GROSS ANATOMY

Lecture Syllabus 2008

ANAT 6010 - Gross Anatomy
Department of Neurobiology and Anatomy
University of Utah School of Medicine

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Welcome to Human Gross Anatomy!

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Course Objectives
The study of anatomy is akin to the study of language. Literally thousands of new words will be taught throughout the course. Success in anatomy comes from knowing the terminology, the three-dimensional visualization of the structure(s) and using that knowledge in solving problems. The discipline of anatomy is usually studied in a dual approach:
• Regional approach - description of structures regionally and their relationships to each other (back, thorax, abdomen, pelvis, perineum, neck, head, upper limb, lower limb)
• Systemic approach - description of the major systems of the body – musculoskeletal, nervous cardiovascular, lymphatic, digestive, respiratory, endocrine, urinary and reproductive

The gross anatomy course (ANAT 6010) is organized around a regional approach to anatomy, but time is taken throughout the course to review information from a systemic standpoint because true understanding requires that both approaches be used. The regional approach is divided into the following 4 Units:
Unit #1 – Back and Thorax
Unit #2 – Abdomen, Pelvis and Perineum
Unit #3 – Neck and Head
Unit #4 – Upper and Lower Limb
Lecture Syllabus
The goal of the lecture syllabus was to:
• Create lecture outlines that are practical and easy to follow during self study and during lecture
• Provide students with clear expectations of the anatomic content to be mastered
Each lecture session of the syllabus begins with a list of “Objectives” that identifies anatomic structures and concepts to be mastered. The goal of the objectives list is to help students focus study time on required content instead of guessing what the instructor expects them to memorize and learn. Similarly to learning a new language there is a large amount of memorization required. However, the end goal is not in memorizing long lists of terms and verbs but of communicating. Anatomy is much the same. There are long lists of structures and concepts to memorize and learn but that is not the end goal. The end goal is applying the anatomic content to clinical/analytical problems. The syllabus is meant to help serve as a guide in this study process. The syllabus and associated objectives are meant to serve as a focus to study time. In addition, homework exercises are provided to aid students in applying anatomic concepts in clinical situations to assess self-mastery of anatomic knowledge and to prepare for the end-unit examinations. The syllabus does not supplant the required textbooks. The authoritative source for lectures (written exams) is Gray’s Anatomy for Students, not the syllabus. The authoritative source for the laboratory practical exam is Gray’s Dissection Guide for Human Anatomy, not the syllabus. If you discover format mistakes or inconsistencies between the content of the syllabus and text books, please let us know, constructively, so that we may revise the syllabus for next year.

Grading and Testing
Cumulative scores for exams, and cadaver autopsy report for a total of 455 possible points.
• 4-Midterm lecture exams consist of multiple choice and constructed response questions (50 points each).
  Hard copies of the written exams will not be returned.
• 4-Cadaver practical exams (50 points each).
• 4-Dissection area cleanliness and Dissection completeness (5 points each)
• 1-Written cadaver autopsy report (35 points ... 5 group report and 30 individual report)
Medical students: Honors/Pass/Fail; Dental students: Letter grade (A-F)
Cheating is unacceptable. Please do not wear baseball caps or other brimmed hats during exams.
Exam dates: Unit #1 - Monday September 15th, Unit #2 - Friday October 10th, Unit #3 - Wednesday November 12th and finally Friday November 5.
Changing dates of exams is not an option, without prior written approval from the Dean’s Office and Course Director.

Remediation
Approved medical school summer anatomy courses (i.e., University of Louisville in Kentucky or PT gross anatomy course at UofU)

Materials
Scrubs and/or white laboratory coat, latex gloves, scalpel blades, scissors, forceps/hemostats (2 sets of other dissection tools are included for each table).
**Required texts**
Drake et al., Gray’s Anatomy for Students (2005)
Atlas: Your choice (recommend Netter’s, or Thieme)

**Dissection Groups**
6 medical students are assigned to each cadaver. They are further subdivided into group “A” and group “B”. Each group will alternate each laboratory period between cadaver dissection and small group activities in the HSEB (i.e., osteology tutorials, radiology review, practice problem solving etc...). The dissecting group will teach the dissected material to the non-dissecting group. For example, when Group A is dissecting the triangles of the neck in the cadaver lab, Group B will be reviewing the osteology of the head and neck. Group A will be responsible for teaching Group B the anatomy of the triangles of the neck to Group A.

**Learning Aids**
The official anatomy website is DIGANAT. The site contains photographic dissections for each session, osteology tutorials, radiographic tutorials, homework questions and other computer assisted instructional aids.
- [http://library.med.utah.edu/diganat/index.html](http://library.med.utah.edu/diganat/index.html)
- username: gross
- password: anatomy

**Bone boxes:** A bone box is assigned to each cadaver table (to be shared between groups A and B)
**Skulls:** A skull is assigned to each dissection group (Group A and Group B both are assigned skulls)

**Health Professions Education Building (HPEB)**
- Address: 520 Wakara Way, Research Park between the Marriott Hotel and Orthopedic Building
- 15 walk from HSEB. The HPEB is shared with the College of Health’s Physical and Occupational Therapy programs (good citizenship is therefore obligatory). The building has 3 levels with a mezzanine between levels and 2 and 3. (Level 1 is the bottom level). Each student is given access to the building 7 days a week from 6AM to 11PM. For the students’ protection against liability, we advise that more than one student be in the laboratory at a time. The cadaver laboratories are located on Level 2 (middle level). The labs have keypad locks with the code for each door being ... 2 and 4 at the same time followed by 3. The student commons area is on Level 3 (top floor). Please feel free to take advantage of the common areas. Changing-Rest rooms are located on all three floors.
- Shuttle bus: To see a schedule for shuttles to and from the medical school and cadaver lab please refer to [http://www.parking.utah.edu](http://www.parking.utah.edu)
- Parking: Limited parking is available at the HPEB facility. Additional parking is located at 615 on the map on the following page. Individual property managers control all other lots in Research Park. Unauthorized use is subject to private, not University, enforcement. Please do not park in the “Patient Parking” at the bottom of the hill in HPEB. Those spots are reserved for patients with multiple sclerosis and Parkinson’s. If student’s take their parking spots they are forced to park elsewhere and will be unable to get to the rehab room on Level 1 and will miss their session. Thank-you for your consideration in this matter.
Cadaver Laboratory

Respect the cadavers

Their donation is for your benefit. No tissues are to leave the laboratory. All inorganic materials accompanying the body (e.g., false teeth, fillings, pacemakers, artificial joints) are to remain with the cadaver. No eating, drinking smoking, cameras or visitors are allowed in the laboratory.

For sanitary reasons

- Scrubs and/or white laboratory coat, close toed shoes and gloves are required in the laboratory. Sandals are discouraged (no protection from dropped scalpels)
- Do not touch anything while you are wearing soiled gloves, except your cadaver, texts and instruments
- Keep the dissection table surface and the floor in your immediate area clean of cadaver wastes
- At the end of each dissection, sweep and mop the area around your table, spray and wipe down your table edges, wash all dissection tools and place them in the plastic container underneath your cadaver table.
- Place the lab stools under the table before you leave the laboratory

The anatomy laboratory must always look clean out of respect for the donors and their families.

When laboratory equipment (saw, mallet, chisel) is used:

- Clean and return the equipment to the proper place immediately after use. Care must be used with all instruments to prevent injury
- When first aid is needed please find one of the laboratory staff

Cadaver Maintenance

The cadaver must remain wrapped in moist shrouds when not being dissected to prevent dehydration

Dissection is enhanced when the area being dissected is sprayed periodically with wetting agent; this also retards dehydration

Refill the bottles from container marked “wetting agent” in the supply room

Keep areas of the cadaver not being dissected covered with moist shrouds and plastic; additional shrouds are available upon request

Do not allow body fluids to pool (build up) in the plastic covers or on the dissection table surfaces

Disposal - 4 Containers

- **White pail** - Body tissues and body tissues only (i.e., fat, skin, muscle etc...). Located under dissection table
- **Red Sharps container** - Scalpel blades and any item that can puncture the skin. Located in each room.
- **Grey pail** - All fluids from the cadaver are drained into the grey bucket at the foot of each cadaver table.
- **Black Trash Can** - Gloves, paper towels and anything else that is not a body tissue, a sharp item or a fluid.

*Adherence to these policies sustains the integrity of the body donor program, improves the laboratory environment and reduces the risk of illness or injury to you and your fellow students. For more information on the body donor program go to www.neuro.utah.edu/related_links/bodydonor/index.html.*
Cadaver Autopsy Report Project Description

Introduction
In the human gross anatomy course, the primary teaching and learning tool is the human cadaver. Often, the cadaver is introduced as the medical student’s first patient. Because the cadaver was at one time a living, breathing human being, the cadaver was in fact a real patient at some point in time. For some reason, often unknown to the student, the patient passed away and his or her body was sent to the University of Utah’s Body Donor Program per the patient’s wishes. As a student, the only information you receive about the cause of death of the cadaver you are dissecting comes from the death certificate. Keep in mind, however, that the cause of death listed on the death certificate is often listed as the immediate cause of death. However, the immediate cause of death may have been preceded by some other long-term disease process(es). As you dissect the cadaver, you may discover pathology or variations from normal anatomy that may or may not have contributed to the death of the individual. You will use these discoveries to compose an autopsy report for your cadaver. A benefit of this exercise is integration of coursework within the medical curriculum. In addition, this exercise will assist you in developing an understanding about normal and pathological structure and function of the human body.

The cadaver autopsy report is modeled after a typical autopsy report from a hospital pathologist or coroner’s office. A pathologist who performs an autopsy will usually be privy to the medical record of the individual and this can be of great assistance in guiding the pathologist in his or her exploration of the body. You, however, do not have that information, nor do you likely have experience in human pathology. Thus, your cadaver autopsy report will be limited in scope. To assist you in this endeavor, pathology faculty and residents will come to the gross anatomy laboratory during particular laboratory sessions (such as when the thoracic and abdominal cavities are opened) and assist you in finding pathologies in the cadaver. They will also take tissue samples from the cadaver and prepare histology slides of those samples for you to analyze in the histology course. As you perform your dissections, you will take notes regarding abnormal or pathological conditions in an Anatomic Pathology Notes packet that will be handed out to each dissection group. At the end of the course, each student will compose a written Cadaver Autopsy Report that summarizes his or her findings (and interpretations) from the cadaver. In addition, you will provide a suspected cause of death (based on your observations) for your cadaver in your written report.

A. Overview and Components of the Project

Grading and Evaluation
This project will comprise 8% of your overall grade in Anatomy 6010. There are two components to the exercise that you will be graded on:

- Cadaver Autopsy Notes – 1 completed packet per group (5 points).
- Cadaver Autopsy Report – 1 written report per individual (30 points).
1. Cadaver Autopsy Notes
Each dissection group will receive an Anatomic Pathology Notes packet at the beginning of the course. As you perform your dissections on the cadaver, you will enter pertinent observations of normal and/or pathologic anatomy that you observe in your cadaver. We recommend having one notebook at each table throughout the term. At the end (or during) each dissection period, read through the appropriate section of the notes packet and answer the questions related to you cadaver’s anatomy/pathology. You must be diligent and record your notes after every dissection period. The activity cannot be done accurately in a single day at, or near, the end of the term because much of the pathology you notice early on will be removed and/or destroyed by subsequent dissection of your cadaver.

2. Cadaver Autopsy Report
Each student will turn in an original written Cadaver Autopsy Report based on observations made on the cadaver and the anatomic pathology notes taken by the dissection group. An example of an autopsy report has been posted to the web site to help you compose your report. In addition, a template for your report (in Microsoft Word™ format) is posted to the web site for you to download.

Due Date: FRIDAY, DECEMBER 5, 2008 (no later than midnight). The report will be docked 5 points for being late. If the report is not received by the following Wednesday no credit will be awarded.
Submission: Email your personal autopsy report to Dr. Morton (david.morton@hsc.utah.edu)
Required Formatting: The report must be typed, contain no more than two pages of single-spaced text, one-sided with 1-inch margins and 12 point font.

B. Instructions for the Cadaver Autopsy Report
Each cadaver autopsy report will have two sections. You will organize Section I according to the directions below so that all reports include the same general information about the cadavers. The same general information text may be written by the group and copied by every student who worked on a particular cadaver. However, each student must write an original report summarizing the anatomic pathologies (Section II). You have two choices concerning how you organize Section II of your report. Directions and suggestions are listed on the next page.

Section I – General Information (Shared text by each student per cadaver)
A. Technical Information
   1. Table number
   2. Cadaver number
   3. Cause of death: State your hypothesis regarding the cause of death.
B. Body habitus
C. Observations of surface anatomy
Section II – Anatomic Pathology Summary (Original text by each student per cadaver)

We recognize that you are not experienced with anatomic pathology and its technical terms, some of which are defined in the Anatomic Pathology Notes booklet that you used in the laboratory. Therefore, we would like you to describe, in plain language, the appearance of the region or organ system you are writing about, and to describe how that appearance was different from normal anatomy. If the region or organ/organ system you are writing about has no abnormality, please describe the normal anatomy for that region or organ/organ system.

You may organize your report based on one of the following options:

A. Summary of **regional anatomic pathology** with integrated histopathology.
   Each group member will choose one anatomic pathology finding for the cadaver and describe the finding. The description should include where the pathology is located, the type of pathology, and the size of the pathology. Compare the regional pathology to normal anatomy for the same region. Repeat those descriptions for the tissue slides, as guided below.
   This may be a good choice if you found multiple abnormalities involving several organ systems in your cadaver (e.g. metastatic tumors located in multiple organ systems). If you choose this approach, have each member of your dissecting group write about a different finding (e.g. student “A” describes lung anatomy and tumors in lung; student “B” describes liver anatomy and tumors in liver; both reports reference the common origin of the tumors). If you choose this approach, all of the reports will collectively provide a summary of your group’s findings.

B. Summary of **organ system pathology** with integrated histopathology.
   Each group member will choose one organ system and describe the abnormal and normal anatomy of the organ system. Compare the organ system pathology to normal anatomy for the same system. Repeat those descriptions for the tissue slides, as guided below.
   This may be a more interesting, informative, or practical approach if your cadaver died as a result of a disease that predominantly affected one organ system (e.g. cardiovascular disease). For some cadavers, only one organ system may be affected. Nonetheless, each group member should write his or her own report (do not copy each other’s reports). If more than one organ system is affected, each group member may write about a different organ system.

Guidance for the histopathology section of the Cadaver Autopsy Report.

You may copy and paste the histology report that you submitted to Dr. Ash. However, we expect you to expand that report by relating the histopathology to the anatomic pathology for your cadaver. We understand that you are not experienced with histopathology. Therefore, we would like you to describe, in plain language, how the tissue samples you obtained from your cadaver differ histologically from normal (if at all). For example, in a slide prepared from a tissue sample taken from a healthy heart ventricle, the cardiac muscle cells should have one to two centrally located nuclei. In contrast, a slide prepared from a tissue sample taken from a pathologic region of the heart, where the gross observations showed a cardiac infarct, the histopathology might show cardiac muscle cells devoid of nuclei. Your report does not have to state the cause of the abnormality. Rather, state your observations.

Given this example, you might state, “Cardiac muscle cells appear to be the normal size and shape, but they are devoid of nuclei.” Once again, remember that you will be revisiting this summary in the pathology course next term so a thorough summary of your current observations will be beneficial to you in the future.
UNIT #1 - BACK AND THORAX
UNIT #1 – BACK AND THORAX

Reading
Gray’s Anatomy for Students (GAFS), Chapters 2-3
Gray’s Dissection Guide for Human Anatomy (GDGHA), Labs 1-9

Lectures
G01 – Back (Dr. Weyrich)
G02 – Overview of CNS and PNS (Dr. Morton)
G03 – Overview of PNS and ANS (Dr. Morton)
G04 – Anterior Thoracic Wall (Dr. Weyrich)
G05 – Lungs (Dr. Weyrich)
G06 – Heart (Dr. Weyrich)
G07 - Mediastina (Dr. Weyrich)
At the end of this lecture, students should be able to master the following:

1) Skin of the back
   a) Identify basic anatomical landmarks of the back (external occipital protuberance, C7 vertebra, angles of the scapula, medial margin of the scapula, spine of the scapula, iliac crest, and boundaries of the trapezius, latissimus dorsi, and erector spinae muscles)
   b) Identify the vertebral level of the following bony landmarks
      i) Root of the Spine of the scapula- T3
      ii) Inferior angle of the scapula- T7
      iii) Iliac crest- L5
   c) Understand the segmental cutaneous innervation (dorsal rami) and vascular supply (posterior intercostal branches) to the back
2) Back Muscles

a) Identify and describe specific attachments, actions, innervation, vascularization, and relations of superficial back muscles (See table)
   
   i) Trapezius
      
      (1) Innervation:
         
         (a) Motor: Spinal accessory nerve (CN XI)- arises from upper segments of the spinal cord, ascends through the foramen magnum to enter the cranial cavity, then exits through the jugular foramen; descends through the posterior triangle of the neck to the sternocleidomastoid and trapezius
         
         (i) Accessory nerve syndromes can occur as it crosses the posterior triangle of the neck resulting in a medial winged scapula, droopy shoulder, or the inability to raise shoulder or arm above the head
         
         (b) Sensory: proprioception through C3 and C4 spinal nerves

   ii) Latissimus Dorsi

   iii) Levator scapulae

   Table of Superficial Back Muscles

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Proximal Attachment</th>
<th>Distal Attachment</th>
<th>Action</th>
<th>Innervation</th>
<th>Vascularization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trapezius</td>
<td>Occipital bone, nuchal ligament, C7–T12 vertebrae</td>
<td>Clavicle, acromion and spine of scapula</td>
<td>Elevates, retracts, depresses, and rotates scapula</td>
<td>Spinal root of accessory n. (CN XI) cervical nn (C3–C4)</td>
<td>Superficial branch of the transverse cervical artery</td>
</tr>
<tr>
<td>Latissimus dorsi</td>
<td>T7 sacrum, thoracolumbar fascia, iliac crest and inferior 3 ribs</td>
<td>Intertubercular groove of humerus</td>
<td>Extends, adducts, and medially rotates humerus</td>
<td>Thoracodorsal n. (C6–C8)</td>
<td>Thoracodorsal artery</td>
</tr>
<tr>
<td>Levator scapulae</td>
<td>Transverse processes of C1–C4 vertebrae</td>
<td>Superior angle of the scapula</td>
<td>Elevates and rotates the scapula; inclines the neck to the same side of contraction</td>
<td>Cervical nn. (C3–C4) and dorsal scapular n. (C5)</td>
<td>Transverse cervical artery Transverse cervical artery</td>
</tr>
<tr>
<td>Rhomboid major</td>
<td>Spinous processes of T2–T5 vertebrae</td>
<td>Medial margin of scapula</td>
<td>Retract and rotate scapula</td>
<td>Dorsal scapular n. (C4–C5)</td>
<td></td>
</tr>
</tbody>
</table>
3) Deep Back Muscles
   a) Identify and describe general attachments, actions, segmental innervation, and relations of the deep back muscles (splenius capitis and cervicis, erector spinae, and transversospinalis muscles)
      (See table)

4) Suboccipital region
   a) Identify and describe the boundaries and contents of the suboccipital triangle
      i) Boundaries: rectus capitis posterior major, obliquus capitis superior, obliquus capitis inferior muscles
      ii) Contents: suboccipital nerve (posterior ramus of C1) and vertebral artery
   b) Identify and describe the general attachments, functions, innervation, and vascularization of the suboccipital muscles
      (rectus capitis posterior major, rectus capitis posterior minor, obliquus capitis superior, obliquus capitis inferior) (See table)
### Table of Suboccipital Muscles

<table>
<thead>
<tr>
<th>Suboccipitals</th>
<th>Attachments</th>
<th>Actions</th>
<th>Innervation</th>
<th>Vascularization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rectus capitis, posterior major,</td>
<td>Occiput, C1, and</td>
<td>Extension and rotation of the head (but in reality stabilization and</td>
<td>Posterior ramus</td>
<td>Vertebral and suboccipital arteries</td>
</tr>
<tr>
<td>rectus capitis</td>
<td>C2</td>
<td>minor adjustments of the position of the head)</td>
<td>of C1</td>
<td></td>
</tr>
<tr>
<td>posterior minor, obliquus capitis superior,</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>obliquus capitis inferior</td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
At the end of this lecture, students should be able to master the following:

1) Overview of the Nervous System (NS)
   a) Discuss the anatomical organization and basic functions of the NS
   b) Define and list the components of the central nervous system (CNS) and peripheral nervous system (PNS); explain the structural and functional divisions of each

2) Spinal Meninges
   a) Describe the three layers of spinal meninges

Dura mater
The dura mater is the most superficial layer of meninges. It forms a sheath around the spinal cord that extends from the internal surface of the skull to the S2 vertebral level. The dura mater evaginates into each intervertebral foramen to surround the spinal nerve and becomes continuous with the connective tissue covering each spinal nerve (epineurium).
   - The epidural space is located between the dura mater and the vertebral canal. A liquid anesthetic agent can be injected into the epidural space to anesthetize the spinal nerve roots surrounding it.

Arachnoid mater
The arachnoid mater is the intermediate meningeal layer, which is attached to the underlying pia by numerous arachnoid trabeculae. The cavity between the arachnoid and the pial layers defines this subarachnoid space. This space contains the cerebrospinal fluid (CSF), which suspends the spinal cord, brain, and nerve roots. Large blood vessels pass within this space. The dural sac is that portion of the subarachnoid space between the conus medullaris (approximately L1 vertebra) and the point at which the coccygeal ligament begins (approximately S2 vertebra). By definition, the dural sac contains only spinal roots suspended in CSF. At the caudal end of the spinal cord, at about the L2 vertebral level, the pia mater surrounding the cord continues as a strand of connective tissue that attaches to the coccyx.
   - The spinal cord terminates in an adult at the L1–L2 vertebral level, whereas it ends at L3 in a newborn. The subarachnoid space extends to about S2. Therefore, using the L4 vertebral spine as reference (located by using the iliac crest as a reference), a needle can be passed with relative safety into the subarachnoid space to sample CSF, as in a lumbar puncture.

Pia mater
The pia mater is the deepest meningeal layer.
   - The denticulate ligaments are lateral extensions of the pia mater that support the entire spinal cord by attaching to the dura mater and maintaining a centralized location of the spinal cord in the subarachnoid space. These ligaments are located in the coronal plane, between the ventral and dorsal roots, and project through the arachnoid mater to attach to the dura mater, thereby creating a series of sawtooth projections of the arachnoid mater.
   - The filum terminale is an extension of the pia beyond the tip of the spinal cord (conus medullaris) that attaches to the coccyx in the vertebral canal.
Central Nervous System
(CNS)

Peripheral Nervous System
(PNS)

Sensory

Motor

Somatic

Autonomic Nervous System
(ANS)

Sympathetic

Parasympathetic

Spinal cord

Dura mater

Dentate ligaments

Pia mater

Subarachnoid space

Arachnoid mater

Dura mater
3) The Spinal Cord
   a) Define the boundaries of the spinal cord from top to bottom and its protection
   b) Compare and contrast white and gray matter
   c) Identify the regions of gray mater on a cross section of spinal cord
   d) Distinguish between various regions of the spinal cord using gray and white mater markings

**Topography and Overview**
The spinal cord receives sensory input from the body tissues via spinal nerves, processes these messages with the brain and sends out appropriate motor responses through spinal nerves. The spinal cord is located within the vertebral (spinal) canal, and extends from the medulla oblongata at the C1 vertebral level and terminates as the conus medullaris at the L1 and L2 vertebral level. In a newborn child, the spinal cord terminates at the L3 vertebral level; in a fetus, it continues all of the way to the sacrum.
In cross-section, the spinal cord consists of both white and gray matter. The white matter consists of neuronal axons, with the myelin appearing white. The gray matter consists of aggregates of neuronal cell bodies, which do not contain myelin, and thus it appears gray.

**White matter of the spinal cord**
White matter is composed of columns surrounding the gray matter. Axons are arranged in the white matter so that those of similar functions are grouped together to form a tract. These tracts are not sharply demarcated from each other and, therefore, there may be some overlap between them.
Bundles of axons in the white matter carry impulses up to the brain from sensory tracts and, conversely, bundles of axons carrying impulses in the white matter down from the brain to neurons in the gray matter of the spinal cord from motor tracts.
The amount of white mater increases at each successive higher spinal segment. Cervical spinal cord levels therefore, possess more white matter as all neurons descending from the brain inferiorly or from body tissues to the brain will pass through the cervical spinal cord. As a result, the sacral spinal cord has the least white mater as most ascending or descending fibers have terminated their trip before that region.

**Gray matter of the spinal cord**
The gray matter forms the letter “H” in cross-section of the spinal cord. The thoracic and upper lumbar levels have relatively small amounts of gray mater because they only innervate the thoracic and abdominal regions. The gray mater consists of the following regions:
- **Ventral horn.** Contains cell bodies of lower motor neurons (LMN) innervating skeletal muscle. The ventral horns are largest in those parts of the spinal cord that serve regions of the body with many muscles. For example, the spinal cord segments C5–T1 that serve the upper limbs (brachial plexus) has a cervical spinal cord swelling, and L4–S3 spinal cord segments serving the lower limbs (lumbosacral plexus) forms a lumbar spinal cord swelling.
- **Lateral horn.** Contains cell bodies of preganglionic sympathetic motor neurons of the autonomic nervous system. The lateral horn is only present in the spinal cords between the T1 and L2 region.
- **Dorsal horn.** Handles sensory impulses entering via the dorsal root.
4) PNS - Spinal Nerves

a) Compare and contrast the structure and function of spinal nerves (roots, ganglia, nerves and rami)
b) Define and identify the 31 pairs of spinal nerves and describe how they form the major plexuses
d) Distinguish between sensory, motor and mixed nerves
e) Contrast the difference between vertebral, spinal cord and spinal nerve levels
f) Trace a nervous impulse through all the parts of a spinal nerve

Spinal Roots
At each spinal cord segment, paired dorsal and ventral roots exit the lateral sides of the cord to form left and right spinal nerves. As a result of unequal growth between the vertebral canal and spinal cord (the vertebral canal is longer than the spinal cord in adults), the nerve roots follow an oblique course from superior to inferior, medial to lateral.

- Only in the cervical region are the segments of the spinal cord at the same level with the corresponding cervical vertebrae. Inferior to the cervical region, each spinal nerve from the thoracic, lumbar, and sacral spinal cord segments exits inferior to its similarly numbered vertebra.
- Dorsal roots convey sensory (afferent) information from body tissues to the spinal cord (i.e., skin to spinal cord). The dorsal root ganglion, a swelling in the dorsal root, houses the cell bodies of all sensory neurons entering the spinal cord for that specific body segment. Ventral roots convey motor (efferent) information away from the spinal cord to the body tissues (i.e., spinal cord to the biceps brachii muscle).
- The spinal cord terminates at the L1 vertebral level in adults. Therefore, the lumbar and sacral nerve roots descending in the vertebral canal below the L1 vertebral level form a mass of nerve roots that resembles a “horses-tail,” hence the name cauda equina. Because the cauda equina floats in the CSF, needle introduced into the subarachnoid space will displace the roots with little possibility of puncture damage.

Spinal Nerves
The spinal roots unite in or near the intervertebral foramen to form a spinal nerve. There are 31 pairs of spinal nerves, formed by the dorsal and ventral roots. They are organized as follows:

- Eight cervical spinal nerves. The first seven cervical spinal nerves, C1–C7, exit the vertebral canal superior to each respective cervical vertebra. The last cervical nerve, C8, exits inferior to the seventh cervical vertebra. The remaining spinal nerves segmentally exit the spinal cord inferior to their respective vertebra, as follows:
  - Twelve thoracic spinal nerves exit inferior to the twelve thoracic vertebrae
  - Five lumbar spinal nerves exit inferior to the five lumbar vertebrae
  - Five sacral spinal nerves exit inferiorly through the dorsal sacral foramina of the sacrum
  - One coccyx spinal nerve exits by the coccyx bone

Rami
The spinal nerve exits the vertebral canal through the intervertebral foramen. Each spinal nerve bifurcates into a dorsal primary ramus and an ventral primary ramus.

- Dorsal rami segmentally supply the skin of the back (in a dermatomal pattern) as well as provide motor innervation to the deep vertebral muscles of the median portion of the back (e.g., the erector spinae and transversospinalis muscles). The dorsal rami do not contribute to the innervation of the limbs or face.
- Ventral primary rami supply the dermatomes and myotomes of the anterolateral portions of the torso as well as the upper and lower limbs.

Note: Dorsal and ventral roots are not the same as dorsal and ventral rami. Dorsal roots convey sensory impulses, whereas ventral roots convey motor impulses. Once these roots unite to form the spinal nerve, all subsequent branches, including the rami, convey both sensory and motor impulses (mixed nerves).
5) Sensory and Motor Neurons

a) Contrast the difference between general and visceral sensory neurons
b) Contrast the difference between somatic and visceral motor neurons

Sensory Neurons
Conduct sensory (afferent) information from the tissues of the body to the CNS; there are two modalities of spinal sensory neurons:

- General (somatic afferent) sensory neurons - convey sensations such as pain, temperature, touch and pressure from body tissues to the spinal cord. Also included are proprioceptive sensory neurons that measure changes in joint position and tension of tendons. General sensory neurons are found in all areas of the skin and general body parts.

- Visceral (visceral afferent) sensory neurons - convey impulses from viscera such as glands, heart, blood vessels, gut tube and other body organs to the spinal cord. These neurons are responsible for the perception of hunger, nausea, sexual excitement, bladder distension, pulmonary airway irritation, blood pressure changes etc... Visceral sensory neurons accompany visceral motor neurons.

Motor Neurons
Conduct motor (efferent) information from the CNS to tissues of the body; there are two modalities of spinal motor neurons:

- Somatic motor (efferent) neurons - innervate skeletal muscles (voluntary).

- Visceral motor (efferent) neurons - innervate smooth and cardiac muscle and glandular tissue (involuntary). They belong to the ANS and can be classified as either sympathetic or parasympathetic visceral motor neurons.
Peripheral nerves (Sensory): The two modalities of sensory neurons are general sensory and visceral sensory.

Peripheral nerves (Motor): The two modalities of motor neurons are voluntary (somatic) and involuntary motor (visceral).
At the end of this lecture, students should be able to master the following:

1) Overview of the Autonomic Nervous System (ANS)
   a) Describe the general functions of the ANS
   b) Describe the function of the sympathetic (“fight-or-flight”) and the parasympathetic nervous system (“rest-and-digest”) in general and with the heart, blood vessels, GI tract, lungs, adrenal medulla and genitalia.

The Autonomic Nervous System (ANS) is the involuntary division of the PNS. The ANS controls homeostasis, cardiovascular, digestive and respiratory functions, as well as salivation, perspiration, pupil diameter, urination, and reproductive functions through innervation of smooth and cardiac muscle and glands. The ANS consists of the sympathetic division and parasympathetic division which typically function in opposition to each other.
   - Sympathetic Division - typically functions in actions requiring quick responses (fight or flight)
   - Parasympathetic Division - Actions do not require immediate reaction (rest and digest)

Some typical actions and features of both systems are listed on the next page.

2) Anatomy of the ANS
   a) Understand that there is one ANS sensory but two ANS motor neurons (pre- and post-ganglionic)
   b) Compare and contrast somatic, sympathetic and parasympathetic divisions of PNS relative to sensory pathways, CNS origin, motor pathways, effectors, roots, rami, ganglia and neurotransmitters released

The ANS possesses both motor and sensory neurons. Sensory neurons monitor changes in the viscera (organs). Motor neurons innervate smooth and cardiac muscle and glands. ANS motor response contains a two-neuron circuit of distribution consisting of pre-ganglionic cell bodies in the CNS and post-ganglionic cell bodies in a PNS ganglion.
<table>
<thead>
<tr>
<th>Organ, Tract or System</th>
<th>Sympathetic</th>
<th>Parasympathetic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pupil</strong></td>
<td>Dilates</td>
<td>Constricts</td>
</tr>
<tr>
<td>Skin</td>
<td>Arrector pili m. contraction</td>
<td>No effect</td>
</tr>
<tr>
<td></td>
<td>Vasoconstriction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sweat and sebaceous gland secretion</td>
<td></td>
</tr>
<tr>
<td>Lacrimal and Salivary Glands</td>
<td>Decreases secretion</td>
<td>Increases secretion</td>
</tr>
<tr>
<td>Heart</td>
<td>Increase rate and strength of contr-</td>
<td>Decreases rate and strength of con-</td>
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<tr>
<td></td>
<td>action</td>
<td>traction</td>
</tr>
<tr>
<td></td>
<td>Dilates coronary vessels</td>
<td>Constricts coronary vessels</td>
</tr>
<tr>
<td>Lung</td>
<td>Bronchodilation</td>
<td>Bronchoconstriction</td>
</tr>
<tr>
<td>Digestive tract</td>
<td>Inhibits peristalsis</td>
<td>Stimulates peristalsis</td>
</tr>
<tr>
<td></td>
<td>Constricts blood vessels</td>
<td></td>
</tr>
<tr>
<td>Reproductive System</td>
<td>Ejaculation</td>
<td>Erection</td>
</tr>
<tr>
<td>Adrenal gland (medulla)</td>
<td>Release adrenaline</td>
<td>No effect</td>
</tr>
<tr>
<td>Overview</td>
<td>Fight or Flight</td>
<td>Rest and Digest</td>
</tr>
<tr>
<td></td>
<td>• Exercise, Excitement, Emergency</td>
<td>• Digestion, Defecation, Diuresis</td>
</tr>
<tr>
<td>Features</td>
<td></td>
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<tr>
<td>Neurotransmitters</td>
<td>Acetylcholine (ACh)</td>
<td>• Preganglionic: ACh</td>
</tr>
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<td></td>
<td></td>
<td>• Postganglionic: ACh, Norepine-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>nphrine and Epinephrine</td>
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<tr>
<td>Origin</td>
<td>Lateral horn of gray matter of T1-L2</td>
<td>Brainstem (CN III, VII, IX, X) a</td>
</tr>
<tr>
<td></td>
<td>spinal cord segments</td>
<td>nd spinal cord segments S2-S4</td>
</tr>
</tbody>
</table>
| Location of Ganglia            | Close to or inside the end organs  | Ganglia are close to CNS (paraverte-
|                                |                                    | bral and prevertebral ganglia)   |
| Rami Communicantes             | Gray and white rami communicantes  | None                             |
| Relative length of pre and     | Short preganglionic; long postgangli-| Long preganglionic; short postgan-|
| post ganglionic fibers         | onic                               | gliconic                         |
2) Sympathetics
   a) Understand pre- and post-ganglionic sympathetic neurons
   b) Describe the concept of referred pain

Sympathetic neurons are responsible for the “fight or flight” response. Just as in the parasympathetic division, the sympathetic pathways in the PNS require a two neuron circuit of pre- and postganglionic sympathetic motor neurons.

Preganglionic sympathetic neuron: The cell bodies originate in the lateral horns of gray matter at spinal cord levels T1-L2.

- Once preganglionic sympathetic neurons exit the spinal cord via the ventral root, the axons pass through a white ramus communicans to enter an adjoining paravertebral ganglion forming part of the sympathetic trunk (the sympathetic trunks flank each side of the vertebral column and look like strands of glistening white beads)
- Although the sympathetic trunks extend from the neck to the pelvis, remember sympathetic fibers arise only from spinal cord segments T1-L2. The ganglia vary in size, position and number.

Once a preganglionic sympathetic neuron reaches a paravertebral ganglion via the white ramus communicans, one of three things happen ... the preganglionic sympathetic neuron can:

1. Synapse with a postganglionic sympathetic neuron within the same paravertebral ganglion and exits via the gray ramus communicans and travels along the ventral ramus to innervate blood vessels, arrector pili muscles and/or sweat glands associated with the dermatome.
2. Ascends or descends the sympathetic chain to synapse in either a supra- or infradjacent paravertebral ganglion. The postganglionic sympathetic neuron will exit at the same level of synapse via a gray ramus communicans and travel along the ventral ramus or exit the paravertebral ganglion in some type of visceral ramus (cardiac splanchnic nerve) to course to an end organ.
3. Course through the ganglion without a synapse and the preganglionic sympathetic neuron will enter a splanchnic nerve to synapse in a prevertebral ganglion (i.e., celiac ganglion) in the abdominal cavity. Once the preganglionic sympathetic fiber synapses in the prevertebral ganglion the postganglionic fiber will course along nerves to innervate end organs such as the liver.
3) Parasympathetics

a) Understand pre- and post-ganglionic parasympathetic neurons

The parasympathetic division is concerned with vegetative functions. Encourages secretory activity on the body’s mucous and serous membranes, promotes digestion by increased peristalsis and glandular secretion, and induces contraction of the urinary bladder.

Brain stem: preganglionic parasympathetic neuron cell bodies originate in the brain stem associated with cranial nerves III, VII, IX and X. They leave the brain stem and synapse in one of the cranial or intramural ganglia. The post ganglionic parasympathetic neurons tend to be short, terminating in smooth or cardiac muscle or glands.

Sacral region: preganglionic parasympathetic neuron cell bodies originate in spinal cord segments S2, S3 and S4. Their axons leave the cord via the ventral rami but form their own nerves called pelvic splanchnic nerves. These nerves project to the pelvis, mix with sympathetic postganglionics in the pelvic plexuses and depart for their target end organs. They synapse with the postganglionic parasympathetic neurons near or in the wall of the end organ. These fibers stimulate contraction of rectal and bladder musculature, and induce vasodilation of vessels to the penis and clitoris (erection).
A  Structure of the autonomic nervous system

Illustrator: Markus Voll  pp. 72-73

Schuenke et al. THIEME Atlas of Anatomy • General Anatomy and Musculoskeletal System © THIEME 2007 • All rights reserved. Usage subject to terms of use. • www.thieme.com/taa
At the end of this lecture, students should be able to master the following:

I) Skin of the Anterior Thoracic Wall
   a) Dermatomes
      i) Describe the segmental innervation (ventral rami) of the anterior skin of the thoracic wall including the following key landmark levels
         1) T4- nipple
         2) T6- xiphoid process
   b) Thoracic topography
      i) Locate the lines of the thoracic wall (midsternal, midclavicular, anterior axillary, midaxillary, posterior axillary, midvertebral, scapular lines)
      ii) Locate major thoracic surface landmarks (jugular notch, sternal angle, infrasternal angle)
2) Breast
   a) Identify and describe the structure and function of female breast components (areola, nipple, suspensory ligaments, lactiferous ducts, and mammary glands) and their relationship to other thoracic structures
   b) The nipples usually lie in the fourth intercostal space in the T4 dermatome

b) Trace the vascular pathways from the aorta to the breast and then back to the superior vena cava
   i) Internal thoracic (mammary) artery/vein
   ii) Lateral thoracic artery/vein
   iii) Posterior intercostal arteries/vein

c) Contrast differences in lymphatic drainage from right and left breasts (right lymphatic duct and thoracic lymphatic duct)
   i) Medial breast- parasternal nodes
   ii) Lateral breast- pectoral nodes of the axillary lymph nodes
3) Thoracic muscles

a) Learn the attachments, actions, relations, vascularization, and innervation for the thoracic muscles as listed in the table

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Proximal attachment</th>
<th>Distal attachment</th>
<th>Action</th>
<th>Innervation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pectoralis major</td>
<td>Clavicle, sternum</td>
<td>Lateral intertubercular groove of</td>
<td>Flexion, adduction, medial rotation</td>
<td>Medial (C8-T1) and lateral (C5-C7) pectoral</td>
</tr>
<tr>
<td></td>
<td>and ribs</td>
<td>humerus</td>
<td>of humerus</td>
<td>nerves</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Pectoral branch of the thoracoacromial trunk</td>
</tr>
<tr>
<td>Pectoralis minor</td>
<td>Ribs 3-5</td>
<td>Coracoid process of the scapula</td>
<td>Protraction and stabilization of</td>
<td>Medial pectoral nerve (C8-T1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>scapula</td>
<td></td>
</tr>
<tr>
<td>Serratus anterior</td>
<td>Lateral border of</td>
<td>Medial margin of the scapula</td>
<td>Protraction and stabilization of</td>
<td>Long thoracic nerve (C5-C7)</td>
</tr>
<tr>
<td></td>
<td>ribs 1-8</td>
<td></td>
<td>scapula</td>
<td></td>
</tr>
<tr>
<td>Subclavius</td>
<td>Ribs one</td>
<td>Clavicle</td>
<td>Stabilize clavicle</td>
<td>Nerve to the subclavius (C5-C6)</td>
</tr>
<tr>
<td></td>
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<tr>
<td>Intercostals</td>
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<tr>
<td>* External</td>
<td></td>
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</tr>
<tr>
<td>* Internal</td>
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<tr>
<td>* Innermost</td>
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</tr>
<tr>
<td>Transversus</td>
<td></td>
<td></td>
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<tr>
<td>thoracis</td>
<td>Posterior, lower</td>
<td>Inner surface of costal cartilage</td>
<td>Segmental innervation by intercostal</td>
<td>Phrenic nerve (C3-5)</td>
</tr>
<tr>
<td></td>
<td>sternum and</td>
<td>2-6</td>
<td>nerves (T1-T11) and the subcostal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>xiphoid</td>
<td></td>
<td>nerve (T12)</td>
<td></td>
</tr>
<tr>
<td>Subcostalis</td>
<td>Inner surface of</td>
<td>Upper borders of ribs 2-3</td>
<td>Elevates ribs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>lower ribs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diaphragm</td>
<td>Xiphoid, costal</td>
<td></td>
<td>Increases the volume of the</td>
<td></td>
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<tr>
<td></td>
<td>margin, ribs 11 and</td>
<td></td>
<td>thoracic cavity for respiration</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12, lumbar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>vertebrae</td>
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</tbody>
</table>
4) Thoracic vasculature

a) Arteries of the thorax

i) Describe the origin, course and distribution of the following thoracic arteries

(1) Internal thoracic artery- branches from the subclavian artery, travels along the internal surface of the ribcage just lateral to the sternum, gives rise to the anterior intercostal and musculophrenic arteries

(a) Anterior intercostal arteries- arise from the internal thoracic and musculophrenic arteries, travel posteriorly between the ribs, anastamose with the posterior intercostal arteries

(2) Posterior intercostal arteries- the first two arise from the superior intercostals artery, the remaining arise from the thoracic aorta, travel anteriorly between the ribs, anastamose with the anterior intercostal arteries

(3) Subcostal artery- branches from the thoracic aorta, travel anteriorly inferior to the 12th rib

ii) Describe the arterial collateral circuitry (aorta, internal thoracic, anterior intercostal, posterior intercostal, and subcostal arteries)
b) Veins of the thorax
   i) Describe the course and drainage pathway of the following thoracic veins
      (1) Internal thoracic vein- travels along internal surface of the rib cage just lateral to the sternum, drains into the brachiocephalic vein
         (a) Anterior intercostal veins- travel anteriorly between the ribs to drain into the internal thoracic vein
         (2) Posterior intercostal veins- travel posteriorly between the ribs; the first three join to form the superior intercostals vein and drain into the brachiocephalic vein; the remaining drain into the azygos system
   ii) Describe the venous collateral circuitry (brachiocephalic, internal thoracic, anterior intercostal, posterior intercostals, superior intercostals, and azygos veins)
G05: Lungs (Dr. Weyrich)

At the end of this lecture, students should be able to master the following:

1) Diaphragm
   a) Describe the attachments, vascularization, and innervation of the diaphragm (See table from G04).
   b) Explain the function of the diaphragm - Respiration - The diaphragm is the prime mover of inspiration. It flattens on contraction, thus increasing the vertical dimensions of the thoracic cavity.
      i) Increase intra-abdominal pressure - In addition to its rhythmic contractions during respiration, one can also take a deep breath to fix the diaphragm to push down on the abdominal viscera and increase the pressure in the abdominal cavity. This may be done to help expel vomit, feces, and urine from the body by increasing intra-abdominal pressure, and preventing acid reflux by exerting pressure on the esophagus as it passes through the esophageal hiatus.
   c) Describe the vertebral levels and anatomical contents of the apertures of the diaphragm
      i) Caval opening (T8) - Inferior vena cava and right phrenic nerve
      ii) Esophageal hiatus (T10) - esophagus and right and left vagus nerves
      iii) Aortic hiatus (T12) - aorta, azygos vein, thoracic lymphatic duct
2) Pleura

a) Describe the location of the visceral and parietal (costal, mediastinal, diaphragmatic, cervical) layers of the pleura

b) Describe the location and significance of the pleural cavity, reflections (pleural and diaphragmatic), and recesses (costodiaphragmatic and costomediastinal)

c) Contrast the differences in the sensory innervation of the parietal and visceral pleura

i) Parietal pleural - innervated by spinal nerves (intercostal nerves and the phrenic nerve)

ii) Visceral pleura - autonomic nerves from the anterior and posterior pulmonary plexuses (parasympathetic fibers from the vagus nerve and sympathetic fibers)
3) Lungs
a) Parts and airways
   i) Describe features of the left and right lungs (apex, base, root, hilum, lobes, fissures and surfaces)

   b) Trace the air pathway from the oral cavity to the main bronchi to the alveoli in the lungs and back
c) Describe the relationships of the bronchi and lungs to other thoracic structures (such as the aorta, azygos vein, sympathetic trunks, esophagus, vagus nerves, pulmonary vessels, vertebral column, thoracic lymphatic duct)

![Diagram of thoracic structures](image)

d) Vascularization of the lung

i) Arteries of the lung

1. Describe the origin, course, destination, and oxygen level of the arteries of the lung

   a. Pulmonary artery - carries deoxygenated blood from the pulmonary trunk, give rise to the lobar arteries

   b. Bronchial arteries (right and left) - carry oxygenated blood to the root of the lung from the aorta (left bronchial arteries) and third posterior intercostals artery (right bronchial artery)

ii) Lymphatics of the lungs

1. Contrast the differences in lymphatic drainage between the left and right lungs
e) innervation of the lung and visceral pleura
   i) anterior and posterior pulmonary plexuses- describe the origin and function of the sympathetic and para-
sympathetic components of anterior and posterior pulmonary plexuses

The pulmonary plexus follows the trachea and bronchial tree, providing parasympathetic and sympathetic
innervation to the smooth muscle and glands of the lungs. The pulmonary plexus is divided and named
according to its position to the root of the lung, where the anterior pulmonary plexus lies anterior and the
posterior pulmonary plexus lies posterior the corresponding bronchus. Branches of the pulmonary plexus
accompany the blood vessels and bronchi into the lung as well.
   · Sympathetic: Postganglionic sympathetic fibers from the T1 to T4 levels of the sympathetic trunk con-
tribute to the pulmonary plexus. Sympathetic innervation causes bronchodilation, vasoconstriction of the
pulmonary vessels, and inhibition of secretions from bronchial glands. Visceral sensory fibers from the
visceral pleura and bronchi may accompany sympathetic fibers as well.

   · Parasympathetic: The pulmonary plexus receives preganglionic parasympathetic and visceral sensory
innervation via the vagus nerve. The vagus nerves are the tenth pair of cranial nerves and have the wid-
est field of distribution to the body. They innervate structures in the head, neck, thorax and abdomen. In
the thorax, the vagus nerves provide all the parasympathetic innervation of the viscera. Parasympathetic
innervation causes bronchoconstriction of the smooth muscle of the bronchial tree, vasodilation of the
pulmonary vessels, and secretion from bronchial glands.
G06: Heart (Dr. Weyrich)

At the end of this lecture, students should be able to master the following:

1) Pericardium
   a) Describe the location and structure of the pericardial layers (fibrous pericardium, serous pericardium, visceral pericardium, and pericardial space)
   b) Understand the vascularization and innervation of the pericardium (pericardiophrenic vessels and the phrenic nerve)

2) Overview of the heart
   a) Describe the layers of the heart (endocardium, myocardium and epicardium)
   b) Describe the general external features of the heart (apex, base, surfaces, and borders)
3) Coronary Circulation

a) Coronary arteries

i) Describe the origin, course, and distribution of the principal coronary arteries and their associated branches

(1) Right coronary artery- originates from the right aortic sinus, descends along the anterior side of the heart towards the right along the inferior border of the right auricle, then wraps posteriorly around the heart; gives rise to the following branches:
   (a) SA nodal artery- usually branches from the right coronary artery; supplies the SA node
   (b) Right marginal branch- supplies the right border of the heart
   (c) AV nodal artery- supplies AV node
   (d) Posterior interventricular artery- supplies both ventricles and the interventricular septum from the posterior side of the heart

(2) Left coronary artery- originates from the left aortic sinus, descends along the anterior side of the heart towards the left, courses between the pulmonary trunk and the left auricle then bifurcates into the following branches:
   (a) Anterior interventricular branch (LAD)- descends along the anterior surface towards the apex supplying the left ventricle and interventricular septum
   (b) Circumflex branch- wraps posteriorly around the heart in the coronary sulcus, gives rise to the left marginal artery
      (i) Left marginal artery- supplies the left border of the heart

b) Cardiac veins

i) Describe the origin, course, and drainage of the principal cardiac veins and their associated tributaries

(1) Coronary sinus- courses along the posterior side of the heart in the coronary sulcus; drains blood from the following cardiac veins to the right atrium
   a) Great cardiac vein (anterior interventricular vein)- ascends from the apex along the anterior side of the heart in the anterior interventricular sulcus
   b) Middle cardiac vein (posterior interventricular vein)- ascends from the apex along the posterior side of the heart in the posterior interventricular sulcus
   c) Small cardiac vein- (right marginal vein)- courses with the right marginal artery, wraps around the right border of the heart in the coronary sulcus

(2) Anterior veins- originate on the anterior surface of the right ventricle, course over the coronary sulcus to drain directly into the right atrium
4) Chambers of the heart

a) Describe the following structures associated with the various chambers of the heart

i) Right Atrium (RA) - sinus venarum, coronary sinus, musculi pectinati, right auricle, sulcus terminalis, crista terminalis, fossa ovalis

ii) Right ventricle (RV) - trabeculae carnae, conus arteriosus, right atrioventricular (tricuspid) valve, chordae tendinae, papillary muscles, septomarginal trabecula (moderator band), pulmonary valve

iii) Left atrium (LA) - pulmonary veins

iv) Left ventricle (LV) - mitral valve, aortic valve, right aortic sinus, left aortic sinus, posterior aortic sinus
5) Heart Valves

a) Describe the valves of the heart

   i) Atrioventricular valves
      
      (1) Tricuspid valve- prevents backflow of blood from the right ventricle to the right atrium during systole
      (2) Mitral (bicuspid) valve- prevents back-flow of blood from the left ventricle to the left atrium during systole

   ii) Semilunar Valves
      
      (1) Pulmonary valve- prevents back-flow of blood from the pulmonary trunk to right ventricle during diastole
      (2) Aortic valve- prevents back-flow of blood from the aorta to the left ventricle during diastole
6) Innervation of heart

a) Cardiac plexus—courses anterior and posterior to the aortic arch to the heart musculature. Describe the origin and function of the sympathetic and parasympathetic components of the cardiac plexus

Sympathetic Innervation of the Heart

Preganglionic sympathetic fibers, originating bilaterally in the lateral horns of the gray matter of the spinal cord between the T1-T5 spinal cord levels, enter the sympathetic chain via the white rami communicantes. Once in the sympathetic chain, fibers travel to the cardiac plexus via two possible routes:

1) Preganglionic sympathetic fibers synapse in the superior parts of the thoracic sympathetic chain and send postganglionic sympathetic fibers directly from the sympathetic ganglia to the cardiac plexuses via thoracic cardiac nerves, and ...

2) The preganglionic sympathetic fibers ascend through the sympathetic chain and synapse in either the superior, middle, or inferior cervical ganglia before sending off postganglionic sympathetic fibers via cervical cardiac nerves to the cardiac plexuses.

Both sympathetic and parasympathetic fibers carry visceral sensory fibers from the heart to the spinal cord and brain, respectively. However, the visceral sensory fibers within the cardiac branches from the cervical and superior five thoracic sympathetic ganglia are sensitive to ischemia (tissue damage due to lack of oxygen). These sensory fibers mediate the visceral pain associated with angina pectoris and myocardial infarctions. Such myocardial ischemic pain is often referred to regions of the T1-T5 dermatomes simply because the visceral sensory fibers enter the spinal cord at the same levels of the segments for the superior five thoracic spinal nerves. The brain may have difficulty differentiation between sensory input from the spinal nerves or from the visceral nerves and thus refer ischemic pain to the same dermatome.

Sympathetic innervation increases heart rate and force of contraction of the heart, and dilates the coronary arteries (Gray’s Anatomy 38th Edition).

Parasympathetic Innervation of the Heart

Preganglionic parasympathetic fibers in the left and right vagus nerves originate in the medulla oblongata and descend through the neck into the thorax to the cardiac plexuses. The synapse of vagal pre- and postganglionic parasympathetic fibers occurs either in the cardiac plexus or in the walls of the heart near the sinoatrial node of the right atrium. Therefore, the cardiac plexus serves as a conduit for not only parasympathetic pre- and postganglionic and visceral sensory fibers but also sympathetic postganglionic fibers.

Parasympathetic innervation decreases heart rate and force of contraction of the heart, constricts the coronary arteries.

In summary, mixed nerves from the cardiac plexus supply the heart with sympathetic fibers, which increase the heart rate and the force contraction and cause dilation of the coronary arteries and parasympathetic fibers, which decrease heart rate, reduce force of contraction, and constrict coronary arteries.
7) Conductive pathway of the heart
a) Describe the nerve conduction pathway of the heart (SA and AV nodes, bundle of His, Perkinje fibers)

The autonomic branches from the cardiac plexus help to regulate the rate and force of heart contractions through influencing the sinoatrial and atrioventricular nodes as follows:

1) Sinoatrial (SA) node: The rhythm of the heart is normally controlled by the sinoatrial node, a group of automatically depolarizing, specialized cardiac muscle cells located at the superior end of the crista terminalis, where the right atrium meets the superior vena cava. The sinoatrial node is considered the “pace-maker” of the heart and initiates the heartbeat, which can be altered by autonomic nervous stimulation (sympathetic stimulation speeds it up whereas vagal stimulation slows it down). The wave of depolarization sweeps down the walls of the atria, stimulating them to contract, and eventually reaches the AV node.

2) Atrioventricular (AV) node: The AV node is located in the interatrial septum just superior to the opening of the coronary sinus. The AV node receives impulses from the SA node, passing them to the atrioventricular bundle (of His).

3) Atrioventricular bundle (of His) – The atrioventricular bundle begins at the AV node and descends through the fibrous skeleton of the heart before dividing into the left and right bundles (of His), corresponding to the left and right ventricles. This divergent pathway ensures that ventricular contraction begins in the region of the apex. Conduction ends near the aortic and pulmonic valves, respectively. Impulses also pass from the left and right bundle branches to the papillary muscles in the corresponding ventricles. In the right ventricle, the moderator band (septomarginal trabeculum) contains the right bundle branch.
8) Blood flow

a) Using the following three images, trace pathway of blood as it travels through the chambers and vessels of the heart to and from the myocardium, lungs and pectoralis major muscle.
At the end of this lecture, students should be able to master the following:

1) Mediastina Overview

a) Identify the boundaries and anatomical contents of the mediastina

The mediastinum is the anatomic region medial to the pleural sacs, between the sternum, vertebral column, first rib, and diaphragm. The mediastinum is further divided into inferior and superior parts by a plane passing from the sternal angle to the T4-T5 intervertebral disc. The inferior mediastinum is classically subdivided into anterior, middle, and posterior parts. Therefore, the four sub-regions of the mediastinum are as follows:

· Anterior mediastinum – The region between the sternal angle, deep sternal surface, the pericardial sac and the diaphragm. The anterior mediastinum contains fat and areolar tissue and the inferior part of the thymus or its remnant. This region will not be discussed further in the text.

· Middle mediastinum – This region contains the pericardial sac and heart, and was discussed in detail in the heart chapter.

· Posterior mediastinum – The region containing anatomic structures deep to the pericardial sac, including the thoracic portion of the descending aorta, the azygos system of veins, the thoracic duct, esophagus, and vagus and sympathetic nerves. This chapter will focus on the structures located in the posterior mediastinum and their projection into the superior mediastinum.

· Superior mediastinum – The region superior to the sternal angle and contains the aortic arch and its three branches, the superior vena cava and brachiocephalic veins, the trachea, esophagus, the phrenic and vagus nerves. The superior mediastinum also contains the thymus but it is usually atrophied in the adult and presents as a fatty mass.
2) Superior mediastinum

a) Thymus
   i) Describe the location, function, and age related changes of the thymus

b) Vasculature of the superior mediastinum
   i) Aortic arch- courses superiorly, posteriorly, the inferiorly at the level of the manubrium (vertebral levels T4 and T5); arches over the pulmonary arteries and left primary bronchus
      (1) Describe the origin, course and distribution of the branches of the aortic arch
         a) Ligamentum arteriosum- remnant of the fetal ductus arteriosus; runs from inferior surface of the aortic arch to the left pulmonary vein
         b) Brachiocephalic trunk- (first branch) ascends to the right; bifurcates into the right common carotid and right subclavian arteries
         c) Left common carotid artery- (second branch) travels along the left side of the trachea to the neck
         d) Left subclavian artery- (third branch) ascends to the left towards the left arm
   ii) Veins of the superior mediastinum
      (1) Describe the origin, course, and destination of the following veins of the superior mediastinum
         a) Brachiocephalic veins- formed by the union of the internal jugular and subclavian veins; receives blood from the arms, head and neck as well as lymph from the right and thoracic lymphatic ducts
         i) Left superior intercostal vein- drains the left second and third intercostal veins and sometimes the left fourth posterior intercostal vein, bronchial veins, and pericardiophrenic veins; courses over the aortic arch to empty into the left brachiocephalic vein
         b) Superior vena cava- formed by the combined brachiocephalic veins; drains blood from all regions above the diaphragm except the heart into the right atrium
c) Nerves of the superior mediastinum
   i) Vagus nerve (CN X)- supplies parasympathetic innervation to most of the body
      (1) Describe the general course and distribution of the vagus nerves
      (a) Recurrent laryngeal nerves- describe the topographical differences between the right and left recurrent laryngeal nerves
   ii) Phrenic nerve (C3-5)- supplies the diaphragm
      (1) Describe the general course of the phrenic nerves through the superior mediastinum
3) Posterior mediastinum

a) Nerves of the posterior mediastinum
i) Thoracic sympathetic trunks
   (1) Describe the location, relations, and nerve fiber contents of the sympathetic trunks
   (2) Lower thoracic splanchnic nerves- supply sympathetic innervation to the abdomen
      (a) Describe the spinal level contributions, course, and destination of the lower thoracic splanchnic nerves
         (i) Greater splanchnic nerve- (T5-T9) carries preganglionic sympathetic fibers to the celiac ganglion
         (ii) Lesser splanchnic nerve- (T10-T11) carries preganglionic sympathetic fibers to the superior mesenteric ganglion
         (iii) Least splanchnic nerve- (T12) carries preganglionic sympathetic fibers to the aorticorenal ganglion
b) Vasculature of the posterior mediastinum

i) Veins and lymphatics of the posterior mediastinum

(1) Describe the origin, course, and destination of the major veins and lymphatic vessels of the posterior mediastinum

(a) Thoracic lymphatic duct- originates at the cisterna chilis; ascends along the vertebral column, empties into the junction of the left internal jugular and subclavian veins
(b) Azygos vein- ascends along the right side of the vertebral column forming a collateral circuit between the superior and inferior vena cavae; drains the back and thoracoabdominal walls through the right ascending lumbar and posterior intercostal veins; also receives drainage from the mediastinal, esophageal, bronchial, hemiazygos, and accessory hemiazygos veins; drains into the superior vena cava
(c) Hemiazygos vein- ascends along the left side of the vertebral column, crosses at T9 to drain onto the azygos vein; receives drainages from left ascending lumbar, the three inferior posterior intercostal, inferior esophageal, and mediastinal veins
(d) Accessory hemiazygos vein- crosses over T7 and 8 from the left side of the vertebral column to join the azygos vein; drain the left 4-8 posterior intercostal veins
ii) Thoracic aorta- descends through the thorax at first to the left of the spine, then become more midline as it perforates the diaphragm at T12

1) Describe the origin, course, and distribution of the branches of the thoracic aorta
   a) Bronchial branches- supply the trachea, bronchi, and lymph nodes
   b) Pericardial branches- supply the posterior pericardium
   c) Posterior intercostal branches- course in lower nine intercostal spaces; supply body wall muscles and skin
   d) Superior phrenic branches- branch from lower region; supply superior surface of the diaphragm; anastamose with the musculophrenic and pericardiophrenic arteries
   e) Esophageal branches- supply the esophagus; anastamose with left inferior phrenic and left gastric branches
   f) Subcostal branches- lowest branches of the thoracic aorta; course interior to the twelfth rib