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HAPS EDucator

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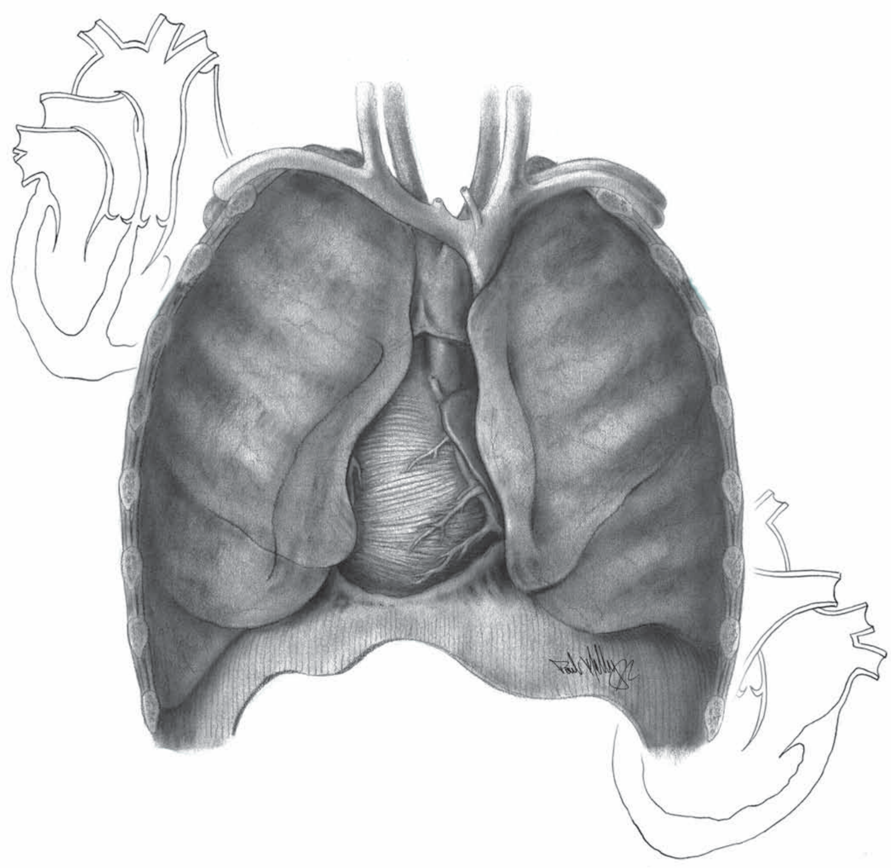

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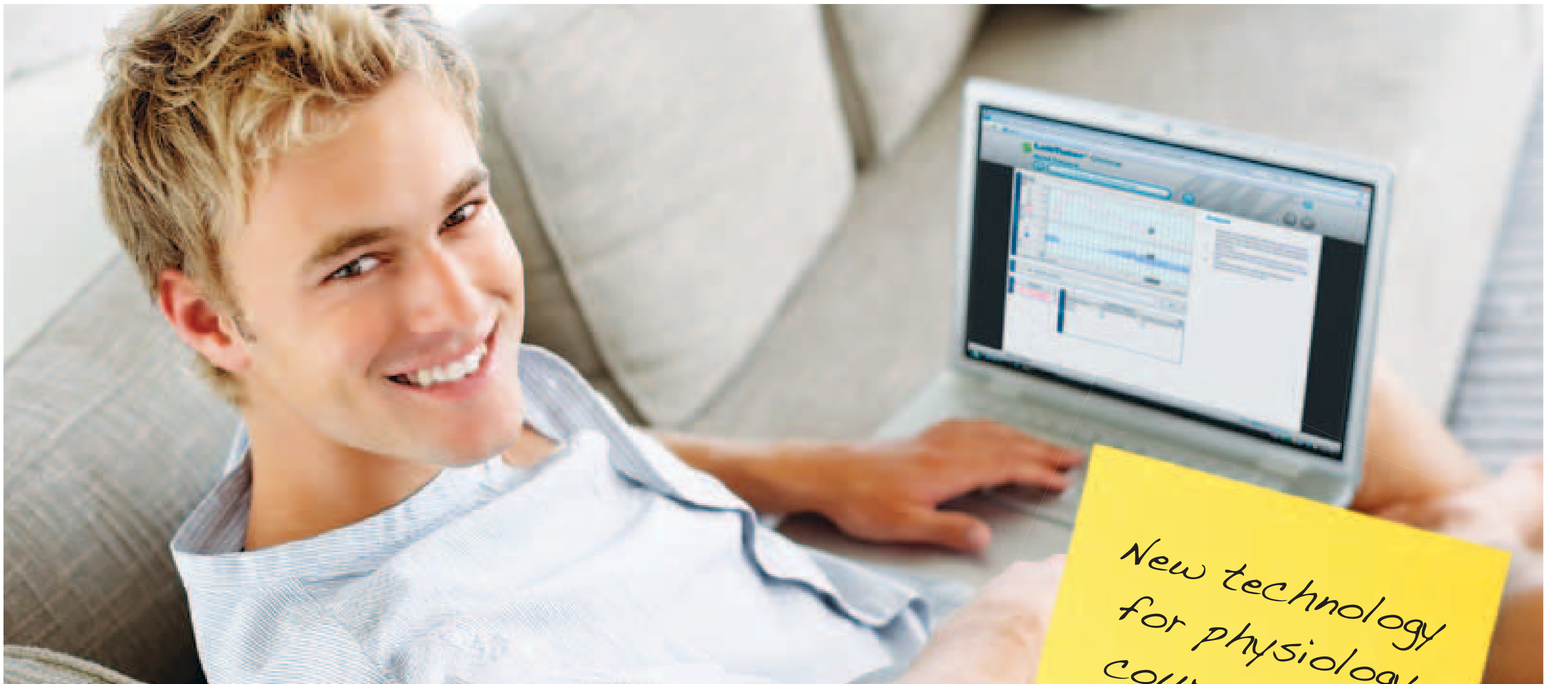

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HAPS
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HAPS-EDucator is the official publication of the Human Anatomy and Physiology Society (HAPS) and is published four times per year. Major goals of the Human Anatomy and Physiology Society are to promote communication among teachers of human anatomy and physiology in colleges, universities, and related institutions; to present workshops and conferences, both regional and national, where members can obtain information about the latest developments in the health and science fields; and to encourage educational research and publication by HAPS members.

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Cover art: Paul Kelly is a graduate student in the Biomedical Communications program at University of Toronto and an alumnus of the University of Illinois Chicago. While at UIC, Paul studied anatomy and physiology with HAPSter Mary Lou Bareither. This image of dextrocardia is one example of Paul's work in diverse media. His intention is to develop the most effective means of visual storytelling.

From the Executive Director

Thank You HAPS Members….

I started my work as the HAPS Executive Director in January. Working for HAPS is a return to my roots as a professor. I taught Human Anatomy and Physiology at North Country Community College in the 80's. The chance to serve the profession and the discipline through HAPS is the capstone of my career in education.

I am still learning about HAPS, but I am very impressed with how much has been accomplished by the many dedicated volunteers who have led HAPS for so many years. The decision to hire an Executive Director shows how the HAPS leadership has recognized that HAPS is at the point where further growth and development will need full-time professional support. I clearly see how important it is to keep HAPS the friendly, welcoming organization that has been one of its hallmarks. At the same time, member services should be expanded with more value added to your membership and I will work with the HAPS leadership to see that this happens. I see my role as one that supports and serves the HAPS leadership and thereby the whole membership.

Getting to Know Me….

I retired as President of Broome Community College in 2008. I have been working as a consultant for higher education primarily in planning, sustainability initiatives, and leadership development. I have worked in community colleges for almost 30 years. My teaching experience includes the high school, college, and university levels. My Bachelor of Arts and Master of Science Degrees in Biology were from Wayne State University (Detroit, MI.) My Doctorate in Biology was earned at Idaho State University. I have completed a Management Development Program at Harvard University and an Administrative Leadership Program at Cornell University.

Other positions I have held include President of the Titusville Campus of Brevard Community College in Florida, Vice President of Instruction and Dean of Mathematics, Environmental and Natural Sciences at Red Rocks Community College in Colorado. While at North Country Community College located in Saranac Lake, New York, I taught biology and A & P, and then directed the Continuing Education efforts for that college.

As an expert in planning, organizational development, leadership development, and educational technology, I have published and made numerous national presentations in these areas. Outside of education, I have worked as a professional ski patroller, EMT, and appeared in numerous community theater productions. I am an avid, competitive athlete participating in tennis, golf, cycling, and skiing regularly. I also enjoy boating and sailing as well as SCUBA diving. For all of these sports I am often accompanied by my adult sons Andrew and Alexander.

I hope to see you all in Denver!

Larry Spraggs
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Human Anatomy and Physiology Society

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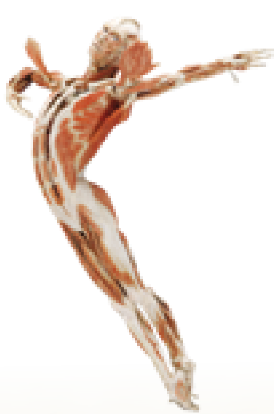
Rocky Mountain Inspiration

Terry Harrison
HAPS Annual Conference Coordinator
Arapahoe Community College Biology Faculty

One way that the dictionary defines "inspiration" is "the drawing of air into the lungs". At high altitude, that might be a little more difficult than at sea level. Another definition is the action or power of "moving the intellect or emotions". This will not be difficult this year in Denver. Though both definitions are apt for what you will be doing this summer in the Mile High City at the 24th annual HAPS conference, the later is what we in the conference committee are hoping will happen to you this year and are working hard to foster and support. Indeed, the update seminars, poster sessions, and workshops are designed to move your intellect to an even greater understanding and appreciation of Anatomy & Physiology and the get-togethers with co-Hapsters, the banquet, and the stunning tour through the Rocky Mountains are designed to move your emotions.

The conference committee would like to inform you of some of the most recent updates and plans that have been made to make sure you become inspired this summer.

BODY WORLDS and The Story of the Heart



Great news for Hapsters, an all new BodyWorlds exhibit will be in Denver during the HAPS conference this year! The committee had already planned to have the traditional Sunday night get together at the Denver Museum of Nature and Science prior to the announcement that this new exhibit would in fact be held in the museum at the same time. Despite our best efforts to coordinate a viewing, the Body Worlds exhibit will be closed on Sunday evening. Please make plans to visit another day during your stay in Denver!

Dancing Hapsters

Whether performing for the President of the United States in Washington, DC, for major sports franchises, for VIP parties catering to Hollywood elite, or for socialite brides across the country – Funkiphino has the energy and talent to bring a party to life. Funkiphino is a hugely popular and in-demand horn band. The 12 members of the high energy funk bank infuse explosive horn lines, old-school Hammond organ sounds, and pumpin' bass with their intoxicating vocals and slammin' harmonies.

In 2005, Funkiphino was the band of choice for the 55th Presidential Inaugural Ball in Washington, DC. The band's excellence has earned them nominations and spots as Best Funk Band from Westword Magazine and Marquee Magazine as well as being the "go-to" band for the Denver Bronco Association and for numerous government officials.

Seeing Blue in Denver

Not to be confused with the infamous "Blue Stallion" that welcomes passengers to Denver International airport (DIA), the "Blue Bear" stands peering in to the Colorado Convention Center, just outside the west exit of the Denver Hyatt Regency Hotel. The giant 3-story blue bear is a sight conference attendees will see and will serve as the landmark that guides attendees to Denver's light-rail transport system, which will be used to transport everyone to

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and from the workshops being hosted by Arapahoe Community College in Littleton. Conference attendees in Denver will be asked to "Look for the Blue Bear" to locate the light-rail station near the Hyatt.

Top Notch Speakers with a Colorado Flavor

The world famous forensic anthropologist Diane France, who has been referred to as the "bone detective," will give an update seminar. The world renowned forensic botanist Vickey Trammell will be the banquet's keynote speaker; she will share interesting stories in her own enthralling way from her many years of teaching A&P. The architect of the Visible Human will also speak as will research specialists from many of Colorado's best institutions on topics related to high altitude physiology as well as neurophysiology.

Climbing to Denver

This year's conference logo shows Skully climbing up a mountain and the artwork in the lobby of the Denver Hyatt Regency hotel symbolizes the climb of man to higher levels. Katherine Lee Bates was inspired to start penning the famous poem that became "America the Beautiful" during a trip up to Pikes Peak in Colorado in 1893. She wrote "…when I saw the view, I felt great joy. All the wonder of America seemed displayed there,

with the sea-like expanse." A visit to Colorado has inspired many people in many ways. How will a visit to Denver and the HAPS conference this year inspire you?

■

The State of the Art of Respiratory Control

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Introduction

When students of health care disciplines take a cardiopulmonary resuscitation (CPR) course, after initially protecting their personal safety, they are taught to check for and ensure (A) a patent airway, (B) adequate *breathing*, and (C) adequate *circulation* (through a pulse check and chest compressions, if needed). As an Emergency Medical Technician, I saw firsthand how important airway and breathing were to my trauma and medical patients. Indeed, if you can't breathe, nothing else matters. If you don't have an airway, you've got nothing.

It was these perspectives gained from a previous career Emergency Medical Services, along with an interest in high altitude hypoxia, which led me to pursue graduate work in respiratory control. Following recent workshops that I presented at the HAPS Annual Conferences in New Orleans (2008) and Baltimore (2009), I offer here a summary of the current state of the art of the field of neural control of breathing. What follows will be a summary of current understanding in two sections: (1) respiratory rhythm generation and (2) respiratory chemoreflexes through central and peripheral chemoreceptors. Lastly, I'll finish with an example of clinical applicability of these principles, namely, central sleep apnea.

Respiratory Rhythm Generation

Cardiac physiologists have it relatively easy. They can remove a heart from a frog or other such specimen and it continues to contract rhythmically, albeit slightly faster than *in vivo* with the absence of parasympathetic vagal efferents. The approximately 1% of cardiac cells that have intrinsic pacemaker ability are within the heart itself, proximal to the muscular effectors they control. Conversely, the behavior of respiration is the result of the intrinsic activity of the nervous system, and the effectors (respiratory muscles) are quite a bit more distal to the respiratory rhythm and pattern generator. Further, the neurons that generate the respiratory rhythm and pattern are buried within the central nervous system where nearby neurons have other functions and most of the cells are neuroglia and are, thus, difficult to access, isolate, and characterize.

What we do know is that the respiratory rhythm and pattern generator is located within the brainstem. Lumsden (1923) initially showed this in anesthetized cats, where serial rostral to caudal dissections through the brain showed that respiratory activity ceased following a final dissection caudal to the fourth ventricle. Although this *necessity* experiment was a nice demonstration of the rostral-caudal position of what was then referred to as the mysterious 'neode vital' for breathing, the ventral-dorsal location was still unclear. Also, whether or not there was only one nucleus responsible for respiratory rhythm and pattern generation or if the rhythmic behavior was the result of a distributed network of neurons throughout the brainstem was also unknown. These two considerations are still a matter of debate and experimental investigation.

Neuroscientists have devised increasingly sophisticated techniques since Lumsden. We are now close to (a) isolating the rostral-caudal/ventral-dorsal location of a number of potentially intrinsically rhythmic neurons and (b) characterizing their phenotype.

In the mid to late 1980s, a group of researchers in California, led by Jack Feldman, discovered what they thought might be the nucleus responsible for rhythm generation in the brainstem of rats. Located ventrally at about the level of cranial nerve XII, this area became known as the PreBotzinger Complex (PreBotC). This area and the Botzinger complex it was located behind were named after a bottle of German wine that was on the dinner table at a conference where a group of neuroscientists were debating the topic of potential excitatory and inhibitory brainstem regions involved in respiration. This study was published by Feldman's group in the prestigious journal Science (Smith et al. 1991).

About the same time, a Japanese group led by Ikuo Homma was investigating a more rostral area in the ventral brainstem. They identified a brainstem region located next to the nucleus for cranial nerve VII that generated action potentials just before inspiration, and therefore might be the respiratory rhythm generator (it is now termed the parafacial respiratory group; pFRG). Their study was published in 1987 in a much less prestigious neuroscience journal (Onimaru et al.

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1987), and this brainstem region was largely ignored until recently. Now, there are integrated models emerging, whereby the pFRG and the PreBotC areas likely interact to generate the respiratory rhythm. Interestingly, the PreBotC neurons express opioid receptors, and their rhythmic activity is suppressed by opioid agonists (like morphine) in a dose-dependent manner (Mellen et al. 2003). This gives us a clue as to the proximal cause of the potentially lethal effects of morphine and heroin overdoses in humans.

The majority of the experimental evidence for the site of mammalian rhythm generation over the last two decades has been focused on these two ventral respiratory group (VRG) nuclei. This work has displaced the previously held view that the dorsal respiratory group (DRG) was intrinsically rhythmic and mediated respiratory behavior. What the DRG certainly does is serve as an integrating center for peripheral afferents. These inputs include vagal afferents from pulmonary stretch receptors, vagal aortic chemo- and baro-afferents, and glossopharyngeal carotid chemo- and baro-afferents. A recent anatomical demonstration showed a pathway of connections from carotid chemoreceptors, through the glossopharyngeal nerve (CN IX), through the DRG, to a group of central chemoreceptor cells on the ventral surface which then project to the VRG (Guyenet et al. 2009).

Although most of the recent compelling evidence for intrinsically rhythmic nuclei is found in studies of the pFRG and PreBotC areas of the VRG, it is possible that the respiratory rhythm and pattern generation in the intact system is the emergent property of a distributed network of neurons including, but not restricted to, these two well-studied areas. In the future we may see more areas emerge as important, like the DRG again, the pontine respiratory group (PRG; involved in timing), the midbrain and hypothalamus and even the cerebral cortex. In reduced animal models, ‘breathing’ is nothing like the eupneic pattern observed in intact animals and humans. This suggests that eupnea is indeed the result of interactions between multiple areas receiving multiple sensory afferents. Also, the quaint notion of eupnea is likely incorrect anyway. All you need to do is to monitor your own breathing while you get on with the activities of your day. You’ll observe the variability in breathing pattern as you talk, eat, and exercise; however, your blood gases remain relatively stable just the same. Thus, the activity of the rhythm and pattern generating neurons are state-dependent. What that means is that, *in vivo*, they are only rhythmic in the presence of particular tonic and phasic afferent inputs. These afferents include descending inputs from the cortex and hypothalamus, vagally-mediated inputs from pulmonary stretch receptors (Hering-Breuer reflexes) and the inputs from central and peripheral chemoreceptors, to name but a few.

Respiratory Chemoreflexes

Blood gas homeostasis is coordinated in part through central and peripheral respiratory chemoreflex feedback loops, each with its own respective sensitivity and onset delay. The slower-acting central respiratory chemoreceptors, located at various locations throughout the brainstem, increase ventilation linearly in response to increases in brain tissue CO_2/[H+]. The faster acting peripheral respiratory chemoreceptors, located at the bifurcation of the common carotid arteries and in the aortic arch, respond to changes in both arterial CO_2 and O_2. The dominant afferent input that maintains breathing when you are conscious is the descending “wakefulness drive” from the cortex. Because, normally, blood gases stay relatively constant while you are awake, the central and peripheral chemoreceptors are likely not playing a very important role, although there is tonic input from both even when blood gases are normal. However, once asleep or anesthetized an individual is solely dependent on inputs from these chemoreceptors to maintain breathing stability.

Central Chemoreceptors

The sensitivity of the brainstem to CO_2/[H+] has been recognized since Leusen (1954) demonstrated conclusively that perfusion of the cerebral ventricles of dogs with acidified artificial cerebral spinal fluid (aCSF) increased respiration in a linear dose-dependent fashion. Further, Mitchell and colleagues (1963) showed that breathing increased when the pH of the aCSF was decreased along the ventrolateral surface of the cat medulla (Mitchell et al. 1963), thus identifying the first brainstem regions likely containing respiratory chemoreceptors. These regions were found along the superficial ventro-lateral medulla and were named after their founders: Mitchell, Schlafke and Loeschcke.

Central respiratory chemoreceptors are (1) intrinsically sensitive to CO_2/[H+] and (2) connected to the respiratory network in such a way that their stimulation is sufficient to increase ventilation. Recently, potential candidates for the role of central respiratory chemoreceptors have been identified throughout the brainstem. However, the region most studied is a region called the retrotrapezoid nucleus (RTN) along the superficial ventral surface of the brainstem, roughly matching the original Mitchell area identified in the 1960s. Although controversial, central chemoreceptors likely monitor brain tissue CO_2/[H+] (not CSF, as was widely assumed from interpretations of Leusen’s work). However, the proximal stimulus and cellular transduction mechanism is currently unknown. The central chemoreceptors are likely to be protected from rapid changes in blood gases by the temporal delay in both CO_2 transit from the lungs and equilibration in the large tissue and fluid compartment of the brain.

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The traditional view is that central chemoreceptors dominate the ventilatory chemoresponse to CO_2. However, peripheral chemoreceptors also contribute to ventilatory responsiveness to inspired CO_2 *in vivo* (see below).

Tissue CO_2/[H+] in the brainstem, which is the stimulus for central chemoreceptors, is a function of metabolism (source) and the effectiveness of washout from the brain blood flow and pulmonary ventilation (sink). Thus, CO_2 does not diffuse into the chemoreceptors from the blood as many textbooks state, as the gradient for CO_2 is most certainly out of the brain tissue into the blood. Based on metabolism, blood flow, and ventilation, CO_2 accumulates in tissue stimulating the central chemoreceptor neurons. It is this slow accumulation in tissue that accounts for a lung to ventilatory response delay of the central chemoreflex of ~30 seconds (Smith et al. 2006)

Peripheral Chemoreceptors

The carotid bodies were initially discovered by Heymans in the 1930s (Heymans et al. 1931). Heymans showed that hypoxic blood flowing through the bifurcation of the common carotid artery stimulated ventilation, a discovery for which he won the Nobel Prize in 1938. These sensory receptors are located bilaterally at the bifurcation of the internal and external carotid arteries and monitor O_2 and CO_2/[H+] of arterial blood flowing through a small carotid body artery, which branches off either the external carotid or occipital artery. Owing to their convenient location just off the aortic arch, the carotid bodies respond rapidly to changes in blood O_2 and CO_2 at the lung. The lung to ventilatory response delay of the peripheral chemoreflex has been reported to be between 10-15 seconds (Smith et al. 2006).

Stimulation of the carotid body depolarizes type I glomus cells by an intracellular transduction mechanism that ultimately involves closing of potassium channels. Once depolarized, intracellular calcium rises and glomus cells release a number of excitatory transmitters (e.g., ACh, substance P, ATP, 5-HT) which increase action potential frequency in the carotid sinus nerves (CSN). The neurons of the CSN merge with cranial nerve IX (glossopharyngeal) and convey the chemosensory information from the carotid body to the DRG in the brainstem. The CSN displays tonic activity under normoxic conditions which increases in a hyperbolic fashion with reductions in O_2. This activity translates to a similar hyperbolic pattern of ventilation in awake humans in response to reductions in alveolar O_2. CSN denervation eliminates the acute ventilatory response to hypoxia in adult animals and humans, suggesting the carotid body likely contributes most of this response.

The contribution of the carotid body to the ventilatory response to increases in CO_2 has been more difficult to characterize, but is likely around 30% of the total response in normoxic conditions. Further complicating the contribution of the carotid body to CO_2 ventilatory responsiveness, the sensitivity of the peripheral chemoreceptors to CO_2 is O_2-dependent. Lahiri and DeLaney (1975) showed that the tonic activity recorded in single CSN afferent fibers increased linearly with carotid body CO_2 in anesthetized cats. Moreover, a hypoxic background potentiated the responsiveness to CO_2, whereas a hyperoxic background reduced the responsiveness to CO_2. In awake human subjects, a similar relationship between alveolar CO_2 and O_2 was demonstrated in ventilation initially by Nielsen and Smith (1952). The result of this stimulus interaction is a fan of curves that later became known as the 'Oxford Fan' in the 1970s, after the Oxford University researchers who worked out protocols to study this phenomenon extensively in humans. Other studies in animals suggest that this CO_2-O_2 interaction is mediated entirely from the carotid body, and is independent of the central chemoreceptors.

How afferents from the carotid bodies may interact with central chemoreceptors to mediate intact *in vivo* chemoreflexes is currently a matter of investigation and debate among modelers and experimentalists. Recent evidence suggests that the stimulation or inhibition of one receptor might change the sensitivity of the other chemoreflex when the ventilatory output is measured, further complicating the understanding of an already elusive control system.

The aortic chemoreceptors (i.e., aortic bodies) are located in the aortic arch and send afferent traffic in the aortic depressor nerve, which merges with cranial nerve X (vagus) to ultimately synapse with the DRG in the brainstem. These sensory receptors were discovered by Comroe in the 1930s (Comroe 1939). He placed the tip of a catheter in the aortic arch region of cats and applied localized hypoxia. Although specific aortic arch hypoxia causes increases in ventilation in cats, it is now accepted that it is quantitatively less important in humans. However, the aortic bodies may play a more important role in recovering peripheral chemosensitivity after CSN denervation, revealing a potentially important example of plasticity within the neural control system.

Clinical Applicability

Although many afferent inputs modulate breathing when awake, sleeping subjects are solely dependent on inputs from chemoreceptors to maintain stable breathing. Because the respiratory rhythm and pattern generator are state-dependent, removal of inputs makes the system susceptible to instability.

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Sleep Apnea

It has recently been estimated that up to 17% of the North American population has some form of sleep apnea, much of it undiagnosed (Young et al. 2002). Sufferers may have up to 100 apneic episodes an hour, affecting sleep quality and wreaking havoc on blood gases. The many nocturnal arousals leave the patient with daytime fatigue and at risk for workplace accidents, and the intermittent hypoxia is a risk factor for various cardiovascular diseases. The most common type of sleep apnea is obstructive (OSA), where the patient "can't breathe" because of a collapsed airway. This condition is highly correlated with obesity, particularly neck circumference. With the obesity epidemic raging in North America, currently over 30% of North Americans have a body mass index of 30 kg/m2 (the threshold for classification of obesity), likely affecting the sleep quality of millions of people. (Ford and Mokdad 2008). However, when the control system itself is compromised, patients can also suffer from central sleep apnea (CSA), where the patient "won't breathe". Up to 50% of patients with congestive heart failure and almost everyone sleeping at high altitude has some degree of CSA.

Sleep unmasks a sensitive apneic threshold for CO_2, which may be only a few mmHg less than normal arterial levels (Dempsey et al. 2004). If the level of CO_2 drops below this critical threshold during sleep, apnea will ensue. The primary factor that puts some people at risk for CSA is that they also have increased sensitivity of central and/or peripheral chemoreflexes. This increased sensitivity may lead to ventilatory overshoots in response to even mild chemostimulation, initiating a cycle of alternating hyperpneas and apneas as the patient's arterial CO_2 oscillates above and below the threshold. It is likely that central and obstructive apneas are occurring simultaneously in many patients, where an initial obstructive episode causes a stimulation of chemoreceptors through arterial hypoxia and hypercapnia. An inappropriately large chemoreflex in response to these stimuli drives the CO_2 back below the threshold, reinforcing the oscillation. Ongoing research will determine why some patients have increased sensitivity of chemoreflexes and what kinds of treatments will assist in stabilizing breathing in these subjects during sleep.

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Suggested Reading - Reviews

Respiratory Rhythm Generation:

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Across major league baseball, no-hit, no-run games occur approximately twice per year. A perfect game (no opponent reaches base) is much rarer--only 18 in the 134 year history of the big leagues (average of about once every 7.5 years). Like most fans, I've never had the good luck of seeing a "no-no". Indeed, the team I grew up rooting for, the New York Mets, have not had a pitcher throw a no-hitter in their forty-eight years of existence. (Some say it's the curse of Nolan Ryan: the Mets traded Ryan after his first six seasons and he went on to throw a record seven no-hitters during his career). But last semester in my human anatomy class, I experienced something that resembled the excitement of witnessing a no-hitter.

Danielle Drasher, a pre-physical therapy student, provided the gem. She went the entire semester without getting a single question wrong. Eleven quizzes, three practical exams, four unit tests and a comprehensive final, all perfect. That's 726 consecutive questions answered correctly. For me, that rivals the "27 up, 27 down" of a perfectly pitched ball game.

As HAPS members know, anatomy is not easy. Knowing your ischial tuberosity from your olecranon in lab is hard enough, but many students really struggle on multiple choice exams: class average percent scores on my unit tests this semester were in the sixties or low seventies. But Danielle aced them all. I've taught the course for sixteen years, and no one has done this (or come all that close) before.

Danielle kept a calm and personable demeanor throughout the term. She would ask a question occasionally, but not all that often. We talked about baseball during the playoffs, and I had asked her how on Earth she could wear her N. Y. Yankees jersey (and Yankees jacket and assorted Yankees T-shirts). She was a knowledgeable fan and fun to talk with. A few weeks into the semester, I made a remark about her streak of great quizzes, and she hinted that she didn't want to be jinxed. Any baseball fan should have known this, but I wasn't thinking that far ahead yet, and really just expected it to end soon. But after about the tenth perfect paper, I started showing the exams to my kids at home, and when they would see me grading, they would ask about it, and they started rooting for her to pull it off.

I didn't think that the story was going to have such a happy ending. On the last lab practicum, I had graded one of Danielle's answers as incorrect. I saw her later that day and told her that her streak resembled DiMaggio's 56 game hitting streak, but that it was over. She took my comments graciously and admitted she wasn't completely sure where the subclavian artery ended and the axillary artery began in the fetal pig. I thought about this and confessed to myself that I wasn't sure either--it was a question that a colleague had chosen for the practicum. But I went home and told my kids the bad news. As I was cleaning up the lab the following morning I pulled out a reference book and furthered the dissection on the exam specimen in question. It turned out that Danielle was correct and my colleague and I had it wrong (the marker was just proximal to the branch point of the subscapular artery). It was a little good fortune to complement a lot of hard work, and it made her story even more compelling.

The final exam covered the entire semester and consisted of one-hundred multiple choice questions. That morning I tried to act casual as I handed out papers, and I proctored in my most nonchalant manner (one I've cultivated through years of proctoring boredom). I took extra care when completing the answer key. Soon after Danielle turned in her exam and left the room, I held up her scan form and my answer key to the bright light of the window—nary a difference.

Danielle gave me permission to write this, and she thanked me for my help during the term. I felt lucky to have been in the roles of coach and umpire. It's the only time in my life I've rooted for someone wearing a Yankees jersey.

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GOTCHA! Strategies for Student Engagement in A&P

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I have a confession to make. I have been reading books outside our discipline of anatomy/physiology. I have been talking with people outside of it, too. My name is Chris and I am an active-learning addict. These adventures have turned my teaching upside down. I now spend as much time imagining and retooling active-learning exercises as I do reviewing my content before teaching it. Like a good addict, I crave to get my colleagues hooked, too.

Here is a sample of exercises and projects I have used to engage students. These exercises require students to construct learning for themselves. After a time, students can shape their own exercises. I might enter the classroom on a good day and find students drawing on the board, or running a quiz-bowl to prepare for a test.

These exercises vary in difficulty and intensity. I can pick the "right" exercise for a given group of students to customize learning as we proceed through the course. For example, if work done early in the semester uncovers deplorable writing skills, I will build in a concerted series of progressive writing assignments[1] to remediate the situation. Likewise, if a particular group squirms in distaste at the prospect of a crafty project, I can float a more left-brain approach.

In my class, all active-learning exercises earn points towards a course grade. They could also be offered as ice-breakers, or for extra credit. Here is a trio of active-learning exercises, which I call "A&Pers".

A&Per #1: Introduction
Subject: Anatomical Terminology
Difficulty: Beginner

I keep a catalog of pictures of the human body, including popular photographs, artistic renderings,[2] and cadaver photos[3] such as those in The Visible Human Project[4]. I project these on the screen and have students identify key points of terminology, such as body regions, body cavities, planes of section, and directional terms. I let them answer independently, and then again with a partner, to improve their grade. This particular strategy has the fortuitous side-effect of validating group work and creating community in the classroom.

A&Per #2: SFU (Structure-Function Unit)
Subject: "Form follows function"
Difficulty: Variable

An early version has the student select a common household object (pasta fork, funnel, hammer, CD case, etc.). Then the student is exhorted to meticulously observe and catalog the structural features (S) of the object. Next, the student infers the purpose (F) of each feature. Finally, the student develops a synthesis statement, explaining in a paragraph how this object is designed to fulfill its function (SFU).

A later version has the student engaging in the same S → F → SFU progression with reference to specific anatomical structures. This can be done at any level of organization in the human organism, of course. I challenge the students to explain the SFU of a key organ in each organ system that we investigate. The students gradually develop a way of thinking and are able to deduce patterns. For example, after they have seen multiple instances of folding as a solution to increase surface area, they "get it" --- "Hey, it's that folding thing again!" --- without a declarative statement from me.

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A&Per #3: Opposite & Complementary
Subject: Nervous System versus Endocrine System
Difficulty: Advanced
This multi-modal exercise helps provide continuity between the first and second semesters of A&P, in which Nervous System is taught in A&P 1 and Endocrine System in A&P 2. Part I of this A&Per is a brainstorming exercise in teams (Endo Team and Neuro Team). Students investigate answers to a battery of questions about their system and complete a matrix. Part II is the development of a written "brief" by each team which explains the unique way in which control and regulation is achieved by that system. Part III is an oral argument in front of the opposing team and the instructor about the style and efficacy of their system in providing that control and regulation function.
This A&Per could also be used in the service of other opposite and complementary issues, e.g., comparing and contrasting Sympathetic versus Parasympathetic Nervous Systems, or, male versus female reproduction.

In talking shop with my colleagues in education, I surmise that I am a graduate of the "transmission model of education". My professors stood behind a lectern and broadcasted facts and concepts. We students received this wisdom. This worked alright for me. It would work for some of my students, but not very many!

On the other hand, active learning is a dynamic fit for the contemporary student, who sometimes has attention issues or arrives at college with sub-par preparation in the fundamentals. Active learning finds and grabs the student where s/he lives. It is ultimately fun – for everyone – and that is a potent motivator. If crafted thoughtfully and thoroughly, active learning can yield a "Gotcha!" teaching moment.

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1 Thanks to Amy Cheng Vollmer, who teaches Microbiology at Swarthmore College, for the language of the Progressive Writing Assignment.
2 Linda Moussakova from St.-Laurent College, Montreal, also uses fine arts images, as I learned at the HAPS 2009 Annual Conference.
3 Jacqueline VanHoomissen from University of Portland in Oregon, also uses cadaver photos to stimulate discussion in her classroom.
4 The Visible Human Project is an NIH-supported data-base of cadaver photographs. For preview images and license agreements, see www.nlm.nih.gov/research/visible/visible_human.html

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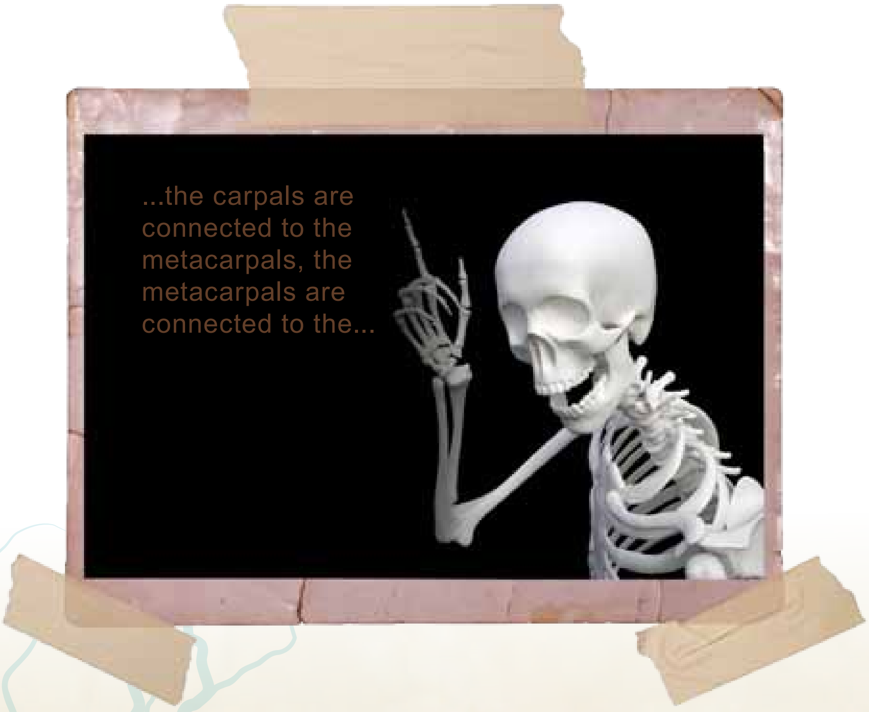

Teaching From the Trenches

I Assist, Therefore I Am: The Rise of the Teaching Assistant

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Most hierarchies are well-defined. The British aristocracy, for example, maintains very clear status distinctions that assign certain roles and responsibilities to its members. It may be rigid and intolerant, but at least everyone knows where they stand. This is unfortunately not the case in Academia. While undergraduates occupy the very bottom of the totem pole and seasoned tenured faculty the very top, the graduate student occupies a transitional placement. Brand new graduate students may be more advanced than undergraduates in status only, while Ph.D. candidates may only be months from full faculty positions. For this reason alone it would be difficult to summarize the experiences of all graduate teaching and research assistants. The problem becomes more difficult when one tries to map out interdepartmental differences. Some departments provide lots of teaching opportunities for their graduate students, while others actively keep their grads out of the classroom. As interdisciplinary graduate students, we are in a unique position to get the skinny on assistantships in both the social and medical sciences. Collectively we've been grading, teaching, lecturing, leading, tutoring, mentoring, assisting, and directing courses and labs in Anthropology and Medical Sciences (and a few other disciplines here and there) non-stop for the last four years. We've formally studied pedagogical methodologies and we've informally developed many of our own. Long story short--- we've seen some of what works in the world of graduate teaching assistantships and we've seen and heard a lot of what doesn't. While our discussion here may be sprinkled with cringe-worthy anecdotes (and we're confident the readers of the HAPSEDucator won't find themselves referenced below), our purpose is to provide some insight into graduate students' needs, expectations, experiences, and lives in hopes of improving professor-graduate student relations.

Why We Teach

For the money. Just kidding!..Sort of. Obviously securing funding is an important concern for graduate students and teaching assistantships are often our best (if not only) hope for affording our educations. That said, while we are desperate for funding, most of us relish the opportunities that teaching assistantships provide. After a lifetime of sitting in classes and labs, all of us are eager to switch roles. We've internalized hundreds of different teaching styles and we're just chomping at the bit to try our favorites out on unsuspecting undergraduates.

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In addition to the power trip we (naively) assume teaching will confer, most of us are actively interested in *educating*. In fact, many of us entered graduate school with the sole intent of becoming instructors and professors. Even in Research I institutions where teaching is often regrettably undervalued, graduate students enthusiastically pursue pedagogical training and development. Perhaps our enthusiasm can be chalked up to 'youthful' idealism, or perhaps it's because we're still freshly haunted by the effects of bad teaching. In fact, we know many graduate students who have vowed to give their future students a better classroom experience than they had. In some cases these indictments against our recent instructors are justified, but in others we now recognize them to be a little unfair. For many long-standing faculty members, pedagogical training wasn't encouraged or even available during their graduate education. Most faculty members have long since concretized their teaching styles while students' learning styles and expectations have continued to evolve. Even those faculty members using innovative techniques are occasionally thwarted by unfortunate circumstances or the personality of the class. We cannot blame faculty for not keeping up with the latest pedagogical literature or for being discouraged by an uncooperative class, but we can suggest some willing liaisons to help bridge the teaching divide…

The Many Faces of TAs

Teaching assistants come in all shapes and sizes. Some are only responsible for photocopying. Others design, organize, and execute their own stand-alone courses. Most fall somewhere in-between. Each type of assistantship has its own advantages and disadvantages; to properly understand the plight of TAs, it's important to understand the scope of these roles. Here we present a rough field guide to the most common TA varieties:

The Assistant

(a.k.a. The Gopher): In its purest form, the Assistant does just that—they assist the primary instructor in the management of the course. With class sizes regularly reaching over 90 students, Assistants are a critical necessity. Tasks often include photocopying, taking attendance, managing course websites, responding to students' emails, managing grade books, acquiring and setting up audio-visual equipment, and generally helping with the 'housekeeping' involved in most classes. Assistants are happy to assist but we recommend being specific in your requests (How many copies do you need?) and reasonable in your time expectations (Sorry, 20 minutes is not enough time to make 400 copies).

The Grader

(a.k.a. The Mind-Reader): Often the roles of Assistant and Grader are conflated so in addition to the tasks typically assigned to the Assistant, the Grader… grades. At its simplest, this means the Grader collects Scantron sheets, drops them off at the scanner, picks them up, and types up the grades in the grade book. At its most complex, the rubric-less Grader attempts to psychically figure out how her faculty member wants an assignment graded while simultaneously trying to match other co-Graders and maintain a normal grade distribution. One suggestion might be to include your Graders in designing the rubric, which not only keeps everyone on the same page, but also provides the TA with insight into assignment design. Yet even with the best of rubrics, Graders are often the first to succumb to crippling cynicism thanks to their exposure to undergraduate writing. That's not to say that grading doesn't have its rewards. Every Grader lives for the day a student references "disposable" thumbs, or calls the mons pubis "the calcaneal spongarius".

The Discussion Leader

(a.k.a. The Directionless) The Discussion Leader is an Assistant/Grader who also manages his/ her own discussion sections. This degree of autonomy can be exciting for the Discussion Leader, who can direct students into meaningful dialogues that expand upon the class lecture. Conversely, this degree of autonomy can be terrifying for the Discussion Leader whose instructor has provided no guidelines, projects, or background for the lecture, yet expects all co-Discussion Leaders to direct identical dialogues within their respective sections. It then often falls on one of the Discussion Leaders (frequently whoever goes first) to arrange activities that other sections will then "borrow". While this experience may help to prepare the first TA for future teaching, it also results in a disproportionate amount of time spent preparing for class. We recommend providing a list of objectives, including any necessary warnings or helpful suggestions, for your TAs to use in facilitating discussion.

The Lab Instructor

(a.k.a. The Over-Directed): At their best, Lab Instructors are guides, identifying and demonstrating materials to their students in a hands-on fashion that empowers the student. At their worst Lab Instructors are automatons, forced to mechanically follow scripts and shill rote memorization in the vain attempt to promote utopian equality and fairness. It is important to realize that lab instructors are individuals and thus the dream of identical lab experiences is unrealistic. Instead, it may be more beneficial to TA and student alike if general material guidelines are provided to TAs who, in turn, can adapt the presentation of these requirements to their specific lab sections. While we recognize that

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this may result in some discrepancies in energy input (which would come to light via teaching evaluations), it also allows TAs to become more invested in their teaching.

The Stand-Alone

(a.k.a. The Scared $#*!-less) The Stand-Alone instructor encapsulates all of the above tasks. They design and organize their own class. They write their own syllabi. They make up their own assignments, exams, and rubrics. They build their own lectures and labs. They grade everything themselves. The Stand-Alone is typically a seasoned graduate student who has been put through the paces with other assistantships. The experience is exciting, empowering, and the ideal preparation for their future role as a faculty member. Every so often, however, a novice graduate student gets saddled with his/her very own class where she/he will teeter precariously on the brink of a nervous breakdown and will forever-after refer to the experience as a “baptism by fire”. In an attempt to avoid this situation we recommend maintaining the TA hierarchy as much as possible so that the TA gradually develops pedagogical skills over time. This hierarchy maintenance also allows graduate students to better understand how, and to whom, positions are assigned. If for some unforseen reason novices are forced into a stand-alone positions, it is important to provide them with as many resources and as much guidance as possible (which books/ images/ lectures to use, etc.).

“I want your input…But not really”: The misuse of TAs

Even the best teaching scenarios are challenging for graduate students. We juggle our teaching duties with coursework, research, second jobs, and occasionally—a personal life. Many may never have taken the course they are teaching or have held different roles in other assistantships. Therefore it is important for boundaries to exist in faculty/assistant expectations. Unfortunately these boundaries may be transgressed. Several departments in our university have adopted a Teaching Assistant Bill of Rights to protect graduate students from mismanagement. These documents are important in that they formally define the role of assistants and empower students to defend themselves against serious abuses. Yet TAs may face more insidious obstacles than direct abuse in their teaching experiences. Primarily, there can be a fundamental lack of respect for TAs that manifests itself in ways that are hard to define but cause short-term stress and irritation in addition to a long-term disenchantment with teaching.

A few examples of TA mismanagement: We know a Lab Instructor whose faculty member followed her around the room, judging and criticizing her answers to students’ questions. We know Graders who have been verbally abused by their primary instructor because they “graded something wrong” despite the absence of a requested rubric. We know dozens of TAs who have been saddled with unrealistic grading loads. One faculty member assigned her 90-student class ten papers throughout the semester-at three pages each. That’s 2,700 pages of grading (not including the tests) on top of other duties, coursework, and not much sleep.

Faculty can further undermine the agency and confidence of their assistants through false offers of collaboration. TAs are eager to contribute their experience and opinions to their courses and are delighted to be included in course planning, decision-making, lecturing, etc. By allowing TAs to participate in these activities faculty can lighten their work load and provide assistants with experience. TAs are less delighted, however, when it becomes apparent that this “inclusion” constitutes nothing but lip-service. By excluding graduate students from this process, faculty indicate, at best, a lack of faith in their assistants and, at worst, a total disregard for their opinions and developmental needs.

Getting the most out of your TAs

While we paint a fairly grim picture of TA experiences we know that the majority of faculty members aren’t out to demoralize us. We understand that faculty life is just as busy and complex as graduate life—and after all we’re all only human. That said, we have some final suggestions that we believe will go a long way to improving TA/faculty relations.

For TAs:

1) Be upfront in asking to help with other tasks (writing assignments, lectures, etc.). Often faculty are more than happy to let you take on some more responsibilities, it just doesn’t really occur to them that you’d want to.
2) Act like a professional member of the teaching staff. While we recognize that a big part of being a TA is being closer to the students than the main professor, acting like the adult you are can make a big impression. Unfortunately, so does running in at the last minute in your sweatpants, stained tee-shirt and bed-head without the grading done.
3) Make the most of the opportunities you are given. If you have an extra class period, try something new. Introducing your faculty member to new teaching strategies may impress them enough to let you do more. This initiative has frequently worked well for us in the past and often impresses more than just the professor for that class. Students also appreciate it when you try these new techniques because it gives them some variety in the classroom.

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For faculty members:

1) Please be organized and keep us in the loop. We plan our schedules around you and your course so when we get a frantic email at 10 pm asking us to do/fix/grade something immediately we are resentfully compelled to interrupt our study/social/sleep schedules to deal with the issue. We understand that the unexpected happens (as we hope you do in return) but frequent disorganization and lack of communication shows a lack of respect for our time and abilities.
2) If one of our suggestions for test questions/grading/activities cannot be used, make sure to explain why. We are students attempting to learn how to teach, so explaining why things are done the way they are is incredibly helpful.
3) The more you allow us to assist in decision-making, the more invested we will be in the course. For example, let us (or even make us) give a lecture and then write the test questions for that section. This will provide more supervised experience with these activities and will also demonstrate some trust.

All that said, the number one suggestion we can make to faculty is this: Treat us like the future colleagues we are. While there is understandably a lot of grunt work involved in assistantships, we are not directionless drones. Many of us embrace this opportunity and see it as an important step in our professional development. We look to you for guidance and mentoring but we want to be treated as academic adults. We may be students, but we are also the future of Academia. We are willing and able to shoulder the weight of teaching and we look forward to working with you.

Acknowledgements:

We would like to thank Marsha C. Sousa and Valerie Dean O'Loughlin for inviting us to write this article. We would also like to thank the countless students and colleagues who have produced and shared the numerous anecdotes recounted above. Teaching would not be the same without them.

■

Edu-Snippets

Preliminary Snippets

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

by Roberta Meehan
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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 your ideas into our EDU-Snippets column, I have been continuously amazed at how many teaching and demonstration ideas are easily transferred from one instructor to another through Snippets. Please keep your wonderful ideas coming!

I. Snippet Maximus

*Theresa Bidle (Hagerstown Community College, **bidlet@hagerstowncc.edu**) had an idea for maximizing student learning in the Anatomy and Physiology lab.*

In the past, students would come unprepared to lab -- many times not even knowing which lab was to be completed that week. They also would hurry to complete the lab in as little time as possible. Not surprisingly, they would then score poorly on the lab quiz the next week.

In order to increase student preparedness and thus increase student mastery of the material, I instituted two changes. Students are now required to: (1) complete a pre-lab exercise before coming to lab, usually one-page of questions relating to the lab material; and (2) participate in a "check-out" activity at the end of the lab session to demonstrate a certain level of comprehension and understanding. For example, as a "check out" for the lab on the heart, each student is required to trace blood through the heart using a large diagram that is hung in the front of the room. An additional benefit of this "check out" exercise is that it forces students to learn the proper pronunciation of specialized anatomical terminology. It also provides feedback to the instructor regarding student understanding.

II. Structural Snippet

HAPS members sent in several ideas to help our students grasp those pesky structural concepts.

A. Cellular

Tama Fox (South Seattle Community College, auntama@gmail.com) sent two great low budget ideas for demonstrating cellular structure.

For the first project, I blow up a balloon inside of a clear plastic sandwich container (the kind you can get at a deli). I use a square one with a green balloon to symbolize plant cells. I use a round container and a yellow balloon for animal cells.

When the set-up is in place, I demonstrate that a strong cell wall plus turgor pressure helps keep the "cell" strong as well as helping it to maintain its shape. I overfill the yellow balloon, causing the glycocalyx cover to "shatter" open. From there the students can discuss the various principles involved in maintaining strength and cellular integrity.

For the second project, I take a baggie of cooked noodles and project them on a screen. This shows that space between the noodles is darker than the noodles themselves. I have found that this is good for understanding what they see under a microscope when viewing such tissues as collagen.

B. Cardio-Muscular

Meanwhile, Pat Bowne (Alverno College, pat.bowne@alverno.edu) sent in an interesting way to demonstrate a concept that is often skimmed over.

To demonstrate conduction between cardiac myocytes, I have the students all hold hands, interlacing fingers to represent intercalated discs. Then one acts as the pacemaker, raising her hands, and the others all follow suit. I can act as the SNS or PNS and speed or slow the pacemaker.

[Editor's comment: A line-up like this would also be a very good way to demonstrate the differences between depolarization and repolarization in the cardiac system and the rest of the body. Students can act it out right there in the line.]

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C. Skeletal

Dennis Kingery (Metropolitan Community College, dkingery@mccneb.edu) thought of a wonderful way to use those grossly malformed Halloween skeletons. Put this one on file for the next time you teach bones!

In the Halloween retail market I find model skeletons offered for sale inexpensively -- four six-inch replicas for a dollar. I use them as a brief review of student knowledge of the skeleton.

Working in groups, the students are asked to list structural/functional inaccuracies in the replicas, other than size, of course, and the devices that are used to fasten the parts together. In the ones I have, I notice that the forearm bones both resemble radii, the phalanges seem to emerge directly from the carpals and tarsals, the number of ribs is reduced, the distal femur resembles a fork with the patella lodged between its two tines, etc. The hip joints are functional, but without that joint's usual freedom of motion. No other joints are mobile.

Replica hands are a separate item, each about 3 inches long, ten for a dollar. In these there are 14 carpals per hand and the thumb lies in the same plane as the fingers.

An alternative approach to this skeletal use could be the question, "How functional would your skeleton be if it were built this way?"

I have found this a marvelous "conceptual awareness" exercise.

III. Snippets from Light to Hydrogen to Myelin

From Mary Ellen DeHoff (UC Clermont College, maryellen.dehoff@uc.edu) came three interesting uses of props – each with a totally different purpose. Props always seem to be so useful, and what most of us have found is that props do not have to be complicated or expensive to be highly effective.

Here are three very simple teaching exercises using props (student and otherwise) that I have found to be very effective in giving students a "visual" insight into certain concepts.

1. To demonstrate the formation of the myelin sheath by oligodendrocytes around CNS axons, I use a pencil and a half-used tube of toothpaste from home. The pencil represents the axon. The toothpaste tube is an oligodendrocyte, with the cap acting as the nucleus. The actual tube itself represents the plasma membrane, and the toothpaste inside represents the cytoplasm. I place the pencil at the bottom of the tube and roll up toward the cap. The action of squeezing the toothpaste up toward the cap shows how the cytoplasm of the oligodendrocyte is squeezed out of the axonal region as the plasma membrane forms concentric layers wrapping around the axon. Students are reminded of the rich phospholipid content of the plasma membrane, and this is related to the lipid content of the myelin sheath around the axon.

2. When teaching the special sense of vision, I include the pupillary light reflex. Students already have knowledge of the midbrain/mesencephalon, so it is a good way to incorporate preexisting knowledge with new information. I first draw a cross-section of the midbrain, showing the students both the location of the Edinger-Westphal nuclei and how each branch of the optic nerve (right and left) has axons that eventually reach both the right and left Edinger-Westphal nuclei. Students already have knowledge of the parasympathetic effects on pupillary constriction, and of the oculomotor nerves that control this constriction. They are shown how parasympathetic axons from each Edinger-Westphal nucleus travel via the oculomotor nerve to each eye. In response to a light stimulus (brought to the E-W nucleus via the optic nerve) these parasympathetic axons excite the pupillary constrictor muscles. To demonstrate how the light signal coming from one eye can cause pupillary constriction in both eyes, I dim the lights and have students shine pen lights into each of another person's eyes, watching for constriction in the opposite eye. They think it is so COOL, and they are able to understand a new neurological pathway that incorporates multiple aspects of preexisting knowledge. This experiment can also be used as a platform to discuss how the pupillary light reflex is useful in diagnosing lesions/trauma affecting cranial nerves II or III or the midbrain area.

3. To teach the effects of hydrogen bonds forming between water molecules, specifically how water expands in a solid form (is less dense) due to these bonds, I take my students to the elevator outside our classroom. Holding the elevator door open, we count the maximum number of students who can fit into the elevator with their arms at their side. Each student represents a water molecule in a fixed volume of water. To demonstrate how water is less dense as a solid in that same fixed volume, we count the number of students who can fit into the elevator with their arms out on each other's shoulders. Simple and fun!

IV. Fast and Fun Snippets

Tama Fox (South Seattle Community College, auntama@gmail.com) also sent some "all purpose" ideas. Tama tells us there are great demos in science magic books, which are often found in junk stores! Here is one of her ideas.

This is how I float a needle over a beaker of water:
1. Float a small piece of tissue paper/kimwipe onto water (cut to sewing needle length - don't touch to sides of beaker).

2. Add needle on top of tissue. Tissue sinks as it wets but needle stays on top. (Remove paper beforehand if desired.) Fun for lab practicals or in class ("explain").

3. When projected onto a board, add amphipathic detergent and watch the needle sink. Fun for class discussion ("explain").

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Meanwhile, Ken Saladin (Georgia College & State University, ksaladin@ windstream.net) posted this on the HAPS discussion list.

This is an astonishing demonstration! http://www.flixxy.com/water-drop.htm

And Robert Rawding (Gannon University, rawding001@gannon.edu) suggested that if we wanted some fun and fast facts, we should take a look at this medical mnemonics page.

Some of these are really quite interesting. http://www.medicalmnemonics.com/cgi-bin/browse.cfm

V. And We Hope You Will….

Keep those cards and letters coming! We thank you all for your EDU-Snippet contributions. Your ideas are tremendous! Someone suggested a focus using students themselves as props. You probably noticed that a number of the Snippets in this issue do exactly that. It would be good to see some more of these ideas.

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.
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