instructors. I look forward to future conferences!

Sarah Lovern

Concordia University

I first learned about the scholarship opportunity from a colleague. She said HAPS was a great organization and wondered if I would like to apply. I also joined HAPS because I thought the resources I saw online would be valuable and the dues were reasonably low compared to other societies with which I’ve been associated. Upon finding out that I received the Robert Anthony scholarship, I went to the HAPS webpage and found a roommate to share hotel costs. This was a great opportunity to get to know another HAPS member and save money. With the scholarship for the meeting costs and the reduced cost for housing, I went to my division chair and asked for additional funding for the conference. He agreed and I was able to attend the entire meeting. Without the scholarship, I would not have been able to do so. This was extremely valuable to me as both the update seminars and workshops were beneficial to my teaching. It was very nice to hear cutting edge research from various disciplines as well as to gain simple, new techniques that I can implement in my courses this school year. It was also extremely helpful to meet people in between workshops and seminars to compare what works and what doesn’t in our courses. I took away so many useful tips from this meeting! I also went to the committee meeting on Testing & Assessment and I look forward to working with this group in the future. HAPS is an extremely supportive group and I’m glad I joined. I may not be able to attend the annual meeting each year, but I certainly plan to attend in the near future.

Courtney E. Leik

Rosemont College

I am grateful to have received the Robert B. Anthony Scholarship this year to attend my first Annual Conference of the Human Anatomy and Physiology Society (HAPS). It was an incredibly enriching experience! I was most impressed with the welcoming, collegial atmosphere that characterized the entire conference. It was clear to me that members are committed to the organization and to each other’s professional growth. This friendly, collaborative learning environment created by HAPS members was evident beginning with registration and the special first-timer badge, to the first-timer’s breakfast, to the annual meeting, and to all of my interactions with members. I thoroughly enjoyed the scavenger hunt to encourage first timers to meet committee chairs and, importantly, to learn more about the activities of the Society. The opportunity to connect with committee chairs definitely plants seeds for future involvement. I also valued meeting other individuals new to the organization at the first-timer’s breakfast. Throughout the conference I met many extraordinary individuals dedicated to their own professional development as well as that of other members. Everyone was excited to share strategies, tools, experiences, etc. to enhance one another’s teaching of anatomy and physiology. It was such a positive, supportive atmosphere!

As I stated in my scholarship application, I had several goals in regard to my own professional development for this year’s conference. Specifically, I wanted to: 1) learn methods and tools for teaching muscular and skeletal anatomy, 2) learn techniques to apply course material for development of students’ analytical abilities, and 3) meet other educators passionate about the teaching and learning of anatomy and physiology. I attended several workshops to enhance my teaching of muscular and skeletal anatomy (“Secrets of the Skulls: What the Human Skull Reveals About the Person Long After Death” and “Get’em Moving! Multiple Methods for Teaching Muscle A&P”) and learned of activities to reinforce skeletal muscle anatomy from other members (e.g. using magazine images for identification of various muscles or covering a skeleton with crepe paper to represent skeletal muscles). “Utilization of Clinical Vignettes to Promote Critical Thinking in Physiology” and “A&P Case Studies Workshop- How to Build a Teaching Case Study” provided me with tools to engage students and to enhance their critical thinking skills. I also had the opportunity to meet many wonderful people and become a more active member of this professional community enthusiastic about and committed to the teaching and learning of anatomy and physiology. Although it wasn’t a focus, the update seminars were informative and will have a positive impact on my teaching. I look forward to future update seminars to keep me current on new advances in the field. The HAPS conference was an overall success: I achieved my professional development goals to enhance my own instruction while meeting many wonderful individuals who are also passionate about the teaching and learning of anatomy and physiology.

A couple of additional comments about the structure of the conference and logistics- I thought that the conference facility and location were great (in regard to proximity to restaurants, historic area, baseball stadium, etc.). I also liked the general organization of the conference. Specifically, there was the right balance of update seminars, workshops, social activities, and free time. My only disappointment was that I couldn’t attend all the workshops that interested me! I am glad to realize that many workshops are summarized in the HAPS Educator. Thank you again for this incredible experience. I look forward to continued involvement with this supportive, collaborative community.

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David B. Thorp
Gonzaga University
A big thank you to the scholarship committee and board members for granting me a Robert Anthony scholarship to attend the Baltimore meeting. Before joining HAPS I had grown a bit disenchanted with some of the conferences I regularly attended. Although I have always enjoyed these meetings from a research perspective, I was always disappointed in the lack of discussion about undergraduate teaching in Physiology. I am now very happy to be a member in a professional organization that takes a larger role in progressing undergraduate teaching in the Health Sciences. Attending the HAPS meeting in Baltimore was a wonderful experience. I enjoyed the opportunity to spend time discussing the challenges and rewards in teaching Anatomy and Physiology with likeminded colleagues and I applaud the membership for the passion that was demonstrated in the teaching of A&P.

Heidi Bustamante
University of Colorado at Boulder
Last year, a colleague of mine suggested that I join the Human Anatomy and Physiology Society after we had discussed my interest in teaching. I am currently working as an instructor both at the community college level and the university level teaching a variety of lecture and lab based courses. When I joined the Human Anatomy and Physiology Society, I was immediately introduced to many online resources. These various resources improved my quality of teaching as well as broadened my knowledge of physiological concepts in relation to current research. One of the most helpful and enjoyable aspects of becoming a member of the Human Anatomy and Physiology Society was the chance to attend the annual conference. I had the privilege to attend the conference this last May with the help of the Adjunct Grant. From the first day of the conference through to the end, the various committee chair members and organizers made the conference a stimulating and informative experience by offering a variety of different activities from update seminars to poster presentations and workshops. The workshops introduced me to teaching techniques that other faculty members have used to improve the quality of learning for their students. I have since taken some of these ideas and implemented them in my classroom and have seen a significant improvement in student performance. These workshops also offered insight into developing computer software and how these different computer programs might be used in the classroom to facilitate the study of Human Anatomy and Physiology. Several different topics were covered in the update seminars offered throughout the conference and I found these seminars to be very helpful. These update seminars gave me insight into some of the latest research and provided me with the proper information that I may then be able to relay to my students in the classroom.

In addition to increasing my knowledge on various topics in Human Anatomy and Physiology, I was also able to make connections with faculty members from different institutions around the country. Getting to know so many people within the same discipline is not only a great way to network and maintain an essential line of communication, but also proved to be a way to form life-long friendships. I would like to thank Richard Faircloth and the Human Anatomy and Physiology society Grants and Scholarships Committee. The Adjunct Grant made this trip possible for me and it was an invaluable experience. I look forward to future conferences and to many years as a member of the Human Anatomy and Physiology Society.
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