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EDucator

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COVER ART - Original Photography by Robert Sturman

Robert Sturman graduated from UCSC with a B.A. in Art and an emphasis in Painting and Drawing and attended The Memphis College of Art for two years. He studied under Italian master painter, John Torina, whose ephemeral images echo in Sturman’s work. The subject of two New York Times articles, Robert Sturman’s art captures the timeless grace and embodied mindfulness of asana. A dedicated yoga practitioner himself, Sturman’s work has increasingly gestured at something beyond the physical, something transcendent. His stunning repertoire runs the gamut from yogis perched on rocks surrounded by the Pacific Ocean, to African orphans practicing yoga in Kenya, to breast cancer survivors; bare-chested and scarred. Sturman’s portraits, whether set in the lively streets of Manhattan, the expansiveness of Malibu’s beaches and canyons, the timeless elegance of Walden’s New England, or the bleakness of San Quentin Prison, remind us that there is beauty everywhere.

On the cover, Susan White Phillips is photographed on a rock overlooking Long Island Sound at sunset in The Mermaid pose.
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The HAPS-EDucator is the official publication of the Human Anatomy and Physiology Society. As such, the HAPS-EDucator aims to foster the advancement of anatomy and physiology education by facilitating the collaboration of HAPS members through the publication of a biannual journal. Journal articles may include, but are not limited to, those that discuss innovative teaching techniques (e.g., the use of technology in classrooms or active learning practices), original lesson plans or lab exercises, reviews of trending topics in anatomy and physiology, and summaries of newsworthy events (e.g., seminars or conferences that not all society members can attend). Additionally, an extra issue of HAPS-EDucator will be published after the Annual Conference, highlighting the update speakers, workshops and poster presentations. All submitted articles will undergo a peer-review for educational scholarship. Articles not immediately accepted will be returned to authors with feedback and the opportunity to resubmit.

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The complete “Author Submission Packet” is available at this link: http://www.hapsweb.org/?page=HAPSED.

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

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

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Abstract: The regular practice of yoga is believed by many practitioners to have a calming effect on both the mind and the body. There has been a steady increase in the popularity of yoga in the general population and on university and college campuses. This article examines the interface between yoga and anatomy and takes a close look at yoga from the point of view of the instructor, a student of yoga and the possible future of yoga in healing musculoskeletal disorders.

In the fast-paced world of modern higher education, stress is neither uncommon nor unexpected. Today’s colleges and universities foster a results-oriented environment in which students are constantly observed, tested, graded and encouraged to strive for recognition and success. Health-conscious students on campuses across the country are increasingly turning to the practice of yoga in search of stress reduction, inner awareness, and inner strength. The current generation of young people is perhaps ideally suited for incorporating yoga into their life style. They have already transitioned to highly individual, technology-centered programs in search of intellectual enlightenment. The pursuit of physical and spiritual enlightenment through the practice of yoga would seem to be a logical extension for this highly motivated, inner-directed cohort.

Recent years have witnessed an explosion in the practice and study of yoga and today, an estimated 20 million Americans are believed to practice some form of yoga on a regular or semi-regular basis. While this number should not suggest that all of these individuals practice consistently, it does illustrate the extent to which the practice of yoga has permeated our culture. Yoga’s popularity is reflected on college and university campuses throughout the country. A quick survey of fitness classes offered at several universities in the Northern Virginia area shows that a variety of yoga classes are offered multiple times a day throughout the week, which suggests that students are consistently filling these classes (Crain 2012, Melnick 2012).

The academic study of yoga is beginning to make its way into the curriculum of mainstream universities where yoga is used as a pedagogical tool to teach complex concepts such as “feminism, the body, oppression, and the privatization of stress.” These classes, with names like “Mind, Body and Medicine” and “Embodied Understanding” blend standard lectures and assignments with the regular practice of yoga (Musial 2012). Loyola Marymount University now offers a Master’s of Yoga Studies, which is intended to meet “the needs of Yoga students and teachers who are seeking to enhance their knowledge of the Yoga tradition in both theory and practice” (http://bellarmine.lmu.edu/yoga/). These examples serve to illustrate that yoga is moving beyond a simple exercise trend to a place where Eastern philosophy now has legitimacy in Western culture. While students enjoy the stress-reducing and social aspects of yoga class, the benefits to the body are also quite clear. The consistent practice of yoga under the watchful eye of a highly trained instructor can develop the muscular system in unique ways.

A yoga instructor’s view:
People frequently ask me about getting started in yoga. The question is often asked with a mixture of curiosity and dismissal. They want to know all about yoga because they think it will help them become calmer, more focused and more flexible in both body and mind and they want to be generally happier. However, they are also convinced they cannot do yoga because it will not provide enough stimulation and because they believe they are not flexible enough. This sort of exchange usually leaves me thinking that yoga could help these people a lot if they would only give it a chance.

(Continued on next page)
When I started yoga 6 years ago at the age of 38, I had three young children and was a stay-at-home mom who spent little time on anything other than fulfilling the needs of my family. I was finding it hard to relax at the end of the day and very difficult to fall asleep at night. I was curious about yoga because I thought it might provide me with some constructive solace in the midst of caring for my growing family. I thought that perhaps it would help me to relax and maybe even make me a better mom. To be fair, I did not jump right into trying yoga as soon as the curiosity struck. In fact, I sat on the thought for several years. I had taken a few yoga classes as a teenager and an occasional class during a holiday and I had enjoyed those experiences. But for the most part I felt that I had too much to do each day to focus on anything like yoga. The thought of taking time out of my week to just chill out in a yoga studio for an hour was simply unthinkable. The irony, of course, was that this was the precise moment in my life when I could have used it most. But setting that aside, it doesn’t really matter when you start yoga. It just matters that you do it.

An important thing to remember about developing a helpful and flourishing routine of yoga practice is to start slowly and to come to your mat as consistently as you can – baby steps. Like anything that is worth the effort, yoga requires patience. I have learned by coming to my mat consistently and plugging away at the process, that change happens slowly over time. But when you look back, you will find you have covered an extraordinary amount of ground. My mind, body and spirit have been totally transformed in the last 6 years. I can’t really over state this fact.

The aspect of yoga that I have found to be the most transformative for my body is an emphasis on proper alignment in every pose. I began yoga in the anusara tradition, which is a form of Hatha yoga that focuses deeply on alignment of the body under some very basic principles. This type of specific and often intense physical practice, which is found in many other forms of yoga as well, creates strength and flexibility in an extraordinary number of muscle groups; even my toes got stronger! And through this process of physical development, I found that my mind became a little quieter too.

There are so many poses in yoga and they all provide benefits to the body and the mind. Some of them, if done incorrectly or overdone, can also be harmful, so you want to make sure that you are with a qualified instructor and that you know your body’s limitations and respect the range of motion that is available to you. Below are a few poses that illustrate just some of the many benefits a steady practice of yoga has to offer.

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### Anatomy and Yoga

The link between yoga and anatomy is a strong and natural one. Yoga can be used as a framework within which to expand the study of skeletal elements, human musculature, joint cavity construction and general articulations. In Europe and North America, yoga is traditionally associated with asanas or poses and pranayana, which are breathing techniques. Both have their origins in traditional Indian spiritualism, which can be traced back 5,000 years. Though clearly an athletic activity, the ultimate goal of yoga is to forge a union of body, mind and spirit. Yoga is easily distinguished from ordinary gymnastic exercise by its emphasis on focusing the mind and developing self-awareness (Cramer 2013).

Using yoga as a framework, every pose becomes an anatomy lesson. The language of yoga is not the language of anatomy but the raw materials for both disciplines are essentially the same. Consider Vrksasana, the Tree pose, from the examples below. In terms of joint movements, the spine should be neutral and the pelvic girdle is held level with the floor. In the upper limbs there should be a slight degree of shoulder flexion and adduction. The elbow is flexed, the forearm pronated and the wrist, hand and fingers are extended. In the lower limbs there is neutral hip extension and neutral knee extension on the standing leg while on the lifted leg the hip is flexed, laterally rotated and abducted and the knee is flexed with dorsiflexion at the ankle (Kaminoff and Matthews 2012).

In terms of muscle functions for the Vrksasana pose, balanced contraction of the quadriceps and hamstrings, coupled with contraction of extrinsic and intrinsic muscles of the foot, gastrocnemius, soleus and tibialis anterior, permits the body to balance on a single leg. A slight lateral shift of the pelvic girdle over the standing leg for balance and to keep the pelvic girdle level, is accomplished by the contraction of gluteus medius, gluteus minimus, piriformis, obturator internus, the superior and inferior gemellus and tensor fascia latae (Kaminoff and Matthews 2012).

In the lifted leg of Vrksasana, hip flexion is accomplished by the contraction of the iliacus and psoas major. To laterally rotate the lifted leg and accomplish abduction at the hip requires the action of gluteus maximus, gluteus medius, the posterior fibers of gluteus minimus, piriformis, obturator internus and externus, superior and inferior gemellus, and quadratus femoris. Pressing the foot into the standing leg is accomplished by contraction of adductor magnus and adductor minimus. Pectineus, adductor longus, adductor brevis, and gracilis allow for the passive lengthening of the lifted leg (Kaminoff and Matthews 2012).
Tadasana (Mountain pose):

The yoga instructor: Tadasana is basically standing. But it is standing in proper alignment, which can be challenging to many of us who have not stood properly in our whole lives. In any yoga pose, you start with your foundation, so your feet must be planted firmly on the mat with the weight of your body distributed equally across the sole of each foot. The feet should be hip width distance apart and parallel with all ten toes facing forward. The front of the ankle should be in line with the knee cap and the greater trochanter should be in line with the outer ankle bone which will mean for most of us that the hips move towards the back of the body a little more than we are used to. Once you have aligned the legs and the hips, the tailbone should tuck down slightly allowing the lower belly to be toned. The lower rib cage should not be thrusting out, but be pulled in just a bit. The shoulders should move down the back to broaden the collarbones and the palms should face forward. The front and back of the neck should be long and the upper palate, the diaphragm and the pelvic floor should be on the same plane.

A well-aligned Tadasana will improve posture, strengthen the buttocks, thighs, knees and ankles and tone the low belly.

Targeted muscles include: All body muscles; enabling neutral extension of the spine, neutral extension of the upper limbs and neutral extension of the lower limbs and knee with dorsiflexion at the ankle (Kaminoff and Matthews, 2012). Tadasana is roughly the yoga equivalent of anatomical position and serves as a point of reference for all other yoga poses.

Vrksasana (Tree Pose)

The yoga instructor: For Vrksasana, start in the Tadasana pose. Place more weight into the right leg and take the sole of the left foot to the upper inner thigh of the standing leg. Draw your hands to heart center and focus on something low to the ground. Send the hips back slightly, tuck the tailbone and lift the heart. Lift the hands to the sky and maybe take the gaze up as well. Draw to the centerline of the body and hold for several breaths. Switch sides.

Vrksasana will strengthen the legs and the muscles along the spine. It will strengthen and open the groin, hips and inner thighs, and improve balance and mental focus.

Targeted muscles include: gluteus maximus, gluteus medius, iliacus, psoas major, pectineus, adductor longus, adductor brevis, adductor magnus, sartorius, gracilis, gastrocnemius, soleus, tibialis anterior, quadriceps and tensor fasciae latae (Kaminoff and Matthews 2012).

Ardha Matsyendrasana (Half Lord of the Fishes pose)

The yoga instructor: Come to sit with the left leg bent, knee on the mat and draw the right leg over it with the sole of the right foot flat on the mat – the right knee will be pointed to the ceiling. Press your fingers into the mat behind you, lift the heart and straighten the back then reach the left arm up to the sky and twist to the right. Draw that left elbow to the outside of the right thigh and twist more deeply. Switch sides.

Ardha Matsyendrasana will give the internal organs a gentle squeeze, which aids in digestion. The pose improves spinal mobility, and stretches the back, hips, shoulders and neck. It requires a generally healthy spine however and should be avoided if you have any preexisting spinal injuries or pain.

Targeted muscles include: rhomboideus, serratus anterior, muscles of the rotator cuff, erector siniae, piriformis, gluters medius hamstrings, adductor longus, adductor brevis (Kaminoff and Matthews 2012).

In the Half Lord of the Fishes (Ardha Matsyendrasana) joint movements include rotation of the spine toward the top leg in the pose accompanied by a neutral scapula, shoulder abduction and elbow flexion in the arm that is contralateral to the top leg. The back arm of the pose exhibits extension at the shoulder, extension at the elbow and dorsiflexion at the wrist. In the lower limbs, the top leg in the pose exhibits flexion and adduction at the hip and flexion at the knee while the bottom leg exhibits flexion, lateral rotation and adduction at the hip accompanied by flexion at the knee and plantar flexion at the ankle (Kaminoff and Matthews 2012).
In Half Lord, rotation of the spine towards the leg requires the contraction of the internal oblique, erector spinae and splenius capitus on the top leg side of the pose and external oblique, rotatores, and multifidus spinae on the bottom leg. Sternocleidomastoid positions the head. In the upper body, the muscles of the rotator cuff stabilize the head of the humerus in the arm that is contralateral to the top leg. The rhomboideus group adducts and performs downward rotation of the scapula, thereby positioning the scapula securely on the rib cage. The arm is extended against the leg by the posterior deltoid and the elbow is flexed by biceps brachii. The head of the humerus in the back arm of the pose is stabilized by the muscles of the rotator cuff while serratus anterior helps secure the scapula to the rib cage and resists adduction of the scapula on this side. The shoulder and elbow are extended by triceps brachii (Kaminoff and Matthews 2012).

In the lower limbs, the top leg is flexed and adducted by adductor longus, adductor brevis and pectineus. Passive lengthening of the top leg is accomplished by piriformis, superior and inferior gemellus, obturator internus and externus, quadratus femoris, gluteus maximus, gluteus medius and gluteus minimus. The bottom leg is laterally rotated at the hip by obturator internus and externus, quadratus femoris, piriformis and the superior and inferior gemellus muscles. Sartorius laterally rotates and flexes the hip, the hamstrings flex the knee and the leg is flexed and adducted by adductor longus and adductor brevis. Gluteus medius, gluteus minimus allow for passive lengthening of the bottom leg (Kaminoff and Matthews 2012).

Supta padangusthasana (reclining leg stretch pose)

Photo is used with permission of Sharon Ellis, Medical Illustrator of the text Yoga Anatomy

The yoga instructor: Lie on your back with your legs stretched out in front. Start by bending the right leg and clasp the back of the thigh with interlaced fingers. Press the thigh into the hands and gently stretch the leg straight so the sole of the foot is pointing to the ceiling. Flex both feet. Relax the shoulders down to the mat. Make the front of the throat long. Switch sides.

Supta Padangusthasana is great for easing the low back after back bends or after a stressful day at the computer. It helps to align the pelvis properly and gently stretches the hamstrings.

Targeted muscles include: hamstrings, gastrocnemius, soleus, gluteus medius, gluteus minimus, gluteus maximus, piriformis, adductor magnus, longus and brevis (Kaminoff and Matthews 2012).

Shallabasana (locust pose)

Photo is used with permission of Sharon Ellis, Medical Illustrator of the text Yoga Anatomy

The yoga instructor: Lie on your belly and feel the pelvis get heavy on the floor. Extend your arms in front of you and draw the shoulder blades down your back. Take a deep breath and lift everything you can off the mat. The heart should move forward and up, the feet should move back up, the shoulders come down the back as the heart moves forward and your hands move away from your seat.

Shallabasana strengthens the back, buttocks, and the backs of the arms and legs. It opens the chest and shoulders and helps to align the spine. It also stimulates the internal organs. It is a pose that should be avoided if you have any spinal injuries.

Targeted muscles include: triceps brachii, serratus anterior, erector spinae, gluteus maximus, hamstrings, soleus (Kaminoff and Matthews 2012).

These are just a few of the many yoga poses that strengthen multiple muscle groups, improve flexibility and increase range of motion over time. Proper alignment is at the heart of this improvement in the body - which can lead to a quieting of the mind and spirit as well. You don’t need to be a yoga master over night! But if you want to start to do something good for your body and your mind, come to class, come to your mat and just get started. Make yoga a part of your life and let the changes work their magic over time.

A student’s perspective:

At first the idea of adding yoga to a college curriculum may not seem like the best idea. Students are likely to see it as a class where you can simply show up and receive an A just for being there. I would be lying if I said that this idea did not cross my mind when registering for Yoga in my senior year at Arcadia University. I thought that yoga would be a great addition to my strenuous schedule as well as help
me reach a lifetime goal of touching my toes. Well, I have now graduated from Arcadia University and I still cannot touch my toes, but the benefits of yoga are something that I appreciate every day of my life. Listed below are the three primary holistic benefits that I have experienced while practicing yoga in the university setting.

1. Who needs coffee when you have yoga?

How many people wake up every morning with the overwhelming need to have a cup of coffee to get their day going? I know I did! I am not saying that I have completely removed coffee from my diet since a cup of coffee is nice every once in a while. However, my coffee intake reduced significantly after starting yoga. Consider also that many people have an urge to spread out their arms and stretch when they first wake up. In this case, think of yoga as just a continuation of what your body naturally wants. It is not uncommon to feel a euphoric rush during or after yoga; this is your body thanking you for stretching it out before a long day and releasing endorphins that make you feel good. I always felt more alert and ready to take on the day after each yoga class.

2. Mindfulness is a must for happiness.

Most people don’t realize that yoga goes beyond its physical practice. Yoga encompasses many different areas; one of the most important to me was focusing on mindfulness. At the end of each class we would have a 5-10 minute meditation period. During this time our instructor would say something that I will never forget: “Let yourself go. Be mindful that you are exactly where you need to be at this point in time so all other worries should be released from your consciousness”. At first this was not an easy thing for me to do because my mind might be already focusing on a human anatomy exam 20 minutes later. After awhile I came to realize how important mindfulness is. No matter what you are doing in life, assuming that you are not hurting anyone else, it is okay. Accept that it is what you need or want to be doing and you will find yourself a happier person.

3. Yoga helps your posture. Good posture keeps you healthy.

In January 2014, I will begin my studies to become a Doctor of Physical Therapy. Prior to this I have had numerous experiences in a variety of physical therapy settings. One common trend I found in all of the therapists was the importance of good posture. If your body is strong where it needs to be, flexible where it needs to be, and the natural curvature of your spine is aligned correctly then your chances of injury will be reduced significantly. Yoga does just that; the stretches and poses are designed to strengthen, elongate, and improve posture. I was a college soccer player in the best shape of my life and with yoga I was still discovering muscles that I never knew existed.

Overall the introduction of yoga into the Arcadia University curriculum was one of the most pleasant surprises I encountered during my experience there. It taught me the importance of approaching health through a holistic lens. Through improving mental and anatomical function, yoga should be considered as a great alternative to tradition fitness methods. I believe that its popularity on college campuses will continue to grow as an increasingly health conscious student body fills our colleges and universities.

A glimpse into the future

In addition to the stress reduction benefits touted by university students, yoga may also prove to be an effective means of coping with several types of medical conditions. Recent clinical studies have shown that yoga may help to alleviate the symptoms of arthritis, fibromyalgia, low back pain and even irritable bowel syndrome. It may also help to improve the overall health of those at risk for type-2 diabetes and cardiovascular disease. (Cramer 2013).

The profile of the average yoga user is somewhat mixed but physicians are interested in developing such a profile for its predictive value in assessing those most likely to have an interest in helping themselves through the healing process. The average yoga user is most likely to be a young, white, well-educated female who uses yoga to treat musculoskeletal disorders. Those who practice yoga are less likely to smoke but, interestingly, more likely to drink alcohol. They are generally in good health and less likely to be obese but somewhat more likely to have mental health conditions such as depression and anxiety. The average practitioner of yoga is more likely to have a variety of musculoskeletal and/or musculoskeletal conditions including rheumatoid arthritis, gout, osteoarthritis and lupus. They frequently suffer from severe sprains and may be prone to asthma but they are less likely to suffer from hypertension and COPD. It is believed that most patients are reluctant to tell their physician they do yoga but they will frequently acknowledge whenever a physician has recommended the practice of yoga as a facilitator of good health. Recent research has centered on the use of yoga for specific medical conditions, notably disorders of the respiratory and cardiovascular systems and psychiatric disorders such as schizophrenia (Cramer 2013, Birdee 2008, Hartfiel 2012).

Yoga poses are based primarily on isometric muscle contraction, which appears to yield both clinical and non-clinical applications. The far-reaching effects of yoga are attributed to the complexity and multidimensionality of yoga movements and poses. One area that shows particular promise for the future of yoga in helping to treat a medical condition centers on low back pain. Low back pain is very prevalent in our society today, causing large expenditures in health care and missed days of work. It is usually defined as localized pain that occurs between the

(Continued on next page)
12th rib and the inferior gluteal folds. Low back pain may be accompanied by leg pain on one or both sides and in 90% of cases, the pain is described as being non-specific. Low back pain is also sometimes described as lumbar-sacral spinal pain. It is most often characterized as continuous low-level pain interspersed with acute pain. The causes of low back pain are complex and poorly understood but the toll it takes on patients is expressed in limitations to their daily activities and functions including walking, running, turning and reaching for objects. The mechanisms by which yoga may reduce low back pain remain largely hypothetical. It may be that increased tissue flexibility is helpful in pain reduction as is the potential for the release of endorphins and enkefalins. The need for critical evaluation of the literature on the use of yoga techniques in pain management is evident. In spite of this, the majority of studies on the relief of low back pain with yoga are positive (Posadzki 2011).

This article presents two detailed examples of how yoga poses may be broken down into their component anatomical elements and three more general examples of well known yoga poses with the primary muscles used in each pose highlighted. Those who have an interest will be wise enough and creative enough to design a variety of anatomical lessons based on yoga poses. It would also be interesting to integrate the balance and equilibrium components of the inner ear and the regulatory and control functions of the nervous system into the yoga framework.

About the authors:

Susan White Phillips has a Masters in Political Science from Boston College and she is a certified yoga instructor at Elements Yoga and Wellness Center in Darien, CT. She has been practicing yoga since 2007. Susan is the mother of three children and active in charity work in her hometown of Darien, CT.

Sarah Cooper is co-editor of the HAPS EDucator. She has taught human anatomy, general biology, and interdisciplinary science at Arcadia University since 1981. She also teaches a first year seminar in forensic anthropology, serves as the pre-nursing adviser, and has been a member of the university judicial board since 1982.

Spencer Lalk graduated from Arcadia University in 2013 with a B.A. in Sports Psychology. While at Arcadia, Spencer was captain of the Men’s Soccer Team as well as a study abroad participant in Scotland and Australia. In January 2014 he will enter the Doctor in Physical Therapy program at the University of St. Augustine in San Diego California.

Illustration Credit: Sharon Ellis illustrated the book Yoga Anatomy. She has a Master’s degree in Medical Illustration from the University of Texas Southwestern Medical School

Literature cited:


Forgotten Student Profile #443

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Pedagogical Diversity in Introductory Human Anatomy and Physiology Class in a Small College Setting

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Abstract: Human Anatomy and Physiology (A&P) is a challenging introductory course required for pre-nursing/allied health students. This article presents various teaching approaches that are designed to appeal to diverse groups of students in a small college setting. The use of enhanced power-point, interactive whiteboards, A&P visual simulation CDs, and in-class review and assessment techniques were introduced in an A&P class over 4 years and their impact on learning was evaluated through student surveys, records of performance, and the evaluations of the instructor. Approximately 86-97% of the surveyed A&P students rated these teaching tools as useful or fair. Overall, average student grades improved significantly between the academic years 2006/07 and 2009/10 and a significant increase was also seen in the A&P students’ evaluation of the instructor during the same period. Additional teaching tools used in the class are also described. The diverse pedagogical approaches described here represent a mix of traditional low tech and innovative high tech tools that suit the small college setting and might have significance beyond a single discipline.

Keywords: Anatomy and physiology education, undergraduate education, pedagogical diversity, digital imaging, interactive whiteboard, anatomy and physiology course, innovations

Introduction

Human Anatomy & Physiology (A&P) is a high demand introductory course required for undergraduate pre-nursing and allied health students. At Ohio University Zanesville, A&P has been taught in a two-quarter class series (Bios 130 and Bios 131) that covers the structures and functions of the human body. The nature of the subject and the amount of material covered make A&P a challenging subject early in the college career of the students, who cite abstract physiological concepts and endless memorization of anatomical terms and structures as the major challenges of the subject (Johnston and MacAllister 2008). A&P pedagogy would benefit from a variety of active and passive teaching techniques (Minhas et al. 2012) that collectively make the subject more bearable and digestible to the students and encourage them to succeed through learning concepts rather than memorizing facts (Miller et al. 2002). In this article, various teaching approaches that are designed to appeal to diverse groups of student while enhancing the students’ understanding of the subject are discussed. These approaches represent a mix of traditional and innovative strategies that might have significance beyond a single discipline. A common feature of these tools is their ease of use and comparative low cost, which make them affordable to small colleges. Students’ ratings of individual teaching tools and their overall impact on student performance on the subject and student evaluations of the instructor are presented and discussed.

Course Structure

The A&P class is designed with diversity of pedagogy in mind. Students are taught and assessed through a variety of activities that are specifically designed to enhance their understanding of the subject. To accommodate the new generation of learners who learn better through interactive technology, the A&P courses incorporate a Web-based educational content management system, BlackBoard, version 9.0, extensively. Chapter-based objectives and learning
outcomes, PowerPoint lecture outlines, and laboratory study guides as well as review questions, quizzes, links to textbook interactive tutorials, and useful websites are posted online ahead of class meetings.

Unlike a traditional approach in which grades are earned only through quizzes and examinations, students receive up to 25% of their final grade through carefully selected activities based on learning the main facts and concepts of the subject. A major component these activities are group of assignments that are outcome of students articulation and comprehension of specific topics. To avoid routine, these assignments come in different formats, for example, writing fictional stories, matching questions, do-it-yourself and short essays. An example is to write a fictional story using some of the terms used to describe regions and landmarks of the human body or the terms used to described diarthrosis. Another example is to ask students to list and compare facial expression muscles used in smiling versus frowning using themselves or friends as objects. Points are also offered for class participation through questions and in-class discussions among the students and feedback to allow for adjustment of teaching style. Participation points could be earned through contribution to specialized discussion boards on the class BlackBoard (Blackboard Inc., Washington, DC) website. Two discussion boards are set up online. The first is devoted to chapter-by-chapter discussions, and the other is open for questions and/or comments about class related material. The latter is usually very popular as students share topics and applications related to the class material as they read it or hear it in the news and from other sources, adding real-life connections to student learning. The most significant use of these discussion boards is the exchange and sharing of study tips and useful study material. Additional points related to comprehension of the material are earned through vocabulary quizzes throughout the academic term. These quizzes are based on word elements of medical and anatomical terms essential for understanding the subject.

The remainder of the class grade (75%) is divided between four lecture and four laboratory examinations throughout the academic term. Because of the continuous assessment process (Sadler 1989), student attention and participation are maintained and points are earned every week of the academic term. In addition, overall student grades are not significantly affected by poor performance in an individual assignment or examination.

### PowerPoint Resources

A&P is a highly visual subject that requires the display and breakdown of high quality figures and illustrations for optimal understanding and comprehension of the material. Conventional PowerPoint slides may improve students’ attitude toward the presentation of course material and have gradually replaced the overhead projector as the main teaching equipment in the classroom. A&P PowerPoint presentations were supplemented with additional images and illustrations, links to additional study resources, embedded animations/videos and review questions. Whenever available, special attention is paid to animations to present the concept more effectively compared to static illustrations and text (Carmichael and Pawlina 2000). Review questions are provided on separate slides at the end of the presentation, and answers are highlighted in subsequent slides. This allows students to test their understanding of the topic right after they study the material.

Students’ rating of the use of PowerPoint resources in A&P classes was highly positive (Table 1). In their feedback, students applaud the additional online resources as a knowledge enrichment tool. They also like the opportunity to bring printouts to the classroom for better follow up and note taking.

#### Table 1. A&P students’ rating of various teaching tools introduced to the class from 2007 to 2009.

<table>
<thead>
<tr>
<th>How do you rate the impact of following tool on your understanding of A&amp;P</th>
<th>Students responding:</th>
<th>Percentage of students rating tool as useful or fair (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Useful</td>
<td>Fair</td>
</tr>
<tr>
<td>PowerPoint resources</td>
<td>89</td>
<td>3</td>
</tr>
<tr>
<td>Use of the SMART board in the classroom</td>
<td>67</td>
<td>23</td>
</tr>
<tr>
<td>A&amp;P simulation CD (A&amp;P Revealed)</td>
<td>54</td>
<td>26</td>
</tr>
<tr>
<td>IF-AT review and assessment</td>
<td>77</td>
<td>6</td>
</tr>
</tbody>
</table>

#### Interactive Whiteboard technology

Whiteboard interactive products are internationally recognized as educational tools to enhance classroom learning. Various format of SMART board (SMART technologies, Calgary, Canada) are utilized in the A&P classroom and laboratory sessions. Due the large class size (54 students), the podium unit of the SMART board (model ID350) is used in the lecture room while a wall-mounted unit (model 680) is used in the laboratory (18 students capacity). The ability to control computer applications directly from the display,
write notes in digital ink and highlight details and key points helps energize presentations and motivate students as well as enhancing the classroom learning process. Being able to simply touch the surface to get started, switch screen and play animations and videos make the SMART board an outstanding tool for engaging the students, especially in large classes. The SMART board is used to highlight fact and key structures during PowerPoint presentations in lectures and laboratory sessions as well as during animations, video presentations and digital camera projections from microscope (Higazi 2011). It is also being used as stand alone instructional tool for writing and illustrational purposes. Students also use SMART board to show key structures or landmarks during interactive review sessions.

Students related well and engaged with learning when SMART board technology was used. Students’ rating of the impact of the SMART board on attention and overall learning of A&P material was highly positive (Table 1). In written feedback, students made special reference to convenience and ease of follow up and note taking as reasons for their favorable view of this technology. Although the highlighted documents are saved and could be made available to the students, they usually prefer their own notes taken during class sessions.

**Visual simulation and laboratory sessions**

Laboratory sessions are essential to understanding A&P as they are designed to reinforce lecture concepts through visual and practical means. At Ohio University Zanesville, A&P students spend more time in laboratory learning than in lectures. Learning is reinforced through the use of models, hands-on experiments, computer simulations, and dissection exercises. It is extremely beneficial to use diverse approaches in laboratory sessions to accommodate the needs of visual, aural, read/write, and kinesthetic learning styles (as explored in VARK learning styles) (Fleming and Mills 1992). It is also important to introduce some fun activities to retain students’ interest in these sessions.

Several laboratory sessions that provide hands-on experiences for Health Sciences students were introduced. For example, a DNA extraction session using a DNA necklace kit (Item #211138, Carolina Biological Supply Company; Burlington, NC) introduces students to the molecules of life and heredity covered in the textbook. This exercise also represents a fun activity in which students extract DNA from their own cheek cells and keep it as a necklace. Additional laboratory sessions cover blood count and typing and HIV testing based on a simulated ABO and Rh Blood-Typing Laboratory Activity and Discovery and Clinical Diagnosis of HIV by ELISA Laboratory Activity (Items #36 V 0019 and #85 V 3518, WARD’S Natural Science; Rochester, NY) to reinforce concepts and facts of the cardiovascular and immune systems respectively. The class also benefited from the occasional availability of some fresh animal organs, e.g. hearts, lungs, kidneys provided to us by nearby certified slaughterhouse.

Digital human cadaver dissection software has provided small institutions with limited access to advanced facilities with visual simulation multimedia aids that allow students to actively explore human anatomy. The value of stereoscopic cadaver images in demonstrating the underlying anatomy has been reported (Perry et al. 2007). At Ohio University Zanesville, the Anatomy and Physiology Revealed CD (University of Toledo 2007) has been bundled with the A&P class textbook for use by the students in and out of the classroom. The use of this visual simulation tool has provided detailed images, a cadaver dissection tool, and the ability to manipulate images in addition to access to extra review material and animations. Alternative visual simulation tools are available, including Practice Anatomy Laboratory, Real Anatomy Software, A.D.A.M. Interactive Anatomy, Virtual Human Dissector, and the Atlas of Human Anatomy.

Major obstacles for students using supplementary CDs are knowledge of how to efficiently use the CD and a lack of clear correlation between the textbook and the CD materials. Hence, a portion of the first laboratory is reserved for demonstrating the use of this tool, its value, and providing a correlation guide on how to find relevant material on the CD. Frequent reminders about the importance of the CD as a learning and review tool also seem to increase its use and impact on the student learning. Student feedback on the impact of the visual simulation aid CD has been positive (Table 1). Students who did not see the positive impact of the CD usually reference lack of time to use it. Use and impact of these visual simulation CDs is expected to improve as Ohio University Zanesville moves from quarters to semesters.

**Live Digital Imaging (LDI) in Histology**

The study of histology and cell structure is an integral part of any A&P course. The study of microanatomy helps correlate structure and function and provides a glimpse into a microscopic world that often sparks the imagination of students. However, students consider histology as the most challenging topic in their introductory Human Anatomy and Physiology class (Higazi 2011). More institutions are moving toward replacement of the traditional microscope-based histology learning with virtual microscopy learning amid concerns of losing the valuable learning experience of traditional microscopy. The use of live digital imaging

(Courtesy of Dr. Bruce Higazi, Department of Anatomy, Ohio University Zanesville.)
(LDI) of microscopic slides on SMART board as an innovative tool to enhance histology learning has been integrated in the A&P class. This interactive LDI system set-up allowed real-time illustration of microscopic slides with highlighted key structural components and also provided the students with relevant study and review material (Higazi 2011). The significant impact of interactive LDI on student learning of histology on student grades and performance was recently reported (Higazi 2011). Student ratings of the impact of the interactive LDI on their Histology learning continues to be highly positive, suggesting that a majority of students who valued this learning approach also improved their learning of the material as a result. This interactive LDI technique represents a highly efficient and affordable tool to enhance student histology learning that combines the benefits of traditional and virtual microscopy and is likely to expand student knowledge and interest in A&P and health science careers.

Off Campus visits: Bodies - The Exhibition

Another beneficial learning tool for students is field trips. A relevant example for introductory A&P classes is the anatomical exhibition of human bodies (http://www.bodiestheexhibition.com/). This is an exhibition of plastinated human bodies specially dissected to show various organs and organ systems. The exhibition provides students with an unprecedented opportunity for learning human A&P, especially for small colleges that lack access to human cadavers. A&P students are fortunate to visit the exhibit whenever it is accessible. Such visits provide students with a unique access to actual human cadavers in which anatomical facts and concepts can be further comprehended and appreciated. In addition, the instructor’s presence as a guide at the exhibit provides value-added learning through questioning and the highlighting of anomalies.

One student summarized the benefits of this off-campus activity as follows: “I don’t believe that there is another teaching tool, that could be as useful and neat as this exhibit. To actually see what the human body looks like on the inside and outside is just amazing. Pictures in books, and models, or slides on a CD, just cannot compare to this exhibit and the fact we see things we have gone over in class, is awesome”. Another student wrote, “This Exhibit was amazing. I think that actually seeing real bodies and every body part helped me to put everything that I have learned from the class together”.

However, the exhibit is not permanently accessible and it was not possible to make such visits every year as part of the curriculum. Moreover, it might incur some expense on the students, such as for admission and transportation. This teaching tool was not evaluated due to its temporal nature and accessibility.

Alternatively, visits to a nearby prosected cadaver gross anatomy laboratory are being planned.

In-class review and assessment techniques

A&P students are required to master many terms, facts and concepts about the human body, most of them in a short period of time. An important component of the class is the review of this information in a manner that improves retention, recall, and understanding. The use of multiple-choice testing-review in a group format fosters student-to-student accountability within learning teams in an active learning environment. A low-tech format of this approach introduced in A&P classes at Ohio University Zanesville is the scratchable answer form represented by the Immediate Feedback Assessment Technique (IF-AT®) (Epstein et al. 2002).

IF-AT is based on a multiple-choice procedure that provides immediate informational feedback to students for each question and permits the allocation of partial credit when used in classroom assessment exercises. Students are provided with a scratch-off sheet that matches the correct answers to multiple-choice questions. The students discuss each question in-group and agree on an answer and then scratch off their sheet to get immediate and corrective feedback.

The impact of the IF-AT on student performance and attitude toward the subject can easily be recognized, and students enjoy using the technique (Table 1). Students’ written comments highlighted the value of exchange of knowledge, immediate feedback, and its entertaining nature. The main disadvantages of the IF-AT are that the forms are non-scanable and the creation of assignments is time-consuming. In addition, some high achieving lone-learner students indicated that it takes off their study time.

A more recent and advanced classroom alternative for providing instructional immediate feedback in a large class is the audience response (clicker) systems (ARS) (Wood 2004). ARS relies heavily on technology to provide detailed real-time data on the assignment being given and the student responses. However, its price tag might make it less affordable to small colleges.

Overall Impact

The pedagogical tools described above were introduced into A&P teaching over four-academic years from 2006/07 to 2009/10. Student-based evaluations were performed on an average of two classes following the introduction of each of these tools (Table 1). A sample proportion test indicated that 97% of the surveyed students rated both the PowerPoint resources and the use of the SMART board in the classroom as useful or fair in their learning of A&P material with a 95% confidence interval (CI) of 92-99%. IF-AT was
rated useful or fair by 94% of the student while 86% rated the A&P revealed CD as useful or fair with a 95% CI of 87-98% and 78-93% respectively (Table 1).

The overall impact of these diverse pedagogical methods was evaluated through comparison of average student performances in A&P and average student evaluations of the instructor per academic year from 2006 to 2010 using an unpaired t-test computed with SAS statistical software, version 9.1 (SAS Institute, Cary, NC).

Annual average grades of 72 students in 2006/07, 122 in 2007/08, 133 in 2008/09, and 89 in 2009/10 showed an overall significant improvement over the study period from an average of 81% in the academic year 2006/07 to 85% in the 2009/10 academic year (p = 0.002). At the annual level, significant improvements were also seen between the academic years 2006/07 and 2008/09 (p = 0.001), 2007/08 and 2008/09 (p = 0.026) while there was no significant difference in students performance between the academic year 2008/09 and 2009/10 (p = 0.496) (Figure 1; Table 2).

A&P lecture and laboratory sessions showed significant improvement from < 4 in 2006/07 to a rating of 4.5 (p ≤ 0.001) in 2009/10 (Figure 2). This improvement in the student evaluations of the instructor was first seen between the academic years 2006/07 and 2007/08 (p = 0.0102) and continued throughout 2010 with the exception of between the academic years 2007/08 and 2008/09 (p = 0.6213) (Figure 2).

Figure 1. Mean students’ grades in my A&P classes (Bios130 and Bios131) at Ohio University Zanesville from 2006 to 2010. Incomplete grades were excluded from the mean.

Figure 2. Mean students’ evaluations of the A&P instructor from 2006 to 2010. * indicates p ≤ 0.05; ** indicates p ≤ 0.001.

### Discussion

Students are diverse in background and academic preparation and have different needs and learning styles. No single teaching method works best for everyone. The use of a variety of pedagogical treatments optimizes learning for all students (Wood 2009) and helps them repair misconceptions and develop more appropriate concepts. This article reviewed several pedagogical tools, mostly nontraditional and innovative, used in an introductory A&P courses in a small college setting to improve student learning and perception of the subject matter. Most of these pedagogies, e.g. student work done cooperatively in small groups, in-class and out of class learning activities, active learning, formative feedback, etc. were reported as research-based promising aspects of course organization (Froyd 2008) for undergraduate STEM learning.

The collective efficacy and importance of such diverse pedagogical tools was evident through simultaneous improvement in overall

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### Table 2. p – values of the differences in A&P classes performance based on average student grades per academic year from 2006/07 to 2009/10.

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<td>2006-2007</td>
<td></td>
<td>0.081</td>
<td>0.001</td>
<td>0.002</td>
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<tr>
<td>2007-2008</td>
<td>0.081</td>
<td></td>
<td>0.026</td>
<td>0.043</td>
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<tr>
<td>2008-2009</td>
<td>0.001</td>
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<td>0.495</td>
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<tr>
<td>2009-2010</td>
<td>0.002</td>
<td>0.043</td>
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Similarly, average student evaluations of the instructor on a 1-5 scale of 98 students in 2006/07, 185 in 2007/08, 210 in 2008/09 and 242 in 2009/10 for both (Continued on next page)
student performance in class and student evaluations of the instructor. Studies designed to measure the impact of individual pedagogies, e.g. the SMART board, the in class review technique, PowerPoint resources, visual simulation CD, etc. would demonstrate the importance of these tools. The confounding effects of these pedagogies prevented performance-based evaluation of individual approaches with the exception of the LDI system, which was recently described and evaluated (Higazi 2011). However, the significant improvement in A&P student grades and student evaluations of the instructor reported here appear to correlate and indicate enhanced student knowledge of the subject (Bryson 1974). It also suggests the value of diversity in pedagogy in facilitation of student learning and perception of the material. The affordability and scope of the pedagogical approaches described here also imply their effectiveness in many subjects at the small college level. In addition, the latest student evaluations of the A&P instructor reported here (Figure 2) was equivalent to the campus mean of all classes offered per academic year on our campus. This study was performed in a regional campus of Ohio University that offers ten bachelor’s and five associate degree programs and nearly 400 classes per quarter.

It is interesting to note that formative student surveys indicated that students’ ratings of the class in terms of difficulty was maintained mostly at the difficult to very difficult level, despite the improvement in both student grades and student evaluations of the instructor over the period of the study. While the integration of these pedagogical methods seems to have made the subject more understandable and bearable but not necessarily easier as it required additional commitment in terms of time and effort on the part of the students. Other factors that might have helped to improve nursing and allied health students’ learning of the subject were the frequent reminders and the use of examples that stress the relevance of A&P to their future classes and real clinical practice (Levey 2009) throughout the class.

The diverse pedagogical approaches described here represent an attempt to follow recent trends of the incorporation of visual and interactive technology into a variety of active and inquiry-based learning pedagogical methods that have led to significant improvement in A&P learning and perception (Brown 2010). Such integration of diverse pedagogy has encouraged A&P students to work more toward using their powers of reasoning to develop a real understanding of the subject (Krontiris-Litowitz 2009). These pedagogies also represent efficient and affordable tools with a universal nature and broad scopes that render them suitable for instruction in related disciplines in small colleges with limited resources. In addition, these pedagogies and technologies might also benefit students who do not realize the relevance of science to their daily lives and careers. Depending on their classroom environment and needs, instructors may choose one or more of these pedagogies to supplement their own teaching styles and enhance the learning experiences of their students.

ACKNOWLEDGEMENTS

The author is grateful to Dr. James Fonseca, Dean of Ohio University Zanesville, for purchasing some of the teaching equipment used here and for his continuous encouragement and facilitation of innovative teaching pedagogy. I would also like to thank my student Ms. Ashley Hunter for compiling the student survey data; Dr. Taj Mohamed and Mr. Amir Osman for assistance with statistical analysis; Mr. Michael Nern for his critical reading of the manuscript. Finally, I am indebted to my A&P students for their interest, support, and feedback.

Literature Cited


(Continued on next page)


From the students in a one semester advanced human physiology survey course for senior biology students, the majority heading to medical school, physician assistant programs, or other allied-health field.

ODE TO PHYSIOLOGY, UPON REFLECTION

Looking back you will likely agree you’ve learned a lot of physiology. The crux of the matter is homeostasis for which you now know the basis. Neurons use voltage and current for speed to respond to internal and external need. Hormones use blood for transportation to look for receptors to form a relation. Blood is in turn impelled by the heart through valves that thump at stop and start. Blood regularly takes a special trip for purification and O2 it can ship. The kidney is the target of much blood, which then removes the remaining crud. The unbeautiful gut brings in the food; its actions can occasionally be rude. Each of us is proof that bodies work; bodies amazingly rarely go berserk. Thanks for being a part of our team; you made it fun to work at full steam. From what you’ve learned, you will not lose in whatever future endeavors you choose. How the body works, you now have a clue. We wish you good luck in all you pursue.

Andrew J. Lokuta, Ph.D. and Donata Oertel, Ph.D. Department of Neuroscience University of Wisconsin School of Medicine and Public Health
Interteaching: Successes and Frustrations in Implementing Active Learning Methodology in Anatomy and Physiology

David E. Mercer, MD
Salem State University

Abstract: Every semester, students voice their frustration concerning the amount and complexity of material in Anatomy and Physiology courses. Much of their frustration results from traditional lecture classes that promote passive, superficial learning. Interteaching is an active learning technique based on behavioral analytic theories that has primarily been implemented in psychology courses. Over the past decade, the methodology has been used in other fields of study and consistently has been shown to improve exam scores in empirical studies. In this paper I will describe the components of Interteaching as intended by the developers, and how other researchers have modified Interteaching to fit their student populations in other fields of study. In addition, I will explain how Interteaching was implemented in a second semester Anatomy and Physiology course, and resulted in higher exam scores than traditional lecture alone. Lastly, I will list the students’ praises and frustrations with the technique in its original form, and describe the modifications I made based on student feedback.

We, as instructors in Anatomy and Physiology, have struggled for ways to engage students who need to learn as much as they can in short periods of time – such as a semester, a quarter, or even a six-week summer session. The problem is not unique to A&P but I dare say it is enhanced by the magnitude and complexity of the material. The majority of healthcare students need a broad knowledge base for board examinations and admission exams to further their careers but also need critical thinking skills to provide optimum patient care and advice. With such time constraints, students tend to rely on rote memorization as a short-term solution to survive the next exam. Critical thinking skills, which require time to develop, are sacrificed to maximize recall of facts and figures.

Furthermore, one of the most challenging aspects of the education of healthcare professionals is the transition from classroom to bedside. Many students unfortunately have the attitude that the A&P course is a necessary evil to their goal of becoming a healthcare professional. Students rarely recognize the connection between serum potassium levels and how it would relate to the patient in Room 307 with a cardiac dysrhythmia or other existing condition. One of the major goals of our teaching careers should be to make this transition of learning concepts in A&P to applying concepts less difficult and a foremost priority.

For the past couple of years, I have been using Interteaching to engage and challenge students, and to illustrate connections between basic science concepts and clinical presentations. Interteaching, when compared to traditional lecture, has consistently been shown to raise exam scores in both small and large classroom setting. Although developed in and mostly for psychology courses, Interteaching has been used in other fields as well. In this paper, I will describe Interteaching as originally developed by behavioral analysts and will share some of the modifications developed by subsequent researchers in other fields. Finally, I will share the modifications to the traditional Interteaching methodology that I have made, to teach A&P to our student population at Salem State University (Saville et al. 2005, 2006, Goto and Schneider 2009, Scoboria and Pascual-Leone 2009).

Interteaching is originally based on the behavioristic approach of Keller’s Personalized System of Instruction in which operant conditioning techniques are applied to cognitive learning. Emphasis is placed on self-paced learning, and mastery of a unit is required, before one can move on to the next unit. Although this approach seems to work well with online instruction, it is complex and labor intensive in the classroom. Boyce and Hineline took the theoretical behavioral analytic approach to develop Interteaching. To summarize, students are assigned readings and online activities prior to class. They are given preparation guides with questions to answer, based on the reading and activities. In class, students separate into pairs to discuss and teach one another the concepts addressed in the preparation guides. The goal is to have a conversation about the material. They work together to master the major concepts while the instructor circulates and answers brief questions, allowing the conversation to move forward. Afterward, the students fill out a feedback form to identify aspects of the experience that helped them to understand the material and to ask for further clarification on concepts that still are problematic. Based on the feedback, the instructor gives a clarifying lecture to address any misconceptions. Then the class moves on to the next unit. After I describe the student population enrolled in A&P in our institution, I will discuss each component.

(Continued on next page)
of this method in detail, mentioning the modifications other researchers have reported, and the modifications I have created for A&P (Boyce and Hineline 2002, Keller 1968).

Students
Our two-semester A&P course was originally developed as a support course for nursing students and applied health majors. The only biology majors allowed to enroll were those concentrating their studies in nuclear medicine technology or non-clinical medical technology. Recently, the biology department developed a bio-medical concentration program, which resulted in the A&P course opening up to biology majors interested in biotechnology or professional schools (e.g., medical, dental, veterinarian, physician assistant programs). More than 85% of the A&P students are full-time, lower division students. About 60% have outside jobs (average of 21 hours per week) to meet the monetary demands of school. All are interested in healthcare professions.

Preparation Guides
Preparation guides list discussion questions about the material in the reading assignments. (Your learning objectives can be used to easily make the main points you want your students to master.) In the original description of Interteaching, preparation guide questions were higher-level Bloom’s taxonomy learning questions (application, analyze, evaluate, synthesis) based on the reading. Saville et al. mention that the range of about 10-12 questions was optimal, depending on the complexity and length of the reading material and the time between sessions. The questions should challenge the students and promote discussion in the Interteaching classroom sessions. The answers to the preparation guides are written out by students and checked by the instructor, but this isn’t mandatory. Students may check each other’s answers to the questions as well, and rate their partner’s preparation on the feedback form (discussed below). However, in my experience, students are hesitant to give negative evaluations of other students, especially when the source of the evaluation is known (Saville et al. 2011).

Classroom Interteaching Session
The class can start with a clarifying lecture from the previous Interteaching session (details to follow). Scoboria et al. report that a brief “orientation” lecture is beneficial and helps the students to focus on the learning goals of the day. After the 10-15 minute lecture, students divide themselves into pairs as originally described in this method. They should work with someone new for each session. By working in pairs, students feel the need to be able to contribute to the conversation. By adding more students to the group, the burden is lessened and the temptation of “social loafing” increases. Although Scoboria et al. report groups can increase to four students without this problem, I have commonly noted loafing in groups of three. Obviously, groups of three are unavoidable with an odd number of students, or when students arrive late and join a pair after the session has started. However, students are more likely to come prepared, if they cannot count on more partners. Working with a new partner reduces the chances of friends continually being paired and increases exposure to other students with different capabilities. In my experience, low performing students, who work with high achievers, tend to incorporate better study techniques from the better-prepared student. An athletic training major commented how well her partner was prepared and would work harder for the next session (which she did). At the beginning of the semester, students tend to pair with other students who are equivalent in ability. By forcing new partners each time, there is more blending of student skill levels that reduces artificial tiers developing as the semester progresses. Finally, the goal is for each student to think through and answer all questions on his/her own. To ensure this happens and reduce the possibility of labor division (dividing the questions among themselves to turn in as a group), students genuinely benefit from the impromptu meeting of a new partner (Scoboria et al. 2009).

When the students start their conversations, they take the original preparation guide questions and discuss the concepts that answer the questions. The requirement to organize their thoughts in such a way as to explain complex ideas to another person deepens long-term learning. Even when the other student is unprepared or didn’t understand the question, the teaching student benefits from the explanation. As quoted in many variations from Frank Oppenheimer to Phil Collins: “The best way to learn something is to teach it”. The instructor moves through the groups listening for questions, ensuring groups are staying on task, and intervenes when a concept is not explained correctly. Occasionally, when several groups are having the same misconception, overall class announcements can give the entire class hints to the correct outcome. Depending on the complexity and number of preparation guide questions, Interteaching sessions last from 30-40 minutes.

In the original form of Interteaching, quality points were awarded to a pair of students if both of them performed well on the following exam. However, Saville and Zinn noted there was no difference in student performance with or without quality points being earned (Saville and Zinn 2009).

In my experience with Interteaching, a problem presents itself toward the end of the semester. Students tend to become less challenged as they master the techniques of the sessions, when they are teaching the same questions as are found in the preparation guides. Especially with high achievers, the sessions become shorter as the discussions are more to the point and less exploratory. Goto and Schneider recognized this in their food science classes and developed an

(Continued on next page)
approach of dividing the preparation guides. Half of the class would answer Preparation Guide A and another Preparation Guide B. The A students would work on their answers in pairs while the B students would do the same. When they were comfortable with their answers, the A students would join with the B students in a new group of four to teach the others their assigned concepts. Then the instructor would present synthesis-type questions to the class before the conclusion of the session (Goto and Schneider 2010).

I also noticed a problem with my low achieving students (or more accurately, the no-time-to-achievers). With more distractions outside of class, these students have less time to reflect on, and to analyze the material that they have just read. They are lucky if they read the assignment, and completed the questions. When they come to class, they can give only the facts and figures, but cannot put them together before class to be effective in the Interteaching session. I address this problem with modifications to the traditional Interteaching discussed in a later section.

Feedback Forms
At the end of the session, each student will fill out a form to give feedback about the experience. The form asks basic information about the following: 1) who was their partner; 2) their partner’s preparation (rating and reasons for the rating); 3) how long they needed to complete the task; 4) was the amount of time sufficient to complete the session; 5) which concepts were the most difficult to learn and why; 6) which concepts would they want addressed in the clarifying lecture; and 7) any interesting information they learned in the exercise. Because the forms are kept confidential, the partner peer evaluation is more honest. Also, questions on the form allow students to report misunderstanding without announcing their questions in front of their classmates.

Clarifying Lecture
The instructor gathers the feedback forms and puts together a clarifying lecture of about 15-20 minutes addressing the most commonly requested concepts. In the original description of interteaching, the clarifying lecture came just after the session. However, Saville et al. demonstrated that the clarifying lecture could be at the beginning of next class meeting, or even a week later for weekly courses. There was no difference in test scores for classes that gave the clarifying lecture just after the Interteaching session versus the start of next class meeting. In my experience, it was more practical to collect the feedback, make a list of topics students wanted clarified, and develop the lecture for the next meeting. My thoughts were more organized and I could transition between seemingly unrelated topics with better segues. Also, I can develop and use clicker (i.e., electronic personal response system) questions (asking about the same concept but different

- **Course Exams**
- **Final Exam**

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**Figure 1.** Average A&P course and comprehensive final exam scores using traditional lecture only (n=16 students), Interteaching only (n=12 students), and Interteaching plus lecture (n=12 students). The averages on the course and final exams were significantly higher in the two semesters in which Interteaching was used (course exams p<0.05; final exams p<0.5). To keep the populations as similar as possible, only data from continuing education students were used.

(Continued on next page)
went back to traditional lecture for the majority of class improvement in learning. The following semester, I data (both published and my own) demonstrated I was not giving up on Interteaching because the Semester Major Adjustments after the First online course".

Based on my frustrations and student feedback, I made several adjustments to Interteaching to make for a better educational tool. The major change in this new approach involves asking different questions in the preparation guide than in the Interteaching session. The students in the first semester had difficulty answering the Bloom's higher-level questions in the preparation guide on their own. Many questions in the preparation guide were left blank and the Interteaching sessions resulted in long periods of quiet blank stares into space. I switched the preparation guide questions to lower-level Bloom's taxonomy (knowledge and comprehension type questions). This helped them come to class prepared with the basic level of understanding of the reading, and then the challenging questions would be contained in the Interteaching sessions, which I will describe below. This follows the flipped-classroom approach in which basic knowledge is obtained outside the classroom but evaluating, synthesizing, and applying the information to new situations occur inside the class where students can seek and receive guidance. Another change is that I allow them to keep their preparation guides as a reference during the Interteaching sessions. This gives them an incentive to answer the preparation guide questions more thoroughly, and to more clearly see connections between the readings and case study. As they are working on the case study, I go around the room to scan each student's preparation guide and quickly rank the quality, noting the reasons for the rating (more detail below). I can check about 40 students in 50 minutes. It also allows me to answer questions about the exercise as I travel around the room. While I did answer student questions before this change, students seem to be more likely to ask questions when I am checking their preparation guides.

The Interteaching starts with the pairing of students who will work together to answer questions based on Bloom's upper tiers of learning, i.e., application, analyze, evaluate, synthesis type questions. Notes and books were not used during the classroom session,
forcing the students to be prepared with the preparation guides. The Interteaching session questions were mostly, but not always, case studies. Cases are either disease states, which emphasize physiology, or everyday normal activities that illustrate how simple actions require complex planning and adjustments by the nervous and muscular systems. As students read through the case, they answer discussion questions that demonstrate their mastery by applying their knowledge from the reading to the case. The sessions usually last for thirty minutes to one hour, depending on the complexity of the case and the number of questions (usually 10-15 questions). Students do need more time as they work through a case, since answering the questions is not based on rote recall.

Grading is simplified with the use of rubrics. The emphasis of the score is placed on participation and effort, not on being 100% correct with the Interteaching answers. Learning comes from the teaching of and the collaboration with others. About one half of the grade comes from the preparation guide and the other from the classroom session.

Unlike some users of Interteaching, I grade the students’ preparation. Preparation guide questions are written and checked during the in-class session. The preparation guides are graded on the length of answers, content/depth of the answer, organization (i.e., legibility, useful as notes for studying, etc.), and originality (required to be in their own words and not copy/pasted from other sources). In grading preparation guides, I did not read them word-for-word, but scanned for key topic answers. Points were awarded based on class average (more points if a student wrote more in-depth answers than the rest of the class, fewer points for shorter answers or copied textbook sentences, no points for sentence phases that didn’t answer the question).

Interteaching sessions were graded mostly on participation. Interteaching answers were graded for correctness; however, points were based on the class average. (More points were given if the student scored above the class average, fewer if below the class average, and even fewer if far below the average - which rarely occurred for an honest effort.) Points were also earned by staying on topic during the session, being on time and not leaving early, peer evaluation from the feedback form, and giving thoughtful, relevant feedback. (See Figure 2 for the rubric.)

Figure 2. Grading rubric used to evaluate students’ preparation for the Interteaching sessions, participation in the Interteaching sessions (including attendance, staying on topic, and peer evaluation), and correctness of Interteaching answers. From left to right, the rubric is organized from higher to lower performance. Students were scored out of a total of 100 points.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Ratings</th>
<th>Pts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prep Guide - Completeness</td>
<td>90-100%</td>
<td>15 pts</td>
</tr>
<tr>
<td>Prep Guide - Content</td>
<td>In Depth, Fully Answered, Clear (Above Average)</td>
<td>15 pts</td>
</tr>
<tr>
<td>Prep Guide - Content</td>
<td>Adequate Answer Length, Fairly Detailed (Average)</td>
<td>10 pts</td>
</tr>
<tr>
<td>Prep Guide - Usefulness</td>
<td>Well Organized, Legible, Useful for Study (Above Average)</td>
<td>10 pts</td>
</tr>
<tr>
<td>Prep Guide - Original Answers</td>
<td>All answers are original</td>
<td>10 pts</td>
</tr>
<tr>
<td>Prep Guide - Original Answers</td>
<td>Evidence of copied from text or other sources</td>
<td>5 pts</td>
</tr>
<tr>
<td>Prep Guide - Original Answers</td>
<td>Mostly copied from text or other sources</td>
<td>0 pts</td>
</tr>
<tr>
<td>Class Session - IT Feedback Form</td>
<td>Fully Completed, Thoughtful, Useful Comments</td>
<td>10 pts</td>
</tr>
<tr>
<td>Class Session - IT Partner Rating</td>
<td>Rating 6-7</td>
<td>10 pts</td>
</tr>
<tr>
<td>Class Session - Focus</td>
<td>Stays on Topic, Attentive</td>
<td>10 pts</td>
</tr>
<tr>
<td>Class Session - Fully Attended</td>
<td>Attended Full Time</td>
<td>5 pts</td>
</tr>
<tr>
<td>Class Session - IT Exercise Answers</td>
<td>Above Class Average</td>
<td>15 pts</td>
</tr>
<tr>
<td></td>
<td>Class Average</td>
<td>10 pts</td>
</tr>
<tr>
<td></td>
<td>Below Class Average</td>
<td>5 pts</td>
</tr>
<tr>
<td></td>
<td>Significantly Below Average</td>
<td>0 pts</td>
</tr>
</tbody>
</table>

Total Points: 100
Interestingly, with the combination of Interteaching and lecture the overall average course exam scores dropped only slightly when compared with the Interteaching only semester scores. Comprehensive final exam scores fell more (about 7%), but were still higher than the traditional lecture only semester. Student feedback has been much more positive and in line with published reports. They see the connections between basic science topics and clinical presentation. Typical student comments include: "I like being able to see how the book ties in with real patients"; "The Interteach exercises helps me focus my studying on important points"; and "I like being able to talk with other students and work out the problems before taking exams".

Limitations
As you probably have noted, this approach requires planning and preparation. The first semester of implementing Interteaching was very time consuming for me. A better approach would be to evolve into Interteaching. An instructor can plan for three to four Interteaching sessions in a semester very easily as they continue with other teaching modalities. The following semester the instructor can add a few more. The case studies can be re-used every semester as long as they do not become public outside of the classroom. Just as with exams, the learning objectives of the exercises would be compromised if students were able to look up case study questions ahead of time.

Student resistance tends to be high when using the original Interteaching methodology with very little traditional lecture. Some salesmanship will be needed at the start and several times through the semester. Showing actual data of improved exam grades helps soothe anxieties, especially if you can show their grades compared to traditional lecture exam grades from previous semesters.

Keeping some traditional lecture or using other types of learning activities in your toolkit can minimize the end-of-the-semester fatigue mentioned by some researchers and observed by myself. It is always good to shake things up when students can predict your next move.

Conclusion
Since its inception, Interteaching has been empirically tested and shown to improve student engagement, and improve exam scores when compared to traditional lecture. The methodology has been successfully applied in a number of fields of study, including A&P, as described here. In its original form, Interteaching may be too challenging for typical A&P students who may need more guidance to help them through complex topics. However, when combined with flipped-classroom techniques (obtaining basic knowledge outside of the classroom and engaging in higher level learning exercises in the classroom) and case studies, the results seem to be more palatable for students, while deeper learning is still achieved as reported by student feedback and higher exam scores.

Literature Cited


Reproducing Useful Copies of Fragile, Natural Bones with a 3-D Scanner and Printer

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devans@pct.edu

And
Eric Albert, Computer Aided Design
Pennsylvania College of Technology
An Affiliate of the Pennsylvania State University

The Department of Natural Sciences at Penn College has an outstanding natural human bone collection. Many of the items have unusual structures and for the most part they have been in our hands for 40+ years. In the course of teaching the lab sections on the skeleton, unavoidable accidents happen and some of our more interesting bones are endangered. We thought we had a stark choice: go blundering on until all of the bones are dust or pointlessly warehouse them away from the students.

However, there are many applications of 3-D scanning and printing. For example, surgeons are creating, in advance of a procedure, 3-D copies of the body part upon which they will operate (Coughlan 2013). Plastic surgeons also use the technique in facial reconstruction (Anon 2013). Therefore, we hit upon a third alternative: copy the bones. Dr. Albert, an expert in computer-aided design, had the expertise, equipment, and material so the idea was put to him.

How does this work? Without going into elaborate details, we want to provide enough information so that HAPS members, should they decide to do so, can conduct the same exercise. The scanner is a NextEngine unit - the manufacturer can be found at www.nextengine.com and that site has abundant information on the scanning method (i.e., laser triangulation) and detailed specifications. The machine creates a “point cloud” that is in turn transformed into a standard object shape definition file, called an STL file.

The 3D printer is a Dimension SST1200es from Stratasys. It uses ABS plastic and is a Fused Deposition Modeler. Think of it as a hot melt glue gun that is computer numerically controlled. It lays down layer by layer in .010” thickness each slice of the model in the Z dimension (i.e., vertical), stacking them one by one to build the object. More information on the actual printer can be found here: http://www.stratasys.com/3d-printers/design-series/performance/dimension-1200es

The scan took two hours of machine processing time and about 30 minutes of human time for post-processing with the software (to clean up the scan). The Dimension machine took 11 hours 14 minutes to construct the model, and it consumed 3.88 cubic inches of model material and 3.32 cubic inches of support material (overhangs have to have a scaffold on which to build). It was built with a hollow interior to save material as well as approximate the feel of the bone. The support material is dissolved in a hot water bath with sodium hydroxide then the model is washed to remove this and dried. As both materials have the same price, $4.66/cu in, the total physical cost is $33.55, which is very inexpensive for an anatomical model!

It would have been possible to make a replica using another machine at Penn College, roughly costing a total of $12.00, but that equipment was unavailable this semester. Using that alternative would give a much smoother surface, but at a much higher density of material.

We chose our most fragile and most interesting of the ossa coxae in our collection as the photographs of the original clearly demonstrate—see Figs 1-4. There are several unusual features of that specimen and as these have been instructive to literally generations of students so we decided it was to be the first “guinea pig.”

Readers may consult Figs. 1-4, showing various views of the original and of the copy. The 3-D copy is not perfect; note the enlarged vacant area in the copy’s ilium. This effect arises because the laser of the scanner was not reflected while scanning the very thin area of the natural ilium. Other features, as in the very rough auricular surface of the natural bone, are less distinctive in the replica. On the other hand and clearly on the plus side, the copy is certainly not irreplaceable (we have kept the file for possible future use) and this specimen might well weather several more generations of students.

(Continued on next page)
Of course, HAPS members may choose one of the sources of plastic bone replicas for absolutely no equipment and material costs so that may be more the way to go for many in our predicament. The expertise and experience in running the two machines will also not be easy to come by. On the other hand, the materials required are quite reasonable so once someone has passed the start-up hurdles, events will proceed much less expensively. Therefore, it is up to the reader to decide if the uniqueness of a few specimens is worth the time and expense to make one’s own in-house 3-D bone replicas.

Anon. BBC News South west Wales: http://www.bbc.co.uk/news/uk-wales-south-west-wales-24926598


Acknowledgement: Thanks to Henriette Evans for the photographs.
Primal Pictures and the Human Anatomy & Physiology Society (HAPS) are proud to be working together to provide a scholarship fund to recognize and support an exceptional student in the academic year 2013-14. Through this collaboration, our goal is to promote excellence in anatomy and physiology, encourage innovation and celebrate learning.
EDU-Snippets: Solidly Basic Snippets

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

Roberta M. Meehan
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Phoenix, AZ
biology@ctos.com

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

For this issue, EDU-Snippets received some hands-on (or brains-on) ideas for working with some very basic foundational concepts—concepts that traverse much of anatomy and physiology. While each of the exercises presented here was initially designed for introductory college courses, all of these ideas can easily be modified or adapted for middle school, junior high, or high school classes. This is a good selling point for your college students with children in various other educational settings. Also, if you have students in advanced (or even graduate) classes, these projects can be modified or upgraded for them too! EDU-Snippets encourages you to take these ideas and run with them!

I. Cyclic Snippet

Deanne Bell and John Burns, Jr. (Fresno Pacific University, Deanne. bell@fresno.edu) start us off with a unique approach to some of the basics (representative events) of the cell cycle. Their chart should be quite clear.

TIME TO SPLIT
(Pool Noodle Mitosis with Reel Roller Centrosomes)

Applications:
Cell Cycle – Mitosis – Homologous Chromosomes – DNA Replication

Materials:
The items listed provide one set of long chromosomes and one set of short chromosomes.

Pool Noodle Chromosomes
4 - 8 pool noodles
Cut pool noodles to make representative sets of chromosomes.
Optional ideas: add sex chromosomes; use different colors and shapes of pool noodles to represent homologous chromosomes or to differentiate the replicated DNA; use colored duct tape to represent banding patterns or alleles as suggested by Jennifer Farrar & Kelsi Barnhart,


Centromeres
8 strips of ½” Velcro sticky back tape 20 - 30 cm long
8 d-rings 5/8” wide
Insert the Velcro tape through a d-ring and wrap around each individual pool noodle to represent a centromere with its kinetochore

Centrosomes
2 x reel rollers
50 meters of string
8 x 1/16” aluminum ferrules
8 x small swivel eyebolt snaps/ hooks
Each reel will represent the centrosomes. Cut a section of string 2-3 meters in length to be a spindle fiber for each sister chromatid. Divide the number of strings between each reel. Securely attach (tape or tie) one end of the strings onto the appropriate reel roller. Use the ferrules to attach the other end of the strings to swivel eyebolt snaps. So now you should have 2 reels, each having 4 long strings with eyebolts swivel hooks attached. The string spindle fibers connect to the d-ring kinetochores on the sister chromatids via the swivel hooks.

Cell membrane and nuclear envelope
2 colors of flagging ribbon

Supplies can be found at discount stores and/or hardware stores depending on the time of the year.

Safety Precaution:
Warn students to be careful with the reel & metal swivel hooks.

Demonstration:
Have student volunteers perform a “cell theater” to physically demonstrate mitosis with pool noodles as chromosomes. Students play out their roles as the instructor.

(Continued on next page)
discusses the process of the mitosis. Have someone record it so you can play it back to the class at a later date.

The cell starts in G1 phase with a large circle of flagging ribbon as a cell membrane, one student with the reel roller centrosome in the cytosol, flagging ribbon as a nuclear envelope, diploid number of chromosomes (one student needed per chromosome). For this discussion there are 2 long chromosomes and 2 short chromosomes. Thus four students in the nucleus each with one pool noodle.

To represent S-phase, another 5 students will be given matching centrosome and chromosome structures. Instruct them to stand directly behind the students with their corresponding structure. Attach sister chromatids together at the Velcro centromere to represent chromosome replication. The Velcro strips should connect and firmly hold the sister chromatids together.

Representing G2 phase, a student or teacher can check structures to see of they are ready to pass into mitotic phase.

During prophase the centrosomes (the students with reels) should begin walking away from each other to opposite poles of the cell. Point out homologous chromosomes – maybe have them stand near each other. Remove the flagging ribbon of the nuclear envelope.

During metaphase students holding the chromosomes should align themselves along the middle of the cell with each of the sister chromatids towards a different centrosome. During this time, have two volunteers unroll the spindle fiber strings from each reel roller centrosome and attach spindle fibers to the d-rings on appropriate sister chromatids via the swivel snap hooks.

To demonstrate the effect of Anaphase, the centrosome students wind in the reel rollers to pull apart the sister chromatids and reel the chromosomes towards opposite poles of the cell.

To represent telophase, remove the swivel hooks from the d-rings when the chromatids reach the centrosomes. Reinsert flagging ribbon around each set of chromosomes to represent the nuclear envelopes. Cut the cell membrane flagging ribbon and move ends to form two new cell membranes around the two daughter cells.

II. Osteo Snippet
Karen Groh (Good Samaritan College of Nursing and Health Science, karen.groh@email.gscollege.edu) has a great idea for helping students visualize what happens in the osteon, a concept many of our students have difficulty with. As you will see as you go through this Snippet, Karen’s idea will work easily and quickly (and with no expense!) and it can be easily modified (also with no expense!) for just about any osteo-contingency. Karen explains…

When we were talking in class about the structure and function of an osteon and how osteocytes in the lacunae are in contact with one another via gap junctions between cellular processes extending into the canaliculi, the students often seemed baffled until I had them model it. This is what I did.

I asked for four volunteers. One volunteer acted as a capillary and other three became osteocytes. For the capillary, I chose someone in a red shirt because capillaries are filled with red blood cells. I asked the student in the red shirt to stand in front of the class. I then informed the class that that student was the capillary running through the central canal of the osteon. Then I had a second student, osteocyte #1, stand a short distance away and put her hand on the capillary’s shoulder. I explained to the class that osteocyte #1 was in a lacuna, which was fairly close to the capillary, so she could reach out a process to the capillary to obtain nutrients and eliminate waste products. I then had osteocyte #2 stand a couple of feet away from osteocyte #1 and osteocyte #3 stand a few feet from osteocyte #2.

“But what about these two osteocytes?” I asked the class. “How are they going to get nutrients from the capillary and eliminate their waste products? They are too far away from the capillary.”

Then I had osteocytes #1 and #2 hold hands. “Look at this!” I said. “They’ve formed a gap junction in the canaliculus. Osteocyte #1 can pass substances back and forth from the capillary to osteocyte #2 via the gap junction right here,” I said, pointing to their linked hands. “Materials and gases can also pass through the extracellular fluid in the canaliculus.” Then I had osteocytes #2 and #3 link hands and I explained how nutrients and gases could pass from the capillary to osteocyte #1, to osteocyte #2, and finally to osteocyte #3. When I modeled the osteon this way, the students finally “got it!”

III. Skeletal Snippet
Meanwhile, Robert Crocker (Farmingdale State College, SUNY, rcrocker@nycc.edu) came up with a great way finish up the skeletal system. As he explains…

As a wind-up to the skeletal anatomy labs, I run the following contest:

At each lab table, I have a plastic box with an unarticulated skeleton in it. For a few extra credit points, whichever table correctly lays out the disarticulated skeleton on the lab table first wins.

Rules:
Use the articulated skull
Represent the vertebral column with 1 bone from each region
1 rib on each side
L/R appendicular bones must be on the correct side.

The students get no warning that this will happen. They have a ball! This semester I am going to play the “Final Jeopardy” music to increase sympathetic dominance!

(Continued on next page)
IV. Potential Snippet
Julia Schmitz (Piedmont College, schmitzjm@gmail.com) took a textbook idea and modified it in a way that should help everyone understand action potentials. Julia tells it this way:

The biology textbook by Raven et al describes an action potential as a stadium wave. Depolarization occurs when the individual is in the process of standing up. The peak of the action potential is reached when the individual raises his or her hands. Repolarization takes place when the individual sits down again.

I take this example one step further and have my students do a stadium wave in class. It takes a couple of tries to get them in the rhythm of doing a wave, but once they do, it makes a great example of how to show the action potential moving down the length of the axon. I also talk about how the wave can only go one way and this is just like the action potential. The students realize they have to wait for the person next to them to be at the peak before they can start. Also, they can’t pass the wave back to the person who just gave it to them because of the “undershoot” (too much potassium diffusing out).

Next, I talk to the students about myelinated axons and how in the myelinated fibers, the action potential occurs only at the Nodes of Ranvier. I then have every third student become a Node of Ranvier. I then have every third student become a Node of Ranvier. I then have every third student become a Node of Ranvier. I then have every third student become a Node of Ranvier. I then have every third student become a Node of Ranvier. I then have every third student become a Node of Ranvier. I then have every third student become a Node of Ranvier.

As these Nodes do the stadium wave, the students see how the action potential can travel faster because not everyone is being activated.

Reference:

V. “Pop” Physiology Snippets
The members of HAPS always come up with such interesting and unique ideas! This series of ideas from Andrew Petto (University of Wisconsin – Milwaukee, ajpetto@uwm.edu) is certainly no exception.

In our general-education and introductory courses in A&P, students often have difficulty visualizing dynamic processes that are fundamental to body function. Here are three examples that use Tootsie Pops® to make tangible the dynamics of counter-current systems, the electron transport system, and an interesting twist on the basic physiology of electron transport. Students who volunteer get to keep the pops.

A. Counter Current Snippet
a. Create two “pools” of fluids: one with a high concentration of solutes (pops) and one with a low concentration.
b. Before beginning, have the students count the number of “particles” in each pool.
c. Then set up the pathways for the solution to flow; be sure that the pathways are adjacent to each other for some of their course; make it clear where they converge and where they diverge. Stress that exchange can occur only when the two streams are adjacent.
d. Review the rules of simple diffusion: whenever an individual with ANY number of pop is next to an individual with FEWER pops, then the one with more pops has to be given one at a time to the one with fewer until they are equal (if the fluids are moving at the same pace, of course, then this is a 1-to-1 exchange between the same two individuals until the reach equilibrium). If there is an unequal number of pops between any two pairs, then the odd pop passes back and forth the way particles do in simple diffusion.

b. Before beginning, have the students count the number of “particles” in each pool.
c. Then set up the pathways for the solution to flow; be sure that the pathways are adjacent to each other for some of their course; make it clear where they converge and where they diverge. Stress that exchange can occur only when the two streams are adjacent.
d. Review the rules of simple diffusion: whenever an individual with ANY number of pop is next to an individual with FEWER pops, then the one with more pops has to be given one at a time to the one with fewer until they are equal (if the fluids are moving at the same pace, of course, then this is a 1-to-1 exchange between the same two individuals until the reach equilibrium). If there is an unequal number of pops between any two pairs, then the odd pop passes back and forth the way particles do in simple diffusion.

e. Count the number of pops in each “stream” and the number of people holding them. The ratio of the number of particles to the number of people is the “concentration”.

f. Then begin the “flow”. First do concurrent streams. Count the number of particles exchanged as the two streams converge and then diverge; and then record the resultant “concentrations” that occur after the exchange is complete.

g. Then “re-set” the pools (go back to the original “concentrations”) and run the countercurrent flow. Repeat the calculations.

Your students will be amazed (and probably never forget) at how many more particles get moved from the higher to the lower concentration fluid with the countercurrent.

Once you have done this, then you can challenge students to apply the concept by creating a similar demonstration for various systems in the body.

B. Electron Snippet
Another difficult concept for students is the way in which movement of an electron through the electronic transport system (ETS) can make energy available for regeneration of ATP. A simple demonstration using Tootsie Pops® to represent electrons sometimes helps for general-education and introductory students in A&P.

This works best in “theater” type classrooms, because the physical descent from the top of the room down to the podium is a nice metaphor for the decreasing energy level of the electron. You may have to make some adjustments to meet the geography of your classroom.

Students representing hydrogen pick up an “electron” pop and gather at the back of the room. Students on the rows represent enzymes in the ETS.
The first enzyme takes an electron associated with one of the “hydrogen” nuclei and passes it down the aisle on the side away from the aisle.

As the pop passes down the rows, the hydrogen ions follow. At intervals, a student in the second seat in from the aisle will stand up as the electron passes by. These represent the regeneration of a molecule of ATP.

When the pops arrive at the bottom of the stairs (or end of the aisle), the last enzyme in the chain passes off a pop to a student representing oxygen (who accepts 2).

Two hydrogens grab a hold of the pops bound to the oxygen, and the new HOH molecule leaves the stage so that a new oxygen can accept more electrons.

C. Cyanide Variation Snippet

In a twist on this activity, have another student (or the instructor) play the role of cyanide. The cyanide restrains the arms of the last students in the aisle, preventing them from handing off the pops to the waiting oxygen atoms.

Since these enzymes cannot release their pops, they also cannot accept any more pops from “upstream” and so the whole process of moving electrons down the chain stops. And that means that the students who would stand up as the electrons passed through their associated enzymes stay seated: there is no movement in the chain.

D. Future “Pop” Snippets

EDU-Snippets has heard that Andrew Petto has more “Pop” Snippets just waiting in the wings. Perhaps we’ll see some more in coming issues of the HAPS-Educator.

VI. And We Hope You Will…. Keep those cards and letters coming! Thank you all for your EDU-Snippet contributions. The influx of Snippets has been good! Please keep it up because more are always needed! Your ideas are tremendous! If you have thoughts or ideas, or any other interesting ways – any inspirations at all, great or small – to help our students understand anatomy and physiology, EDU-Snippets would love to hear from you! Once again, EDU-Snippets encourages new submitters to submit – and regulars to keep on contributing!

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!
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Click here to visit the HAAPS committees webpage.