Anatomy & Physiology

openstax COLLEGE™

OpenStax College
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OpenStax College

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Rice University

OpenStax College and Connexions are initiatives of Rice University. As a leading research university with a distinctive commitment to undergraduate education, Rice University aspires to path-breaking research, unsurpassed teaching, and contributions to the betterment of our world. It seeks to fulfill this mission by cultivating a diverse community of learning and discovery that produces leaders across the spectrum of human endeavor.

Foundation Support

OpenStax College is grateful for the tremendous support of our sponsors. Without their strong engagement, the goal of free access to high-quality textbooks would remain just a dream.

The William and Flora Hewlett Foundation has been making grants since 1967 to help solve social and environmental problems at home and around the world. The Foundation concentrates its resources on activities in education, the environment, global development and population, performing arts, and philanthropy, and makes grants to support disadvantaged communities in the San Francisco Bay Area.

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The Maxfield Foundation supports projects with potential for high impact in science, education, sustainability, and other areas of social importance.

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PREFACE

Welcome to *Human Anatomy and Physiology*, an OpenStax College resource. We created this textbook with several goals in mind: accessibility, customization, and student engagement—helping students reach high levels of academic scholarship. Instructors and students alike will find that this textbook offers a thorough introduction to the content in an accessible format.

About OpenStax College

OpenStax College is a nonprofit organization committed to improving student access to quality learning materials. Our free textbooks are developed and peer-reviewed by educators to ensure that they are readable, accurate, and organized in accordance with the scope and sequence requirements of today's college courses. Unlike traditional textbooks, OpenStax College resources live online and are owned by the community of educators using them. Through partnerships with companies and foundations committed to reducing costs for students, we are working to improve access to higher education for all. OpenStax College is an initiative of Rice University and is made possible through the generous support of several philanthropic foundations.

About OpenStax College's Resources

OpenStax College resources provide quality academic instruction. Three key features set our materials apart from others: 1) They can be easily customized by instructors for each class, 2) they are "living" resources that grow online through contributions from science educators, and 3) they are available for free or for a minimal cost.

Customization

OpenStax College learning resources are conceived and written with flexibility in mind so that they can be customized for each course. Our textbooks provide a solid foundation on which instructors can build their own texts. Instructors can select the sections that are most relevant to their curricula and create a textbook that speaks directly to the needs of their students. Instructors are encouraged to expand on existing examples in the text by adding unique context via geographically localized applications and topical connections.

Human Anatomy and Physiology can be easily customized using our online platform (https://openstaxcollege.org/textbooks/anatomy-and-physiology/adapt). The text is arranged in a modular chapter format. Simply select the content most relevant to your syllabus and create a textbook that addresses the needs of your class. This customization feature will ensure that your textbook reflects the goals of your course.

Curation

To broaden access and encourage community curation, *Human Anatomy and Physiology* is "open source" under a Creative Commons Attribution (CC BY) license. Members of the scientific community are invited to submit examples, emerging research, and other feedback to enhance and strengthen the material, keeping it current and relevant for today's students. Submit your suggestions to info@openstaxcollege.org, and check in on edition status, alternate versions, errata, and news on the StaxDash at http://openstaxcollege.org.

Cost

Our textbooks are available for free online, and in low-cost print and tablet editions.

About *Human Anatomy and Physiology*

Human Anatomy and Physiology is designed for the two-semester anatomy and physiology course taken by life science and allied health students. It supports effective teaching and learning, and prepares students for further learning and future careers. The text focuses on the most important concepts and aims to minimize distracting students with more minor details.

The development choices for this textbook were made with the guidance of hundreds of faculty who are deeply involved in teaching this course. These choices led to innovations in art, terminology, career orientation, practical applications, and multimedia-based learning, all with a goal of increasing relevance to students. We strove to make the discipline meaningful and memorable to students, so that they can draw from it a working knowledge that will enrich their future studies.

Coverage and Scope

The units of our *Human Anatomy and Physiology* textbook adhere to the scope and sequence followed by most two-semester courses nationwide.

Unit 1: Levels of Organization

Chapters 1–4 provide students with a basic understanding of human anatomy and physiology, including its language, the levels of organization, and the basics of chemistry and cell biology. These chapters provide a foundation for the further study

of the body. They also focus particularly on how the body's regions, important chemicals, and cells maintain homeostasis.
Chapter 1 An Introduction to the Human Body
Chapter 2 The Chemical Level of Organization
Chapter 3 The Cellular Level of Organization
Chapter 4 The Tissue Level of Organization

Unit 2: Support and Movement

In Chapters 5–11, students explore the skin, the largest organ of the body, and examine the body's skeletal and muscular systems, following a traditional sequence of topics. This unit is the first to walk students through specific systems of the body, and as it does so, it maintains a focus on homeostasis as well as those diseases and conditions that can disrupt it.
Chapter 5 The Integumentary System
Chapter 6 Bone and Skeletal Tissue
Chapter 7 The Axial Skeleton
Chapter 8 The Appendicular Skeleton
Chapter 9 Joints
Chapter 10 Muscle Tissue
Chapter 11 The Muscular System

Unit 3: Regulation, Integration, and Control

Chapters 12–17 help students answer questions about nervous and endocrine system control and regulation. In a break with the traditional sequence of topics, the special senses are integrated into the chapter on the somatic nervous system. The chapter on the neurological examination offers students a unique approach to understanding nervous system function using five simple but powerful diagnostic tests.
Chapter 12 Introduction to the Nervous System
Chapter 13 The Anatomy of the Nervous System
Chapter 14 The Somatic Nervous System
Chapter 15 The Autonomic Nervous System
Chapter 16 The Neurological Exam
Chapter 17 The Endocrine System

Unit 5: Energy, Maintenance, and Environmental Exchange

In Chapters 22–26, students discover the interaction between body systems and the outside environment for the exchange of materials, the capture of energy, the release of waste, and the overall maintenance of the internal systems that regulate the exchange. The explanations and illustrations are particularly focused on how structure relates to function.
Chapter 22 The Respiratory System
Chapter 23 The Digestive System
Chapter 24 Nutrition and Metabolism
Chapter 25 The Urinary System
Chapter 26 Fluid, Electrolyte, and Acid–Base Balance

Unit 6: Human Development and the Continuity of Life

The closing chapters examine the male and female reproductive systems, describe the process of human development and the different stages of pregnancy, and end with a review of the mechanisms of inheritance.
Chapter 27 The Reproductive System
Chapter 28 Development and Genetic Inheritance

Pedagogical Foundation and Features

Human Anatomy and Physiology is designed to promote scientific literacy. Throughout the text, you will find features that engage the students by taking selected topics a step further.

Homeostatic Imbalances discusses the effects and results of imbalances in the body.

Disorders showcases a disorder that is relevant to the body system at hand. This feature may focus on a specific disorder, or a set of related disorders.

Diseases showcases a disease that is relevant to the body system at hand.

Aging explores the effect aging has on a body's system and specific disorders that manifest over time.

Career Connections presents information on the various careers often pursued by allied health students, such as medical technician, medical examiner, and neurophysiologist. Students are introduced to the educational requirements for and day-to-day responsibilities in these careers.

Everyday Connections tie anatomical and physiological concepts to emerging issues and discuss these in terms of everyday life. Topics include "Anabolic Steroids" and "The Effect of Second-Hand Tobacco Smoke."

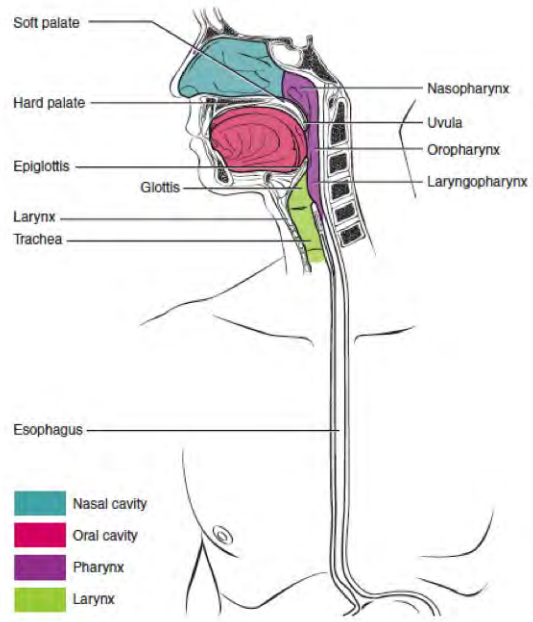
Interactive Links direct students to online exercises, simulations, animations, and videos to add a fuller context to core content and help improve understanding of the material. Many features include links to the University of Michigan's interactive WebScopes, which allow students to zoom in on micrographs in the collection. These resources were vetted by reviewers and other subject matter experts to ensure that they are effective and accurate. We strongly

urge students to explore these links, whether viewing a video or inputting data into a simulation, to gain the fullest experience and to learn how to search for information independently.

Dynamic, Learner-Centered Art

Our unique approach to visuals is designed to emphasize only the components most important in any given illustration. The art style is particularly aimed at focusing student learning through a powerful blend of traditional depictions and instructional innovations.

Much of the art in this book consists of black line illustrations. The strongest line is used to highlight the most important structures, and shading is used to show dimension and shape. Color is used sparingly to highlight and clarify the primary anatomical or functional point of the illustration. This technique is intended to draw students' attention to the critical learning point in the illustration, without distraction from excessive gradients, shadows, and highlights. Full color is used when the structure or process requires it (for example, muscle diagrams and cardiovascular system illustrations).

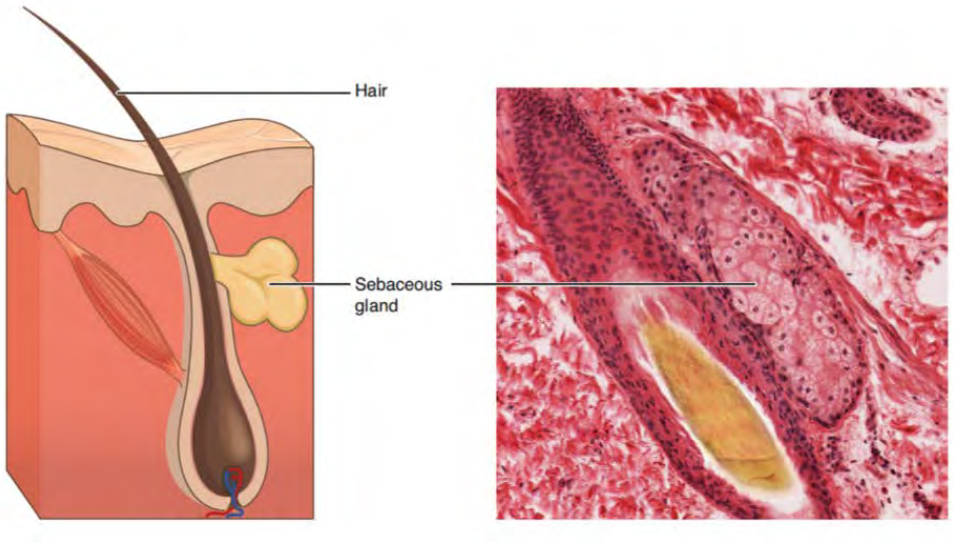


By highlighting the most important portions of the illustration, the artwork helps students focus on the most important points, without overwhelming them.

Micrographs

Micrograph magnifications have been calculated based on the objective provided with the image. If a micrograph was recorded at 40×, and the image was magnified an additional 2×, we calculated the final magnification of the micrograph to be 80×.

Please note that, when viewing the textbook electronically, the micrograph magnification provided in the text does not take into account the size and magnification of the screen on your electronic device. There may be some variation.



These glands secrete oils that lubricate and protect the skin. LM × 400. (Micrograph provided by the Regents of University of Michigan Medical School © 2012)

Learning Resources

The following resources are (or will be) available in addition to main text:

PowerPoint slides: For each chapter, the illustrations are presented, one per slide, with their respective captions.

Pronunciation guide: A subset of the text's key terms are presented with easy-to-follow phonetic transcriptions. For example, blastocyst is rendered as "blas'to-sist"

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Special Thanks

OpenStax College wishes to thank the Regents of University of Michigan Medical School for the use of their extensive micrograph collection. Many of the UM micrographs that appear in *Human Anatomy and Physiology* are interactive WebScopes, which students can explore by zooming in and out.

We also wish to thank the Open Learning Initiative at Carnegie Mellon University, with whom we shared and exchanged resources during the development of *Human Anatomy and Physiology*.

1 | AN INTRODUCTION TO THE HUMAN BODY

Figure 1.1 Blood Pressure A proficiency in anatomy and physiology is fundamental to any career in the health professions. (credit: Bryan Mason/flickr)

Introduction

Chapter Objectives

After studying this chapter, you will be able to:

- Distinguish between anatomy and physiology, and identify several branches of each
- Describe the structure of the body, from simplest to most complex, in terms of the six levels of organization
- Identify the functional characteristics of human life
- Identify the four requirements for human survival
- Define homeostasis and explain its importance to normal human functioning
- Use appropriate anatomical terminology to identify key body structures, body regions, and directions in the body
- Compare and contrast at least four medical imagining techniques in terms of their function and use in medicine

Though you may approach a course in anatomy and physiology strictly as a requirement for your field of study, the knowledge you gain in this course will serve you well in many aspects of your life. An understanding of anatomy and physiology is not only fundamental to any career in the health professions, but it can also benefit your own health.