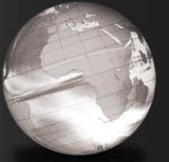


GLOBAL
EDITION



Human Anatomy & Physiology

Erin C. Amerman

ALWAYS LEARNING

PEARSON

Quick Reference

CORE PRINCIPLES in A&P

referenced throughout this book

In Chapter 1, Amerman introduces **four core principles** and highlights them throughout the book to remind you of the overall theme of human anatomy and physiology – homeostasis – and the core principles that revolve around maintaining it.



Feedback loops are homeostatic control mechanisms in which a change in a regulated variable causes effects that *feed back* and in turn affect that same variable.



The form of a structure best suits its function.



A gradient is present any time more of something exists in one area than in another and the two areas are connected.



Cells in the body generally communicate via electrical signals or chemical messengers to coordinate functions in the body.

phag/o-, eat: *autophagy* = self eating; condition of a cell digesting itself
pharyng/o-, throat: *glossopharyngeal* = pertaining to the tongue and throat
phleb/o-, vein: *phlebotomy* = incision into a vein
phot/o-, light: *photophobia* = fear or dislike of light
phys/i-, function: *pathophysiology* = study of the altered physiology of disease states
pin/o-, drink: *pinocytosis* = condition of cell drinking
plex/u-, network, twisted: *nerve plexus* = network of nerves
pneum/o-, **pneumat/o-**, air, breath: *pneumothorax* = air in the thoracic cavity
pneumon/o-, lung: *pneumonitis* = inflammation of the lung
pod/o-, foot: *podiatrist* = medical specialist of the foot and ankle
proct/o-, rectum: *proctoscope* = instrument used to examine the rectum
pseud/o-, false: *pseudoanemia* = pallor of mucous membranes and skin without other signs of true anemia

psych/i-, mind: *psychopathology* = study of diseases of the mind
pulmon/o, lung: *intrapulmonary* = within the lung
pyel/o-, pelvis: *pyelonephritis* = inflammation of the renal pelvis
py/o-, pus: *pyoderma* = condition causing pus to form in the skin
pyr/o-, fire: *pyrolysis* = breakdown of a chemical by elevated temperature
ren/i-, kidney: *adrenal* = pertaining to an area next to the kidney
rhin/o-, nose: *rhinorrhea* = drainage from the nose
sarc/o-, flesh, soft tissue: *sarcolemmal* = pertaining to the outer covering of a muscle fiber (the plasma membrane)
scler/o-, hard: *scleroderma* = hardening of the skin
sigm/o-, S-shaped: *sigmoidoscopy* = examination of the S-shaped portion of the colon
sin/u-, cavity: *sinusoid* = resembling a sinus or cavity
son/o-, sound: *sonogram* = data recorded using sound waves

spir/o-, breathe: *spirometry* = measurement of breathing
stat/i-, to stop, standing still: *hydrostatic* = pertaining to fluids not in motion
systol/i-, contract, standing together: *systolic pressure* = blood pressure during the heart's contraction
therm/o-, temperature: *thermogenesis* = generation of heat
thromb/o-, clot: *thrombosis* = abnormal condition of a blood clot
tom/o-, cut, slice: *dermatome* = instrument that takes slices of skin
tox/o-, poison, toxin: *neurotoxin* = toxin causing damage to the nervous system
tympan/o-, drum: *tympanoplasty* = reconstruction of the eardrum
urin/o, urine: *oliguria* = production of little urine
vas/o-, **vascul/o**, vessel: *extravascular* = outside a blood vessel
vesic/o-, **vesicul/o-**, bladder, small sac: *vesiculotomy* = surgical incision of the seminal vesicle
viscer/o-, organ: *visceral* = pertaining to an organ
vit/a-, life: *vital* = pertaining to life

Quick Reference

CORE PRINCIPLES in A&P
referenced throughout this book

In Chapter 1, Amerman introduces **four core principles** and highlights them throughout the book to remind you of the overall theme of human anatomy and physiology – homeostasis – and the core principles that revolve around maintaining it.



CORE PRINCIPLE
Feedback Loops

Feedback loops are homeostatic control mechanisms in which a change in a regulated variable causes effects that *feed back* and in turn affect that same variable.



CORE PRINCIPLE
Structure-Function

The form of a structure best suits its function.



CORE PRINCIPLE
Gradients

A gradient is present any time more of something exists in one area than in another and the two areas are connected.



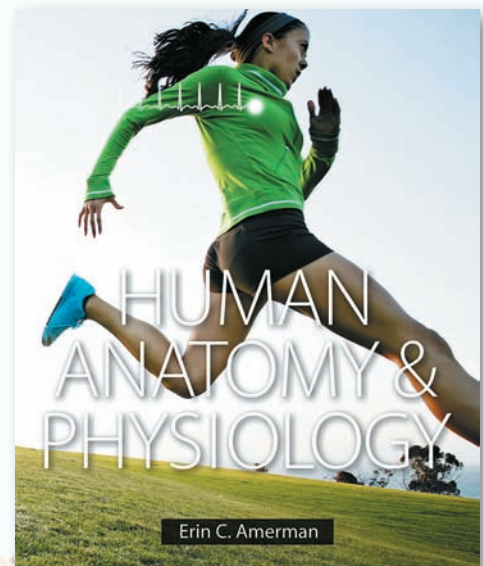
CORE PRINCIPLE
Cell-Cell Communication

Cells in the body generally communicate via electrical signals or chemical messengers to coordinate functions in the body.

Amerman is with you every step of the way

Three key tools to help you succeed in A&P

1



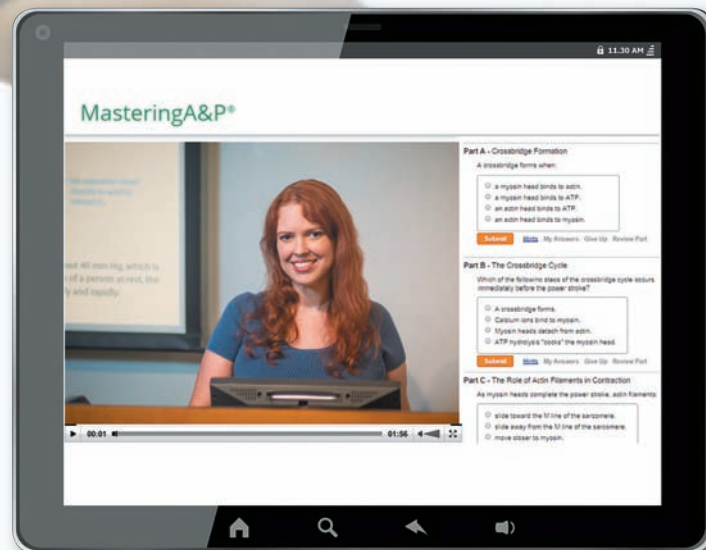
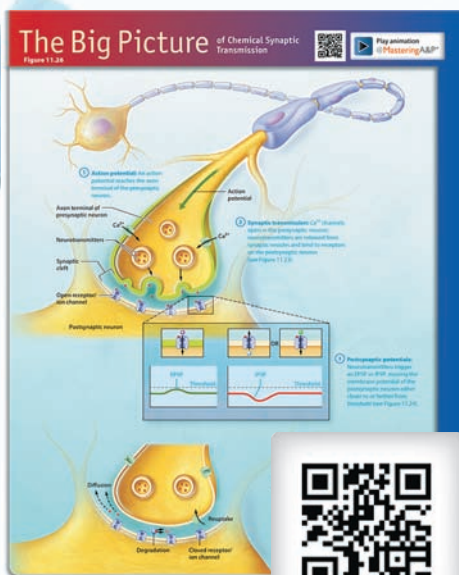
Amerman text

- Read textbook explanations you can understand.
- Study figures that help you focus on **one-concept-at-a-time**.
- Get coaching on the tough topics via **Concept Boosts**.



2

3



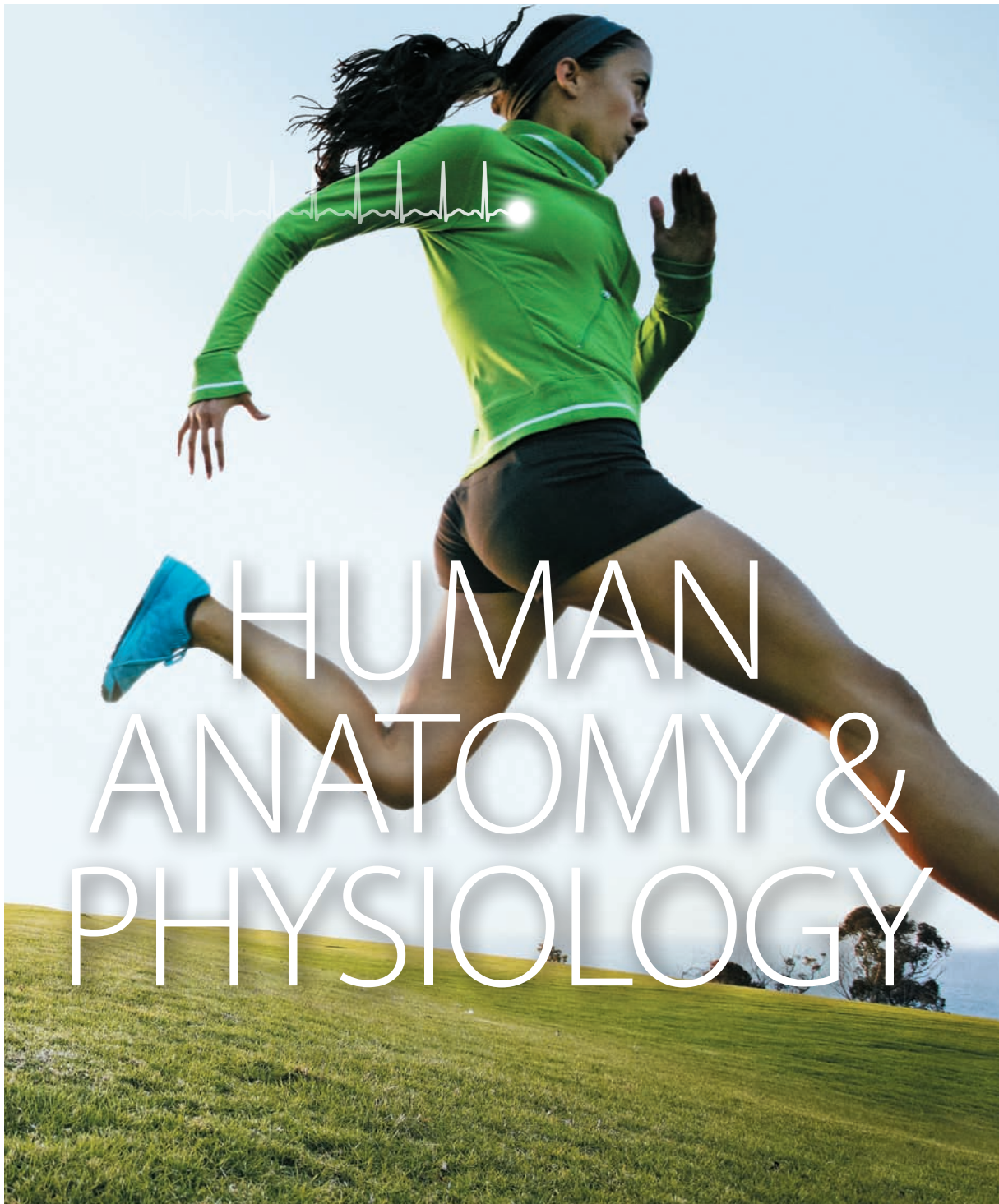
Big Picture figures with Animations

- Scan the QR code and watch **Big Picture figures** come alive as Amerman narrates physiological events. With these **mobile-ready Big Picture Animations**, you can study A&P on-the-go, anywhere, any time.
- Play with interactive quizzes for each animation, where you can draw, predict, apply and more.

If you don't have a QR code reader on your smart phone, go to your phone's app store and download one of the free QR reader apps.

MasteringA&P®

- Access **MasteringA&P** assignments for Concept Boost Video Tutors and Big Picture Animations, Practice Quizzes, *Practicing A&P: Active-Learning Worksheets*, **NEW!** Interactive Physiology 2.0, and more.



Erin C. Amerman

Florida State College at Jacksonville

PEARSON

*This book is dedicated to Elise, Chris, my mom,
and all of my students—past, present, and future.*
—Erin Amerman

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Erin C. Amerman

Erin Amerman teaches anatomy and physiology at Florida State College at Jacksonville; she has been involved in anatomy and physiology education for more than 14 years as an author and professor. She received a B.S. in cellular and molecular biology from the University of West Florida and a doctorate in podiatric medicine from Des Moines University. She is also the author of the best-selling *Exploring Anatomy and Physiology in the Laboratory*, now in its second edition, with Morton Publishing Company. Erin is deeply committed to helping her students succeed in the A&P course and to generating curiosity and excitement about the material and its application in their future health careers. She is a member of the Human Anatomy and Physiology Society (HAPS) and enjoys attending the annual HAPS conferences, especially when they are in locations that have ample hiking opportunities and many different species of snake.

When not writing or teaching, Erin enjoys spending time with her family and her menagerie of rescued cats, dogs, pet rats, snakes, tetras, and a turtle. She also practices karate and kobudo (she recently earned her second black belt) and loves photographing the local wildlife around her home in rural northern Florida. She can often be found hiking around the prairie with a camera and snake hook in hand.



Virginia Irintcheva

Media Author

Virginia Irintcheva is the author of the Big Picture Animations and interactive figures and assessments in MasteringA&P®. She also served as an editorial advisor and reviewer of key concepts in this book. She is an associate professor at Black Hawk College in Moline, Illinois, where she has been teaching courses in anatomy and physiology, medical terminology, and biology for more than 8 years. Virginia was born and raised in Bulgaria. She earned a B.S. in biology and Spanish from St. Louis University, under whose auspices she studied in Madrid, Spain, as well as in Missouri. She received her Ph.D. in pharmacological and physiological sciences in 2006 from that school. Her primary research interests are cell signaling and, specifically, the effects of the coagulation protein thrombin and the family of Ras proteins on cell growth and proliferation. As a teacher, her fundamental goal is to create an environment of effective communication by promoting mutual respect and successful learning. Virginia strives to teach her students not only what to learn but also how to learn and why they are learning.

Outside the classroom, Virginia likes to travel, visit family in Europe, snowboard, hike with her dog, and ride her horse.

Preface

To the Student

Welcome to the fascinating study of the human body! Though you and I might never meet in person, I consider you and every other student who uses this textbook to be “my” student. Just as I want to ensure the success of the students in my classroom, I am similarly invested in your success. For this reason, this book was designed with *you* in mind—every feature, study tool, and media presentation is intended to help you achieve your goals.

This book was written not only for you, but also *about* you. The great thing about human A&P is that no matter what your goals are, it is relevant to your life. Human A&P is you; it’s also me, your family, your friends, and indeed every human who ever lived or will live. There’s nothing in the study of A&P that is irrelevant or esoteric, because every single detail revolves around you and your life. How many other courses can make that claim?

So dive right in and begin to explore the science of you. I sincerely hope that you enjoy your study of human A&P and find it as fascinating and wondrous as I do.

—Dr. Amerman
erin.amerman2014@gmail.com

To the Instructor

Why a New A&P Textbook?

I get the question “Why did you write this book?” quite regularly. The short answer to this is that writing and teaching are just in my DNA somewhere. For the long answer, we have to look back in time and start with my 5-year-old self.

When I was in kindergarten, I was placed with another kid, Kyle, into a separate group for reading time because we were the only two kids in the class who could already read. It struck my 5-year-old brain as inconceivable that so many of my classmates couldn’t read. Reading was so *easy*; anyone could do it! Maybe, I reasoned, they just needed a book to teach them how to read. So I gathered up some construction paper and crayons and got to writing. And thus my first “textbook” was born: *The Bird and Mr. Bear*.

Fast forward a few years to my medical school education. While in medical school, I co-taught a human physiology course, and during my first class I had one of those “aha” moments: Teaching somehow just “felt right.” I connected with my students, and they connected with me. This feeling only grew over the next two semesters. But still, I was in medical school, and who would be crazy enough to go through the pain of medical school, graduate, and then not ever practice as a physician?

Well, it turns out that *I* was crazy enough to do just that. I was lucky enough to find a full-time position teaching anatomy and physiology. And while I loved teaching, there were far more challenges than I had anticipated. My students were different

from my former classmates. The difference wasn’t in intelligence—my students were smart. But, this new generation of students seemed to be ill-prepared for the rigors of a college science course. They lacked study skills, they had little to no background in science, and—alarming— they couldn’t read or understand their textbooks. For these reasons, so many bright, motivated students struggled with the course.

As a teacher, this was the last thing I wanted to see. So I did the same thing I did in kindergarten: grabbed some paper and started writing. First came my own lab exercises, which were followed by lecture outlines and notes. As I wrote, I “Amermanized” the content (a term coined by a student) with concise prose, simple diagrams, stories/analogies, and active learning exercises. My students’ responses were enthusiastic; indeed, many asked if they could return their textbooks and just use my notes instead.

A vision for a new textbook began to form in my mind: one for today’s students. It would:

- be written at a level my students could understand and, at the same time, still provide the information they need;
- anticipate where they need help with the science and provide the necessary in-the-moment coaching; and
- reduce cognitive overload and present information—in both text and art—in manageable chunks that are more easily digestible.

Eight years later, my vision finally became reality with the publication of *Human Anatomy & Physiology*. I am thrilled to be able to offer this text and its ancillary materials and I sincerely hope it has a positive impact on students’ lives and education. This is what I have wanted since *The Bird and Mr. Bear*—to help people learn.

Key Features

Many of the key features found in this textbook, the companion workbook, and media came directly from my experience teaching and working with a range of students and seeing what helps them learn. These features include the following:

- **How to Succeed in A&P** in Chapter 1 introduces students to core study skills, including how to manage time, how to take notes, and how to study for an A&P exam. I also guide students through how to use the textbook, workbook, and online tools.
- Recurring **Core Principles** icons appear throughout the book and remind students to recall and apply four core principles introduced in Chapter 1: Structure-Function, Feedback Loops, Gradients, and Cell-Cell Communication.
- Over 50 **Concept Boosts** and **Study Boosts** coach students on key A&P concepts that are often difficult or tricky. Additional emphasis is placed on explaining challenging topics, often incorporating familiar analogies and simple illustrations, giving students a boost in fully understanding the content.
- **Concept Boost Video Tutors** walk students through selected Concept Boost topics that are particularly tough to understand.

These Video Tutors are assignable in MasteringA&P® and are also available in the Study Area of MasteringA&P.

- **One-concept-at-a-time art** focuses on teaching one concept per figure so that a student can instantly grasp the key idea without being distracted by a sea of details. For key physiology concepts, unique sequence figures unpack information systematically so that each scene contains only the most important information, again making it easier for today's students to focus on key details.
- **In-the-moment visual reminders** of key foundational science concepts appear as needed to help students recall and apply given concepts.
- **Big Picture figures** visually summarize key physiological processes and anatomy concepts, highlighting only what is most important.
- Mobile-ready **Big Picture Animations** with interactive quizzes bring the Big Picture figures to life and help reinforce students' understanding of each step in a key process. These animations are assignable in MasteringA&P and are also available in the Study Area of MasteringA&P.
- **HAPS-based Learning Outcomes** begin each module within a chapter. Additionally, the assessments in MasteringA&P are organized by these Learning Outcomes.
- **Pronunciations** use phonetic sounds (instead of traditional symbols) to help students learn correct pronunciations.
- **Flashback** questions encourage students to think about previously learned concepts they will need to apply in order to understand upcoming discussions.
- **Quick Check** questions appear throughout each module to test students' basic understanding of the material. Answers to Quick Check questions are available in the Study Area of MasteringA&P.
- **Apply What You Learned** questions at the end of each module ask students to think critically and apply what they've just learned to a real-world scenario.
- **A&P in the Real World** features highlight clinical conditions and disorders that illustrate and reinforce key A&P concepts discussed in the chapter.
- **Chapter running case studies** with assessments challenge students to apply their knowledge of key A&P concepts to a real-world clinical scenario, while allowing instructors to “flip” the classroom and incorporate critical thinking and/or group activities. These cases can be found in the Instructor's Guide in MasteringA&P and are also assignable in MasteringA&P.
- **Practicing A&P: Active-Learning Workbook** helps engage the kinesthetic learner with labeling, drawing, and build-your-own summary-table exercises that students can complete as they read the textbook. This workbook is available as downloadable PDF worksheets in the Study Area of MasteringA&P.

The Development Story

Making this book, including the text, the art, and the media, was an intensive, collaborative process. Each draft of the manuscript was sent to A&P instructors and other content experts to evaluate the breadth, depth, and accuracy of coverage; the art program; and the overall pedagogical effectiveness. Our team

worked closely together to analyze the feedback and determine which changes were necessary to improve each chapter. Each subsequent draft took into account the reviewers' feedback to make sure that we identified the key challenging concepts that students struggle with and that we included a way to help students better understand those concepts (such as giving them closer attention via a Concept Boost, or “unpacking” a complex topic gradually over a series of well-paced figures).

Accuracy and Currency

During the production process, when art was rendered and each book page was laid out, we went through another extensive reviewing process to ensure that accuracy and clarity were maintained in all materials. We also reviewed the pages with various focus groups to be certain that the final presentation delivers an effective, reader-friendly experience for students and instructors alike.

One of our goals was ensuring that this book is not only accurate but also as up-to-date as possible. Key topics throughout the book were researched, and in some cases we updated our presentation to reflect current understanding. Examples include up-to-date discussions of endocytosis and calcium homeostasis, of new evidence suggesting that PTH is the main regulatory hormone in humans and calcitonin is not as relevant as we once thought, of learning and memory in the central nervous system chapter, and of increased public health concern about children not being vaccinated because parents believe vaccines are linked to autism.

Class-Tested and Approved

Anatomy and physiology students across the country also contributed to the development of *Human Anatomy & Physiology*. Over 4000 students provided feedback through extensive class testing prior to publication. We asked students to use the chapters in place of, or alongside, their current A&P textbook during their course. We then asked them to evaluate numerous aspects of the text, including how clear and understandable the writing style is, how well it explains and coaches on difficult topics, whether the text helps them see the “big picture” of key physiology processes and anatomy concepts, whether the figures are easier to read and understand, and how well the Big Picture Animations help them to visualize and grasp physiology topics. Through these student reviews, the strengths of *Human Anatomy & Physiology* were put to the test, and it passed. Overwhelmingly, the majority of the students who class tested it would prefer to use this textbook over their current textbook.

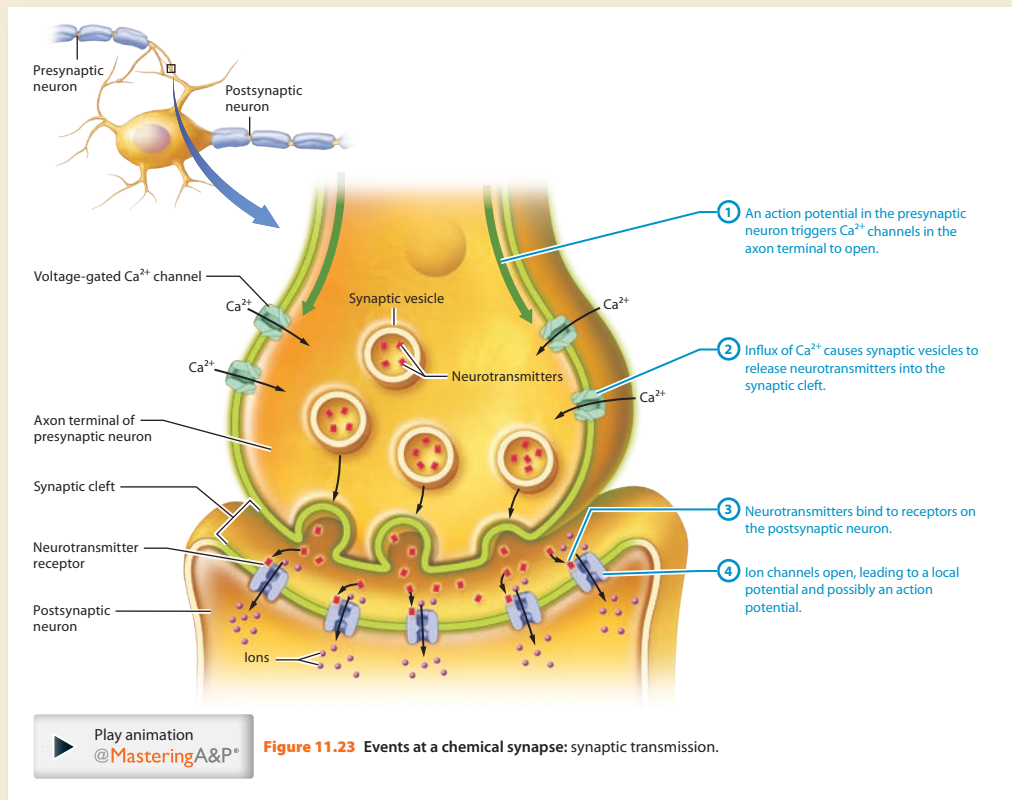
In addition, our market development team interviewed over 75 A&P instructors, gathering feedback on how well the text builds conceptual understanding, how well the author coaching helps demystify tough or tricky concepts, and how well the *A&P in the Real World* boxes illustrate key concepts and cover key clinical topics. Instructors also reported on the accuracy and depth of the content overall. All comments, suggestions, and corrections were analyzed and addressed by the author and editorial team prior to publication.

Are your students overwhelmed by the amount of information in the course?

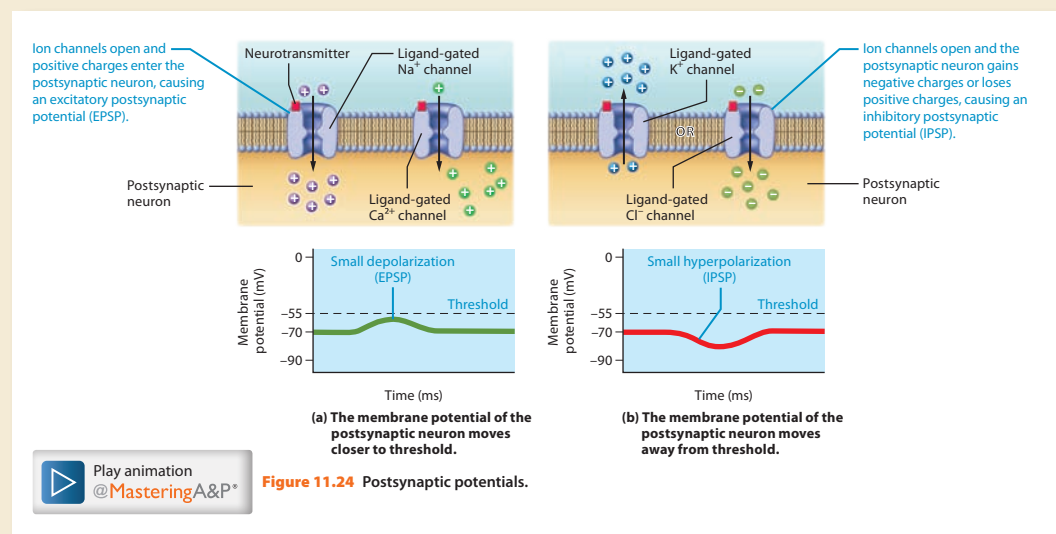
One-concept-at-a-time art

Drawing from her experience in the classroom and the latest research in cognitive science, Amerman reduces cognitive overload by visually unpacking key information using one-concept-at-a-time art and Big Picture figure visual summaries.

This figure shows the first concept: how synaptic transmission occurs at a chemical synapse.



This figure shows the second concept: how postsynaptic potentials are triggered.



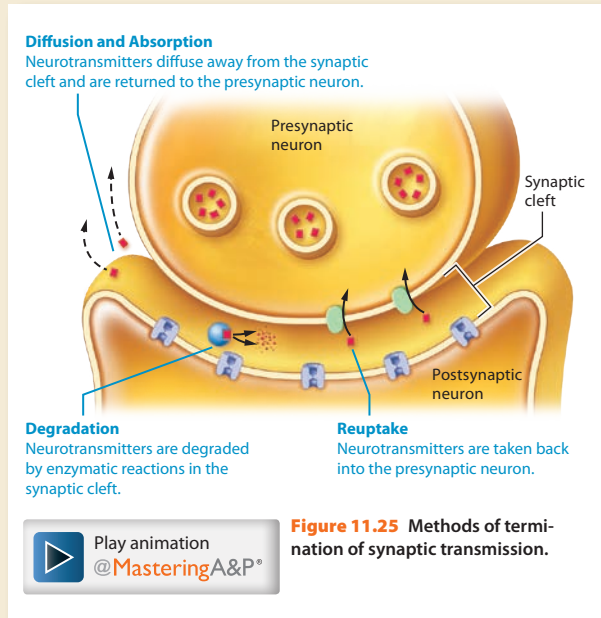
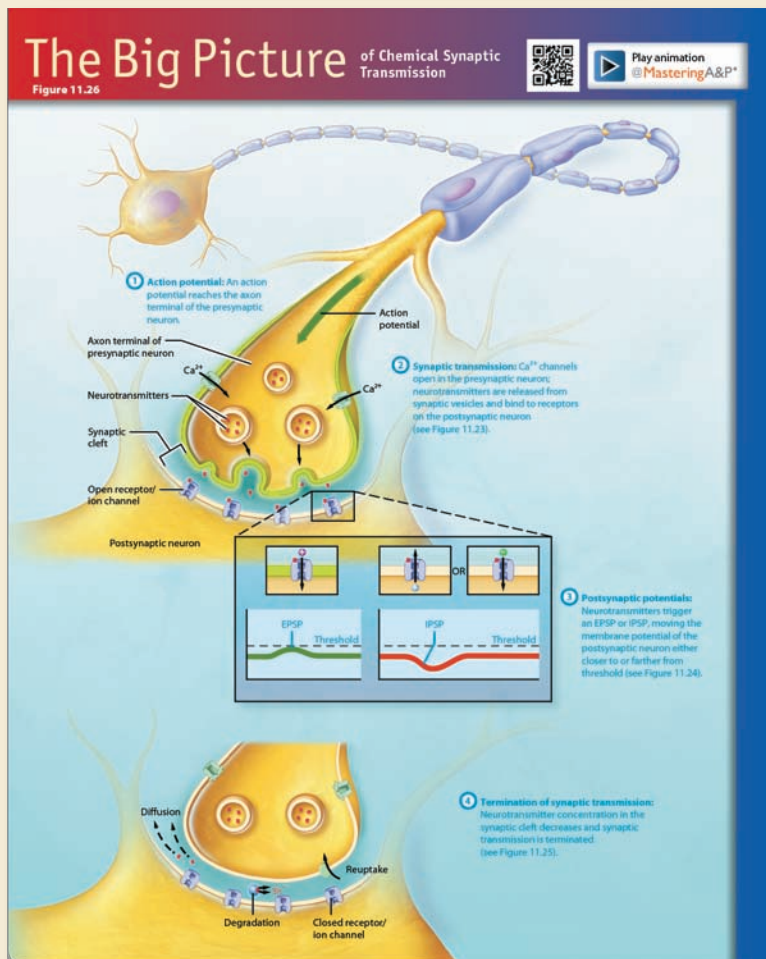


Figure 11.25 Methods of termination of synaptic transmission.

The next figure shows the third concept: how synaptic transmission is terminated.

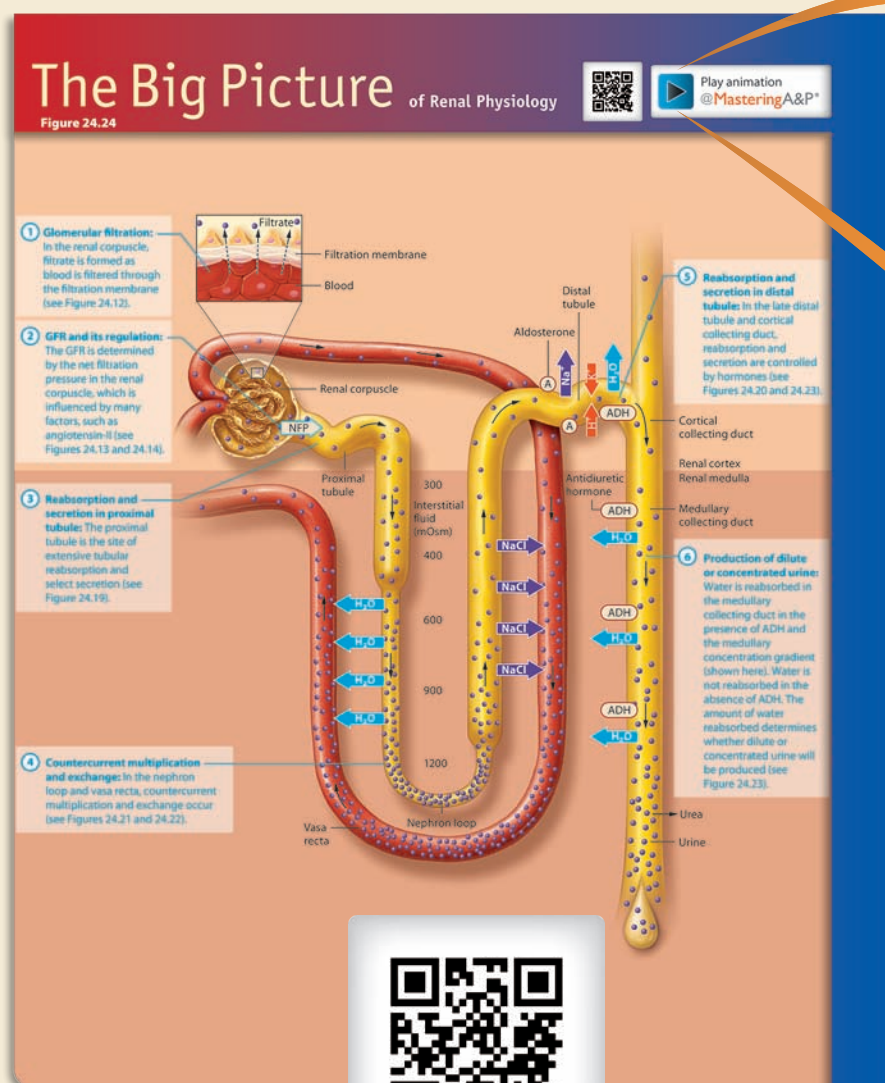


The Big Picture figure summarizes the key events of chemical synaptic transmission.

Would your students benefit from another mode of learning A&P concepts?

Big Picture Animations

With Amerman's mobile-ready Big Picture Animations, students can study and review A&P topics anywhere, any time. These animations help students visualize events occurring at the molecular level and reflect the same terminology and explanations found in the Amerman textbook to ensure a consistent learning experience. Each animation is narrated by Amerman and includes interactive quizzes with instant feedback. These animations are also assignable in MasteringA&P® and are available in the Study Area of MasteringA&P.

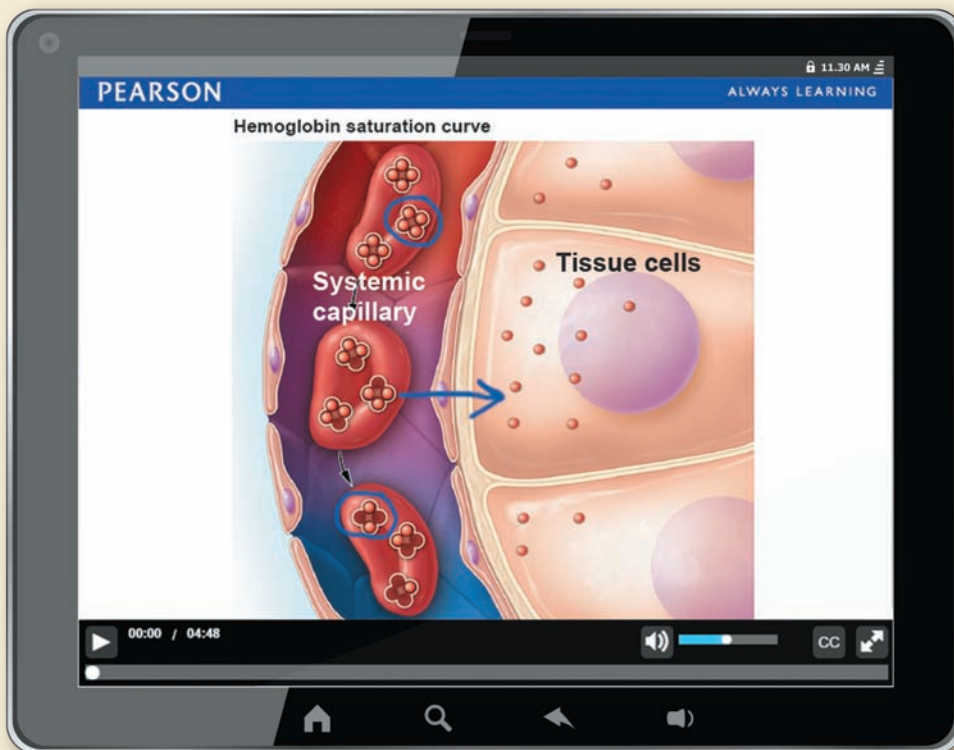


Scan to watch Figure 24.24.



Concept Boost Video Tutors

Students get just-in-time coaching on-the-go with Amerman's mobile-ready Concept Boost Video Tutors. Select Video Tutors feature the author talking directly to students and coaching them through tough-to-understand or tricky topics. These Video Tutors are assignable in MasteringA&P® and are also available in the Study Area of Mastering A&P.



"The Big Picture Animations are AWESOME! I truly love the way they are presented—plus, the quizzes that follow are sure to engage my students and give them the immediate feedback they expect."

—William Huber, St. Louis Community College at Forest Park

Are there concepts you know in advance your students will struggle with?

Concept Boosts

In her classroom, Amerman gives her students extra coaching in advance of those tough-to-understand concepts, *right when they need it*, and she has built that same strategy into her textbook. She anticipates where students will need extra help and then provides just-in-time coaching via Concept Boosts. Each Concept Boost focuses on tough-to-understand or tricky concepts.

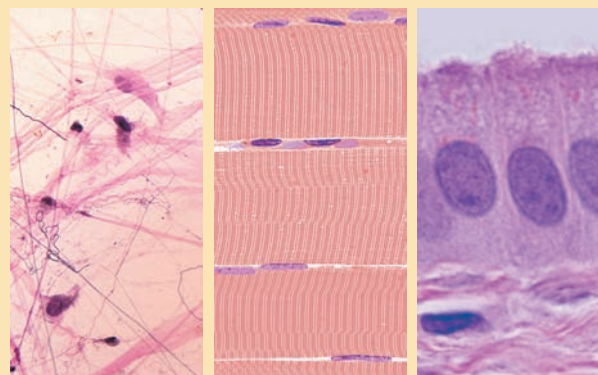
Amerman is first and foremost a great teacher and it shows. She anticipates where students get tripped up and provides the extra help. Her writing style is simple and straight to the point. She writes much like how an instructor teaches a lecture, which I love.

—Richard Gonzalez Diaz, Seminole State

ConceptBOOST >>>

“But It All Looks Pink!” Part 2

In Part 1 of this Concept Boost, we discussed how to orient yourself to the different components of a tissue section. Now we’ll take it a step further and identify the tissue from which a section was taken. Let’s try it with these examples:



Example A

Example B

Example C

This isn’t as difficult as it appears, particularly if you use a methodical, step-by-step approach:

1. **Identify the cells and the ECM.** Start with the basics you were given in the first part of this Concept Boost (on p. 128) and label the cells you see in Examples A, B, and C. Now move on to the ECM. Remember, the ECM consists only of ground substance and protein fibers. The ground substance will generally stain a uniform color (or simply appear clear). The protein fibers can take on various forms in different tissues, but they will generally stain darker than the ground substance, and they will always lack nuclei. Identify the protein fibers and ground substance in Examples A, B, and C.
2. **Notice how the cells are shaped and arranged.** Are the cells packed tightly together, or are they widely spaced? Do they form a continuous sheet, as in epithelial tissue—or do they seem to be surrounded by ECM, as in connective tissue? Are the cells all identical, or are there clearly different types? Do the cells have “arms” extending from a central body? Explain how the cells are shaped and arranged in Examples A, B, and C.
3. **Notice how the ECM is arranged.** Is the ECM confined to one specific part of the tissue, or is it spaced evenly between the cells? Does ground substance predominate, or are protein fibers the main elements? What types of protein fibers can you see? Explain how the ECM is arranged in Examples A, B and C.
4. **Determine the class of tissue.** Using your analysis in the preceding steps, now you are ready to identify the class of tissue. Determine the type of tissue in Examples A, B, and C. ■

Answers: A: loose connective tissue, B: skeletal muscle tissue, C: simple columnar epithelium

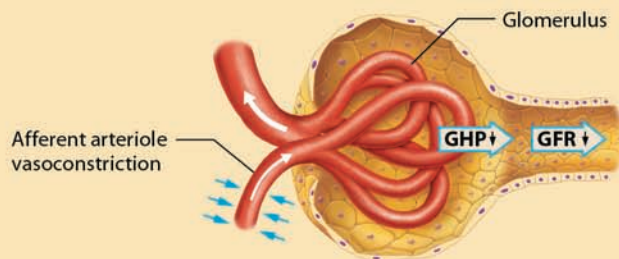
ConceptBOOST >>>

How Changes in Arteriolar Diameter Influence the GFR

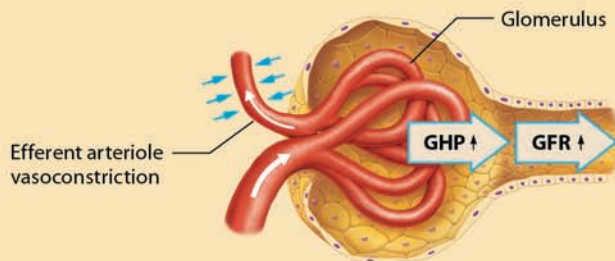
As we discussed earlier, filtration will occur only when a net pressure gradient in the glomerulus drives fluid out of the blood and into the capsular space. The size of this gradient determines how much filtration takes place—a small gradient will lead to only minimal filtration, whereas a large gradient leads to heavy filtration. Several factors determine the size of the pressure gradient in the glomerulus, but one of the most easily adjustable factors is the diameter of the afferent (entering) and efferent (leaving) arterioles. When either arteriole constricts or dilates, this changes the glomerular hydrostatic pressure (GHP), and therefore the entire net pressure gradient also changes.

You can think of blood flowing in and out of the glomerulus as being similar to water flowing in and out of a sink, where the afferent arteriole is the faucet, the basin is the glomerulus, and the efferent arteriole is the drainpipe. Keep this analogy in mind as we explore how this mechanism works:

- Vasoconstriction of the afferent arteriole “turns down the faucet.” This allows less blood to flow into the glomerulus, which decreases the GHP and the GFR:

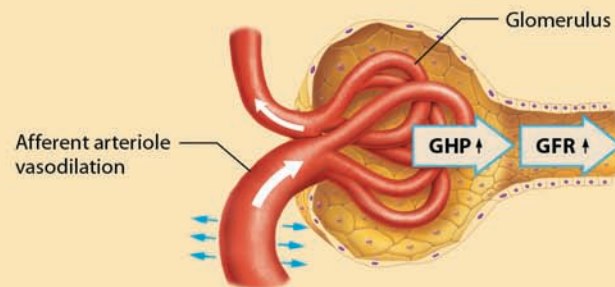


- Vasoconstriction of the efferent arteriole “clogs the drain.” This causes blood to back up within the glomerulus, which increases the GHP and thus increases the GFR:

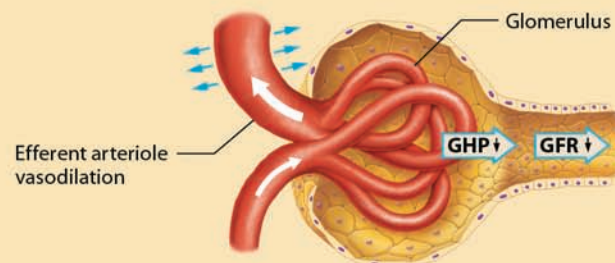


Vasodilation has the opposite effects:

- Vasodilation of the afferent arteriole “turns up the faucet.” This increases the GHP and the GFR:



- Vasodilation of the efferent arteriole “unclogs the drain,” allowing increased flow out of the glomerulus. This decreases the GHP and the GFR:



In the upcoming sections, you'll see that the main mechanisms the body uses to control or maintain GFR work by causing one or more of these physical changes. ■

Are your students prepared for the rigor of A&P?

MyReadinessTest™

MyReadinessTest for A&P prepares students *before* their A&P course begins.

Students can get free online access the moment they register for your A&P course. MyReadinessTest assesses students' proficiency in study skills and foundation concepts in science and math, and tutors them in core areas where they need additional practice and review, before they even set foot in an A&P classroom. It offers:

- **Student online access** upon registration for their A&P course
- **Diagnostic Test and Cumulative Test** based on learning outcomes from a widely used primer, *Get Ready for A&P* by Lori Garrett
- **Personalized Study Plan** based on students' test results that includes practice questions with tutorials
- **Flexible Testing** that allows instructors to edit the Diagnostic Test or implement their own placement test or exit exam
- **Gradebook** that automatically records students' results

The image displays two overlapping screenshots from the MyReadinessTest platform. The top screenshot shows a test interface for '4.1 Basic Chemistry' with the objective: 'Differentiate between ionic, covalent, and hydrogen bonding.' A question asks, 'During chemical bonding, which specific subatomic particles form the bond?' with three multiple-choice options: A. protons, B. neutrons, and C. electrons in the first shell. A green 'Excellent!' notification is visible, stating 'Excellent! Only the outer electrons form the bond.' The bottom screenshot shows a video player with a play button and a diagram of an atom. The diagram labels the 'nucleus' and shows a yellow rectangular box with a play button in the center, representing a video tutorial. The video player shows a progress bar at 00:43 of 05:13.

How to Succeed in A&P

Amerman includes a special section, “How to Succeed in A&P,” in Chapter 1, with discussion of how to manage time, how to take notes, how to study for an A&P exam, and how to use the textbook, the companion *Practicing A&P: Active-Learning Workbook*, and online tools.

Core Principles

In Chapter 1, Amerman introduces **four core principles** and then highlights them throughout the textbook to remind students of the overall theme of human anatomy and physiology—homeostasis—and show how the core principles revolve around maintaining it.

ing that we have only about 3 liters of plasma. Therefore, your entire plasma volume is filtered by your kidneys about 60 times per day.

The kidneys are able to filter blood so efficiently in part because the glomerular capillaries are remarkably permeable. However, even with fenestrated capillaries, filtration will happen only if a pressure gradient is present to push water and solutes through the filtration membrane (an example of the Gradients Core Principle, p. 26). In this section we discuss the forces that allow this process to occur.



CORE PRINCIPLE
Gradients

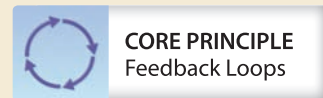
However, even with fenestrated capillaries, filtration will happen only if a pressure gradient is present to push water and solutes through the filtration

membrane (an example of the Gradients Core Principle, p. 26). In this section we discuss the forces that allow this process to occur.

Filtration Pressures

Let's first review the two forces that drive fluid movement in a typical capillary bed:

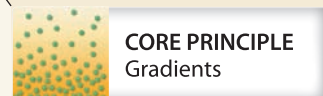
- **Hydrostatic pressure.** *Hydrostatic pressure* is the force of a fluid on the wall of its container. In the case of blood cap-



CORE PRINCIPLE
Feedback Loops



CORE PRINCIPLE
Structure-Function



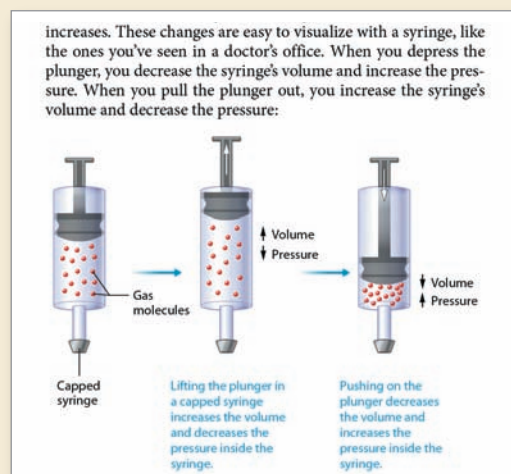
CORE PRINCIPLE
Gradients



CORE PRINCIPLE
Cell-Cell Communication

In-the-Moment Visual Reminders

In addition to coaching via Concept Boosts, Amerman provides in-the-moment visual reminders of key foundational science concepts students need to recall and apply to understand a given concept.



Do your students understand A&P concepts the first time they encounter them?

MasteringA&P® Assignable Content

With MasteringA&P, students get it by doing self-paced tutorials that reflect your course objectives, provide personalized coaching, and respond to each student's progress. Coaching activities include immediate specific wrong-answer feedback and hints that emulate the office-hour experience to focus the students' learning and keep them on track.

MasteringA&P helps instructors maximize their class time with easy-to assign, customizable, and automatically graded assignments that motivate students to learn outside of class and arrive better prepared for lecture and lab. Pre-built MasteringA&P courses and assignments are available to get you started easily and quickly.

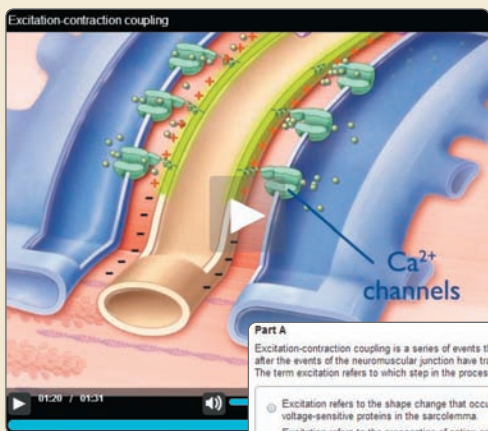
Assignable Coaching Activities include:

Big Picture Animation Activities

The Big Picture Animation Activities help students visualize physiological events occurring at the molecular level and reinforce understanding of key concepts learned in the chapter. These mobile-ready animations are narrated by the author and reflect the same terminology and explanations found in the Amerman textbook. Activity assignments include multiple-choice questions with hints and specific wrong-answer feedback, interactive ranking and sorting exercises, and labeling activities.

Concept Boost Video Tutor Activities

These videos and assignments feature the author talking directly to students and coaching them through tough-to-understand or tricky topics.



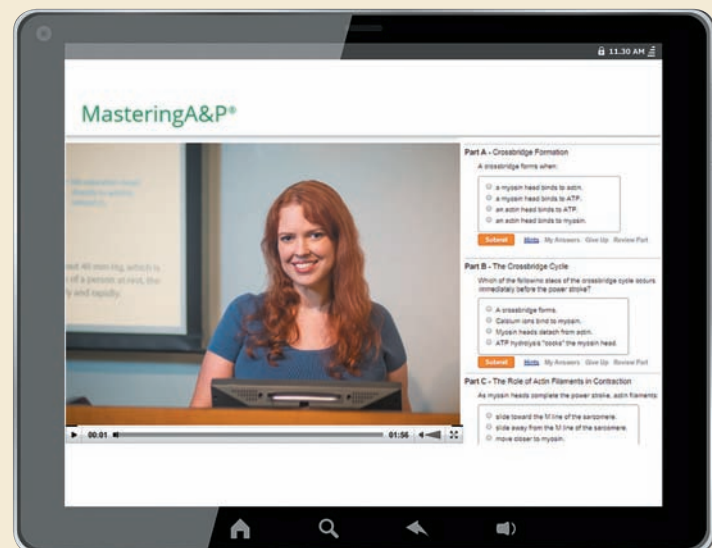
Excitation-contraction coupling

Part A
Excitation-contraction coupling is a series of events that occur after the events of the neuromuscular junction have transpired. The term excitation refers to which step in the process?

- Excitation refers to the shape change that occurs in voltage-sensitive proteins in the sarcolemma.
- Excitation refers to the propagation of action potentials along the axon of a motor neuron.
- Excitation, in this case, refers to the propagation of action potentials along the sarcolemma.
- Excitation refers to the release of calcium ions from the sarcoplasmic reticulum.

[Submit](#) [Hints](#) [My Answers](#) [Give Up](#) [Review Part](#)

Incorrect; Try Again
Action potentials propagating the length of an axon of a motor neuron trigger the events at the neuromuscular junction. These events must occur prior to excitation-contraction coupling.



MasteringA&P®

Part A - Crossbridge Formation
A crossbridge forms when:

- a myosin head binds to actin.
- a myosin head binds to ATP.
- an actin head binds to ATP.
- an actin head binds to myosin.

[Submit](#) [My Answers](#) [Give Up](#) [Review Part](#)

Part B - The Crossbridge Cycle
Which of the following steps of the crossbridge cycle occurs immediately before the power stroke?

- A crossbridge forms.
- Calcium ions bind to myosin.
- Myosin heads detach from actin.
- ATP hydrolysis "cocks" the myosin head.

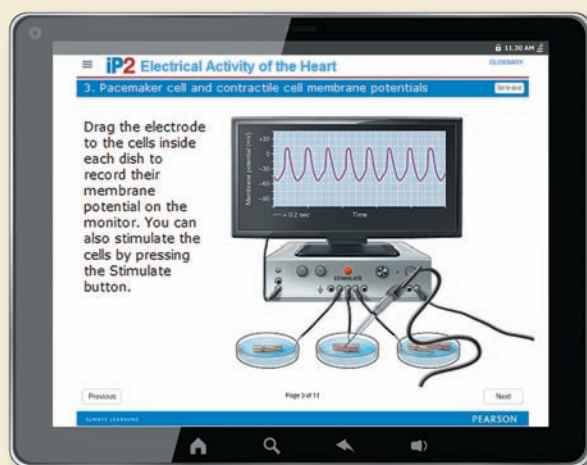
[Submit](#) [My Answers](#) [Give Up](#) [Review Part](#)

Part C - The Role of Actin Filaments in Contraction
As myosin heads complete the power stroke, actin filaments:

- slide toward the M line of the sarcomere.
- slide away from the M line of the sarcomere.
- move closer to myosin.

Interactive Physiology 2.0 Activities

This award-winning tutorial program helps students advance beyond memorization to a genuine understanding of complex physiological processes. I.P. 2.0 features brand-new graphics, quicker navigation, and more robust interactivity, so students can explore, draw, predict, and more. Includes activities for 2.0 and 1.0.



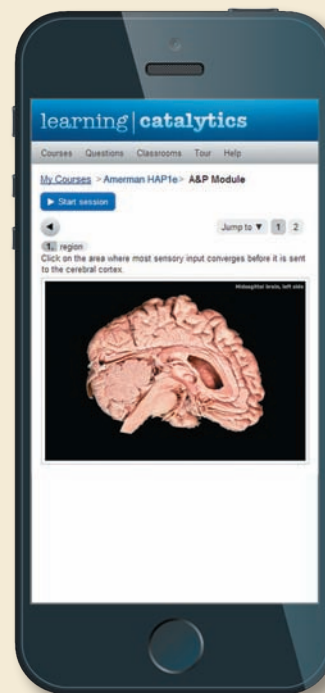
A&P Flix Activities

These 3D movie-quality animations of key physiological processes include coaching activity assignments that use a variety of question types and levels.



Learning Catalytics

This classroom lecture tool is a “bring your own device” engagement, assessment, and classroom intelligence system. With Learning Catalytics, instructors can flip the classroom and assess students in real time using open-ended tasks to probe their understanding. Students use their smartphone, tablet, or laptop to respond to questions in class.



Also Assignable in MasteringA&P

- **NEW!** *Get Ready for A&P* Learning Styles Assessment
- *Get Ready for A&P* Diagnostic Test, Chapter Tests, and Cumulative Test
- *Get Ready for A&P* Video Tutors
- Chemistry Review Activities
- Reading Quiz questions
- Art-labeling and Sequence-the-steps Activities
- Art-based questions
- Chapter Running Case for each chapter in Amerman
- Chapter Test questions
- Test Bank Questions
- Clinical Case Study Coaching Activities
- PAL 3.0 Test Bank with images
- **NEW!** Bone and Dissection Videos
- PhysioEx 9.1 with assessments

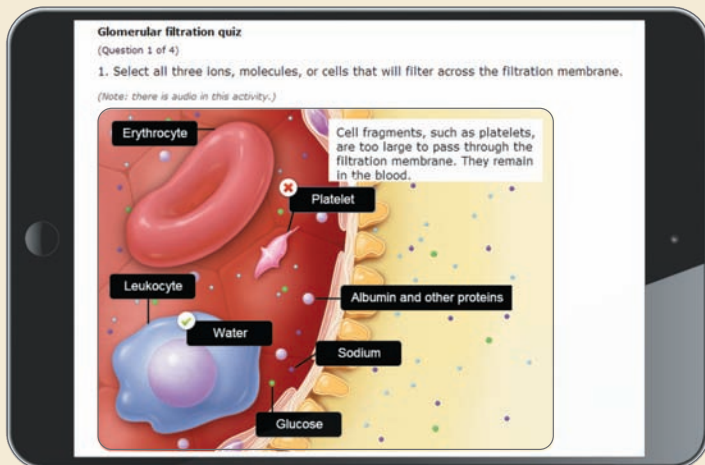
Do your students have the tools to suit their different learning styles?

MasteringA&P® Study Area

The Study Area includes a wide selection of study and practice tools to engage students and meet the needs of different learning styles and study strategies.

Big Picture Animations

Narrated by the author, these animations help students visualize key physiological processes and reinforce student understanding via interactive self-quizzing with immediate feedback.



Concept Boost Video Tutors

These videos of select Concept Boosts highlighted in the textbook feature author Amerman teaching directly to students and coaching them through tough-to-understand or tricky topics.

Practice quizzes, art-labeling, and sequence-the-step activities

A rich variety of practice quizzes and activities gives visual and kinesthetic learners varied practice learning key structures and processes.

Practicing A&P: Active-Learning Worksheets

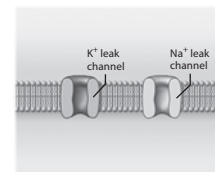
These worksheets written by Amerman help engage the kinesthetic learner with labeling, drawing, and build-your-own-summary-table exercises that students can complete *as they read the textbook*. Available in downloadable PDFs in the Study Area of MasteringA&P®.

52 Practicing A&P Active Learning Exercises

Key Concept: What are the three main types of ion channels and how do they differ?

Draw It: Ion Gradients and Ion Movements

Below is an illustration of a plasma membrane with sodium and potassium ion channels. Draw the sodium and potassium ions in the correct distribution for a resting cell. Then, draw arrows to show in which directions the ions will diffuse when the channels open.



Key Concept: How does the movement of positive ions lead to a negative resting membrane potential?

Describe the Steps: Changing the Membrane Potential

Fill in the blanks to describe what happens to the membrane potential of a neuron when ion channels open and close.

A small, local change in the membrane potential of the neuron is called a/an _____. It may have one of two effects: It may make the membrane potential more positive, a change called _____, or it may make the membrane potential more negative, a change called _____. If a positive change in membrane potential reaches a value called _____, _____ channels open, initiating an event known as a/an _____. This event has three phases in a neuron: (1) _____, mediated by the influx of _____ ions; (2) _____, mediated by the outflow of _____ ions; and (3) _____, mediated by the continued outflow of _____ ions.



Author podcasts

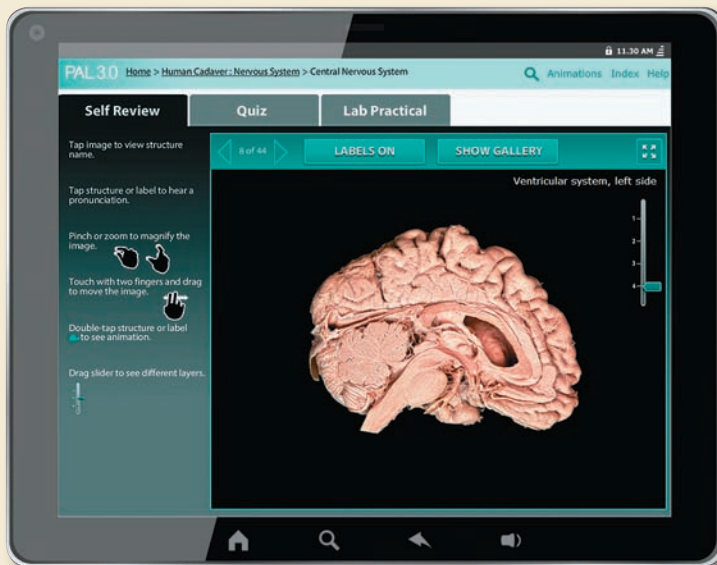
Narrated by the author, these podcasts give on-the-go students and auditory learners the opportunity to review the tough topics in A&P. Available as downloadable MP3 audio files in the Study Area of MasteringA&P.



practice
anatomy
lab™

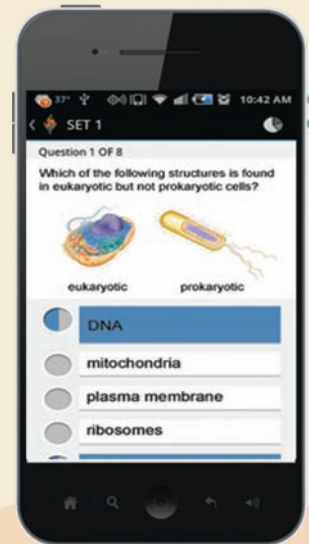
Practice Anatomy Lab™

PAL is a virtual anatomy study tool that gives students 24/7 access to the most widely used lab specimens including human cadaver, anatomical models, histology, cat, and fetal pig. PAL 3.0™ includes randomized multiple-choice quizzes and fill-in-the-blank lab practical questions.



Dynamic Study Modules

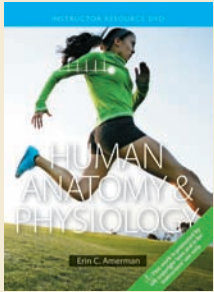
Designed to enable students to study effectively on their own, Dynamic Study Modules help them quickly access and learn the concepts they need to be more successful on quizzes and exams. These flashcard-style questions adapt to a student's performance and include art and explanations from the Amerman textbook to cement the student's understanding. Modules can also be assigned in MasteringA&P.



Also Available in the Study Area

- *Get Ready for A&P*
- Student Lecture Outlines
- Answers to Chapter Quick Check questions
- Chapter Running Cases
- Clinical case studies
- eText
- Interactive Physiology 2.0 and 1.0
- A&P Flix 3D animations
- PAL 3.0 app
- Bone and Dissection Videos
- PhysioEx 9.1

Instructor Supplements



Instructor Resource Material with PowerPoint® Lecture Outlines

by Suzanne Pundt

- All illustrations and photos from the text as presentation-ready labeled and unlabeled JPEG files
- All illustrations and photos from the text as presentation-ready editable PowerPoint® files
- Customizable PowerPoint® lecture presentations including embedded Big Picture Animations, Concept Boost Video Tutors, Interactive Physiology, and A&P Flix
- *Instructor Guide with Chapter Running Case Studies* in Microsoft Word®
- *Student Lecture Outlines* in Microsoft Word®
- Test Bank in Microsoft Word®
- TestGen test generation and management software

Instructor Guide with Chapter Running Case Studies for Human Anatomy & Physiology

by Christopher Amerman

Includes chapter learning outcomes, suggested lecture outlines, and chapter running case studies with questions that are tied directly to the chapters in the Amerman textbook. Available via MasteringA&P

Student Lecture Outlines for Human Anatomy & Physiology

by Patty Bostwick Taylor

Fill-in-the-blank chapter outlines ask students to fill in key details, allowing them to stay engaged during lecture. Available as customizable Word files via MasteringA&P

Printed Test Bank for Human Anatomy & Physiology

by Patty Bostwick Taylor

Contains thousands of test questions including multiple-choice, matching, true/false, short answer, and essay. Available via MasteringA&P

Acknowledgments

Believe it or not, this book you are now holding has been nine and a half years in the making. When I first started writing it, my daughter wasn't even 2 years old; now she is halfway through fifth grade. But I was certainly not alone on this journey, as a huge number of people were involved in bringing this book to life. Saying a simple "thank you" in the acknowledgments seems so insufficient given the quality and quantity of their contributions, but these thanks are genuine and heartfelt.

I will start with my family because they lived for nine and a half years with the day-to-day stresses that come with a project of this magnitude. Were it not for the help and understanding of my husband Chris Amerman, my daughter Elise, my mother Cathy Young, and my dear friend David Ferguson, this book would have never been completed. They served as a source of unwavering support, encouragement, and ideas. Elise was also incredibly patient and understanding with how much I had to work, and I am so thankful for that. I should also thank my dogs for making sure to bark and howl each and every time I was in a phone meeting, and my cats for never failing to lie exactly in the middle of whatever I was trying to do.

Next is the core team of the book, which I've come to think of as parts of the brain, each performing absolutely vital functions that maintained homeostasis of the whole book. First is Serina Beauparlant, who, as editor-in-chief, is our brainstem. She has tirelessly performed all of those critical behind-the-scenes functions, ranging from wrangling budgets and securing administrative support to running focus groups and analyzing reviewer feedback. It has been Serina's driving force that kept the book alive over these long years. Simply put, without her, there would be no book.

Our team's cerebral hemispheres are our two brilliant developmental editors: Suzanne Olivier and Laura Southworth. As our text development editor, Suzanne is the left cerebral hemisphere. Her ability to logically and patiently approach a chapter from a "big picture" perspective ensured our chapters maintained a consistent narrative flow. It's impossible to overstate her role—not only did Suzanne always manage to find a chapter's sticking points, but she also always proposed solutions to these problems that made the chapter better. The readability, logical flow, and text-art coordination of this book are largely due to Suzanne's efforts.

Laura Southworth, as our art development editor, is the right cerebral hemisphere. Laura not only is a very talented artist but also has an incredible ability to analyze a figure and work magic to make it teach better. This is in part due to her amazing skill for visual-spatial layout (a skill I absolutely lack), which is arguably the most important part of a figure. No matter what we gave her or how rough our ideas or sketches, Laura turned it into gold. This is why "Let's ask Laura" became our mantra when Suzanne and I were working on a chapter. Any time we were perplexed by a figure, Laura unfailingly found a solution.

The role of team thalamus was played by project editor/manager Nicole Tache (néé Graziano). This is a high compliment, as without a functional thalamus, absolutely nothing can get done! Just as the thalamus processes and routes information into and out of the cerebral hemispheres, Nicole processes, edits, and sorts all material for the chapters and supplements for this project. Basically, without Nicole, we would have all been utterly lost.

Rounding out the team is Barbara Yien, our cerebellum. Barbara has been involved with this project from the very start, first as a project editor and now as the Director of Development. Her even-keeled approach has helped troubleshoot scheduling, budgeting, and our marketing efforts. Whenever we come to a sticking point, we look to Barbara, who always manages to find a way to correct the "motor error" and keep everything balanced and on track.

(Now that I've written this, I'm wondering exactly what part of the brain I represent on the team. The basal nuclei? Maybe the hypothalamus? Hopefully not the pineal gland, as I don't want to make my students sleepy. . . .)

Every member of this core "brain" team deserves the highest praise for their skills, dedication, and willingness to persistently climb the mountain that was this book. I am beyond grateful to them for this, and I am also deeply thankful for their friendship.

Assisting the core team was a group of incredibly talented people without whom the book could not have happened: art development editor Elisheva Marcus and text development editor Alice Fugate; our indomitable marketing team of Allison Rona, Derek Perrigo, Michelle Cadden, Leslie Allen, Jessica Moro, Mansour Bethoney, Patrice Jones, Tim Galligan, Christy Lesko, and Yez Alayan; design director Mark Ong; copyeditor Bonnie Boehme; photo researcher Maureen Spuhler; media development editor Eric Leaver; the Pearson media team, including Lauren Fogel, Stacy Treco, Laura Tommasi, Caroline Power, Katie Foley, Cheryl Chi, Kristen Sanchez, Aimee Pavy, Sarah Young-Dualan, and Kyle Doctor; our production team of Nancy Tabor, Jane Hoover, Caroline Ayres, Dorothy Cox, and Kirsten Forsberg; our manufacturing buyer Stacey Weinberger; Animated Biomedical Productions; and editorial assistant Arielle Grant.

Next I want to thank and acknowledge everyone who contributed to the book, including Virginia Irintcheva, who authored the script and storyboards for the book's animations and interactive figures and assessments in MasteringA&P; Chris Amerman, who contributed Chapter 8 and authored the Instructor Guide; Bert Atsma and Mark Seifert, who contributed Chapter 9; Sheri Boyce, who contributed Chapter 15; Karen Keller, who contributed Chapters 26 and 27; Patty Bostwick Taylor, who authored the Test Bank, Student Lecture Outlines, and Dynamic Study Modules; Suzi Pundt, who authored the PowerPoint lecture slides; Jeff Engel, who provided answers to

the Quick Check questions; Betsy Brantley, who reviewed the book's clinical coverage; Winston Charles Poulton, who helped produce the Concept Boost Video Tutors; photographer John Wilson White and model Luiza Silva, who contributed the body movements photos in Chapter 8; and William Karkow, Nina Zanetti, Patricia Wilhelm, and Tom Appleton, who carefully reviewed/contributed light micrographs for select chapters. Each of these people devoted a huge amount of time and effort to this project—as I'm sure they will tell you, authoring materials is hard work! I am so grateful that each of them was willing to share his or her talents and play a role in the success of this project. I am also grateful to the Editorial Consultants who provided invaluable feedback on teaching ideas and carefully accuracy-checked pages and to all of the many academic reviewers, class testers, and focus group attendees who have shared their time, expertise, and ideas with us.

I would also like to sincerely thank Lauren Harp, Executive Marketing Manager. I met Lauren in 2005 when she was the marketing manager for natural sciences. She passed my name along to Serina as a potential author after we had a two-hour-long conversation in my office about what I would like to see in a textbook. Had she not done this, *Human Anatomy & Physiology* likely wouldn't exist.

Finally, none of this would have been possible without the unwavering support of Vice President and Editorial Director of Life Sciences Frank Ruggirello, Managing Director of Pearson Science Paul Corey, Editorial Director of Pearson Science Adam Jaworski, and Finance Director of Pearson Science Hogan Nymberg. All have supported this project from the beginning, and it was only because of their continued encouragement and belief in our team that you are holding this book right now. They have my eternal gratitude for allowing us to bring our vision to life.

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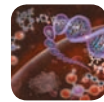
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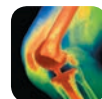
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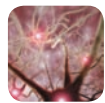
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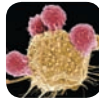
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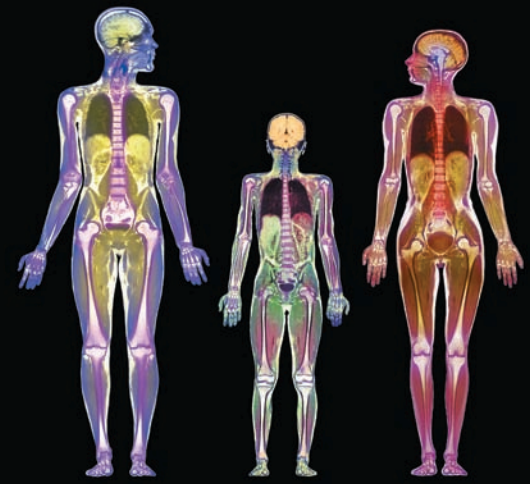
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1

Introduction to Anatomy and Physiology



The body has fascinated humankind since ancient times. Many of the earliest ideas about the form and function of the human body were wildly inaccurate. For example, gods and demons were believed to cause most diseases, the heart was perceived as the seat of intelligence, and the brain was viewed as merely a useless mass of tissue. However, through centuries of observation, experimentation, and imagination, we have dramatically expanded our knowledge of the human body. Much of this has resulted from the application of *science*, a way of observing and measuring natural phenomena in order to try to explain them. But so much remains to learn about the way our bodies are built and how they function. Studying the human body is like a treasure hunt, with fascinating “gems” still to discover.

This chapter introduces you to the world of anatomy and physiology. **Human anatomy** is the study of the structure or form of the human body, whereas **human physiology** (fiz'-ee-AWL-oh-gee) is the study of the body's functions. Although we define the two terms separately, the body's structure and function are closely related, a fact that we explore in depth throughout this text. The common name of your course, anatomy and physiology (A&P), reflects this connection.

The topics we discuss in this chapter form the foundation for the remaining chapters. We begin with a special section on how to succeed in an A&P course. An overview of the field and a discussion of the properties of all living organisms follow. After examining the language of A&P and the basic organization of the human body, the chapter concludes with recurring themes in A&P—those ideas that form the core of the field and the basis of our study in the rest of this book.

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MODULE

1.1

How to Succeed in Your Anatomy and Physiology Course

Learning Outcomes

1. Describe how to determine your learning style, read a textbook, budget your time, and study for quizzes and exams.
2. Explain how to make the best use of class and laboratory time.
3. Describe how to use this book and its associated materials.

Photo: Colored magnetic resonance imaging (MRI) whole body scans of a man (left), a woman (right), and a nine-year-old boy.

The world of anatomy and physiology often feels like a foreign and intimidating place to new students. And in a way it is—A&P is new territory for most people, and comes with a language all its own. Mastery of this material requires not only attendance at all lecture and laboratory sessions but also investment in a great deal of study time outside class. But what is the best way for you to study? And how should you make the most of your time in class and in lab? Furthermore, how should you use this book and its associated resources? This introductory module answers these questions and more. Read on, and find out how you can develop the skills needed for success in your A&P course.

How to Develop Study Skills

“I don’t know why I don’t get good grades. I study so much, and yet it doesn’t seem to help me do well on the exams. How can I improve my test scores?” Sentences like these have been uttered by students everywhere. Many students put in a great deal of effort for little reward. This can be demoralizing, making a person feel just not “smart enough” to excel in tough courses. But this is usually not even remotely the case; instead, the problem centers on simply not knowing how to study and make effective use of time. The next subsections offer help and guidance with these tasks.

What’s Your Learning Style?

It might surprise you that people learn in different ways. For example, you might be able to understand a process just from hearing it described, another person might need to see the process diagrammed, and yet another might have to manipulate a three-dimensional model to truly understand the process. These different ways of learning are known as **learning styles**. They are also called *learning preferences*, since they are not absolute.

We can classify learning styles in several ways. The most common way, and the one we use here, categorizes learners according to four basic styles:

- **Visual/Verbal.** Individuals classified as **visual/verbal** learners fare best when reading written material such as notes and textbooks and looking at diagrams, illustrations, and visual multimedia presentations (such as animations).
- **Visual/Nonverbal.** A **visual/nonverbal** learner usually best understands concepts through the use of diagrams, illustrations, and other visual media without text.
- **Auditory/Verbal.** As implied by the name, an **auditory/verbal** learner does well when listening to lectures, presentations, or when discussing material with a group. These individuals tend to prefer text-based materials rather than visuals.
- **Tactile/Kinesthetic.** The **tactile/kinesthetic** learner thrives in an environment where he or she can physically manipulate a specimen. These individuals excel in practical settings, including the anatomy and physiology lab.

You may be able to determine your learning style just from reading the descriptions, or you may wish to take an online test to determine it. Note, though, that very few people have strictly one type of learning style. Realistically, most people use a combination of more

than one. The key is figuring out which one or which combination fits you the best. For example, you might find that you retain and understand information better in class if you listen rather than take notes, a feature of an auditory/verbal learner. However, you might also need to make notes and draw diagrams to help you study, which characterizes a visual/verbal learner. If this is the case, try recording your lectures so that you can listen during class, and then taking notes *after* class from the recorded lecture. Experiment with different strategies to find what works best for you.

How to Read a Textbook

Reading your textbook is a must, but what is the best way to go about it? The first mistake many students make is trying to read a textbook as if it were a novel, starting at the first page and reading through it sequentially until the end. However, it’s pretty obvious that textbooks aren’t novels, and they therefore shouldn’t be read as such. Instead, try an approach known as the SQ3R method, which involves the following steps: *survey*, *question*, *read*, *recite*, and *review*. Let’s look at each of these steps in more detail.

- **Survey.** Before reading any chapter, you should do an initial survey, during which you skim the chapter and its figures. Begin by reading the headings and the Learning Outcomes at the beginning of each section. As you skim, take note of the key terms that are in boldface as well as the figures and tables. After finishing the initial survey, read the chapter summary. This initial survey will give an idea of what you will be focusing on and will make you more familiar with the content as you read.
- **Question.** The next step is to form questions about the chapter’s content that you should answer as you read. These questions can be fairly broad and simple. For example, if you’re reading about the heart, ask the following questions: “What do I know about the heart?” “How is the heart structured?” and “How does the heart’s structure relate to its function?” If you find yourself struggling to come up with questions, a good place to start is the Learning Outcomes at the beginning of each section. Take a look back at the Learning Outcomes on the first page of this section, and notice how easily each outcome can be turned into a question.
- **Read—actively.** Now you are ready to go on and read the chapter. As you read, it is most important to read *actively*, as active reading—the process of reading while engaging in some sort of activity with the text—promotes active learning. In other words, to learn most effectively, students must do more than just read: They must also listen, write, discuss, and be engaged in solving problems. A novel is fine to read passively because you are interested in the plot, which keeps you turning pages. In addition, you don’t necessarily have to remember the details of a novel—they are more like icing on the cake of the plot. But with a textbook, there is no overarching plot, no matter how interesting you might find the material, and the details are often critical. Active reading is, therefore, a must. Reading can be made active in many ways, the first of which is to take notes and make diagrams as you read. In addition, this book has many other

resources to help you read actively, which are detailed in a later section of this module.

- **Recite.** Part of reading actively is reciting the material—speaking aloud—as you read through it. This might seem strange, but speaking while reading engages more parts of your brain and helps you retain more of what you’ve read. It is particularly important in sciences such as A&P, which have a great number of new, often foreign-sounding words. We’ve provided pronunciations after many new terms to help with this.
- **Review.** The final step is reviewing what you have read. This can be done in many ways, including answering quiz questions found in the book, writing summaries, or discussing things aloud with study partners.

Note that you should read your textbook in this manner *before* going to the class at which the topic is discussed. We explain why in a later section.

Managing Your Time

Whatever your approach, one fact remains: Studying takes time, and we don’t have a way to add extra hours to the day. Perhaps the number one mistake made by students is not allotting enough time for regular studying every week, which eventually necessitates “cramming” for the exam. It goes (almost) without saying that cramming does not lead to success, in either the short or the long term.

So, how can you avoid the need for cramming? The answer is surprisingly simple: make a schedule and budget your time. Plan out your time at least a week before your exam, and budget several hours each day for studying. Allow more hours than you are likely to need in case something unexpected comes up and disrupts your schedule. You might want to schedule specific activities each day; for example, Monday might be for reviewing notes, Tuesday for meeting with a study group, and Wednesday for a different activity. To maximize study time, think about *all* of your time—you might be able to study, for instance, with a study group or during your commute to and from school or a job (**Figure 1.1**).



Figure 1.1 Some ways to maximize your study time.

How to Study for an Exam

Now that you know how to read the book, you are probably wondering how to apply this in studying for quizzes and exams. The answer to that is, of course, complicated, as no two people arrive at identical study strategies. However, the following methods have been found to work for many people:

- **Find out as much as you can about the exam.** Your professor isn’t in the business of tricking you and will generally answer questions about the exam well before it is administered. Ask about the format of the exam—are the questions multiple choice, short answer, matching, or a mixture of many different types? Will the questions be fact-based or application-based? In addition, find out if your professor has made available sample exam questions or old exams for students to practice on. If you are unable to glean much information, use your first exam in the class for future reference.
- **Take advantage of the resources available to you.** A variety of resources for this book are available to help you study for exams, including the companion workbook and several features within the text. These resources also include many online practice tools. (See the section later in this module for details.) The more questions you answer, the better prepared you will be for the exam, because you will find out what you do know and, more importantly, what you *don’t* yet know. Your college or university might also have resources for help, including tutors, computer labs, and the A&P lab.
- **Form a study group.** People with certain learning styles, particularly auditory/verbal and tactile/kinesthetic, do quite well in study groups. Find a group of classmates at the beginning of the semester with learning styles similar to yours, and meet regularly to go over tricky concepts, take practice tests, and offer one another support. Note that visual/verbal and visual/nonverbal learners may experience more success in studying alone, at least until they are ready to practice with the material.
- **Use whatever study techniques help you.** Depending on your learning style, a variety of techniques can help you master the material, including concept maps, coloring and



drawing exercises, flashcards, models, mnemonics, and other tools that you can find online. Some materials may prove more useful in preparing for lab quizzes, whereas others may work better for lecture exams.

- **Take care of yourself and manage your stress.** This bit of advice might sound obvious, but some students tend to neglect their basic needs, including nutrition, health, and sleep. Multiple studies have demonstrated that a lack of these three necessities, particularly sleep, interferes with the ability to learn and retain information. As part of taking care of yourself, do what works best to alleviate stress, perhaps going for a run or singing to a favorite piece of music. Stress can be particularly problematic in the week before an exam, when you might favor an extra hour of studying over an extra hour of sleep. However, in this case, another hour of sleep might actually be more helpful to your grade than an additional hour of studying.

Quick Check

- 1. What are learning styles? Which learning style(s) best describe(s) you?
- 2. How should you approach reading a textbook, including this one?
- 3. What are some study strategies to improve your chances of success?

How to Make the Best Use of Class and Lab Time

To this point, we have been discussing what you do *outside* class to maximize your chances of success. But what you do *in* class is every bit as important to your success. It is doubly important in A&P, because you will likely have a laboratory period as well. The next two sections discuss how you can make the best use of time in class and in lab.

Come Prepared

Perhaps the most important step you can take to enhance your classroom and laboratory experience is to come prepared. You are assigned reading to help you become familiar with the material *before* you come to class or lab. Why is this important? There are several reasons. The first is simple: Attending a lecture without first learning about the material is like visiting a foreign country without knowing one word of its language. It is as difficult to find your way through unfamiliar material as it is to navigate foreign roads whose signs are in a language you don't speak. In other words, it's very easy to wind up lost.

Another important reason to read the lecture material before class is that your professor prepares lectures with the assumption that you have already read the assigned material. He or she uses the lecture to discuss details of the reading and explain its concepts, not start at the very beginning. If you are unfamiliar with the material in general, you won't benefit from a discussion of its details.

A final reason has to do with the way the brain processes information. Consider this example: A person is driving past a horse field and says to his companion, "Hey, look, my friend told me that there's a zebra in that field." The companion looks at the field blankly and sees only horses. "What zebra?" the companion asks. The driver points and says, "It's right there, in front of you." After a moment of staring, the companion finally realizes that there is, indeed, a zebra standing in the field, surrounded by horses. Why couldn't the companion see the zebra, when it was there all along? The answer is that her brain did not expect a zebra to be present in the middle of a horse field, and so her brain simply didn't perceive the zebra's presence. The driver knew the zebra was there and so his brain did perceive its presence. This is a true story—the companion who had trouble seeing the zebra was yours truly, the author of this book.

In the same way that someone might not perceive a zebra that he or she doesn't expect to be there, your brain will not perceive concepts and information that it didn't expect in class. If the information in the lecture is foreign to you, your brain simply isn't likely to register it. However, if you read the material before lecture, you will be able to "see the zebra" in your classroom, and do better on your exams and quizzes as a result.

How to Take Good Notes

Many professors present their lectures using PowerPoint®, and many also make these presentations available online for students to read before class. You might think that if you print out your professor's presentation and take it to lecture, your notes for class are as good as taken. This couldn't be further from the truth. Although it's not a bad idea to look over your professor's presentations before class, these are by no means a substitute for class notes.

The best way to take notes during class is to bring along the notes you took while reading. Leave several lines between each main point in your notes so that you can add as needed while your instructor lectures. Come to class equipped with a highlighter so that you can identify points emphasized by your instructor.

As with other topics we have discussed, note taking should be individualized according to what works best for you. If you have an auditory/verbal learning style, ask your professor if you can record his or her lectures. If you are a visual/nonverbal learner, you might do best if you take notes in the form of diagrams. Experiment with different strategies to find out what works best for you.

Quick Check

- 4. Why is it important to read the material before you come to class and lab?
- 5. What are some strategies for taking good notes in class?

How to Use This Book and Its Associated Materials

The study tips and strategies we have discussed so far are fairly universal and could be applied to any course you are taking,

including A&P. Let's now move on to some hints and tips for this course, and in particular, this book and its associated materials. You should know above all that this book was written specifically with *you* in mind. Students today are different from those who took A&P 20 years ago. Today's students are busier; many work in addition to taking a full-time class load, some take care of families, and some might not have any background in the sciences. Every single feature of this book was carefully crafted to help meet the needs of today's student—*your* needs. The hallmark of the approach in this book is to provide coaching that guides you through the material and gives additional explanation of the most critical and difficult topics. Let's tour the features found in this book, and discover how to make the best use of them.

Modules

Each chapter is divided into sections that we call *modules*. A module is a block of text with definitive starting and stopping points that covers one core concept and its related principles. The text is organized in this manner to divide the material into more manageable chunks and to help you make the most efficient use of limited time. It usually works best to master the material in one module before moving on to the next one. Every module contains several features to help you master the material, which we discuss next.

Learning Outcomes

As you likely noticed at the start of this module, every module starts with Learning Outcomes, or a list containing the core concepts and relating principles you should come to understand in each module. Students have a tendency to breeze past the Learning Outcomes, but, as with all of the other features of this book, they are there for one main reason: to help you. Use them to your advantage—read them prior to starting the module as part of the “survey” portion of the SQ3R method, and then revisit them after finishing the module. Take a look at the Learning Outcomes for this module; you'll notice they are written in a way that makes it easy to adapt them into a quiz for yourself and/or your study group.

Try an experiment for this chapter: Take the end-of-chapter quiz (called Assess What You Learned) after reading the chapter, without first looking at the Learning Outcomes. Then, work with the Learning Outcomes and write down the answers to each one of them. Now, take the quiz a second time to see how much better you can do with the help of the Learning Outcomes.

Concept Boosts and Study Boosts

Without question, certain concepts of A&P are more challenging than others. Such concepts often require a bit of coaching, perhaps more explanation, or another way of looking at them. This is provided for you in the form of short sections called Concept Boosts (an example is shown in **Figure 1.2**), which are intended

Quick Check

Quick Check questions assess your recall of material you've just read.

Figure 24.13 Net filtration pressure in the glomerular capillaries.

We can combine these three forces to yield the glomerular net filtration pressure (NFP), the total pressure gradient available to drive water across the filtration membrane and into the capsular space. To find the glomerular NFP, we subtract the two forces that oppose filtration (GCOP and CHP) from the one that favors filtration (GHP):

$$\begin{aligned} \text{NFP} &= \text{GHP} - (\text{GCOP} + \text{CHP}) \\ &= 50 \text{ mm Hg} - (30 \text{ mm Hg} + 10 \text{ mm Hg}) \\ &= 10 \text{ mm Hg} \end{aligned}$$

Quick Check

- 4. What is the GFR?
- 5. Which three pressures combine to determine the net filtration pressure? Which pressure(s) promote filtration? Which pressure(s) oppose filtration? See answers on page 45.

Factors That Affect the Glomerular Filtration Rate

Flashback

1. What are the primary functions of the hormones angiotensin-II and atrial natriuretic peptide? (p. 000)
2. What happens to a blood vessel when blood pressure increases and the vessel is stretched? (p. 000)

Glomerular filtration is essentially the “gatekeeper” of renal physiology because it begins the process of waste removal. The GFR determines how rapidly the blood is cleansed of metabolic wastes, how effectively the kidneys can carry out both tubular reabsorption and secretion, and how well the kidneys are able to maintain homeostasis in the body.

ConceptBOOST >>>

How Changes in Arteriolar Diameter Influence the GFR

As we discussed earlier, filtration will occur only when a net pressure gradient in the glomerulus drives fluid out of the blood and into the capsular space. The size of this gradient determines how much filtration takes place—a small gradient will lead to only minimal filtration, whereas a large gradient leads to heavy filtration. Several factors determine the size of the pressure gradient in the glomerulus, but one of the most easily adjustable factors is the diameter of the afferent (entering) and efferent (leaving) arterioles. When either arteriole constricts or dilates, this changes the glomerular hydrostatic pressure (GHP), and therefore the entire net pressure gradient also changes.

You can think of blood flowing in and out of the glomerulus as being similar to water flowing in and out of a sink, where the afferent arteriole is the faucet, the basin is the glomerulus, and the efferent arteriole is the drainpipe. Keep this analogy in mind as we explore how this mechanism works:

- Vasoconstriction of the afferent arteriole “turns down the faucet.” This allows less blood to flow into the glomerulus, which decreases the GHP and the GFR.

Apply What You Learned

- 1. Ms. Douglas has advanced liver disease; because her liver is no longer able to produce plasma proteins, her colloid osmotic pressure has decreased. Predict the effects that this loss of pressure will have on the net filtration pressure and the GFR in her nephrons.

ConceptBOOST >

Concept Boosts give you a “boost” in understanding challenging concepts.

Apply What You Learned

Apply What You Learned questions offer critical thinking opportunities at the end of a module.

Flashback

Flashback questions ask you to recall previous concepts so you can build on them.

Figure 1.2 Selected features of this textbook.

to give you a “boost” in understanding a concept. You shouldn’t treat these sections as optional; in fact, it’s a good idea to give them as much attention as the regular text.

In addition to the Concept Boosts, you’ll find Study Boosts in some chapters. Study Boosts give you study tips for particularly challenging material. They often include mnemonic devices to help you memorize anatomical structures or the steps of physiological processes. Like Concept Boosts, Study Boosts are there for your benefit, and it’s to your advantage to pay close attention to them.

Questions

You will find many different opportunities for self-assessment throughout each chapter, several examples of which are shown in Figure 1.2. Each type of question serves a different purpose, although all are intended to help you discover how well you met the Learning Outcomes. The following list provides an overview of the categories of questions you will find in this book:

- **Flashback questions.** Many sections start with one or more Flashback questions that ask you to recall material from previous modules or chapters. Each Flashback question has an associated page number to help you find the concept in the book. Flashbacks are intended to help you remember previous terms and concepts so that you can build on them and better understand the current material.
- **Quick Check questions.** Quick Check questions are found after each major section within a module. These are generally simple recall questions so that you can assess how well you remember the basic concepts about which you have just read.
- **Apply What You Learned questions.** A module ends with two or more Apply What You Learned questions. These critical thinking and problem-solving questions ask you to analyze and apply the material that you just read. With Apply What You Learned questions, you can test yourself on how well you understand and recall the concepts in the module.
- **Assess What You Learned quiz.** Finally, once you have finished the chapter, you have another chance to assess how well you met the Learning Outcomes. The Assess What You Learned quiz contains three levels of questions, with each level requiring increasingly greater critical thinking skills. The first level, Check Your Recall, measures your ability to recall basic facts of the chapter. The second level, Check Your Understanding, contains critical thinking questions that target how well you understand the main concepts. The third and final level, Apply Your Knowledge, features questions that are often clinically based, which allows you to apply and analyze situations using the information you read about in the chapter. Some of these questions connect concepts you’ve discovered in previous chapters with those in the current chapter.

Like the other features in the book, these questions are intended for your benefit; use them to your advantage. The in-module questions, including the Flashback, Quick Check, and Apply What You Learned questions, are generally best answered

as you read. This enables reading to be active rather than passive, which will increase the ability to retain and understand the material. Experiment with the other question types. You might want to try combining them with the Learning Outcomes to build quizzes for yourself and/or your study group.

Figures

In an A&P course, the art is every bit as important as the text. Indeed, in some cases, the figures are actually *more* important than the text in terms of developing an understanding of the concepts. The figures have been developed to coach you through these concepts. Following are some tips for using the art in this book as a valuable learning tool.

- **Examine the figures as you do your initial chapter survey.** As you read earlier in this module, it’s a good idea to start with a chapter survey before you fully read the chapter, as part of the SQ3R method. This chapter survey should include a perusal of the figures as well as the text. The figures of a chapter will tell a story in and of themselves, even if removed from the text. Examining the figures as part of your initial chapter survey will give you a preview of the story told by the art and will make you better prepared to understand its details as you read later.
- **Identify the concept that the figure teaches first.** Once you start reading the chapter and delving into the figures, begin your interpretation by first identifying the exact concept that each figure teaches. Every effort has been made in this book to make each figure teach a single concept. The name of this concept can generally be found in the figure title, which you can see in the example shown in **Figure 1.3**. Note that if the concept illustrated in the figure sounds foreign to you, it is a good idea to re-read the text section on the subject so that the terms become more familiar.
- **Break the figure into parts, and understand each part before moving on to the next.** After you have identified what you need to learn from the figure, you can explore the figure’s content more deeply. The content of some of the larger figures in this book might look intimidating at first, just in terms of the amount of information they contain. In these cases, it is a good idea to break the figure into smaller, more manageable parts. Often in physiology figures, such as the example in Figure 1.3, this is already done for you in the form of numbered steps with text boxes, which walk you through a process. The blue text explaining these steps is the author’s voice coaching you through a concept. However, in anatomical figures, it may be helpful to imagine lines that divide the figure into sections. This gives you “boxes” with smaller chunks of information to study.
- **Once you understand each part of the figure, examine it as a whole.** After you have mastered and understood the parts of the figure, you can step back and look at the process or structure as a whole.
- **Combine the figure’s content with that of other figures for a more global understanding.** For more complicated anatomical structures or physiology concepts, the content

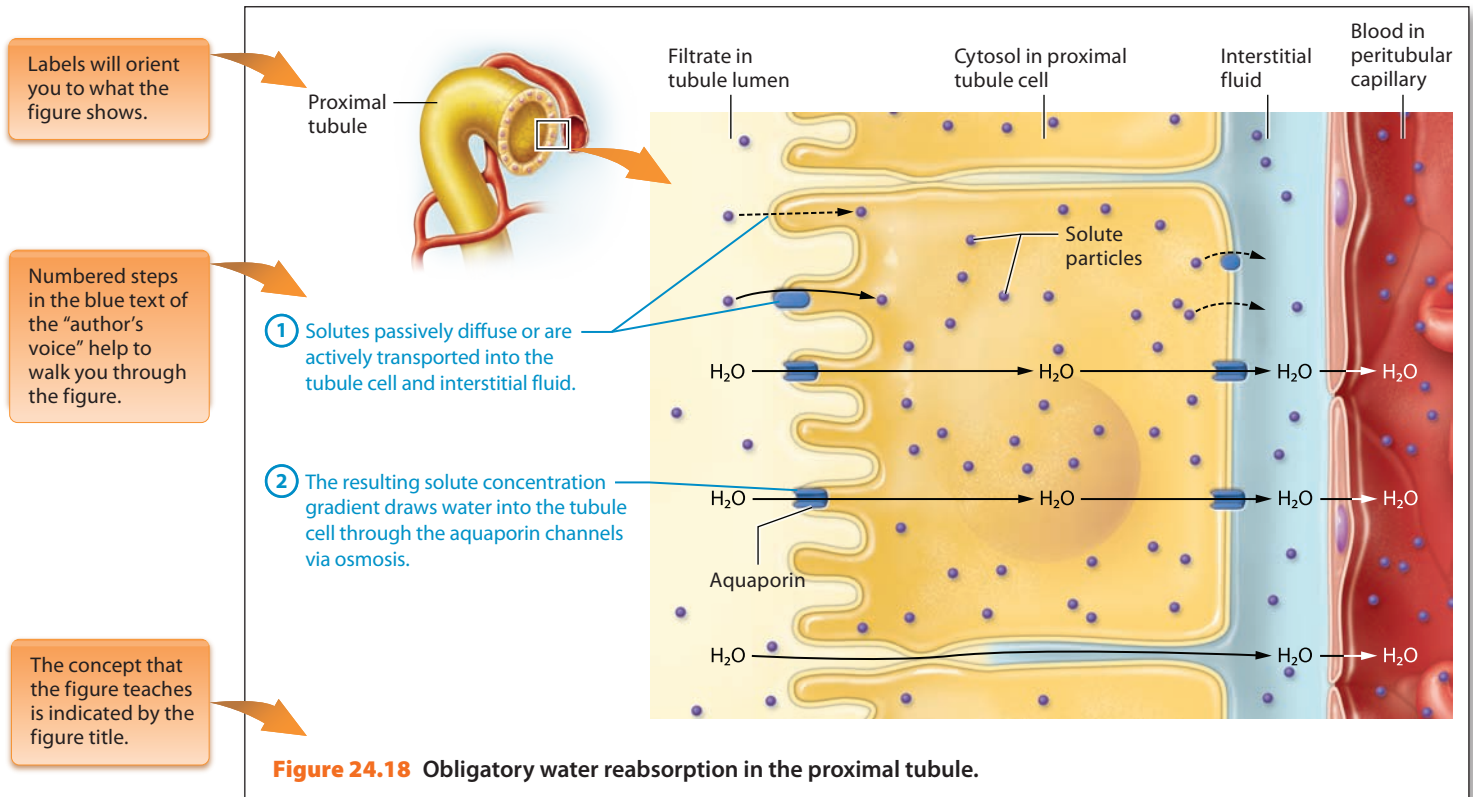


Figure 1.3 How to approach a physiology figure.

might actually be spread out over several figures. In such cases, follow the same steps outlined previously for each figure. After you have interpreted each one, put them all together so that you can see how all the parts combine to make the whole. Sometimes this is done for you in sections and figures called *Putting It All Together: The Big Picture*.

Companion Workbook

Another active learning feature of this text is the companion workbook, *Practicing A&P*. The workbook is not a study guide that you use after reading the chapter; instead it is intended to be used *as you read*. It contains multiple features: sequencing-the-steps exercises; labeling, coloring, and drawing activities; and group exercises. All of these are designed to guide you through the reading, to provide many opportunities to assess your understanding, and to help you practice active reading.

Online Practice Tools

Online practice tools for this textbook can be found on MasteringA&P®. They include chapter practice tests, reading quizzes, art-labeling and sequencing-the-steps exercises (👉 icon), and author-narrated podcasts (🎧 icon). Throughout the book, you will see animation icons (▶), which signal you to view animations. These animations allow you to see an entire physiological process and interact with the textbook figures in an online setting. Additional media found on MasteringA&P include Interactive Physiology® tutorials, PhysioEx™ 9.1 Laboratory Simulations, and Practice Anatomy Lab™ (PAL™) 3.0 virtual anatomy lab study tool.

Quick Check

- 6. How can you use the features found in each chapter?
- 7. How should you approach the study of figures in this book?

Apply What You Learned

- 1. Design a study schedule for yourself up to the first exam.
- 2. Determine several study strategies that will help you succeed in your course.

See answers in Appendix A.

MODULE

1.2

Overview of Anatomy and Physiology

Learning Outcomes

1. List the characteristics of life and the processes carried out by living organisms.
2. Describe the major structural levels of organization in the human body.
3. Define the types of anatomy and physiology.
4. Describe the organ systems of the human body and their major components.
5. Explain the major functions of each organ system.

We begin our study of human anatomy and physiology with the characteristics common to all living organisms. Then, discussion turns to the introductory principles of anatomy and physiology, including the “building blocks” of the human body, and the different subfields of A&P.

Characteristics of Living Organisms

From a biological perspective, we can define living organisms as those sharing the following distinct set of properties:

- **Cellular composition.** The **cell** is considered the basic unit of life, as it is the smallest unit that can carry out the functions of life. All living organisms are composed of cells, from single-celled bacteria to complex multicellular organisms such as humans.
- **Metabolism.** **Chemicals** are substances with unique molecular composition that are used in or produced by chemical processes. Living organisms carry out a wide range of chemical processes that are known collectively as **metabolism**. Metabolic processes include both “building” processes, in which smaller chemicals are combined to form larger ones, such as building muscle, and “breaking down” processes, in which larger chemicals are broken down into smaller ones, as in digestion.
- **Growth.** When the “building” metabolic processes outweigh the “breaking down” processes, the result is **growth**. Growth may come in two forms: an increase in the size of individual cells and/or an increase in the number of cells.
- **Excretion.** Metabolic processes can yield chemicals called *waste products* that the organism cannot use for any purpose. Waste products are toxic if they accumulate, and so the organism must have a way to separate the wastes and remove them. The process by which this occurs is known as **excretion**.
- **Responsiveness.** Living organisms sense and react to changes in their environment known as *stimuli*; this property is known as **responsiveness** or **irritability**. Humans and other animals respond to stimuli perceived through the senses, including sight, smell, hearing, touch, and pain.
- **Movement.** Another key property of life is **movement**. Including this may seem strange at first, because clearly plants don’t get up and take a walk. However, plants do exhibit movement inside and between their cells. Other forms of movement include motion of one or more cells within the organism and movement of the organism itself.
- **Reproduction.** The final property common to life is the ability to carry out **reproduction**. Reproduction takes two forms in multicellular organisms: (1) individual cells reproduce within the organism during growth and to replace damaged or old cells, and (2) the organism itself reproduces to yield similar offspring.

Quick Check

1. List the properties common to all living organisms.

Levels of Structural Organization and Body Systems

The body is constructed from a series of progressively larger “building blocks.” Each type of block is known as a *structural level of organization*. The six levels of organization we’ll cover, illustrated in **Figure 1.4**, are as follows:

1. **Chemical.** The smallest level of organization in the human body is the **chemical level**. Chemicals range in size from tiny *atoms* to complex structures called *molecules*, which are composed of atoms ranging in number from two to thousands. All other levels are made up of combinations of molecules.
2. **Cellular.** Groups of several different types of molecules combine in specific ways to form structures at the **cellular level**. As you will discover in upcoming chapters, the cells in the body vary widely in size, shape, and function.
3. **Tissue.** At the **tissue level**, two or more cell types that cooperate to perform a common function make up a **tissue**. Tissues consist of two components: the cells and the surrounding material known as the *extracellular matrix*. Tissues vary in appearance from the thin, broad sheets that line the body’s internal surfaces to the short, irregularly shaped pieces of rubbery cartilage that make up the nose.
4. **Organ.** The **organ level** consists of two or more tissue types combined to form a structure called an **organ**, which has a recognizable shape and performs a specialized task. Examples of organs include the skin, the heart, and the bones of the skeleton.
5. **Organ system.** At the **organ system level**, the body’s organs are grouped into **organ systems**. An organ system consists of two or more organs that together carry out a broad function in the body. For example, the organs of the *cardiovascular system*, the heart and blood vessels, work together to transport and deliver blood through the body, and the organs of the *digestive system* work together to ingest food, absorb nutrients, and eliminate wastes.
6. **Organism.** The organ systems function together to make up the working human body, an **organism**, at the **organism level** of organization.

Throughout this book we will examine all of these levels of organization, starting at the chemical, moving to the cellular and tissue, and then to organs and individual organ systems. The human body has 11 organ systems; the components and major functions of each organ system are shown in **Figure 1.5**. As we examine organs and organ systems, never lose sight of the fact that all of these organ systems work together to ensure the survival of the organism as a whole.

Quick Check

2. What are the six levels of organization of the human body?
3. List the 11 organ systems in the body.

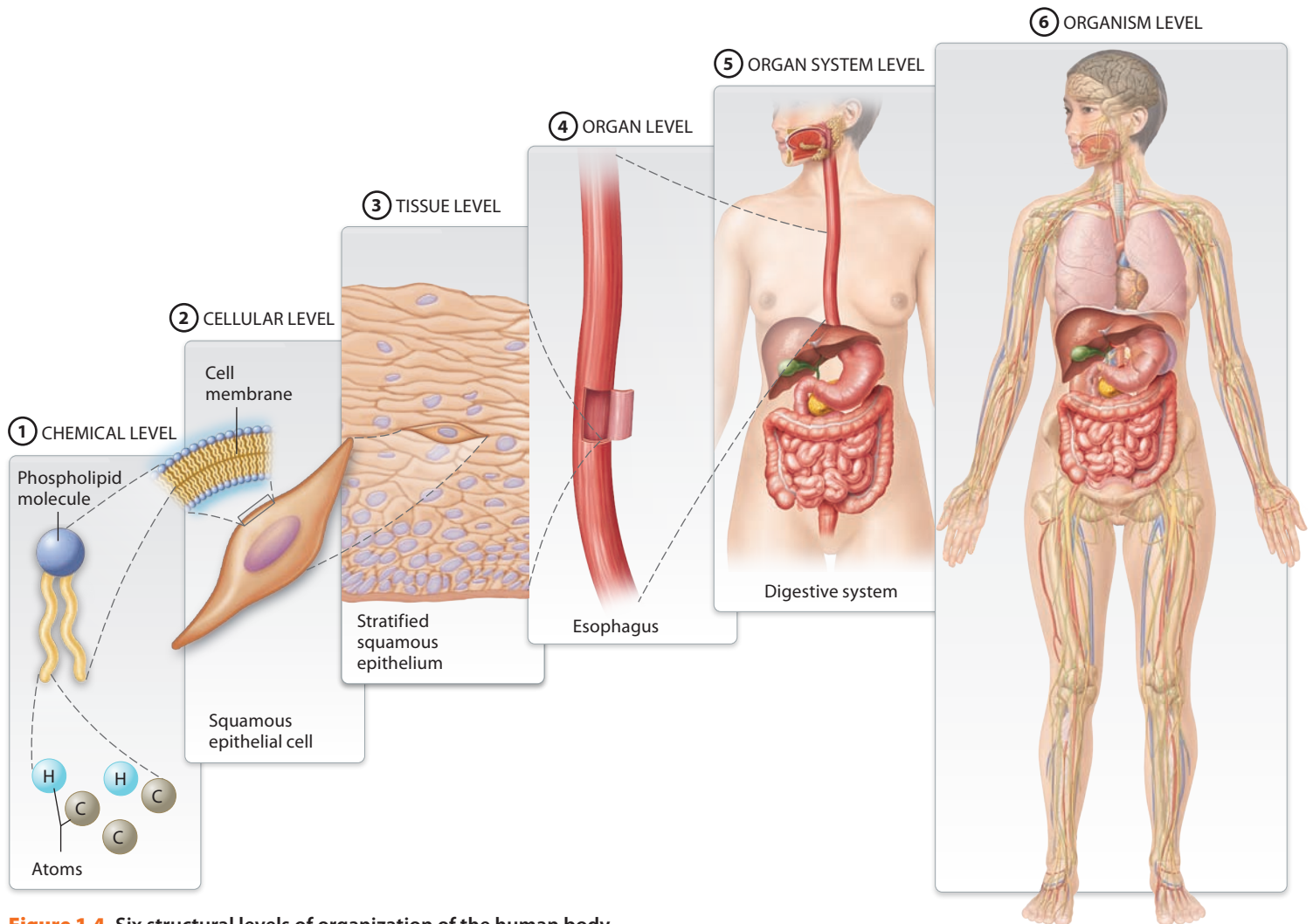


Figure 1.4 Six structural levels of organization of the human body.

Types of Anatomy and Physiology

We can approach the study of anatomy in several ways. In this book, we examine the human body primarily by looking at individual organ systems, which is known as **systemic anatomy**. In another approach, the body can be divided into regions such as the back or head and neck; this is **regional anatomy**. Finally, we can study the surface markings of the body, which is called **surface anatomy**.

Within the broad field of anatomy are numerous subfields for more specialized study. Anatomical subfields are generally classified by the structural level of organization being studied. For example, the field of **gross anatomy** examines structures, including organs and organ systems, that can be seen with the unaided eye. In contrast, the structures studied in **microscopic anatomy** require the aid of a microscope. Topics within the field of microscopic anatomy include **histology** (hiss-TOL-uh-jee; *histo-* = “tissue,” *-logy* = “study of”), the study of tissues, and **cytology** (sy-TOL-uh-jee; *cyto-* = “cell”), the study of cells.

Physiology also has numerous subfields. Typically, physiological specializations are classified according to the organ or organ

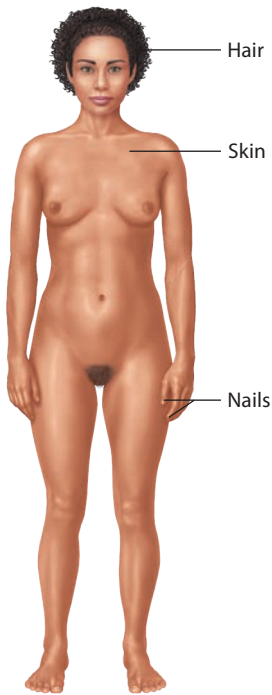
system being studied. For example, *neurophysiology* studies the brain and nerves (*neuro-* = “nerve”), and *cardiovascular physiology* studies the heart and blood vessels. Physiologists may also specialize in levels of organization other than the systemic—some physiologists study the body’s chemical and cellular processes, and others study specific tissues or organs.

Quick Check

- 4. How do gross anatomy and microscopic anatomy differ?
- 5. How are physiological specializations classified?

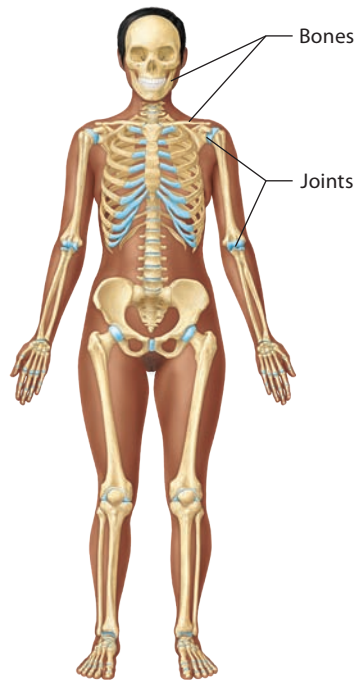
Apply What You Learned

- 1. The condition *hypothyroidism* is characterized by a decrease in the synthesis and secretion of the chemical thyroid hormone from the thyroid gland, an organ in the neck that is part of the endocrine system. Explain how this condition involves all levels of organization in the body.



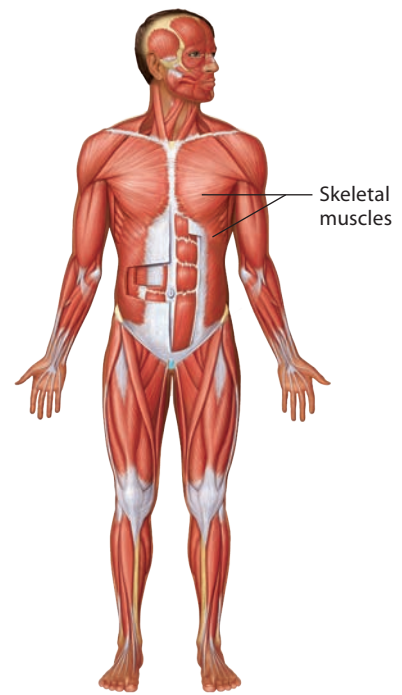
INTEGUMENTARY SYSTEM

- Protects the body from the external environment
- Produces vitamin D
- Retains water
- Regulates body temperature



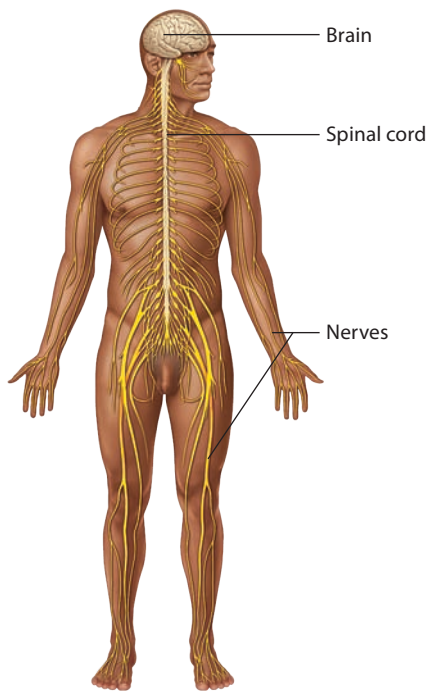
SKELETAL SYSTEM

- Supports the body
- Protects internal organs
- Provides leverage for movement
- Produces blood cells
- Stores calcium salts



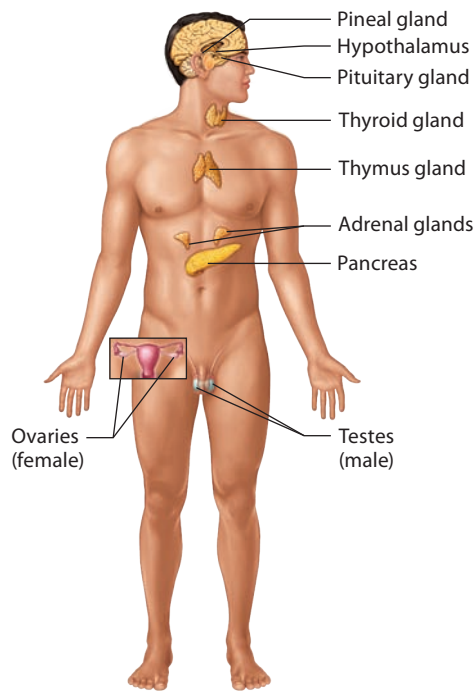
MUSCULAR SYSTEM

- Produces movement
- Controls body openings
- Generates heat



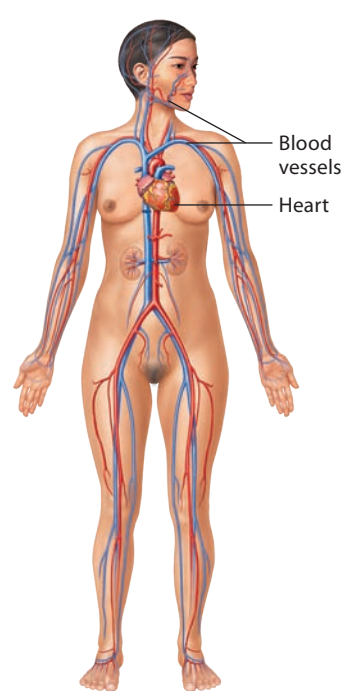
NERVOUS SYSTEM

- Regulates body functions
- Provides for sensation, movement, automatic functions, and higher mental functions via nerve impulses



ENDOCRINE SYSTEM

- Regulates body functions
- Regulates the functions of muscles, glands, and other tissues through the secretion of chemicals called hormones



CARDIOVASCULAR SYSTEM

- Pumps and delivers oxygen-poor blood to the lungs and oxygen-rich blood to the tissues
- Removes wastes from the tissues
- Transports cells, nutrients, and other substances

Figure 1.5 The 11 organ systems of the human body.