Guided Tour Through a Chapter!

Learning Outcomes at the beginning of every chapter will help students understand what they should know after studying the chapter.

Learning Outcomes *After you have studied this chapter, you should be able to:*

6.1 Skeleton: Overview (p. 98)
1. Name at least five functions of the skeleton.
2. Explain a classification of bones based on their shapes.
3. Describe the anatomy of bone. Describe long bone structure, and compare/contrast compact bone and spongy bone.
4. Describe the physiology of bone, including the cells involved in growth and repair, and the process of bone growth, development, and remodeling.
5. Name and describe six types of fractures, and state the four steps in fracture repair.
6. List the surface features of bones, and give examples where each can be found.

6.2 Axial Skeleton (p. 103)
7. Distinguish between the axial and appendicular skeletons.
8. Name the bones of the skull, and state the important features of each bone.
9. Describe the structure and function of the hyoid bone.
10. Name the bones of the vertebral column and the thoracic cage. Be able to label diagrams of them.
11. Describe a typical vertebra, the atlas and axis, and the sacrum and coccyx.
12. Name the three types of ribs and the three parts of the sternum.

6.3 Appendicular Skeleton (p. 112)
13. Name the bones of the pectoral girdle and the pelvic girdle. Be able to label diagrams of them.
14. Name the bones of the upper limb (arm and forearm) and the lower limb (thigh and leg). Be able to label diagrams that include surface features.
15. Cite at least five differences between the female and male pelvises.

6.4 Joints (Articulations) (p. 117)
16. Explain how joints are classified, and give examples of each type of joint.
17. List the types of movements that occur at synovial joints.
18. Explain how damage and degeneration occurs at joints and how it can be treated. Outline possible steps for damage prevention.

6.5 Effects of Aging (p. 121)
19. Describe the anatomical and physiological changes that occur in the skeletal system as we age.

6.6 Homeostasis (p. 121)
20. List and discuss six ways the skeletal system contributes to homeostasis. Discuss ways the other systems assist the skeletal system.

I.C.E.—In Case of Emergency
Broken Bones (p. 101)

Medical Focus
Osteoporosis (p. 102)

Medical Focus
Oh, My Aching Back: Surgical Options for Back Injuries (p. 111)

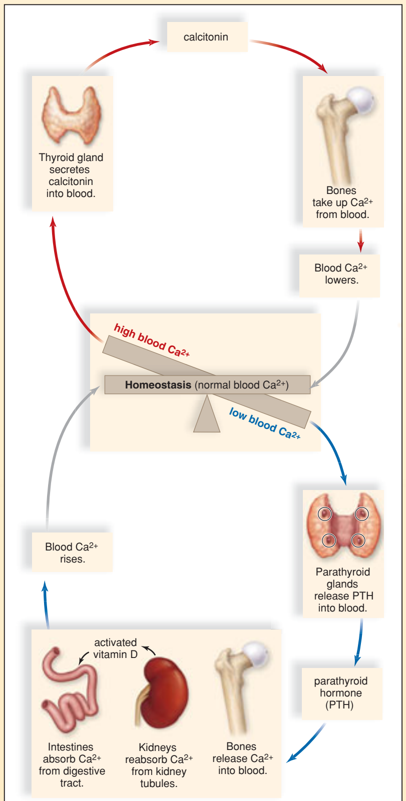
Focus on Forensics
Skeletal Remains (p. 122)

Human Systems Work Together
Skeletal System (p. 123)

Accessible Writing Style More important than any other component of a textbook, the writing must be appropriate for the level of the reader. *Mader's Understanding Human Anatomy and Physiology* features the **perfect writing style for the one-semester course.** It has always been written and designed for the one-semester course, not adapted from a two-semester textbook. Paragraph introductions, explanations, comparisons, and relevant, everyday examples are used with these students in mind. The flow of the text is logical and accessible without being overly "chatty" and consistently makes use of relevant examples and analogies.

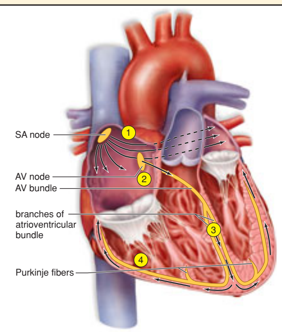
Easy-to-Understand Art covers what's important but leaves out unnecessary, confusing detail.

Good examples of this are the homeostasis illustrations – instead of lots of various colored arrows and boxes with explanations, these simple visual pieces get the message across beautifully.

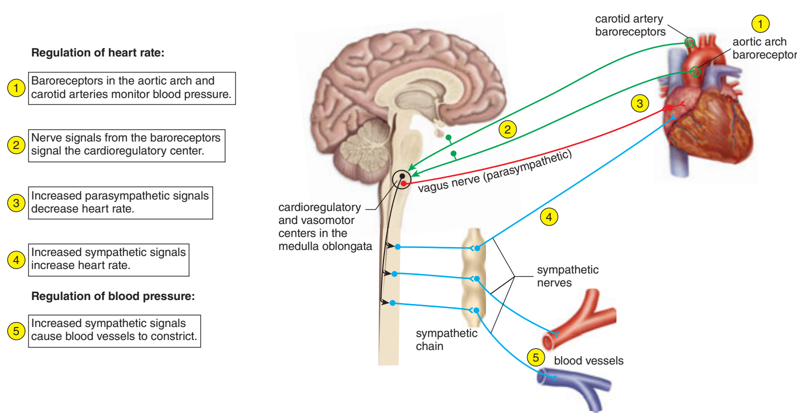


APR **Figure 10.9 Regulation of blood calcium level.** *Top:* When the blood calcium (Ca^{2+}) level is high, the thyroid gland secretes calcitonin. Calcitonin promotes the uptake of Ca^{2+} by the bones, and therefore the blood Ca^{2+} level returns to normal. *Bottom:* When the blood Ca^{2+} level is low, the parathyroid glands release parathyroid hormone (PTH). PTH causes the bones to release Ca^{2+}. It also causes the kidneys to reabsorb Ca^{2+} and activate vitamin D; thereafter, the intestines absorb Ca^{2+}. Therefore, the blood Ca^{2+} level returns to normal.

Another example is stepped-out art, which shows key stages of an illustration identified by numbered circles. This type of explanation builds comprehension sequentially.



APR **Figure 12.5** **Conduction system of the heart.** (1) The SA node sends out a stimulus, which causes the atria to contract. (2) When this stimulus reaches the AV node, it passes through the atrial wall to the AV bundle. (3) Impulses pass down the two branches of the atrioventricular bundle. (4) Numerous small Purkinje fibers carry the electrical signal throughout the ventricle wall. Thereafter, the ventricles contract.



APR **Figure 12.7** **Control of heart activity.** The cardioregulatory center regulates the heart rate, and the vasomotor center regulates constriction of blood vessels, according to input received from baroreceptors in the carotid artery and aortic arch.

Macro to micro figures give the students an overall perspective.

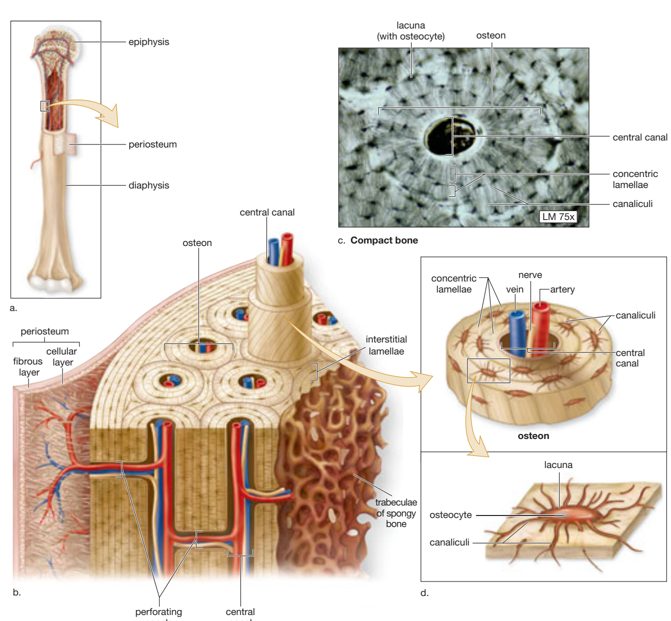
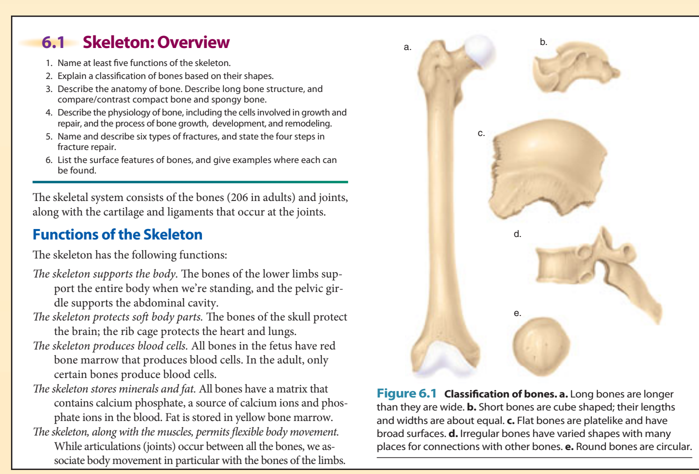


Figure 6.2 **Anatomy of a long bone. a.** A long bone is encased by the periosteum except at the epiphyses, which are covered by articular cartilage. Spongy bone of the epiphyses contains red bone marrow. The diaphysis contains yellow bone marrow surrounded by compact bone. **b.** The detailed anatomy of spongy bone and compact bone is shown in the enlargement. **c.** Photomicrograph of compact bone. **d.** An osteocyte in a lacuna.

Learning Outcomes are now also listed within the chapter! Students will know what that specific section is covering.



6.1 Skeleton: Overview

1. Name at least five functions of the skeleton.
2. Explain a classification of bones based on their shapes.
3. Describe the anatomy of bone. Describe long bone structure, and compare/contrast compact bone and spongy bone.
4. Describe the physiology of bone, including the cells involved in growth and repair, and the process of bone growth, development, and remodeling.
5. Name and describe six types of fractures, and state the four steps in fracture repair.
6. List the surface features of bones, and give examples where each can be found.

The skeletal system consists of the bones (206 in adults) and joints, along with the cartilage and ligaments that occur at the joints.

Functions of the Skeleton

The skeleton has the following functions:

The skeleton supports the body. The bones of the lower limbs support the entire body when we're standing, and the pelvic girdle supports the abdominal cavity.

The skeleton protects soft body parts. The bones of the skull protect the brain; the rib cage protects the heart and lungs.

The skeleton produces blood cells. All bones in the fetus have red bone marrow that produces blood cells. In the adult, only certain bones produce blood cells.

The skeleton stores minerals and fat. All bones have a matrix that contains calcium phosphate, a source of calcium ions and phosphate ions in the blood. Fat is stored in yellow bone marrow.

The skeleton, along with the muscles, permits flexible body movement. While articulations (joints) occur between all the bones, we associate body movement in particular with the bones of the limbs.

a. b. c. d. e.

Figure 6.1 **Classification of bones. a.** Long bones are longer than they are wide. **b.** Short bones are cube shaped; their lengths and widths are about equal. **c.** Flat bones are platelike and have broad surfaces. **d.** Irregular bones have varied shapes with many places for connections with other bones. **e.** Round bones are circular.

Guided Tour Through a Chapter!

Built-in Study Aids such as the *Content Check-Up* and the *Begin Thinking Clinically* features allow students to test themselves over major sections of text before continuing.

Content CHECK-UP!

1. The term for the expanded portions at the ends of a long bone is:
   a. diaphysis.
   b. epiphysis.
   c. periosteum.
   d. articular cartilage.
2. Which type of bone cell breaks down bone and deposits into the blood?
   a. osteoblast
   b. osteocyte
   c. osteoprogenitor
   d. osteoclast
3. The term for a rounded opening through a bone is:
   a. foramen.
   b. tuberosity.
   c. trochanter.
   d. condyle.

Answers in Appendix B.

Begin Thinking Clinically

You're treating an 11-year-old patient in the emergency room. His right eye was struck by a baseball bat, and he's rapidly developing a nasty black eye. What bones might have been broken by the injury?

Answer and discussion in Appendix B.

End of Chapter

Key terms are divided into basic and clinical terms, and include page references. Two levels of additional questions, along with exercises that reinforce medical terminology, are also included with every chapter.

SELECTED NEW TERMS

Basic Key Terms

abduction (ăb-dŭk′shŭn), p. 120
adduction (ăd-dŭk′shŭn), p. 120
amphiarthrosis (ăm″fē-ăr-thrō′sĭs), p. 117
appendicular skeleton (ăp″ĕn-dĭk′yū-lĕr skĕl′ĕ-tŭn), p. 112
appositional growth (ăp″ŭh-zĭsh′ŭn-ŭl grōth), p. 100
articular cartilage (ăr-tĭk′yū-lĕr kăr′tĭ-lĭj), p. 98
articulation (ăr-tĭk″yū-lā′shŭn), p. 98
atlas (ăt-lŭhs), p. 109
axial skeleton (ăk′sē-ăl skĕl′ĕ-tŭn), p. 103
axis (ăk′sĭs), p. 109
ball-and-socket joint (băwl and sŏk′ĭt jōynt), p. 118
bony pelvis (bō′nē pĕl′vĭs) p. 115
bursae (bŭr′sā), p. 118
calcaneus (kăl-kā′nē-ŭhs), p. 116
cartilaginous joints (kăr′tŭl-ăj′ŭh-nŭs jōyntz), p. 117
circumduction (sĕr″kŭm-dŭk′shŭn), p. 120
clavicles (klăv′ĭ-kŭls), p. 112
coccyx (kŏk′sĭks), p. 109
compact bone (kŏm′păkt bōn), p. 98
condyloid joint (kŏn′dĭl-ōyd jōynt), p. 119
coxal bone (kŏk′săl bōn), p. 115
depression (dĭ-prĕsh′ŭn), p. 120
diaphysis (dī-ăf′ĭ-sĭs), p. 98
diarthrosis (dī-ăr-thrō′sĭs), p. 117
elevation (ĕl″ŭh-vā′shŭn), p. 120
endochondral ossification (ĕn″dō-kŏn′drŭl ŏs″ŭh-fĭ-kā′shŭn), p. 100
epiphyseal plate (ĕp″ĭ-fĭz′ē-ăl plāt), p. 100
epiphysis (ĕ-pĭf′ĭ-sĭs), p. 98
eversion (ē-vĕr′zhŭn), p. 120
extension (ĕk-stĕn′shŭn), p. 120
femur (fē′mŭr), p. 116
fibrous joints (fī′brŭs jōyntz), p. 117
fibula (fĭb′yŭ-lŭh), p. 116
flexion (flĕk′shŭn), p. 120
fontanel (fŏnt″ŭh-nĕl′), p. 103
foramen magnum (fŏr-ā′-mĕn măg′nŭm), p. 104
gliding joint (glīd′ĭng jōynt), p. 119
hard palate (hărd păl′ut), p. 105
hematopoiesis (hēm″ăh-tō-pōy-ĕ′sĭs), p. 98
hinge joint (hĭnj jōynt), p. 119
humerus (hyū′mŭr-ŭs), p. 112
ilium (ĭl′ē-ŭm), p. 115
intervertebral disk (ĭn″tĕr-vĕr′tĕ-brŭl dĭsk), p. 108
intramembranous ossification (ĭn″trŭh-mĕm′brān-ŭs ŏs″ŭ-fĭ-kā′shŭn), p. 100
inversion (ĭn-vĕr′zhŭn), p. 120
ischium (ĭs′kē-ŭm), p. 115
ligament (lĭg′ŭh-mĕnt), p. 118
medullary cavity (mĕd′ū-lăr″ē kăv′ĭ-tē), p. 98
menisci (mĕ-nĭs′kī), p. 118
metatarsal bones (mĕt′ŭh-tăr′sŭl bōnz), p. 117
occipital condyle (ŏk′sĭp-ĭ-tŭl kŏn-dīl), p. 104
ossification (ŏs′′ĭ-fĭ-kā′shŭn), p. 100
osteoblast (ŏs′tē-ō-blăst″), p. 99
osteoclast (ŏs′tē-ō-klăst″), p. 99
osteocyte (ŏs′tē-ō-sīt), p. 99
osteon (ŏ′stē-ŏn), p. 98
osteoprogenitor cells (ŏs″tē-ō-prō-jĕn′ĭ-tŭr sĕlz), p. 99
patella (pŭh-tĕl′ ŭh), p. 116
pectoral girdle (pĕk′tō-rŭl gĕr′dŭl), p. 112
pelvic girdle (pĕl′vĭk gĕr′dŭl), p. 115
pelvis (pĕl′-vĭs), p. 115
periosteum (pĕr″ē-ŏs′tē-ŭm), p. 98
phalanges (fŭh-lăn′jēz), p. 117
pivot joint (pĭv′ŭt jōynt), p. 119
pronation (prō-nā′shŭn), p. 120
pubic symphysis (pyū′bĭk sĭm′fĭ-sĭs), p. 115
pubis (pyū′bĭs), p. 115
radius (rā′dē-ŭs), p. 112
red bone marrow (rĕd bōn măh′-rō), p. 98
rib cage (rĭb kāj), p. 109
rotation (rō-tā′shŭn), p. 120
sacrum (sā′krŭm), p. 109
saddle joint (săd′ĕl jōynt), p. 118
scapulae (skăp′yŭh-lā), p. 112
sella turcica (sĕl′ŭh tŭr′sĭk-ŭh), p. 104
sinus (sī′nŭs), p. 103
spongy bone (spŭnj′ē bōn), p. 48
sternum (stŭr′nŭm), p. 111
supination (sū″pĭ-nā′shŭn), p. 120
suture (sū′chĕr), p. 103
synarthrosis (sĭn-ăr-thrō′sĭs), p. 117
synovial fluid (sĭ-nō′vē-ăl flū′ĭd), p. 118
synovial joint (sĭ-nō′vē-ăl jōynt),
synovial membrane (sĭ-nō′vē-ăl m
talus (tă′lŭs), p. 116
tarsal bones (tăr′sŭl bōns), p. 116
temporal process (tĕm′pō-rŭl prŏ
tibia (tĭb′ē-ŭh), p. 116
ulna (ŭl′nŭh), p. 112
vertebrae (vĕr′tŭh-brā), p. 108
vertebral column (vĕr′tĕ-brăl kŏh

Clinical Key Terms

arthritis (ăr-thri′ tĭs), p. 120
bursitis (bŭr-sī′tĭs), p. 118
fracture (frăk′chĕr), p. 101
gout (gŏwt), p. 121
herniated disk (hĕr′nē-ā-tĕd dĭsk)
kyphosis (kī-fō′sĭs), p. 109
lordosis (lŏr-dō′sĭs), p. 109
mastoiditis (măs″tōy-dī′tĭs), p. 10
osteoarthritis (ŏs″tē-ō-ăr-thri′ tĭs)
osteoporosis (ŏs″tē-ō-pō-rō′sĭs), p
reduction (rĭ-dŭk′shŭn), p. 101
rheumatoid arthritis (RA) (rū′mŭh p. 120
scoliosis (skō″lē-ō′sĭs), p. 109
sinusitis (sī″nŭh-sī′tĭs), p. 103

LEARNING OUTCOME QUESTIONS

I. Match the items in the key to the bones listed in questions 1–6.
Key:
a. forehead
b. chin
c. cheekbone
d. elbow
e. shoulder blade
f. hip
g. leg

1. temporal and zygomatic bones
2. tibia and fibula
3. frontal bone
4. ulna
5. coxal bone
6. scapula

II. Match the items in the key to the bones listed in questions 7–13.
Key:
a. external acoustic meatus
b. cribriform plate
c. xiphoid process
d. glenoid cavity
e. olecranon process
f. acetabulum
g. greater and lesser trochanters

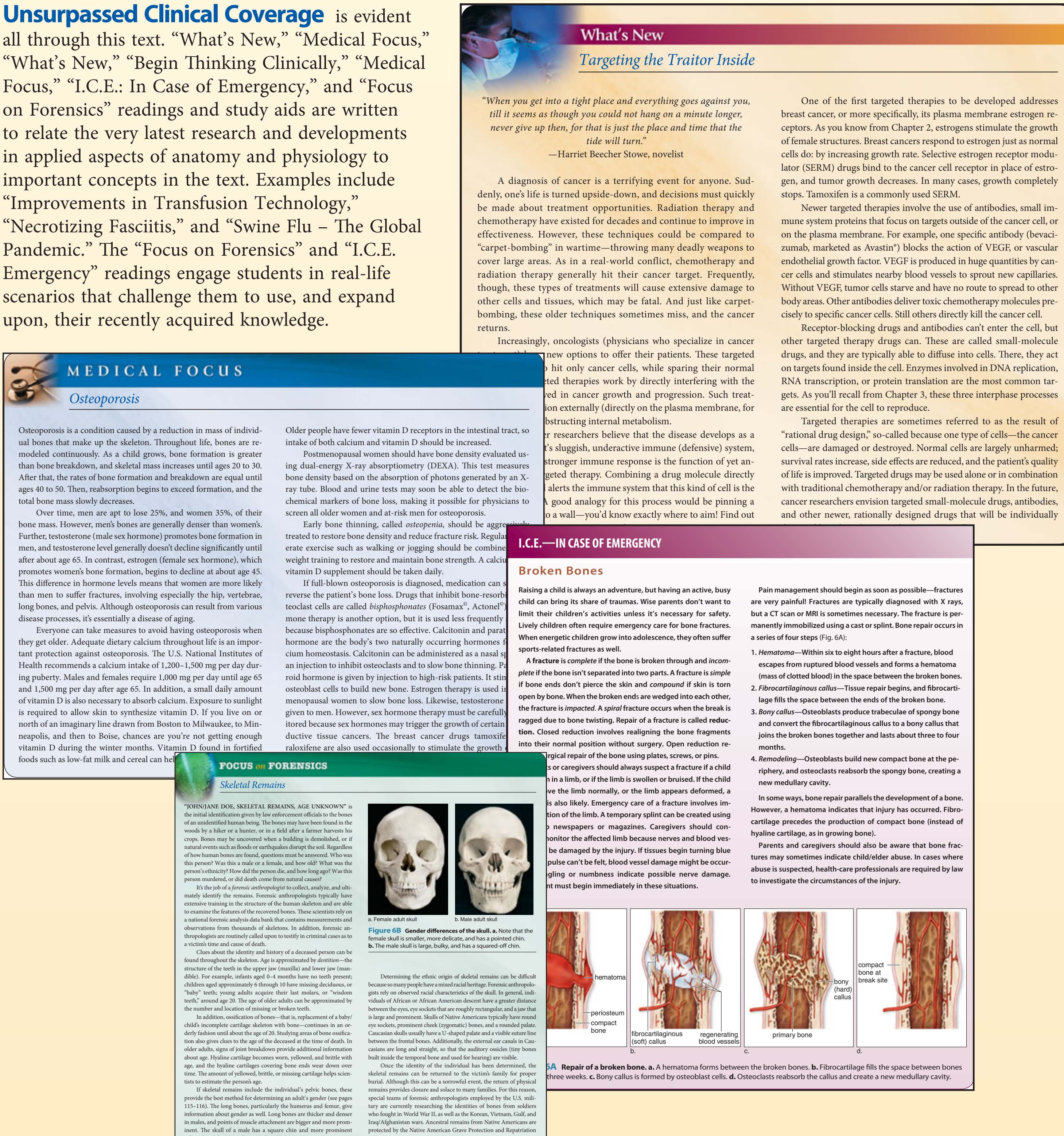
7. scapula
8. sternum
9. femur
10. temporal bone
11. coxal bone
12. ethmoid bone
13. ulna

III. Fill in the blanks.
14. Long bones are ________ than they are wide.
15. The epiphysis of a long bone contains ________ bone, where red blood cells are produced.
17. The sacrum is a part of the ________, and the sternum is a part of the ________.
18. The pectoral girdle is specialized for ________, while the pelvic girdle is specialized for ________.
19. The term *phalanges* is used for the bones of both the ________ and the ________.
20. The knee is a freely movable (synovial) joint of the ________ type.

STUDY QUESTIONS

1. What are five functions of the skeleton? (p. 98)
2. What are five major categories of bones based on their shapes? (p. 98)
3. What are the parts of a long bone? What are some differences between compact bone and spongy bone? (pp. 98–99)
4. How does bone grow in children, and how is it remodeled in all age groups? (pp. 100–102)
5. What are the various types of fractures? Outline the four steps that are required for fracture repair. (p. 101)
6. List the bones of the axial and appendicular skeletons. (p.103 and Fig. 6.4, p. 104)
7. What are the bones of the cranium and the face? Describe the special features of the temporal bones, sphenoid bone, and ethmoid bone. (pp. 103–108)
8. What are the parts of the vertebral column, and what are its curvatures? Distinguish between the atlas, axis, sacrum, and coccyx. (pp. 108–110)
9. What are the bones of the rib cage? List several functions of the rib cage. (pp. 109–111)
10. What are the bones of the pectoral girdle? Give examples to demonstrate the

Unsurpassed Clinical Coverage is evident all through this text. "What's New," "Medical Focus," "What's New," "Begin Thinking Clinically," "Medical Focus," "I.C.E.: In Case of Emergency," and "Focus on Forensics" readings and study aids are written to relate the very latest research and developments in applied aspects of anatomy and physiology to important concepts in the text. Examples include "Improvements in Transfusion Technology," "Necrotizing Fasciitis," and "Swine Flu – The Global Pandemic." The "Focus on Forensics" and "I.C.E. Emergency" readings engage students in real-life scenarios that challenge them to use, and expand upon, their recently acquired knowledge.



What's New

Targeting the Traitor Inside

"When you get into a tight place and everything goes against you, till it seems as though you could not hang on a minute longer, never give up then, for that is just the place and time that the tide will turn."
—Harriet Beecher Stowe, novelist

A diagnosis of cancer is a terrifying event for anyone. Suddenly, one's life is turned upside-down, and decisions must quickly be made about treatment opportunities. Radiation therapy and chemotherapy have existed for decades and continue to improve in effectiveness. However, these techniques could be compared to "carpet-bombing" in wartime—throwing many deadly weapons to cover large areas. As in a real-world conflict, chemotherapy and radiation therapy generally hit their cancer target. Frequently, though, these types of treatments will cause extensive damage to other cells and tissues, which may be fatal. And just like carpet-bombing, these older techniques sometimes miss, and the cancer returns.

Increasingly, oncologists (physicians who specialize in cancer ... new options to offer their patients. These targeted ... hit only cancer cells, while sparing their normal ... ted therapies work by directly interfering with the ... ved in cancer growth and progression. Such treat... ion externally (directly on the plasma membrane, for ... bstructing internal metabolism.

... r researchers believe that the disease develops as a ... t's sluggish, underactive immune (defensive) system, ... stronger immune response is the function of yet an... geted therapy. Combining a drug molecule directly ... alerts the immune system that this kind of cell is the ... A good analogy for this process would be pinning a ... o a wall—you'd know exactly where to aim! Find out

One of the first targeted therapies to be developed addresses breast cancer, or more specifically, its plasma membrane estrogen receptors. As you know from Chapter 2, estrogens stimulate the growth of female structures. Breast cancers respond to estrogen just as normal cells do: by increasing growth rate. Selective estrogen receptor modulator (SERM) drugs bind to the cancer cell receptor in place of estrogen, and tumor growth decreases. In many cases, growth completely stops. Tamoxifen is a commonly used SERM.

Newer targeted therapies involve the use of antibodies, small immune system proteins that focus on targets outside of the cancer cell, or on the plasma membrane. For example, one specific antibody (bevacizumab, marketed as Avastin®) blocks the action of VEGF, or vascular endothelial growth factor. VEGF is produced in huge quantities by cancer cells and stimulates nearby blood vessels to sprout new capillaries. Without VEGF, tumor cells starve and have no route to spread to other body areas. Other antibodies deliver toxic chemotherapy molecules precisely to specific cancer cells. Still others directly kill the cancer cell.

Receptor-blocking drugs and antibodies can't enter the cell, but other targeted therapy drugs can. These are called small-molecule drugs, and they are typically able to diffuse into cells. There, they act on targets found inside the cell. Enzymes involved in DNA replication, RNA transcription, or protein translation are the most common targets. As you'll recall from Chapter 3, these three interphase processes are essential for the cell to reproduce.

Targeted therapies are sometimes referred to as the result of "rational drug design," so-called because one type of cells—the cancer cells—are damaged or destroyed. Normal cells are largely unharmed; survival rates increase, side effects are reduced, and the patient's quality of life is improved. Targeted drugs may be used alone or in combination with traditional chemotherapy and/or radiation therapy. In the future, cancer researchers envision targeted small-molecule drugs, antibodies, and other newer, rationally designed drugs that will be individually

MEDICAL FOCUS

Osteoporosis

Osteoporosis is a condition caused by a reduction in mass of individual bones that make up the skeleton. Throughout life, bones are remodeled continuously. As a child grows, bone formation is greater than bone breakdown, and skeletal mass increases until ages 20 to 30. After that, the rates of bone formation and breakdown are equal until ages 40 to 50. Then, reabsorption begins to exceed formation, and the total bone mass slowly decreases.

Over time, men are apt to lose 25%, and women 35%, of their bone mass. However, men's bones are generally denser than women's. Further, testosterone (male sex hormone) promotes bone formation in men, and testosterone level generally doesn't decline significantly until after about age 65. In contrast, estrogen (female sex hormone), which promotes women's bone formation, begins to decline at about age 45. This difference in hormone levels means that women are more likely than men to suffer fractures, involving especially the hip, vertebrae, long bones, and pelvis. Although osteoporosis can result from various disease processes, it's essentially a disease of aging.

Everyone can take measures to avoid having osteoporosis when they get older. Adequate dietary calcium throughout life is an important protection against osteoporosis. The U.S. National Institutes of Health recommends a calcium intake of 1,200–1,500 mg per day during puberty. Males and females require 1,000 mg per day until age 65 and 1,500 mg per day after age 65. In addition, a small daily amount of vitamin D is also necessary to absorb calcium. Exposure to sunlight is required to allow skin to synthesize vitamin D. If you live on or north of an imaginary line drawn from Boston to Milwaukee, to Minneapolis, and then to Boise, chances are you're not getting enough vitamin D during the winter months. Vitamin D found in fortified foods such as low-fat milk and cereal can hel...

Older people have fewer vitamin D receptors in the intestinal tract, so intake of both calcium and vitamin D should be increased.

Postmenopausal women should have bone density evaluated using dual-energy X-ray absorptiometry (DEXA). This test measures bone density based on the absorption of photons generated by an X-ray tube. Blood and urine tests may soon be able to detect the biochemical markers of bone loss, making it possible for physicians to screen all older women and at-risk men for osteoporosis.

Early bone thinning, called *osteopenia,* should be aggressively treated to restore bone density and reduce fracture risk. Regular ... erate exercise such as walking or jogging should be combine... weight training to restore and maintain bone strength. A calciu... vitamin D supplement should be taken daily.

If full-blown osteoporosis is diagnosed, medication can s... reverse the patient's bone loss. Drugs that inhibit bone-resorbi... teoclast cells are called *bisphosphonates* (Fosamax©, Actonel©)... mone therapy is another option, but it is used less frequently ... because bisphosphonates are so effective. Calcitonin and parat... hormone are the body's two naturally occurring hormones f... cium homeostasis. Calcitonin can be administered as a nasal sp... an injection to inhibit osteoclasts and to slow bone thinning. Pa... roid hormone is given by injection to high-risk patients. It stin... osteoblast cells to build new bone. Estrogen therapy is used in ... menopausal women to slow bone loss. Likewise, testosterone ... given to men. However, sex hormone therapy must be carefully ... itored because sex hormones may trigger the growth of certain ... ductive tissue cancers. The breast cancer drugs tamoxife... raloxifene are also used occasionally to stimulate the growth ...

I.C.E.—IN CASE OF EMERGENCY

Broken Bones

Raising a child is always an adventure, but having an active, busy child can bring its share of traumas. Wise parents don't want to limit their children's activities unless it's necessary for safety. Lively children often require emergency care for bone fractures. When energetic children grow into adolescence, they often suffer sports-related fractures as well.

A **fracture** is *complete* if the bone is broken through and *incomplete* if the bone isn't separated into two parts. A fracture is *simple* if bone ends don't pierce the skin and *compound* if skin is torn open by bone. When the broken ends are wedged into each other, the fracture is *impacted*. A *spiral* fracture occurs when the break is ragged due to bone twisting. Repair of a fracture is called **reduction.** Closed reduction involves realigning the bone fragments into their normal position without surgery. Open reduction re... rgical repair of the bone using plates, screws, or pins. ... s or caregivers should always suspect a fracture if a child ... n in a limb, or if the limb is swollen or bruised. If the child ... ve the limb normally, or the limb appears deformed, a ... is also likely. Emergency care of a fracture involves im... tion of the limb. A temporary splint can be created using ... newspapers or magazines. Caregivers should con... nonitor the affected limb because nerves and blood ves... be damaged by the injury. If tissues begin turning blue ... pulse can't be felt, blood vessel damage might be occur... gling or numbness indicate possible nerve damage. ... nt must begin immediately in these situations.

Pain management should begin as soon as possible—fractures are very painful! Fractures are typically diagnosed with X rays, but a CT scan or MRI is sometimes necessary. The fracture is permanently immobilized using a cast or splint. Bone repair occurs in a series of four steps (Fig. 6A):

1. *Hematoma*—Within six to eight hours after a fracture, blood escapes from ruptured blood vessels and forms a hematoma (mass of clotted blood) in the space between the broken bones.
2. *Fibrocartilaginous callus*—Tissue repair begins, and fibrocartilage fills the space between the ends of the broken bone.
3. *Bony callus*—Osteoblasts produce trabeculae of spongy bone and convert the fibrocartilaginous callus to a bony callus that joins the broken bones together and lasts about three to four months.
4. *Remodeling*—Osteoblasts build new compact bone at the periphery, and osteoclasts reabsorb the spongy bone, creating a new medullary cavity.

In some ways, bone repair parallels the development of a bone. However, a hematoma indicates that injury has occurred. Fibrocartilage precedes the production of compact bone (instead of hyaline cartilage, as in growing bone).

Parents and caregivers should also be aware that bone fractures may sometimes indicate child/elder abuse. In cases where abuse is suspected, health-care professionals are required by law to investigate the circumstances of the injury.

...6A **Repair of a broken bone. a.** A hematoma forms between the broken bones. **b.** Fibrocartilage fills the space between bones ... three weeks. **c.** Bony callus is formed by osteoblast cells. **d.** Osteoclasts reabsorb the callus and create a new medullary cavity.

FOCUS *on* FORENSICS

Skeletal Remains

"JOHN/JANE DOE, SKELETAL REMAINS, AGE UNKNOWN" is the initial identification given by law enforcement officials to the bones of an unidentified human being. The bones may have been found in the woods by a hiker or a hunter, or in a field after a farmer harvests his crops. Bones may be uncovered when a building is demolished, or if natural events such as floods or earthquakes disrupt the soil. Regardless of how human bones are found, questions must be answered. Who was this person? Was this a male or a female, and how old? What was the person's ethnicity? How did the person die, and how long ago? Was this person murdered, or did death come from natural causes?

It's the job of a *forensic anthropologist* to collect, analyze, and ultimately identify the remains. Forensic anthropologists typically have extensive training in the structure of the human skeleton and are able to examine the features of the recovered bones. These scientists rely on a national forensic analysis data bank that contains measurements and observations from thousands of skeletons. In addition, forensic anthropologists are routinely called upon to testify in criminal cases as to a victim's time and cause of death.

Clues about the identity and history of a deceased person can be found throughout the skeleton. Age is approximated by *dentition*—the structure of the teeth in the upper jaw (maxilla) and lower jaw (mandible). For example, infants aged 0–4 months have no teeth present; children aged approximately 6 through 10 have missing deciduous, or "baby" teeth; young adults acquire their last molars, or "wisdom teeth," around age 20. The age of older adults can be approximated by the number and location of missing or broken teeth.

In addition, ossification of bones—that is, replacement of a baby/child's incomplete cartilage skeleton with bone—continues in an orderly fashion until about the age of 20. Studying areas of bone ossification also gives clues to the age of the deceased at the time of death. In older adults, signs of joint breakdown provide additional information about age. Hyaline cartilage becomes worn, yellowed, and brittle with age, and the hyaline cartilages covering bone ends wear down over time. The amount of yellowed, brittle, or missing cartilage helps scientists to estimate the person's age.

If skeletal remains include the individual's pelvic bones, these provide the best method for determining an adult's gender (see pages 115–116). The long bones, particularly the humerus and femur, give information about gender as well. Long bones are thicker and denser in males, and points of muscle attachment are bigger and more prominent. The skull of a male has a square chin and more prominent ridges above the eye sockets or orbits (Figure 6B).

a. Female adult skull
b. Male adult skull

Figure 6B Gender differences of the skull. a. Note that the female skull is smaller, more delicate, and has a pointed chin. **b.** The male skull is large, bulky, and has a squared-off chin.

Determining the ethnic origin of skeletal remains can be difficult because so many people have a mixed racial heritage. Forensic anthropologists rely on observed racial characteristics of the skull. In general, individuals of African or African American descent have a greater distance between the eyes, eye sockets that are roughly rectangular, and a jaw that is large and prominent. Skulls of Native Americans typically have round eye sockets, prominent cheek (zygomatic) bones, and a rounded palate. Caucasian skulls usually have a U-shaped palate and a visible suture line between the frontal bones. Additionally, the external ear canals in Caucasians are long and straight, so that the auditory ossicles (tiny bones built inside the temporal bone and used for hearing) are visible.

Once the identity of the individual has been determined, the skeletal remains can be returned to the victim's family for proper burial. Although this can be a sorrowful event, the return of physical remains provides closure and solace to many families. For this reason, special teams of forensic anthropologists employed by the U.S. military are currently researching the identities of bones from soldiers who fought in World War II, as well as the Korean, Vietnam, Gulf, and Iraq/Afghanistan wars. Ancestral remains from Native Americans are protected by the Native American Grave Protection and Repatriation Act, and must be returned to the leadership of the tribe.