

GLOBAL  
EDITION



# Human Anatomy & Physiology

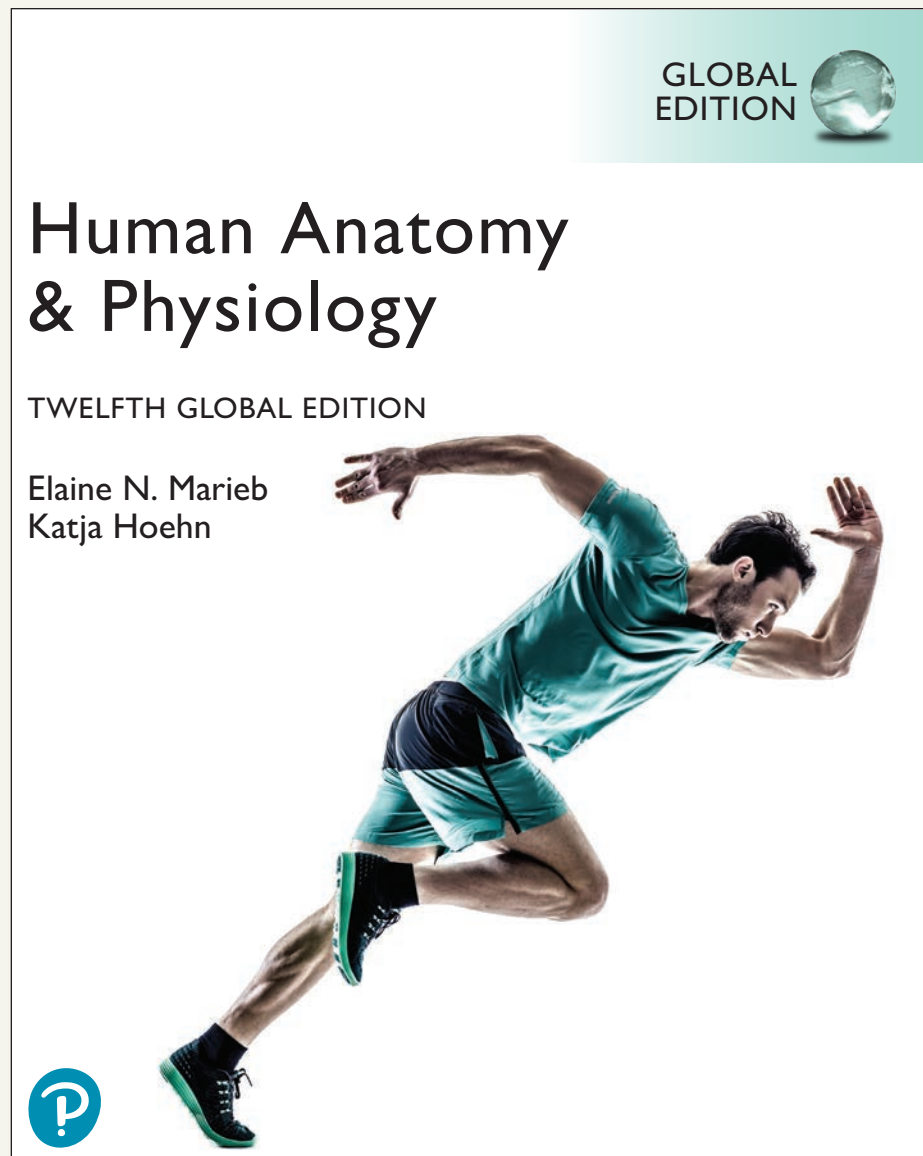
TWELFTH GLOBAL EDITION

Elaine N. Marieb  
Katja Hoehn



# Equipping You with 21st-Century Skills to Succeed in *A&P and Beyond...*

The **12th Edition** of Elaine Marieb and Katja Hoehn's best-selling A&P text and media program motivates and supports both novice learners and expert students, more than ever before. Each carefully-paced chapter guides you in advancing from mastering terminology to applying knowledge in clinical scenarios, to practicing the critical thinking and problem-solving skills that are required for entry to nursing, allied health, and exercise science programs.



# Identify “Big Picture” Concepts Before Exploring Details

Before you look up details and information within a chapter, read the **Chapter-Opening Roadmap**, which visually groups and organizes “big picture” concepts and shows how they are related. To focus your studying, review the numbered **Key Concept Headings**, **Learning Outcomes**, and summaries.

**UNIQUE! Chapter Roadmaps** provide a visual overview of the key concepts in the chapter and show how they relate to each other. Each key concept “brick” in the roadmap corresponds to a numbered section within the chapter.

Each numbered section within the chapter begins with a **Key Concept Heading** that helps you quickly grasp the “big idea” of the discussion that follows.

## 8

# Joints

In this chapter, you will learn that

**Joints determine how bones move relative to each other**

by first asking

8.1 How are joints classified?

then exploring

8.2 Fibrous joints

8.3 Cartilaginous joints

8.4 Synovial joints

Movement of synovial joints

8.5 Selected synovial joints

then asking

8.6 What happens when things go wrong?

and finally, exploring

Developmental Aspects of Joints

**The graceful movements** of ballet dancers and the rough-and-tumble grapplings of football players demonstrate the great variety of motion allowed by **joints**, or **articulations**—the sites where two or more bones meet. Our joints have two fundamental functions: They give our skeleton mobility, and they hold it together, sometimes playing a protective role in the process.

**8.1 Joints are classified into three structural and three functional categories**

**Learning Outcomes**


- ✓ Define joint or articulation.
- ✓ Classify joints by structure and by function.

Joints are classified by structure and by function. The *structural classification* focuses on the material binding the bones together and whether or not a joint cavity is present. Structurally, there are *fibrous*, *cartilaginous*, and *synovial joints* (Table 8.1 on p. 285). Only synovial joints have a joint cavity.

The *functional classification* is based on the amount of movement allowed at the joint. On this basis, there are **synarthroses** (sin'ar-thro'sēz; *syn* = together, *arthro* = joint), which are immovable joints; **amphiarthroses** (am'fē-ar-thro'sēz; *amphi* = on both sides), slightly movable joints; and **diarthroses** (dī'ar-thro'sēz; *dia* = through, apart), or freely movable joints. Freely movable joints predominate in the appendicular skeleton (limbs). Immovable and slightly movable joints are largely restricted to the axial skeleton. This localization of functional joint types makes sense because the less movable the joint, the more stable it is likely to be.

In general, fibrous joints are immovable, and synovial joints are freely movable. However, cartilaginous joints have both rigid

**CAREER CONNECTION**



Watch a video to learn how the chapter content is used in a real health care setting. Go to **Mastering A&P®** > Study Area > Animations and Videos or use quick access URL <https://bit.ly/3P8hiZa>

**Career Connection Videos** feature a health care professional who describes how the chapter content relates to their everyday work. You can access all of the Career Connections videos through an open access web page at <https://bit.ly/3P8hiZa>.

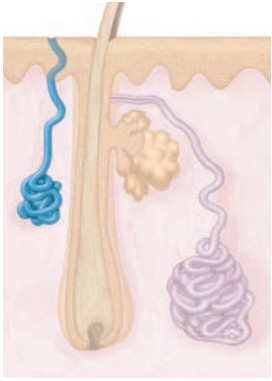
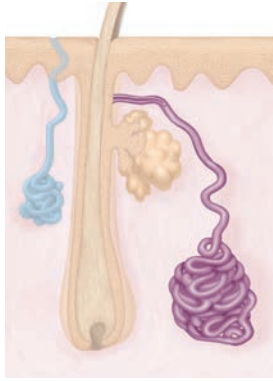

See p. 281

**Learning Outcomes** are presented at the beginning of each chapter section to give you a preview of essential information to study.

# Pace Yourself: Learn & Review the Basics

**Summary Tables** present key information and serve as “one-stop shopping” study tools.

**Table 5.1 Summary of Cutaneous Glands**

	ECCRINE SWEAT GLANDS	APOCRINE SWEAT GLANDS	SEBACEOUS GLANDS
			
<b>Functions</b>	<ul style="list-style-type: none"> <li>• Temperature control</li> <li>• Some antibacterial properties</li> </ul>	May act as sexual scent glands	<ul style="list-style-type: none"> <li>• Lubricate skin and hair</li> <li>• Help prevent water loss</li> <li>• Antibacterial properties</li> </ul>
<b>Type of Secretion</b>	Hypotonic filtrate of blood plasma	Filtrate of blood plasma with added proteins and fatty substances	Sebum (an oily secretion)
<b>Method of Secretion</b>	Merocrine (exocytosis)	Merocrine (exocytosis)	Holocrine
<b>Secretion Exits Duct At</b>	Skin surface	Usually upper part of hair follicle; rarely, skin surface	Usually upper part of hair follicle; sometimes, skin surface
<b>Body Location</b>	Everywhere, but especially palms, soles, forehead	Mostly axillary and anogenital regions	Everywhere except palms and soles

See p. 192

## Sebaceous Glands

The **sebaceous glands** (se-ba'shus; “greasy”), or *oil glands* (Figure 5.9a), are simple branched alveolar glands that are found all over the body except in the thick skin of the palms and soles. They are small on the body trunk and limbs, but quite large on the face, neck, and upper chest. These glands secrete an oily substance called **sebum** (se'bum). The central cells of the alveoli accumulate oily lipids until they become so engorged that they burst, so functionally these glands are *holocrine glands* (◀ p. 156). The accumulated lipids and cell fragments constitute sebum.

**Text Recall icons** guide you to review specific pages where a concept was first introduced.

See p. 193

**Building Vocabulary Coaching Activities in Mastering A&P®** are a fun way to learn word roots and A&P terminology while building and practicing important language skills.

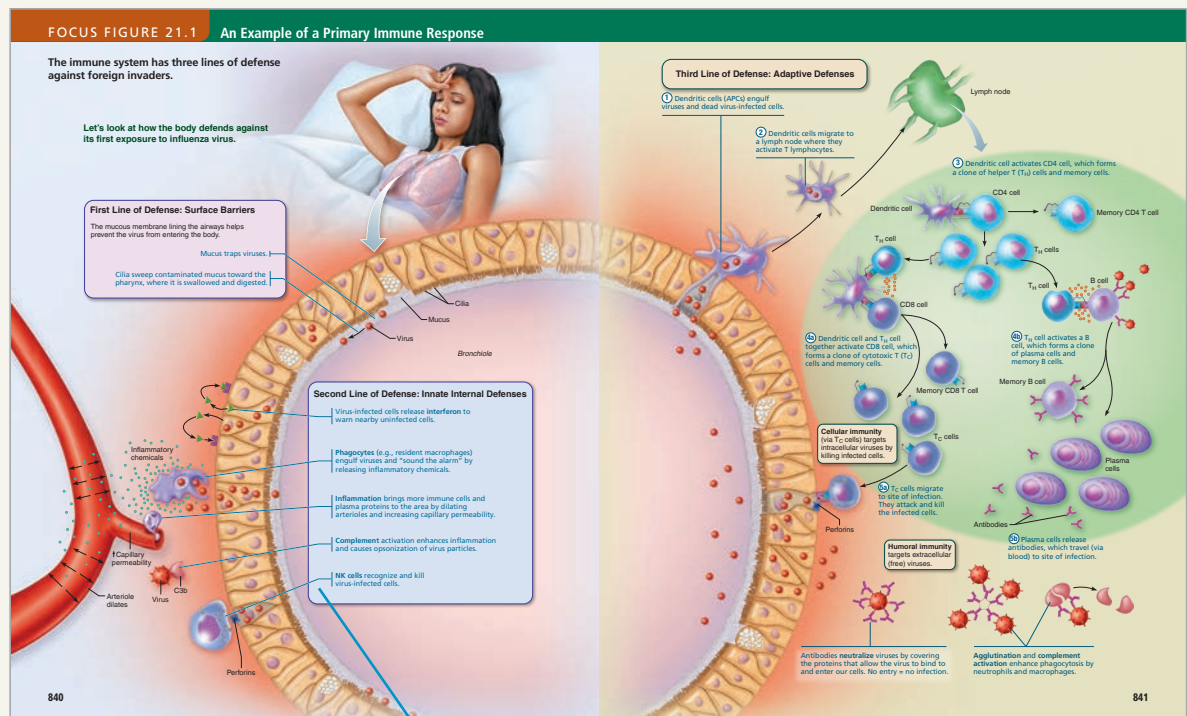
# Study the Figures as You Read the Text

Anatomy and Physiology is a visual science. To succeed, you need to practice and develop visual literacy skills for understanding and interpreting information. To help you achieve this goal, the text and associated figures are tightly integrated so that you do not have to flip pages back and forth to connect visuals with words.

**26 Focus Figures** walk you through complex processes using exceptionally clear, easy-to-follow illustrations with integrated text explanations.

See pp. 840–841

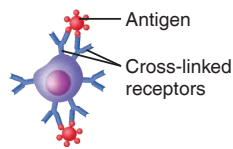
**Focus Figure “Mini-Animation” Coaching Activities** bring some of the Focus Figures to life using short video segments.



**Blue text** represents the voice of an A&P instructor, highlighting important points to remember.

## Activation and Differentiation of B Cells

An immunocompetent but naive B lymphocyte is *activated* when matching antigens bind to its surface receptors and cross-link adjacent receptors together. Antigen binding is quickly followed by receptor-mediated endocytosis of the cross-linked antigen-receptor complexes. As we described previously, this is called *clonal selection* and is fol-



**31 unique In-Line Figures** are strategically placed within the text to visually reinforce the text discussion.

See p. 828



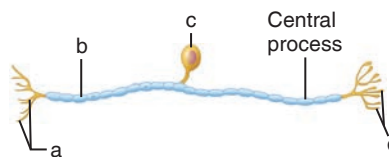
# Apply Your Knowledge to a Range & Variety of Questions

As you build your knowledge and confidence in A&P, practice responding to the more challenging questions—you are likely to encounter similar questions on a test or licensing exam. Your extra effort will pay off at exam time!

A greater **variety and range of self-assessment questions** have been added to the **Check Your Understanding** sections within each chapter and include **Apply, Predict, What If?, Draw, and Make Connections**. Dozens of new **visual questions** ask you to label structures or interpret visual information.

## Check Your Understanding

- How does a nucleus within the brain differ from a nucleus within a neuron?
- How is a myelin sheath formed in the CNS, and what is its function?
- What is the structural classification of the neuron shown below? What is its usual functional classification? Name the parts labeled a–d.
- APPLY** Which structural and functional type of neuron is involved in sensing the smell of your perfume? Which type is needed to transfer the impulses to the brain for integration?



- MAKE CONNECTIONS** Which part of the neuron is its fiber? How do nerve fibers differ from the fibers of connective tissue (see Chapter 4) and the fibers in muscle (see Chapter 9)?

For answers, see Answers Appendix.

See p. 431

**“Draw” questions** ask you to create visuals that reinforce important concepts by drawing a structure, annotating a figure, or creating a summary table.

- DRAW** Create a summary table to help you study the pharynx by comparing and contrasting its three parts. For each part, identify what it conducts (air, food, or both), the type of epithelium found there, and the associated tonsils.

All of the **End-of-Chapter Review questions** are now organized into 3 levels of difficulty based on **Bloom’s Taxonomy categories**:

Level 1: Remember/Understand  
Level 2: Apply/Analyze  
Level 3: Evaluate/Synthesize

	Conducts	Epithelium	Tonsils
Nasopharynx	Air	Pseudostratified ciliated columnar	Pharyngeal Tubal
Oropharynx	Air and food	Stratified squamous	Palatine Lingual
Laryngopharynx	Air and food	Stratified squamous	— (none)

See p. 858 and Answers Appendix

# Prepare for Your Future Career & Practice Solving Real-World Problems

The authors of this text, Elaine Marieb and Katja Hoehn, share insights from their own clinical experience to help you prepare for your future career in health care. All clinical examples and applications are signaled with an easy-to-find “Clinical” label.

**Homeostatic Imbalance** discussions alert you to the consequences of body systems not functioning optimally. Relevant photos have been added to selected discussions for visual reinforcement.

**NEW!** Discussions have been added on Marfan syndrome, brittle bone disease, tetanus, and anxiety disorders.



## HOMEOSTATIC IMBALANCE 4.2

CLINICAL

**Marfan syndrome** is an inherited disorder that causes a change in the types of proteins that comprise elastic fibers. As a result of this change, the elasticity in tissues is reduced, leading to the overgrowth (aortic enlargement and long arms, legs, and fingers) and instability (lung collapse and eye problems) of tissues. Although people suffering from Marfan syndrome are born with the condition, not all of them show symptoms at birth or during childhood; some only develop symptoms as adults.

See p. 158

**Clinical Case Studies** are provided at the end of Chapters 5–29 and challenge you to apply your knowledge to realistic clinical scenarios.

## CLINICAL CASE STUDY

### One-Year-Old Girl with Retarded Growth

Miriam gave birth to a twin boy and girl a year ago. She is concerned about Theresa, her daughter, since her growth and development is much slower than that of her brother. Miriam visits a pediatric outpatient clinic, where she informs the physician



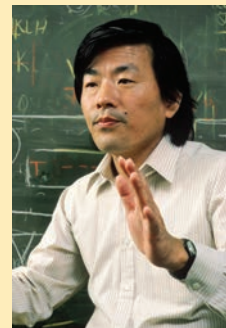
that, apart from having retarded growth, Theresa has a poor appetite, suffers from constipation, and is lethargic. The physician orders blood tests to check Theresa’s growth hormone

See p. 673

**NEW!** Boxes on scientists feature details about the lives and works of eminent scientists. These will show you the human side of science.

### Susumu Tonegawa (b. 1939)

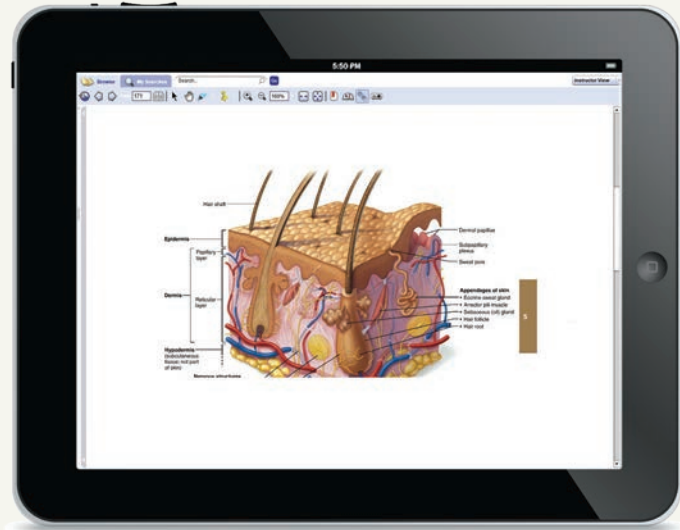
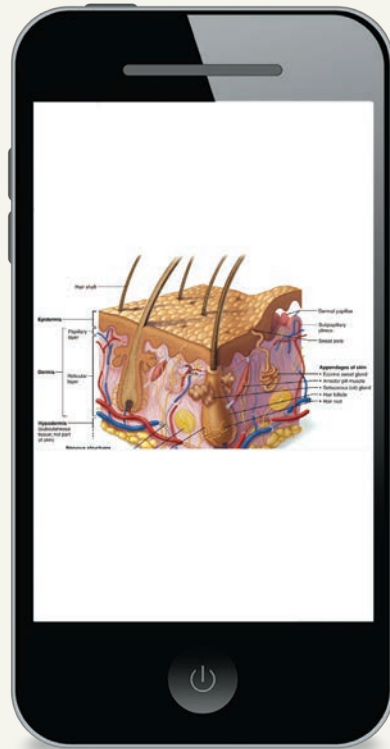
is a Japanese scientist who won the Nobel Prize in Physiology or Medicine in 1987 for elucidating the genetic mechanisms underlying adaptive immunity. A problem in adaptive immunity was that, although the presence of millions of different antibody proteins was known, there weren’t enough genes in the human genome to account for these. So how were all these different antibodies produced? By comparing the DNA of mature and immature B cells, Tonegawa discovered that the regions of DNA that produce antibodies become greatly rearranged as the B cell matures, which is how a small number of antibody-producing genes generate the huge variety of antibodies seen.



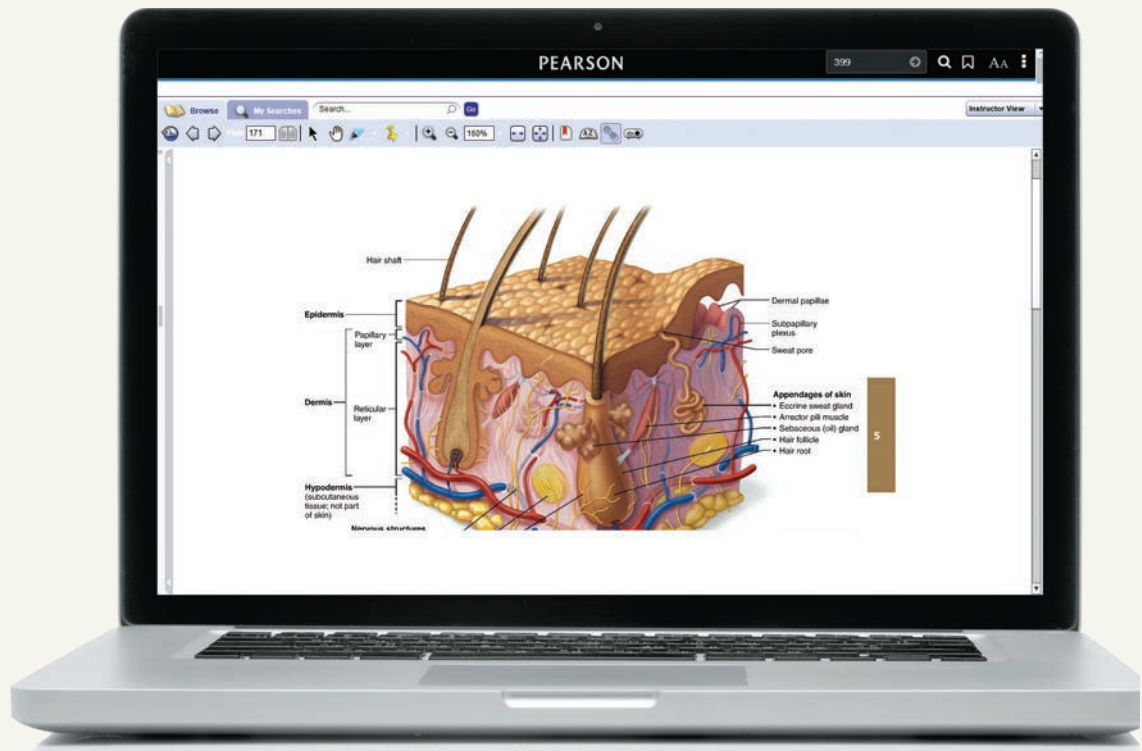
See p. 830

# Access the Complete Textbook Using the Pearson eText

You can read your textbook without having to add weight to your bookbag! Videos and animations in the eText bring key concepts to life, helping you place what you are reading into context.



**Powerful interactive and customization functions** include instructor and student note-taking, highlighting, bookmarking, search, and links to glossary terms.





# Get Online Practice and Coaching with Mastering A&P<sup>®</sup>

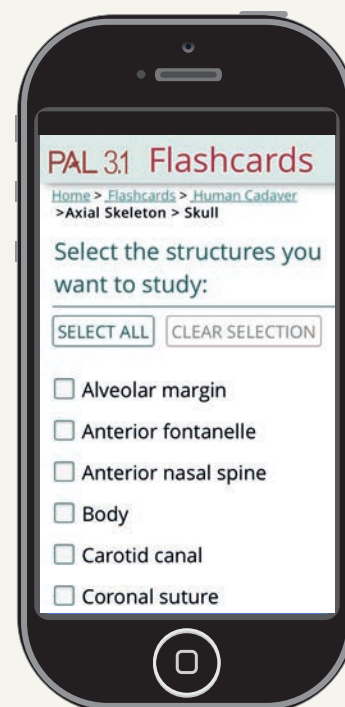
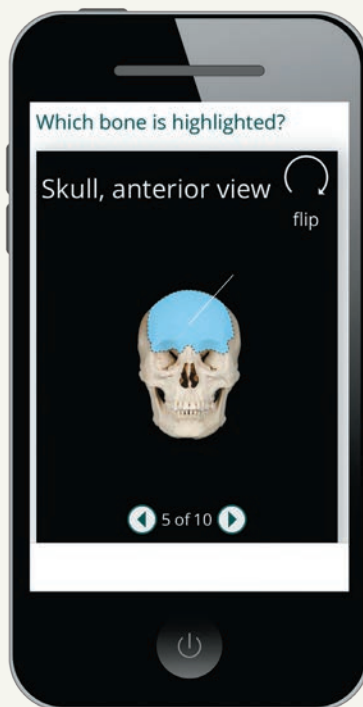
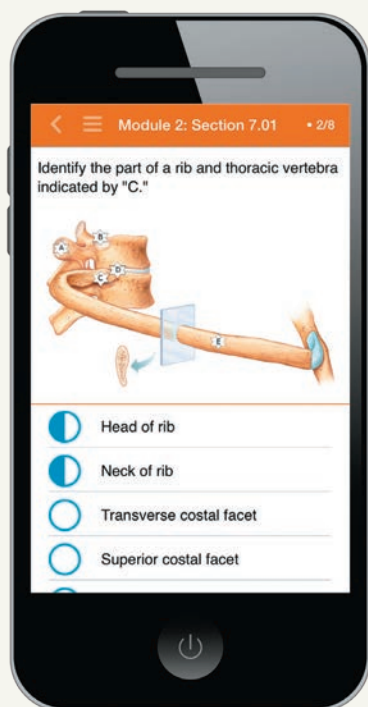
Mastering A&P<sup>®</sup> provides tutorials and review questions that you can access before, during, and after class.

**EXPANDED! Interactive Physiology 2.0 Coaching Activities** teach complex physiology processes using exceptionally clear animations, interactive tutorials, games, and quizzes. IP2 features new graphics, quicker navigation, and a mobile-friendly design. New topics include Pulmonary Ventilation, Tubular Reabsorption and Secretion, and Urine Concentration and Volume. IP2 and IP animations can be assigned from the Mastering A&P<sup>®</sup> item library or accessed through the Study Area.

**NEW!** 10 Histology Videos provide short, focused walkthroughs of some of the most commonly covered tissue types in A&P.

**NEW and UPDATED!** Bone and Organ Dissection Videos, with 23 UPDATED Bone Videos and 3 NEW Bone Videos for fetal skull, cervical vertebrae, and male and female pelvis, cover major bone and organ dissections to help you prepare for lecture and lab.

**PAL 3.1 Customizable Flashcards** allow you to create a personalized, mobile-friendly deck of flashcards and quizzes using images from Practice Anatomy Lab. Use the checklist to select only those structures covered in your course.




**Dynamic Study Modules** are manageable, mobile-friendly sets of questions with extensive feedback for you to test, learn, and retest yourself on basic concepts. Instructors can select or deselect specific questions for assignments from more than 3,000 questions, organized by chapter section.

# Resources for Instructors: Ready-to-Go Teaching Modules

**Ready-to-Go Teaching Modules** help instructors efficiently make use of the best teaching tools before, during, and after class. Accessed through the Instructor Resources area of Mastering A&P® and prepared by expert A&P instructors, each module includes a variety of teaching ideas and ready-to-use resources for teaching 10 challenging course topics.

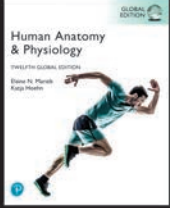

Marieb/Hoehn  
*Human Anatomy & Physiology*,  
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## Ready-To-Go Teaching Modules



Ready-to-Go Teaching Modules make use of teaching tools for before, during, and after class, including new ideas for in-class activities.

The modules incorporate the best that the text, Mastering A&P®, and Learning Catalytics have to offer and guide instructors through using these resources in the most effective way.



 Skeletal System	 Neurophysiology
 Muscular System Physiology	 Kidney Physiology
 Nervous System	 Endocrine System
 Cardiovascular Physiology	 Respiratory System
 Digestive System	 Fluid, Electrolyte, and Acid/Base Balance

**Learning Catalytics** allows students to use their smartphone, tablet, or laptop to respond to questions in class. Visit [learningcatalytics.com](http://learningcatalytics.com) to learn more.



# Additional Support for Students & Instructors

Mastering A&P® offers thousands of tutorials, activities, and questions that can be assigned for homework and practice. Highlights of the assignment options include:

- **Building Vocabulary Coaching Activities** give you practice learning and using word roots in context as you learn new A&P terms.
- **Focus Figure “Mini-Animation” Coaching Activities** bring some of the Focus Figures to life and include assessment questions.
- **Concept Map Coaching Activities** support the concept maps in the text without requiring students to submit their own concept map for grading.
- **NCLEX-Style Questions** give students practice with the kinds of questions that will eventually appear on a licensing exam.

The Mastering A&P® Instructor Resources Area includes the following downloadable tools for instructors who adopt the Twelfth Edition for their classes:

- **Ready-to-Go Teaching Modules** provide teaching tools for 10 challenging topics in A&P.
- **Customizable PowerPoint® lecture outlines** include customizable images and provide a springboard for lecture prep.
- **The figures, photos, and tables from the text** are available in JPEG and PowerPoint® formats, in labeled and unlabeled versions, and with customizable labels and leader lines.
- **Test bank** provides thousands of customizable questions across Bloom’s Taxonomy levels. Each question is tagged to chapter learning outcomes that can also be tracked within Mastering A&P® assessments. Available in Microsoft® Word and TestGen® formats.
- **Animations and videos** bring A&P concepts to life and include A&P Flix 3-D Animations.



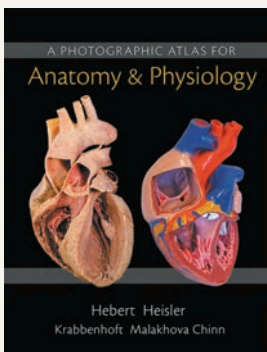
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by Elaine Marieb & Lori Smith

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## A Photographic Atlas for Anatomy & Physiology

by Nora Hebert, Ruth E. Heisler, et al.

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# Human Anatomy & Physiology

TWELFTH GLOBAL EDITION

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# About the Authors

We dedicate this work to our students both present and past, who always inspire us to “push the envelope.”

## Elaine N. Marieb

After receiving her Ph.D. in zoology from the University of Massachusetts at Amherst, Elaine N. Marieb joined the faculty of the Biological Science Division of Holyoke Community College. While teaching at Holyoke Community College, where many of her students were pursuing nursing degrees, she developed a desire to better understand the relationship between the scientific study of the human body and the clinical aspects of the nursing practice. To that end, while continuing to teach full time, Dr. Marieb pursued her nursing education, which culminated in a Master of Science degree with a clinical specialization in gerontology from the University of Massachusetts. It is this experience that informed the development of the unique perspective and accessibility for which her publications are known.

Dr. Marieb gave generously to provide opportunities for students to further their education. She funded the E.N. Marieb



Science Research Awards at Mount Holyoke College, which promotes research by undergraduate science majors, and underwrote renovation of the biology labs in Clapp Laboratory at that college. Dr. Marieb also contributed to the University of Massachusetts at Amherst, where she provided funding for reconstruction and instrumentation of a cutting-edge cytology research laboratory. Recognizing the severe national shortage of nursing faculty, she underwrote the Nursing Scholars of the Future Grant Program at the university.

In 2012 and 2017, Dr. Marieb gave generous philanthropic support to Florida Gulf Coast University as a long-term investment in education, research, and training for healthcare and human services professionals in the local community. In honor of her contributions, the university is now home to the Elaine Nicpon Marieb College of Health and Human Services.

## Katja Hoehn

Dr. Katja Hoehn is a professor in the Department of Biology at Mount Royal University in Calgary, Canada. Dr. Hoehn's first love is teaching. Her teaching excellence has been recognized by several awards during her 24 years at Mount Royal University. These include a PanCanadian Educational Technology Faculty Award (1999), a Teaching Excellence Award from the Students' Association of Mount Royal (2001), and the Mount Royal Distinguished Faculty Teaching Award (2004).

Dr. Hoehn received her M.D. (with Distinction) from the University of Saskatchewan, and her Ph.D. in Pharmacology from Dalhousie University. In 1991, the Dalhousie Medical Research Foundation presented her with the Max Forman (Jr.) Prize for excellence in medical research. During her Ph.D. and postdoctoral studies, she also pursued her passion for teaching by presenting guest lectures to first- and second-year medical students at Dalhousie University and at the University of Calgary.

Dr. Hoehn has been a contributor to several books, written numerous research papers in Neuroscience and Pharmacology,

and has co-authored some of the previous editions of this textbook. For many years, she has also reviewed and authored electronic media that accompanies Pearson anatomy and physiology books.



Following Dr. Marieb's example, Dr. Hoehn provides financial support for students in the form of a scholarship that she established in 2006 for nursing students at Mount Royal University.

Dr. Hoehn is also actively involved in the Human Anatomy and Physiology Society (HAPS) and is a member of the American Association of Anatomists. When not teaching, she likes to spend time outdoors with her husband and two sons. She also enjoys competing in long-course triathlons, and playing Irish flute down at the local pub.

# Preface

Today's students have access to an enormous amount of information about anatomy and physiology. As educators, our biggest challenge is to help students focus on mastering the basic concepts of this field. Providing this firm foundation will help students to become lifelong learners who can critically evaluate new information, connect that information to the

foundation they have already established, and apply it in a clinical setting. How can we help students build a strong foundation in anatomy and physiology? We believe that this new edition of our textbook will help learners by building on the strengths of previous editions while using new and innovative ways to help students visualize connections between various concepts.

## Unifying Themes

Three unifying themes that have helped to organize and set the tone of this textbook continue to be valid and are retained in this edition. These themes are:

**Interrelationships of body organ systems.** This theme emphasizes the fact that nearly all regulatory mechanisms have interactions with several organ systems. The respiratory system, for example, cannot carry out its role of gas exchange in the body if there are problems with the cardiovascular system that prevent the normal delivery of blood throughout the body. The System Connections feature and Make Connections questions throughout the book help students connect new information to old information and think of the body as a community of dynamic parts instead of a number of independent units.

**Homeostasis.** Homeostasis is the normal and most desirable condition of the body. Its loss is always associated with past or present pathology. This theme is not included to emphasize pathological conditions, but rather to illustrate what happens in the body “when things go wrong” and homeostasis is lost. Whenever students see a red balance beam symbol accompanied by an associated clinical topic, their understanding of how the body works to stay in balance is reinforced.

**Complementarity of structure and function.** This theme encourages students to understand the structure of some body part (ranging from a molecule to an organ) in order to understand the function of that structure. For example, muscle cells can produce movement because they are contractile cells.

## Key Features of the Twelfth Edition

The following are the key features of the Twelfth Edition:

**NEW!** Boxes on scientists feature details about the lives and works of eminent scientists. These will show students the human side of science. Please refer to p. 16 for a list of these boxes.

**NEW!** Homeostatic Imbalance discussions have been added on Marfan syndrome, brittle bone disease, tetanus, and anxiety disorders.

**NEW!** We have added tables on the following topics:

- Functions of neurons and neuroglia
- Focal versus diffuse brain injuries
- Antihypertensive medications and renin-angiotensin-aldosterone system

**NEW!** We have updated the content with information on recent developments on topics such as sperm centrioles, using fibroblasts as stem cells, 3D bioprinting used for skin grafts, how COVID-19 causes loss of smell, and juxtacrine.

**NEW!** We have added an *A Closer Look* feature on COVID-19.

**To help students make connections between new and previously learned material.** In order for students to master new concepts, they must link these new concepts with concepts they already understand. In this edition, we help them do this by adding:

- **Text recall icons** (◀). These icons direct the student back to the specific pages where a concept was first introduced.

- **Make Connections questions.** We've added more of this type of question to the Check Your Understanding review questions that follow each module within a chapter. To answer these questions, the student must employ concepts learned previously (most often in previous chapters).
- **New kinds of higher-level questions.** Each chapter has at least five higher-level questions that require students to think more deeply, pulling together strands from multiple concepts. These questions are clearly identified as **APPLY**, **DRAW**, **PREDICT**, **MAKE CONNECTIONS**, and **WHAT IF?** questions.

**To enhance students' visual literacy.** Anatomy is and has always been taught principally through images. Increasingly, however, physiological data is also represented as images, whether it be molecular interactions or graphical descriptions of processes. Throughout their future health care careers, students will need to be able to understand and interpret information presented visually. In this edition, we help them do this through:

- **Focus figures.** Focus figures are illustrations that use a “big picture” layout and dramatic art to guide the student through difficult physiological processes in a step-by-step way. Our Focus figures have been a hit with both students and instructors.
- **DRAW questions in each chapter.** Students often think that they understand an illustration simply by looking at it, but to truly comprehend an illustration and cement its concepts requires a more active learning approach. For this reason we include at least one higher-level review question within each chapter that requires a student either to draw an illustration or to add to an existing diagram.
- **Questions about illustrations.** To help students practice their visual literacy skills, we have added Check Your Understanding questions that include an illustration as part of the question. Some of these are as simple as labeling exercises, but many require more advanced interpretation.
- **Updated art.** Today's students are accustomed to seeing sophisticated photorealistically rendered images. However, many students are not adept at extracting, and thinking

critically about, the relevant information contained in such illustrations. With this in mind we continue to refine and update our illustrations as students' needs change, improving their ability to teach important concepts.

- **In-line figures.** These are small (less than a half-column wide) illustrations or photos strategically located within the text that discuss the concept they illustrate. This edition has 31 such in-line figures.

#### To help students clinically apply what they have learned

- **Updated Homeostatic Imbalance features.** Many of the Homeostatic Imbalance features have been updated. All have been reviewed for accuracy and relevancy. In addition, the updated book design makes these features stand out more clearly.
- **Clinical Case Studies in Chapters 5-29 with + NCLEX-STYLE questions.** The end-of-chapter review questions, which are now organized into three levels of difficulty based on Bloom's Taxonomy categories, culminate in a clinical case study that allows students to apply some of the concepts they have learned to a clinical scenario. Each case study has two questions that are similar in style to those in the NCLEX exam.
- **Clinically relevant photos.** We have a number of photos that have clinical relevance (procedures, conditions, etc.) that will help students apply what they are reading to real-life situations and to their future careers.

As in the previous edition, we have taken painstaking care to ensure that almost all the text and the associated art are covered on the same two-page spread. Although this sounds like a simple goal, it actually takes a great deal of work and has not usually been achieved by other textbooks. We make this effort because it is invaluable to student learning to not have to flip pages back and forth between art and text. Finally, you will notice the appearance of icons referencing Mastering A&P<sup>®</sup> interspersed within the text. This guides students to go to the relevant on-line activities to supplement their learning.

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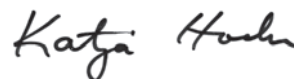
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