Keep students learning in and out of the lab

Empower your students to complete their experiments both in and out of the laboratory. LabTutor 4 Teaching Suite provides remote access to experiments, so students can spend less time in the lab and more time understanding their science.

Increase student engagement and productivity
With over 100 interactive experiments, 500 exercises (including multimedia Medical Laboratories) and real data acquisition, LabTutor engages students as it guides them through experiment exercises, analysis and reporting.

Online prep, reporting and revision
LabTutor’s Online component lets students do pre-lab preparation, post-lab reporting and revision outside the lab with access to their own experiment data. Educators can simply login anywhere to check student progress and reports.

Simplified administration for educators
Centralized administration lets you import student lists, assign any combination of experiments to a specific list or course, and update experiments on lab computers with a single action.

Get your FREE information kit at labtutor.com/learning

Get free access to LabTutor Online with new LabTutor Teaching Systems. Check our website for details.

ADInstruments, Inc. www.ADInstruments.com T: +1 888-965-6040 E: info.na@adinstruments.com
CONTENTS

Articles

Muscle Injury and The Roll of Myosatellite Cells in Muscle Healing and Regeneration  
By Sarah Cooper and Melissa Volk ......................................................... 3

Lumbar Spinal Stenosis  
By Nolan T. Moyer PhD., ARNP-C .......................................................... 8

Introducing Art Into Anatomical Studies  
By Caryn Babaian .................................................................................. 12

Dry Erase and Round Robin Reviews: Hands-0n Formative Assessments  
By Thomas Lehman ................................................................................. 15

Congratualtions to First Timers  
By Thomas Lehman ................................................................................. 16

EDU-Snippets

Snippets  
By Roberta Meehan .............................................................................. 17

COVER ART: Original Drawing by Scott Rawlins. Scott Rawlins graduated from Earlham College with a degree in biology, and holds graduate degrees in museum education and medical & biological illustration from the George Washington University and the University of Michigan respectively. For many years Scott was a museum curator, working in this capacity at the Children’s Museum of Indianapolis, the Calvert Marine Museum and the Public Museum of Grand Rapids, MI. Since 1994 Scott has been a member of the art faculty at Arcadia University where he holds the position of Professor and teaches scientific illustration and design. He regularly exhibits his work nationally and has served on the boards of the American Society of Botanical Artists and the Guild of Natural Science Illustrators. He will assume the role of president the Guild in July. His illustrations have appeared in the Society of Vertebrate Zoology, the Bulletin of the Museum of Comparative Zoology, Invertebrate Biology and Acta Zoologica, among others. Scott is presently acting as a research assistant in the paleontology department at the Academy of Natural Sciences in Philadelphia.

If you know what the Cover Art depicts, email Sarah Cooper coopers@arcadia.edu or Jennelle Malcos. The name of the person to correctly identify the cover art will be announced in the next edition of the Educator.
Co-Editors and Committee Chairs
Sarah Cooper and Jennelle Malcos

Committee Members
Mary Lou Bareither
Pat Bowne
Janet Casagrand
Elaine Chapman
Jorge Cortese
David Evans
Richard Faircloth
Murray Jensen
Kebrét Kebede
Nancy Kincaid
Richelle Laipply
Eileen Lynd-Baltra
Pat Mansfield
Robert Meehan
Mary Orff
Hiranya Roychowdhury
Janet Sherman
Maria Squire
Kathy Starr
Anthony Weinhaus
Nina Zanetti

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

SUBMISSIONS TO HAPS-EDucator
Papers for publication, requests for information, submission of advertisements, and letters to the editor are welcomed. Articles should be submitted to the editor in a Word document as an e-mail attachment. If references are included, please follow the methods in Scientific Style and Format: The CSE Manual for Authors, Editors, and Publishers, 7th edition, 2006. Examples of reference formatting and additional information on formatting the text and figures are provided on the HAPS-EDucator page of The HAPS website (hapsweb.org). Although the HAPS-EDucator is not a peer-reviewed journal, the Editor and the Editorial Advisory Committee reserve the right to determine whether an article is suitable for publication and to make minor editorial changes to the content and style of submitted articles. It is the policy of the Human Anatomy and Physiology Society that any advertising appearing in its publication(s) must be related to the teaching of anatomy and physiology. The HAPS-EDucator Editor and HAPS-EDucator Editorial Advisory Panel jointly determine whether an advertisement meets the criteria of HAPS. Any advertisement that is deemed not to meet the needs of the organization will not be printed, and the advertisement plus any monies collected from the advertiser will be returned. The opinions reflected in advertising that appear in this publication do not necessarily represent the opinions of HAPS. Advertisement of a product in the HAPS-EDucator does not represent endorsement of that product by HAPS. Contact the Editor for information on advertising rates, advertisement size and the procedure for submitting an advertisement to HAPS-EDucator for publication.

DEADLINES FOR SUBMITTING MATERIAL TO HAPS-EDucator: The HAPS-EDucator welcomes submission of articles at any time, and will make every attempt to review and publish suitable material promptly. Deadlines for receipt of material to meet production are: August 1 (Fall issue); November 1 (Winter issue); February 1 (Spring issue); April 15 (Summer issue).

CONTACT THE HAPS-EDucator Editor:
hapsed@hapsweb.org
HAPS, PO Box 2945, LaGrange, GA 30241

The HAPS Educator is published electronically by The Human Anatomy and Physiology Society (HAPS). The written and visual contents of this magazine are protected by copyright. Temporary permission is granted for members of the Human Anatomy and Physiology Society to read it on-line, to print out single copies of it, and to use it unchanged for any non-commercial research and educational purpose, including making copies for classroom use provided the materials are not modified and appropriate acknowledgment is made of the source. All other uses of this material are conditional and require the consent of the editor and when applicable, the other copyright owners. Requests for permission should be directed to the editor via the contact information stated above.

2012 All rights reserved.
Muscle Injury and the Role of Myosatellite Cells in Muscle Healing and Regeneration

Sarah Cooper
Arcadia University
Glenside, PA
coopers@arcadia.edu

Melissa Volk*
BA in Biology
Arcadia University 2012
mvolk@arcadia.edu

Abstract: Following trauma and injury to muscle tissue, myosatellite cells, the primary stem cells in skeletal muscle tissue, are mobilized to facilitate muscle healing and regeneration. The future may hold promise for the use of satellite cells in the treatment of muscle injuries and muscle diseases such as muscular dystrophy.

It can happen without warning. You may be exercising with a little too much weight, running without your usual warm-up, doing exercises for which you lack proper training, or just straining to get a stuck window to go up on a lovely spring day when suddenly you are doubled over with the pain of a torn muscle, wishing you had been more mindful of your regular exercise routine and proper safety precautions.

Skeletal muscle is a composite of two primary materials, muscle fibers and connective tissue. Muscle fibers are responsible for the contractility of muscles and connective tissue provides the structural framework for the muscle and allows for the passage of blood vessels and nerves into and out of the muscle. There are three levels of protective connective tissue sheaths incorporated into each muscle: epimysium, perimysium and endomysium. The smallest, most basic structural unit is endomysium, which is quite delicate and often referred to as the basement membrane or basal lamina of the muscle fiber. Each individual muscle fiber incorporates specific protein complexes, integrins and a dystrophin-glycoprotein complex, that connect myofilaments to the extracellular matrix across the sarcolemma. Most of the integrins are located at the ends of muscle fibers where each fiber attaches to connective tissue at the myotendinous junction (MTJ) while molecules of the dystrophin-glycoprotein complex are evenly distributed along the length of the sarcolemma with somewhat increased concentrations in both the myotendinous junction and the neuromuscular junction. The contractile protein actin binds to the extracellular matrix through dystrophin (Järvinen 2005).

Muscle injuries are very common, accounting for over half of all sports injuries. They can be caused by contusions, lacerations or strains. A contusion is a direct blow or sudden compressive force that is applied to the muscle. Contusions are most often associated with contact sports such as football and soccer. In a strain, the muscle is subjected to force that exceeds the strength of the muscle fiber. This frequently results in a muscle tear at the myotendinous junction. Most strains are associated with activities requiring jumping and sprinting and are most likely to affect muscles that span two joints such as gastrocnemius, rectus femoris and semitendinosus. Lacerations, which occur when muscles are cut, are not common sports related muscle injuries and are usually associated with accidents (Järvinen 2005).

Muscle and bone both have the ability to repair themselves but they accomplish this repair by different means. Bone heals by deposition of new tissue that is identical to the tissue that existed prior to the injury. The scar tissue that forms when muscle heals is different from the original tissue. Regardless of the cause of the muscle injury, three phases have been identified in the repair of injured muscle tissue. The first phase, called the destruction phase, is characterized by the tearing of muscle fibers, death of the torn ends, formation of a hematoma between the torn ends of individual fibers and the inflammatory response. Scar tissue begins to form between the torn ends of muscle fibers within the first day. Fibrin and fibronectin begin to build an internal scaffold inside of the hematoma, which will serve as a place of attachment for invading fibroblasts. Fibroblasts produce fibers that form a connective tissue framework. Scar tissue is formed within the hematoma as collagen invades the connective tissue framework. The scar is initially the weakest part of the injured muscle but after about ten days as collagen continues to build up, the scar becomes sturdy enough to support some contractile stress (Järvinen 2005).

The second phase of muscle repair is known as the repair phase. This phase involves a population of specialized cells known as myosatellite cells, which constitute the primary stem cell population in skeletal muscle. Satellite cells, identified by electron microscopy in 1961, are a population of cells that are located outside of the sarcolemma of muscle fibers. They appear during the process of embryonic muscle formation when a discrete myoblast subpopulation fails to differentiate into new muscle fibers and survives as a...
Myoblasts

Muscle fibers develop through the fusion of mesodermal cells called myoblasts.

Myosatellite cell

Nuclei

Immature muscle fiber

Sarcoplasm

Myofibril

Sarcolemma

Mitochondria

Sarcoplasmic reticulum

Triad

Terminal cisterna

T tubules

Myofibrils

Thin filament

Thick filament

Note the relationships among myofibrils, sarcoplasmic reticulum, mitochondria, triads, and thick and thin filaments.

(Continued on next page)
distinct, mitotically quiescent, mononucleated cell type, which resides on the surface of maturing muscle fibers (Charge and Rudnicki 2004). Their name is derived from the fact that they are few in number, contain very little cytoplasm and are located outside of the muscle fiber itself. These mononucleated cells have been shown to be capable of cell division and they have the ability to form new muscle fibers independent of immune cells, such as leukocytes, that normally invade muscle tissue following injury (Hawke and Garry 2001, Järvinen 2005).

During the repair phase, monocytes, which are released from the torn ends of blood vessels, transform into macrophages that populate the injured area and remove cell debris by digestion with lysosomal enzymes and phagocytosis. This particular phagocytosis is very specific and targets only necrotic material, leaving the basal lamina cylinder of the injured muscle fiber intact. The cleaned and preserved basal lamina of injured muscle fibers serve as scaffold for the attachment of new muscle fibers which will be made by satellite cells. Interestingly, as macrophages are cleaning up the necrotic debris between the torn ends of muscle fibers, they appear to be simultaneously sending survival signals in the form of growth factors to the satellite cells, preserving them and activating them for their cell forming job. Among the growth factors expressed in injured muscle tissue are tumor necrosis factor, fibroblast growth factor, insulin-like growth factor, transforming growth factor, hepatocyte growth factor and several interleukins. Activated satellite cells proliferate in response to these growth factor signals and form myoblasts that fuse into multinucleated myotubes, which eventually mature into new muscle fibers (Järvinen 2005). The repaired ends of muscle fibers don’t usually unite across the injured area of the muscle. Instead they attach to the extracellular matrix of the connective tissue scar that forms between the torn ends of muscle fibers ends. Ultimately, each torn muscle fiber remains divided in half with the two halves connected to each other by scar tissue. The third phase of muscle repair is the remodeling phase. During this phase regenerated muscle fibers mature, the scar tissue contracts and reorganizes and the functional capacity of the muscle is restored (Järvinen 2005, Morgan 2003).

Today, most muscle injuries are diagnosed with the use of MRI screening since an MRI can give a more detailed view of the lesion than the older imaging method, which was ultrasound. A torn muscle can vary in severity through three degrees of muscle fiber involvement from a partial tear to a complete tear; all of which are painful. A first-degree tear is often called a muscle strain or a pulled muscle and it generally involves only about 5% of the affected muscle and is accompanied by mild pain. Typically the range of motion of the muscle is not disrupted and the over all strength of the muscle is not diminished. A second-degree tear is more painful and attempting to contract the muscle results in an increase in the pain. A defect such as an indentation or a bump may be felt underneath the skin at the site of greatest pain. In a second-degree tear, muscle fibers have been torn but the tear does not go all the way through the thickness of the muscle. A third-degree tear is the most painful and serious type of tear. In a third-degree muscle tear or rupture, the muscle is torn all the way across its width and it is impossible to contract it. The torn end of the muscle, which may be in the area of its attachment to the tendon, may form a large, painful bulge that can be seen underneath the skin. This type of tear is accompanied by internal bleeding into the soft tissue of the muscle and may require surgical intervention to facilitate proper healing (Järvinen 2005, Järvinen 2007). However, surgery is not required for most muscle injuries and the vast majority will heal with conservative treatment. Surgery is generally considered only in rare cases where there is a third degree tear accompanied by a large intramuscular hematoma or a second-degree tear if the tear passes through more than half of the belly of the muscle. When surgery is performed, it is usually done in the first three weeks after the injury to facilitate the healing process (Järvinen 2007).

The clinical outcome of a muscle injury is likely to depend on the severity of the injury and the extent of the hematoma that forms at the site of the injury. When blood vessels are torn either an intramuscular or an intermuscular hematoma may form. If the hematoma is intramuscular and confined within the epimysium, increasing pressure inside of the muscle results in less bleeding and the maximum size of the hematoma will be reduced. If the hematoma is intermuscular and blood is free to penetrate the spaces between muscles, the hematoma will be larger and blood loss will be greater (Järvinen 2007).

Muscles that are poorly conditioned or fatigued are prone to lactic acid build up which can decrease both muscle coordination and muscle strength. Fatigued, poorly conditioned muscles are more likely to tear but any muscle can tear if it is overstressed or the demands put upon it exceed the overall strength of the muscle tissue. Immediate treatment of muscle injuries follows the “RICE” principle that dictates rest, ice, compression and elevation for the injury. The goal of this treatment is to minimize bleeding into the site of the injury. Continuing to exercise or move the muscle immediately after the injury will increase bleeding into the muscle tissue and may increase the amount of damage. Activity should be stopped as soon as the injury occurs and treatment should begin immediately. Ice should be applied to the injured area as soon as possible and maintained for 20 minutes at 30 to 60 minute intervals, to slow the amount of blood flow to the muscle tissue. Applying either heat or massage to the muscle immediately after injury will increase blood flow to the damaged muscle and may cause additional trauma to the already damaged tissues. The body’s initial healing mechanisms can easily be disrupted during the first 72

(Continued on next page)
hours by muscle contraction, further impact or attempts at weight bearing so if the injury does not require surgery and is to be allowed to heal on its own, it is desirable to wrap the affected area in an Ace bandage for protection and support. Ice may be alternated with heat after the first three days (Järvinen 2007).

Since muscle tears are fairly common occurrences especially among athletes, it is good to know that the body is capable of healing and regenerating muscle tissue. Muscle healing and regeneration have been acknowledged and well documented since the mid 20th century. Current research has now focused on satellite cell transplantation into the host muscle of experimental animals to determine if satellite cells will dependably differentiate into new muscle fibers that may contribute to an increase in overall muscle quality (Reuveni 2011). Even small populations of cells seem to be capable of taking hold after being grafted into damaged muscle (Sacco 2008), and in the future, transplanting satellite cells may prove to be a viable method of increasing the regenerative potential of damaged or diseased muscle. In reality, however, the use of satellite cells for transplantation into damaged or diseased muscle has several constraints having do with the ability to cultivate them in adequate numbers and to extend their survival rate after injection into damaged muscle tissue (Bentzinger 2010). Even though the current research provides evidence of successful engraftment of satellite cells, the number of regenerating cells remains well below the level required to have a positive effect on diseases such as muscular dystrophy. To have an impact on a diseased cell population, the diseased muscle cells have to be replenished with a healthy set of cells, and transplanted satellite cells must ultimately be grafted into the satellite cell niche, outside of the sarcolemma, where they need to be in order to self-renew and produce healthy new muscle fibers on a continual basis (Otto, 2009). In the long run, repair of damaged muscle through transplantation of satellite cells into host muscle cells depends primarily on the transplanted cell’s ability to self renew when undergoing activation, reproduction and differentiation (Kuang and Rudnicki 2007). Since the extent to which muscle satellite cells are able to regenerate damaged muscle after an injury remains undetermined, future investigations will no doubt branch out to include alternative stem cells types. The ultimate goal will be to help individuals regain muscle function when muscles have been severely injured or rendered useless as a result of disease processes.

(Continued on next page)
Melissa Volk graduated from Arcadia University in May of 2012 with a major in Biology. Excerpts from her Senior Thesis “The Role of Satellite Cells and the Expression of Transcription Factors For Skeletal Muscle Regeneration Following Injury” appear in this article.

Literature Cited


Photo Credit

Illustrations are used with permission.

LUMBAR SPINAL STENOSIS

NOLAN T. MOYER Ph.D., ARNP-C*

Abstract: Spinal stenosis is the narrowing of a section of the spine. It is one of the most common age-related conditions, affecting men in greater numbers than women. This article analyzes the symptoms, diagnosis and treatment options for stenosis of the lumbar region of the spinal canal.

Spinal stenosis is a condition in which one or more areas of the spinal canal become narrowed. This condition puts undue pressure on the spinal cord or the spinal nerves in the area where the narrowing has occurred. Although the symptoms of spinal stenosis vary according to the specific area of the spine that has been affected, they generally include numbness or pain in the back, shoulders, neck, arms or legs. Spinal stenosis is the most common reason that individuals age 65 and over have spinal surgery. Men are affected almost twice as frequently as women (Katz and Harris 2008, Yuan and Albert 2009, Haig and Tomkins 2010). The narrowing may be congenital, acquired or a combination of both. True congenital causes are few and include short pedicles and facets, lamina that are thickened and/or exaggeration of the scoliotic/lordotic curves (Alvarez and Hardy 1998).

To better understand what lumbar spinal stenosis is and how it actually affects individuals, it is important to know the anatomical features that are directly involved in this condition. The vertebral laminae are connected to one another by a tough, flexible ligament known as the ligamentum flavum (the yellow ligament). The openings that are formed on the sides of the spinal canal between two vertebrae are called the intervertebral foramina (clinically identified as part of the lateral recess). It is through these openings that the nerve roots exit. The areas where the inferior and superior processes of the vertebrae meet are called the zygopophyseal joints. These joints are covered by facet capsules and allow the spine to move. The intervertebral discs between individual vertebrae are comprised of a central gelatinous nucleus pulposus that is located within a fibrous outer ring called the annulus fibrosis. Above and below the discs are thin cartilaginous structures called endplates. The endplates help keep the discs from herniating and are responsible for shaping the discs. The discs are reinforced by the anterior and posterior longitudinal ligaments (Strayer 2005).

The most common cause of lumbar spinal stenosis is degeneration of tissues and results in changes to the discs, facet joints and ligaments around the spinal canal. Some of the conditions that contribute to spinal stenosis include hyperthyroidism, Paget’s disease, Cushings disease and acromegaly. Structural changes that may act as contributing factors include herniations/bulges of the discs, ligamentum flavum hypertrophy, bone spur (osteophyte) formation, disc space narrowing and hypertrophy of the cartilage of the articulations around the spinal canal (Alvarez and Hardy 1998). As the human body ages, the discs begin to degenerate and dehydrate causing a decrease in disc height. This leads to increased pressure on the disc by the vertebrae and the disc begins to bulge into the spinal canal. Disc degeneration also places increased pressure on the facet joints. This, in turn, leads to the development of osteoarthritis and hypertrophy of the facet joints. Hypertropy can result in bone spur development and joint capsule thickening, increasing the chance of bone spurs protruding into the spinal canal and/or the intervertebral foramen further narrowing these spaces (Katz and Harris 2008).

The lumbar region is the most common area for stenosis and the symptoms usually appear slowly. Back pain is the first symptom and is generally non-specific. The back pain may first be noticed when a person is walking or standing, and it may get better when the individual is sitting or lying down. Later symptoms such as leg pain, fatigue, numbness and weakness occur in a progressive manner, possibly months or years after the start of back pain. Approximately 90% of individuals with spinal stenosis have leg pain (Fritz et al., 1998). When numbness and tingling occur in the affected area, it is known as neurogenic intermittent claudication syndrome. The claudication is believed to be caused by compression of the microvasculature of the lumbar nerve roots resulting in transient ischemia when the oxygen demand increases during ambulation (Alvarez and Hardy 1998, Strayer 2005).

The classic picture of spinal stenosis is seen when the affected individual walks short distances with a stooped over posture and reports feeling the numbness and tingling characteristic of neurogenic claudication. Neurogenic claudication is a common complaint among the senior population with lumbar stenosis. Patients may present with complaints of heaviness in their legs, pain in the lower legs/buttocks and thighs that increases when they are active and eases when they...

(Continued on next page)
lie or sit down. Upon ambulation, they may report a burning sensation, numbness/tingling, cramps and/or fatigue in their legs. The pain and/or numbness can run along one or more nerve roots in various dermatomes with the symptoms radiating distally in the posterior lateral region (Yuan and Albert, 2009). This is referred to as radiculopathy. As an example, if the L4-5 nerve root is involved, the patient may feel a burning sensation that runs from the buttock along the lateral thigh and leg into the top of the foot and great toe. If the pain is in the L5 or S1 nerve roots, it would be termed “sciatica” and may be described as a shooting or stabbing sensation. Sneezing, coughing and/or straining will very often make the symptoms worse. The symptoms may be unilateral or bilateral, depending on the location of the stenosis (Best 2002). In severe instances, if the sacral nerve roots are impinged, there may be urinary and/or bowel incontinence which is a medical emergency (Alvarez and Hardy 1998).

Patients with lumbar spinal stenosis tolerate bicycle riding because it opens and widens the canal in a flexed position. Similarly, individuals may find that squatting and bending forward, pushing a shopping cart and walking up hills eases the pain of neurogenic claudication. Positions that extend the spine, such as lying prone, can make the symptoms worse by folding in the ligamentum flavum and further narrowing the canal (Alvarez and Hardy 1998).

Making a diagnosis of lumbar stenosis in a timely manner may be difficult because of the slow progression and the early complaints of non-specific back pain. This causes many individuals to attribute their symptoms to the aging process and, as a result, they wait to see their healthcare provider until the symptoms are severe. Occasionally, a minor trauma will occur that makes the symptoms worse. This may result in an earlier visit to the healthcare provider and an earlier diagnosis. Those individuals who present in a timely manner do so second only to upper respiratory conditions (Deyo and Weinstein 2001). A decrease in quality of life has been shown to be a stimulus to seek medical attention (Yuan and Albert 2009).

Not only can it be difficult to make a timely diagnosis, it can also be difficult to make the diagnosis itself. The clinical signs of lumbar spinal stenosis are heterogeneous and neurogenic claudication may not be present when the patient is seen. This means that the healthcare provider must rule out several diagnoses (Goh et al., 2004).

One of the important diagnoses that must be ruled out when assessing patients with low back pain is cauda equina syndrome (CES). The cauda equina (“horse’s tail”) is a bundle of lumbar and sacral nerve roots that exit the spinal cord. These nerves are more resistant to injury than the spinal cord. They innervate the bowel, bladder, lower extremities and sexual organs. CES is an emergent condition that needs to be referred to a neurosurgeon. Signs of this syndrome include bowel/bladder dysfunction and numbness from the genital region through the perineum and into the buttocks (i.e., saddle anesthesia) (Strayer 2005, Ebell 2009).

To best diagnose spinal stenosis, the healthcare provider must take into consideration the physical findings, symptoms and the results of the imaging studies. There are three techniques commonly used to assess back pathologies: x-rays, CT scans and MRI scans. Unfortunately, these are often performed with the patient in a supine position. The supine position is usually not the ideal position to effectively evaluate the spine when using plain films (x-rays) because the symptoms are usually present when the patient is in an upright position. Doing spinal imaging in the upright position allows for the visualization of segmental instability, compression of the cord and/or nerve roots by structures such as the ligamentum flavum, facet joints, bone spurs, cysts, disc pathology, fat material in the posterior epidural space and venous congestion; all conditions which can lead to stenosis (Haig and Tomkins 2010).

X-rays are the most commonly used imaging techniques today. When spinal stenosis is a possibility, x-rays are only used for screening purposes and are not suitable for diagnosis of the condition. Whenever possible, x-rays should be performed with the patient both standing and lying down and the series should include flexion/extension, lateral and anterior/posterior views. Facet arthritis, loss of vertebral disc height, degenerative changes and other pathologies of the spine can be visualized with x-rays.

The CT scan is the most cost effective diagnostic study. It shows bony structures, the shape/size of the spinal canal and compression that can occur from bone spurs. When this scan is performed using contrast dye, the nerve roots and subarachnoid space can be better visualized. The MRI scan is the preferred imaging study for the diagnosis of spinal stenosis. All structures can be seen in multiple planes and the studies can be done with or without contrast dye. An MRI shows soft tissue, vertebral discs, the spinal cord, ligaments, cauda equina, the subarachnoid space and epidural fat with detail. In patients with neurogenic claudication, this type of imaging is more effective due to its ability to exclude other serious conditions such as conus medullaris/cauda equina tumors and infectious disease. There are two types of MRI images, T1 and T2. The T1 image is a weighted para-sagittal view. It is used to evaluate neuroforaminal stenosis. The T2 view is weighted and shows sagittal and axial views that are helpful for evaluating central and lateral recess stenosis (Alvarez and Hardy 1998, Best 2002, Yuan and Albert 2009). Sensitivity and specificity of both the MRI and CT scans are high for lumbar stenosis. Two other useful tests used to distinguish between

(Continued on next page)
Peripheral neuropathy and lumbar spinal stenosis are the electromyography (EMG) and nerve conduction velocity (NCV) tests. Nerve roots are usually involved with lumbar spinal stenosis and lower extremity EMG results are very often abnormal bilaterally and at more than one segment. These tests, however, are not very specific for a routine diagnosis (Fritz et al., 1998).

Treatment modalities for spinal stenosis are numerous and depend in the severity of the stenosis, how long the symptoms have been present, the type of stenosis, any related deformity or instability, coexisting medical conditions or amount of disc degeneration. Treatments and plan of care should be based on the current situation, not what is expected in the future. The usual plan of care begins with conservative treatment prior to obtaining imaging studies. It can include the use of non-steroidal anti-inflammatory medication, muscle relaxants, steroid dose packs, physical therapy, stretching, strengthening exercises, aquatic therapy, treadmill walking (with the use of a harness to take the load off the spine) and the use of a stationary bike. Patients may be instructed to wear a lumbar support (to promote lumbar flexion) for short periods of time to prevent the paraspinal muscles from reconditioning (Yuan and Albert 2009).

Once imaging studies have been completed and the results reviewed, the patient may be referred to pain management or an orthopedic/neurosurgeon depending on the findings and patient symptoms. In pain management, patients may receive a course of three epidural steroid injections over a period of several weeks and/or facet blocks. These injections have analgesic and local anti-inflammatory properties, which help to reduce radicular pain caused by neurogenic claudication. They also provide short-term relief for mild to moderate stenosis when other treatments have failed. They are, however, contraindicated in patients with centrally herniated discs or central stenosis (Best 2002).

Surgical intervention is considered when conservative therapy, over a period of six to twelve months, has not helped. Conditions that may be alleviated by surgery include sleep disturbance due to leg cramps, the inability to perform normal activities of daily living (ADL), inability to sit for more than 30 minutes or walk more than 50 yards, motor weakness and bowel/bladder problems (Best 2002). The goal of any type of treatment is to provide relief from pain and neurological symptoms, as well as to allow patients to resume their normal ADL's. These goals can be achieved with early identification and appropriate treatment modalities.

*Dr. Moyer received his RN in 1985, MS in 1994 and his Ph.D. in 2004. He has been a nationally board certified Nurse Practitioner for 18 years and currently practices in the Tampa Bay region of Florida. He has taught Anatomy and Physiology since 1990, whenever he can fit it into his schedule.

**Literature Cited**


**Photo Credit**

Illustrations are used with permission.

Introducing Art into Anatomical Studies

Caryn S. Babaian
Bucks County Community College
Newtown, PA
babaianc@bucks.edu

This article is based on a case study that was designed and implemented to enhance the work of Dr. Ara Chalian, a head and neck surgeon at the University of Pennsylvania. I wanted to document my observations of his interaction with medical students and, with his cooperation, introduce the application of art to the professional training of medical residents. My intention was to explore the benefits that may be associated with introducing art into an anatomical studies curriculum. I believe that the introduction of art into the anatomy laboratory or classroom allows students to develop a greater appreciation for the intricacy of dissection procedures and provides a mechanism by which students can explore anatomy at a level very different from that of a textbook or a computer screen. The blending of art and anatomical study creates a dynamic union that represents the convergence of cognitive and motor skills that complement each other on many levels. This exercise helped me to better understand the interplay between hands, dissection instruments, vision and tactile experience; all of which must come together in order to produce a successful dissection or observational experience.

In preparation for working with Dr. Chalian’s students I observed many of his surgeries, watched related procedures on youtube videos, read extensively in anatomy textbooks and observed illustrations of appropriate dissection techniques. As preparation for introducing art into the classroom, I recommend that instructors learn a few basic drawing techniques so they can demonstrate these techniques to students. Once students get into the habit of drawing, the laboratory or classroom takes on a workshop-like atmosphere that opens up the class for dialogue, demonstrations and enhanced learning experiences. Students can use their finished art to study from or to create a comprehensive anatomy notebook or perhaps to create an anatomy coloring book.

Use of the Chalkboard

After consultation with Dr. Chalian, I chose to illustrate a thyroidectomy to demonstrate the effective use of the chalkboard in anatomical studies. The accompanying illustration highlights the hand techniques and positions necessary for the proper exposure of the thyroid. The background of the illustration depicts the follicular cells of the thyroid and flanking the piece is the gross anatomy required for complete understanding of the surgery. Drawings of this nature do not need to be artistically excellent in order to engage the student in a comprehensive discovery process; one that integrates the whole with the sum of its parts while facilitating the integration of micro and macro anatomy in the student’s mind.

(Continued on next page)
Use of Anatomical Models

Anatomical models are frequently used for demonstration purposes in anatomy labs. They show the position of organs in systems and students are able to observe multidimensional views of organs and rotate organs in space. However, in and of themselves, models may do little to foster student retention or appreciation for the way organs fit into each other and complement and support each other. Asking students to draw from anatomical models can broaden and intensify the learning experience.

Encouraging students to draw from anatomical models can be a very effective way to simulate a cadaver dissection. While drawing from a model students are able to work in human organ dimensions rather than those of cats or fetal pigs. Drawing from models encourages students to more fully explore special relations and the symmetry and asymmetry inherent in the design of human organisms. Drawing from models also allows students to more fully internalize complex shapes and anatomical relationships.

Advantages of Integrating Art in the Classroom

Many of the images we see of living things today have a slick, smoothed off appearance which is the result of the incorporation of computer technology into virtually every aspect of our educational space. Computer graphics are excellent for animation and enhanced spatial views but they often fail to capture the organic nature of structures. In reality, hearts, livers and bones are very irregular with highly textured surfaces and subtle gradations of hue. They possess infinitely diverse surface markings and patterns. No two organs or structures are ever exactly alike. Drawing form dissections or models may help students appreciate the extremely varied textures and appearances of tissues in a way that is simply not possible with computer graphics.

Drawing in the laboratory and classroom encourages story telling as a learning behavior. Mixing and mingling the micro-perspective of histology with the macro-perspective of gross dissection fosters a dynamic flow of visual and verbal information that coaxes students into thinking about the tissue, organ or procedure in a different way. Students like to talk about the art they have created and with a little encouragement they easily slip into story telling mode. Drawing and story telling help students expand upon their academic abilities and view their subject matter in a more intimate manner.

Through the medium of drawing, students can be encouraged to produce illustrations in comic book format which literally “frames” each action in a dissection or each sequence in a complex physiological process, separating these things into their component parts and ultimately enhancing the student’s learning and retention capabilities. Framing information in this way may make it easier for students to study outside of class by visually organizing the material and triggering memories of the actual experience, which may lead to better comprehension of the activity.

Conclusion

Modeling and drawing in three dimensions is very different from passive viewing. The information students choose to include or exclude from their drawings impacts the way they interpret images and can be useful

(Continued on next page)
to the instructor in attempting to access student comprehension. From an educational perspective and an artistic one, art in the classroom may have the power to transcend potentially confusing technical terminology and raise the overall level of student interest in a way that relatively dry textbook accounts cannot. I encourage you to try it!

Images

Image 1: Vitruvian man created on a chalkboard for an introductory anatomy class. This image won 2nd place in the NSF/Science Visualization Challenge 2006

Image 2: Histology image of thyroid gland showing follicular and parafollicular cells, crayon on paper 2010

Image 3: Chalkboard illustration of Dr. Chalian’s thyroidectomy procedure, 2009

Image 4: Graphite on paper from an anatomical model, 2009

Image 5: Pen and ink on paper from an anatomical model, after DaVinci, 2010

Image 6: Comic book illustration for the comicbook “Dr. C’s Thyroidectomy,” 2011


Acknowledgements:

I would like to thank Dr. Chalian for collaboration and observation of his surgeries.
At the 2012 Annual HAPS Conference in Tulsa, Oklahoma, I presented a workshop on two formative assessment strategies that our department uses to improve student performance within the lecture and lab setting. As open lab hours are limited at Coconino Community College (CCC), we have strived to optimize student learning and retention while in lecture/lab.

**Dry Erase Mats** are small boards on which students can write using dry erase markers. We purchased “Thrifty White Panel-board” at Home Depot (for about $13 for a 4’ x 8’ sheet) and cut it into 12” x 12” pieces. At the end of most lecture/lab sessions, I set out mats, markers, and hand towels; one per student. When each student has obtained their materials, I pose a question to the class. They know not to blurt out the answer, but instead quickly scribble down an answer and holding it up for me to see. I can quickly say “yep”, “nope”, or “spelling” as a response to their answers. The students are free to look through their books or even onto their lab partner’s mats if they get stuck. The purpose of this exercise is to improve their confidence in answering a question without penalty. It also does wonders for practicing spelling. It is fun to see how competitive some of the students can get in this exercise. I will present a dozen or so questions (based upon the material being reviewed and time available) and most students participate enthusiastically. Even unprepared or nervous students learn by copying someone else’s answer and “playing along” (they are still learning through spelling practice and term retention). The activity is a great way for the instructor to quickly see what concepts have stuck and which need to be reviewed (I can quickly see if most students miss a question or misspell a word and review it immediately while it is still fresh in everyone’s mind).

The dry erase mat exercise provides flexibility in the depth of review. Tasks can be superficial (e.g., “Name the lateral forearm bone”) or more in-depth (e.g., “Name all of the flexors that attach to the humerus”). I can ask them to draw and label a structure. We have even cut 24” x 36” mats that groups work on together (e.g., to draw the alimentary canal and list the secretions from each organ).

**Round Robin Review** is a quick way to review a lot of different materials in a fairly brief amount of time. I find it works best in preparation for lab practicals, but have also used it to review for lecture exams. Six stations are set up, each with two review questions and a model, diagram, microscope, or whatever material pertains to the questions. Student groups segregate to each station and are permitted to bring their books and notes. Each group has five minutes to complete the station. After the five minutes, groups rotate to the next station and repeat until all stations have been completed. A typical station may contain a microscope with slide, plastic anatomy model, or dissection specimen, accompanied by questions pertaining to identification, function or relationships of certain structures. There are dry erase mats at each station, allowing the students to practice drawing or listing structures. Groups often complete the review questions early and use the remaining time to quiz each other on different aspects of the station material.

A typical round robin review takes approximately forty minutes (including set-up and clean-up). It is a fast-paced activity that helps students to quickly see which concepts have stuck and which will need reinforcement. When time permits, students can go back to the stations that they feel are most important to review. I have seen group interaction and cohesion improve considerably after implementing this activity. Students bond together, learn how to express concepts correctly to each other, and reinforce correct answers and spelling with their classmates.

The Science Department at CCC has experienced an improvement in concept retention, terminology comprehension, and student confidence since developing and implementing these assessment strategies into the classes. Both strategies demonstrate tremendous flexibility, playing to the particular strengths and focuses of each instructor. They can be used to review past material or reinforce material covered that very day in class. Appreciations go to Bryan Bates, Troy Cayou, Doug Friedman, Ana Novak, and Brad Sarchet for their assistance in the development of these assessment strategies.
Tulsa HAPS
Scavenger Hunt Winners!

During the annual HAPS conference, the Steering Committee likes to make a direct connection with First-Time participants. The Steering Committee (made up of the Chairs of the various committees in HAPS) hosts a Scavenger Hunt where first-timers must track down each committee chair and gain their signature. Along the way, first timers learn about the different committees and how they can become involved. The scavenger hunt is an incredible activity that spans the first two days of the conference, helping first-timers meet many new HAPSters and learn more about the Society and what they can gain from it.

This is the seventh year of the Scavenger Hunt and we have had tremendous feedback about the activity. It’s a blast to see First-Timers from previous years help newcomers to find Chairs and integrate them into the great big family of HAPS. AD Instruments has been very generous in offering prizes each year for First-Time participants (if you look closely next time, you’ll invariably see some HAPSters wearing caps from previous years). Of all of the participants who complete their Scavenger Hunt cards, one lucky winner receives free conference registration to the next year’s conference.

Congratulations to all of the First-Timers who successfully completed the Scavenger Hunt at the 2012 HAPS conference in Tulsa! You demonstrated the enthusiasm and dedication that we like to see in our profession. We look forward to seeing each of you at Las Vegas in 2013!

Bradley Barger
Celina Bellanceau
Manju Bhat
Mahmoud Bishr
Eileen Bush
Janet Casagrand
Beth Cliffel
Julie Collins
Dia-Eldin Elnaiem

Lori Elwell
Anthony Frisicia
Gabriela Galey
Kay Gamble
Lynn Gargan
Tejendra Gill
Roishene Johnson
Kirsten Kapp
Laylonda Maines

Corine McCarthy
John McCastlain
Lindsay McWilliams
James Montante
Patrice Parsons
Karen Pasko
Christine Rigsby
Courtney Ross
Kyla Ross

Jeff Schinske
Zoe Soon
Heather Stottman
Patti Valella
Srikanteswara
Viswanath
Christina Wahl
Jamie Weiss

A special congratulation to Christina Rigsby (Macon State College in Macon, GA), who won a free conference registration to next year’s HAPS conference in Las Vegas, Nevada. Well done!
I. Try Folding a Protein

We have all commiserated with the frustrations that some of our students experience when trying to visualize the basics of protein structure. Nina Zanetti (Siena College, zanetti@siena.edu) came up with a way for students to “walk through” protein structure – including the intricacies of hydrophilic and hydrophobic interactions.

When I teach the importance of protein structure, I have students act out how hydrophobic interactions can affect protein folding. I begin by asking the students to stand up. I tell them that they each represent one amino acid in the protein. Then I have them join hands (lots of joking helps them get past the awkwardness of doing this!) to illustrate the peptide bonds that will link them together to form a polypeptide.

When they have formed a long “chain” of amino acids, I remind them that this is the protein’s primary structure, and the protein cannot yet be functional. While the students continue to remain in this “chain”, I arbitrarily assign those students wearing a particular color shirt (e.g. blue) to represent amino acids with a hydrophobic (nonpolar) side chain, while all the other students will represent amino acids with hydrophilic (polar or charged) side chains.

After explaining this, and reminding students about hydrophobic/hydrophilic interactions, I announce that the polypeptide that they have just formed is in an aqueous environment. I ask them to arrange themselves in such a way that without breaking the “peptide bonds”, they can make the “hydrophobic” amino acids (blue-shirted students) as “happy” as possible. Following the reasoning that hydrophobic molecules are repelled by water, the students jostle around and form an irregular “huddle” in which their blue-shirted classmates are away from the “watery” edge, but are still connected (by held hands) to the chain of “amino acids”.

At that point we stop and have a discussion on where everyone is – both as hydrophobic or hydrophilic amino acids and as parts of a folded protein. We also talk about why the protein is now functional.

II. Find Skin in 40 Simple Steps

Meanwhile, Lakshmi Atchison (Chestnut Hill College, latchiso@chc.edu) (in collaboration with Michael Atchison, University of Pennsylvania) presented us with a way to solve an age-old question. How many layers of skin are there? This is a good exercise for discovering all the integumentary layers – without denigrating what a previous instructor – or textbook – has told your students. For once, let us think INSIDE the box!

When students are questioned about the number of skin layers present in the human body, they usually respond that there are two, or at the maximum three layers. The correct answer is that humans have forty layers! The human body
is protected with 40 skin layers collectively called the integumentary system. This system is a very complex organization of multiple skin layers containing proteins, skin pigments, nerve receptors, blood vessels, hair follicles, subcutaneous fat, and other derivatives that protect our bodies. Buried among the outer skin layers are keratins, which are insoluble proteins that protect our body. Keratin is also a key structural component of hair and nails. Other proteins in the skin give skin its elasticity, tonal quality and durability, and other proteins provide immune functions.

In addition to proteins, buried among the skin layers are special pigments that generate shades of skin color. Our skin also contains numerous skin pores through which many watery and oily chemical substances are secreted that keep our skin soft and pliable, thereby protecting the body from invading bacteria and microbes. Scattered among the skin layers are various skin receptors that give a variety of sensations. Using the simple hands-on model provided here, students are able to quickly grasp the complex structure of skin and its multiple layers.

The model makes use of any square or rectangular plastic box as an educational tool. Using this box, one can “think inside the box” to create a skin model by arranging stacks of precut papers corresponding to the number of different skin layers or strata. Various types of cells that appear on these layers can be drawn on the top of most layers to represent those specific strata. In addition, the distribution of various pigments can be shown by placing very fine colored dots on the layers where the skin pigments are located. Tiny hairs that pierce through the superficial sweat pores can be shown by minute camel hairs peeking from the tiny pores of the surface layer. Blood capillaries and subcutaneous fat can be shown by placing precut reddish and yellowish soft quilts in the bottom of the box.

The use of this model “think inside the box” to learn skin structure and function will serve many purposes. The model enables students to: a) comprehend quickly the complexity of skin structure, b) remember the various skin layers and their number, c) understand the location of various proteins and pigments, and d) comprehend the complex structure and physiology of skin that constitutes the integumentary system crucial for maintaining our body’s thermoregulation and homeostasis.

III. Write Yourself a Cell Cycle

Roberta Batorsky (Penn State, roberta.batorsky@gmail.com) spent some time coming up with ways to help her students understand the cell cycle. She finally decided to try this rather interesting idea where the students design a game and in the process design an understanding of the whole cell cycle.

Here is what I do to help with the conceptual understanding of the cell cycle. Students work in small groups and each group must develop a playable game. Following the game parameters (listed below), I have included pictures of what the students put together to summarize some of their cell cycle games.

1. The purpose of this exercise is to design a game demonstrating the cell cycle.
2. The game can involve normal and/or abnormal cell cycles (cancer, for example).
3. It can show the cell cycle phases.
4. It can involve advancing in the cell cycle or staying in the same phase (G-zero like a nerve cell).
5. It can involve the assembly of substances needed for the cell to advance (spindle, nutrients, etc) to the next phase.
6. It can involve cell division (a reward).
7. It can use dice, or playing cards, or hand drawn cards with messages that the players choose when it is their turn or they land on a square that says “pick a card”.
8. It can be a competition to get to the finish.
9. It can be an animation or a movie (nothing expensive or too time consuming).
10. It can have moving pieces.
11. It should be correct as far as your text is concerned (no SCI-FI).
12. It should be imaginative.
13. It should be able to be seen by students and usage demonstrated (no prototypes- it should be actual).
14. It can have mitosis or meiosis.
15. It can have asexual or sexual reproduction (sexual involves fertilization).
16. It does not have to involve everything to be successful and creative.
17. The students will be the judges (creativity, knowledge, originality).
18. It can look like a video game.
19. No group’s game should be the same as any other group’s game.
20. Groups are responsible for working on this together and all should contribute (Inform me if a group partner does not work).
21. Groups have two weeks to complete their games.

(Continued on next page)
IV. Control the Gamma Neuron Sensitivity

Janet Casagrand (University of Colorado, Janet.Casagrand@colorado.edu) has been concerned with the problems students often have with conceptualizing the stretch reflex. She passed on her very workable and very visual way of demonstrating how this reflex works.

Students often have difficulty in understanding the role gamma motor neurons play in establishing the gain, or sensitivity, of the stretch reflex circuit. Recently I began using a slinky as a model to illustrate differences in the tautness/slackness of intrafusal muscle fibers and to demonstrate the effect that will have on the sensitivity of the muscle spindle afferents to stretch.

I begin by holding the coils on both ends of a slinky so that there is a lot of slack in the coils (“saggy slinky”). I remind the students that the muscle spindle afferents have stretch-sensitive ion channels in their membranes which will open in response to the stretch of the cell’s membrane. I

(Continued on next page)
pull on the two ends of the coils to illustrate that it will take quite a bit of change in the length of the slinky to produce any actual stretch of the coils. Similarly, it will take a lot of stretch of the muscle to open stretch-sensitive ion channels if the intrafusal muscle fibers are very slack.

Next, I stretch the links of a slinky so that the coils are very taut. I pull on the two ends of the coils to illustrate that in this position, it will not take much change in the length of the slinky to produce a significant stretch of the coils. Similarly, it would take very little stretch of the muscle to open stretch-sensitive ion channels if the intrafusal muscle fibers are more taut.

Once the students have an image of the saggy versus taut slinky in mind, they better understand when I discuss the role of gamma motor neurons in setting the tautness/slackness of the intrafusal muscle fibers, and how that is used to regulate the sensitivity of the muscle spindle afferents and the stretch reflex.

V. 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 interesting ways 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 submitting!

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!
HAPS COMMITTEES AND BOARDS

ANIMAL USE
Nicholas Despo, Chair
Thiel College
Greenville, PA
724-789-2067
ndespo@thiel.edu

Distributing the HAPS policy statement, developing animal use Internet links on hapsweb.org, monitoring relevant legislation, and creating a resource packet for HAPS members.

CONFERENCE COMMITTEE
J. Ellen Lathrop-Davis, Chair
Community College of Baltimore County-Catonsville
Catonsville, MD
410-455-6947
elathrop@ccbc.edu

Developing animal use Internet links on hapsweb.org, monitoring relevant legislation, and creating a resource packet for HAPS members.

CADAVER USE
Christine Eckel
West Virginia School of Osteopathic Medicine
400 North Lee Street
Lewisburg, WV 24901
304-647-6226
ceckel@osteo.wvsom.edu

Develops guidelines for the use of cadavers in anatomy instruction.

CURRICULUM AND INSTRUCTION
Ron Gerrits, Chair
Milwaukee School of Engineering
Milwaukee, WI
414-277-7561
gerrits@msoe.edu

Currently developing learning outcomes for the A&P content modules in HAPS Human A & P Course Guidelines. Updating software guide.

EXECUTIVE
Dee Silverthorn, President and Chair
University of Texas-Austin
One University Station C0930
Austin, TX
512-471-6560
silverthorn@mail.utexas.edu

Composed of the HAPS President, President-Elect, Past President, and Treasurer.

FOUNDATION OVERSIGHT
Valerie O’Loughlin, Chair
Indiana University-Bloomington
Bloomington, IN
812-855-7723
vdean@indiana.edu

Makes recommendations to the Board regarding how to invest the money donated to the HAPS Foundation.

GRANTS AND SCHOLARSHIPS
Michael Kopenits, Chair
Amarillo College
Amarillo, TX
806-371-5074
kopenits-ms@actx.edu

Reviews all grant and scholarship proposals, selects proposals to receive funding, and submits its recommendations to the BOD for approval.

HAPS EDUCATOR
Sarah Cooper, Co-Editor
Arcadia University
450 South Easton Road
Glenside, PA 19038
215-572-2179
coopers@arcadia.edu

Jennelle Malcos, Co-Editor
Penn State University
208 Mueller Lab
University Park, PA 16802
607-423-3178
iheyer@yahoo.com

Provides advisory and support services to the HAPS-EDucator Editor, i.e. soliciting and reviewing articles, and proofreading final draft of the HAPS EDucator.

HAPS INSTITUTE
John Waters, Chair
Penn State University
University Park, PA
814-863-1154
johnwaters@psu.edu

HAPS-Institute@hapsweb.org

Oversees program that offers graduate level biology credit courses earned through the University of Washington.

MARKETING
Elizabeth Hodgson
York College of Pennsylvania
441 Country Club Rd.
York, PA 17404
717-815-1530
ehodgson@vc dap., marketing@hapsweb.org

Promotes HAPS in all ways and is the liaison between HAPS and A&P vendors.

MEMBERSHIP
Elizabeth Pennefather-O’Brien, Chair
Medicine Hat College
Medicine Hat, AB, CA
403-529-3956
obrien@mhc.ab.ca

Recruits new members, provides service to members, focuses on membership retention, and compiles membership information.

NOMINATING
Valerie O’Loughlin
Indiana University, Bloomington
Jordon Hall 104
Bloomington, IN 47405
812-885-7723
vdean@indiana.edu

Recruits nominees for HAPS elected offices.

PRESIDENTS EMERITI ADVISORY BOARD
Caryl Tickner
Stark State College
6200 Frank Ave. NW
N. Canton, OH 44720
330-494-6170
clickner@starkstate.edu

An experienced advisory group including all Past Presidents of HAPS. Advises and adds a sense of HAPS history to the deliberations of the BOD.

SAFETY
Linda Nichols, MS
Santa Fe Community College
3000 NW 83 Street
Gainesville, FL 32609
352-395-5708
Linda.nichols@sfc college.edu

Develops standards for safety in the laboratory.

STEERING
Thomas Lehman, Chair
Coconino Community College
Flagstaff, AZ
928-226-4282
tom.lehman@coconino.edu

Comprised of all committee chairs, coordinates activities between committees, and represents collective committee activity to the HAPS BOD.

TESTING
Curtis DeFriez, Co-Chair
Weber State University
Ogden, UT
801-940-6844
801-626-6382 fax
cdefriez@weber.edu

Eric Sun, Co-Chair
Macon State College
Macon, GA
478-471-2752
eric.sun@maconstate.edu

Completed, tested, and approved the HAPS Comprehensive Exam for Human A&P. Developed on-line version.

WEB COMMITTEE
Tom Lancraft, Chair
Petersburg College/Gibbs Campus
St. Petersburg, FL
727-327-8621
webeditor@hapsweb.org

2012 CONFERENCE COORDINATOR
Kebret Kebede
Nevada State College
1125 Nevada State Drive
Henderson, NV 89015
702-992-2614
Kebret.kebede@ns c.nevada.edu

The Committee Chairs invite input from HAPS members and willingly provide information on the activities of their committees.