

THE HUMAN BODY

# BONE AND MUSCLE

STRUCTURE, FORCE, AND MOTION

EDITED BY KARA ROGERS

  
**Britannica**  
Educational Publishing

# **BONE** **AND** **MUSCLE**

**STRUCTURE, FORCE, AND MOTION**



THE HUMAN BODY

# BONE AND MUSCLE

STRUCTURE, FORCE, AND MOTION

EDITED BY KARA ROGERS, SENIOR EDITOR, BIOMEDICAL SCIENCES



IN ASSOCIATION WITH

**ROSEN**  
EDUCATIONAL SERVICES

Published in 2011 by Britannica Educational Publishing  
(a trademark of Encyclopædia Britannica, Inc.)  
in association with Rosen Educational Services, LLC  
29 East 21st Street, New York, NY 10010.

Copyright © 2011 Encyclopædia Britannica, Inc. Britannica, Encyclopædia Britannica,  
and the Thistle logo are registered trademarks of Encyclopædia Britannica, Inc. All  
rights reserved.

Rosen Educational Services materials copyright © 2011 Rosen Educational Services, LLC.  
All rights reserved.

Distributed exclusively by Rosen Educational Services.  
For a listing of additional Britannica Educational Publishing titles, call toll free (800) 237-9932.

First Edition

Britannica Educational Publishing

**Michael I. Levy: Executive Editor**

J.E. Luebering: Senior Manager

Marilyn L. Barton: Senior Coordinator, Production Control

Steven Bosco: Director, Editorial Technologies

Lisa S. Braucher: Senior Producer and Data Editor

Yvette Charboneau: Senior Copy Editor

Kathy Nakamura: Manager, Media Acquisition

Kara Rogers: Senior Editor, Biomedical Sciences

Rosen Educational Services

Alexandra Hanson-Harding: Senior Editor

Nelson Sá: Art Director

Cindy Reiman: Photography Manager

Matthew Cauli: Designer, Cover Design

Introduction by David J. Crerand

**Library of Congress Cataloging-in-Publication Data**

Bone and muscle: structure, force, and motion / edited by Kara Rogers. — 1st ed.

p. cm. — (The human body)

“In association with Britannica Educational Publishing, Rosen Educational Services.”

Includes index.

ISBN 978-1-61530-249-9 (eBook)

1. Musculoskeletal system. I. Rogers, Kara.

QP301.B56 2010

612.7—dc22

2009043138

On the cover: This digital composite shows a close up of a man flexing his biceps. Together,  
bones, such as the humerus (upper arm bone), and muscles, such as biceps and triceps, allow  
humans to move in ways both powerful and precise. *Adam Gault/Digital Vision/Getty Images*

*p. 12 Nucleus Medical Art, Inc. / Getty Images; chapter opener art and pp. 246, 247, 249, 250, 252 ©  
www.istockphoto.com.*

# CONTENTS

## INTRODUCTION 12

## CHAPTER 1: HUMAN SKELETAL AND MUSCLE SYSTEMS 19

### Human Skeletal System 19

#### Axial and Visceral Skeleton 21

#### The Appendicular Skeleton 30

### Human Muscle System 35

#### Evolutionary Context 36

#### Muscles of the Lower Limb 37

#### Muscles of the Upper Limb 39

#### Muscles of the Head and Neck 40

#### Muscles of the Trunk 41

## CHAPTER 2: THE NATURE OF BONE 43

### Evolutionary Significance 43

### Chemical Composition and Physical Properties 44

### Bone Morphology 46

#### Compact Bone 48

#### Cancellous Bone 48

#### Epiphyses 49

#### Osteons 50

#### Bone Marrow 53

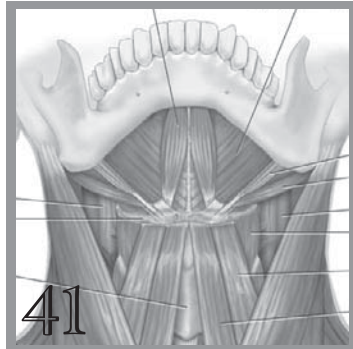
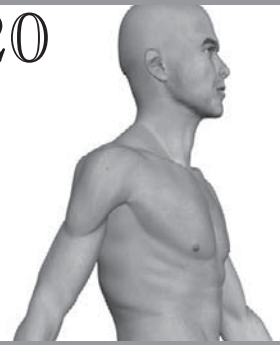
#### Vascular Supply and Circulation 55

### Bone Resorption and Renewal 56

#### Bone Remodeling 59

#### Bone Formation 60

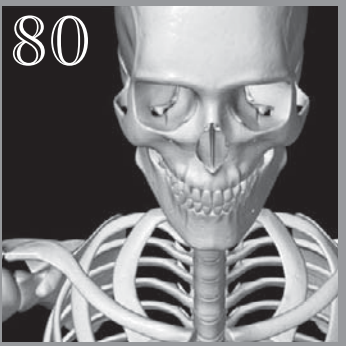
20



41



44



Physiology of Bone 61  
  Calcium and Phosphate  
  Equilibrium 61  
  Physiological and  
  Mechanical Controls 64  
  Hormonal Influences 66  
  Nutritional Influences 68

**CHAPTER 3: BONES OF THE  
HUMAN ANATOMY 72**

Bones of the Head 72  
  The Skull 72  
  Fontanel 73  
  Zygomatic Bone 73  
  Parietal Bone 74  
  Occipital Bone 74  
  Nasal Conchae 76  
Bones of the Vertebral  
Column 76  
  Vertebrae 76  
  The Neck 77  
  The Sacrum 78  
  The Coccyx 78  
Bones of the Upper Body 79  
  Clavicle 79  
  Scapula 79  
  Sternum 81  
  The Ribs 82  
  Humerus 82  
  Radius 83  
  Ulna 84  
  The Hand 84  
Bones of the Lower Body 87  
  The Pelvic Girdle 87  
  Femur 88

Tibia 89  
Fibula 89  
The Foot 90

**CHAPTER 4: THE NATURE OF  
MUSCLE 93**

Striated Muscle 94  
Muscle Fibres 94  
Myofibrils 96  
Myofilaments 98  
Proteins of the  
Myofilaments 100  
Actin-Myosin Interaction  
and Its Regulation 103  
Energy Stores 104  
Molecular Mechanisms of  
Muscle Contraction 105  
Smooth Muscle 106  
Structure and Organization 107  
Initiation of Contraction 109  
Cross-Bridge Cycle and  
ATP Breakdown 110  
Mechanical Properties 111  
Cardiac Muscle 112  
Structure and Organization 113  
The Frequency of  
Contraction 114  
Excitation/Contraction  
Coupling 116  
Force and Velocity of  
Contraction 117  
Response of the Heart to  
Stress 117  
Muscles of Movement 119  
Abductor Muscle 119

