A Storytelling Writing Style

Students and instructors routinely cite Saladin's prose style as the number one attraction of this book. Students doing blind comparisons of Ken Saladin's chapters and those of other anatomy books routinely choose Saladin hands down, finding Saladin

- more clearly written; easier to understand
- fun and interesting to read
- stimulating; not just a dry recitation of fact after fact

Innovative Perspectives

Instructors often say even they learn new facts and novel ways of looking at and teaching things from Saladin's creative perspectives.

Ken Saladin explains his approach to writing … "I remember how difficult it was for me to understand some complicated concepts as an undergraduate. When I proofread my own writing, I try to put myself back in that student frame of mind and write as if I were tutoring my 18-year-old self. I choose my words and paragraph structure carefully, aiming for the clarity that I would have appreciated as a student back then. I write both to reach the cognitive level of the average beginning student, but also to elevate that cognitive level by the time the course is over."

filaments, and *microtubules.* **Microfilaments (thin filaments)** are about 6 nm thick and are made of the protein actin. They form a fibrous **terminal web (membrane skeleton)** on the cytoplasmic side of the plasma membrane. The lipids of the plasma membrane are spread out over the terminal web like butter on a slice of bread. The web, like the bread, provides physical support, whereas the lipids, like butter, provide a permeability barrier. It is thought that, without this support by the terminal web, the lipids would break up into little droplets and the plasma membrane would not

"While reading through the chapters, I can easily visualize the structures in my head and I am confident that an undergraduate anatomy student could do the same."

—Michele Zimmerman
Indiana University Southeast

round cells), and **simple columnar** (tall narrow cells). In the fourth type, **pseudostratified columnar epithelium,** not all cells reach the free surface; the taller cells cover the shorter ones. This epithelium looks stratified in most tissue sections, but careful examination, especially with the electron microscope, shows that every cell reaches the basement membrane—like trees in a forest, where some grow taller than others but all are anchored in the soil below.

Simple columnar and pseudostratified columnar epithelia often have wineglass-shaped **goblet cells** that produce protective mucus

Fresh Analogies

Saladin's analogy-rich writing enables students to easily visualize abstract concepts in terms of everyday experience.

2. Eventually, the perichondrium stops producing chondrocytes and begins producing osteoblasts. These deposit a thin collar of bone around the middle of the cartilage model, encircling it like a napkin ring and providing physical reinforcement. The former perichondrium is now considered to be a periosteum.

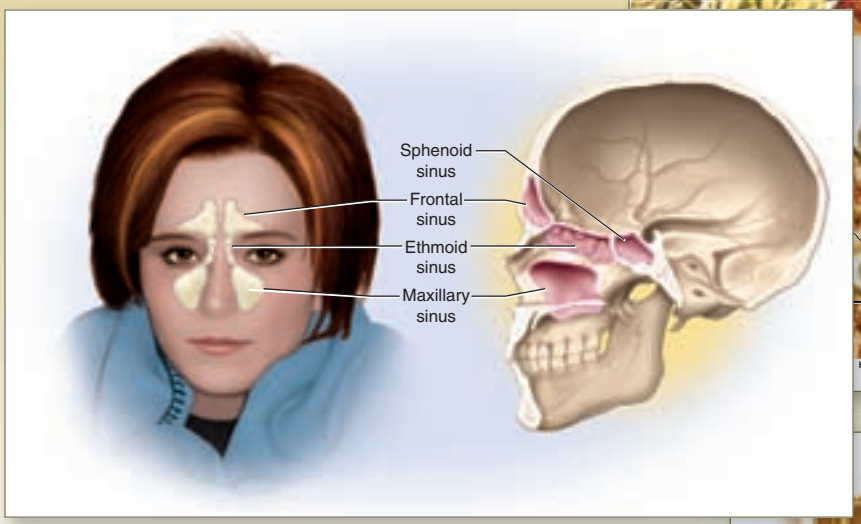
chapter 17. The **hyoid**[28] **bone** is a slender U-shaped bone between the chin and larynx (fig. 7.16). It is one of the few bones that does not articulate with any other. The hyoid is suspended from the styloid processes of the skull, somewhat like a hammock, by the small *stylohyoid muscles* and *stylohyoid ligaments.* The medial **body** of the hyoid is flanked on either side by projections called the **greater** and

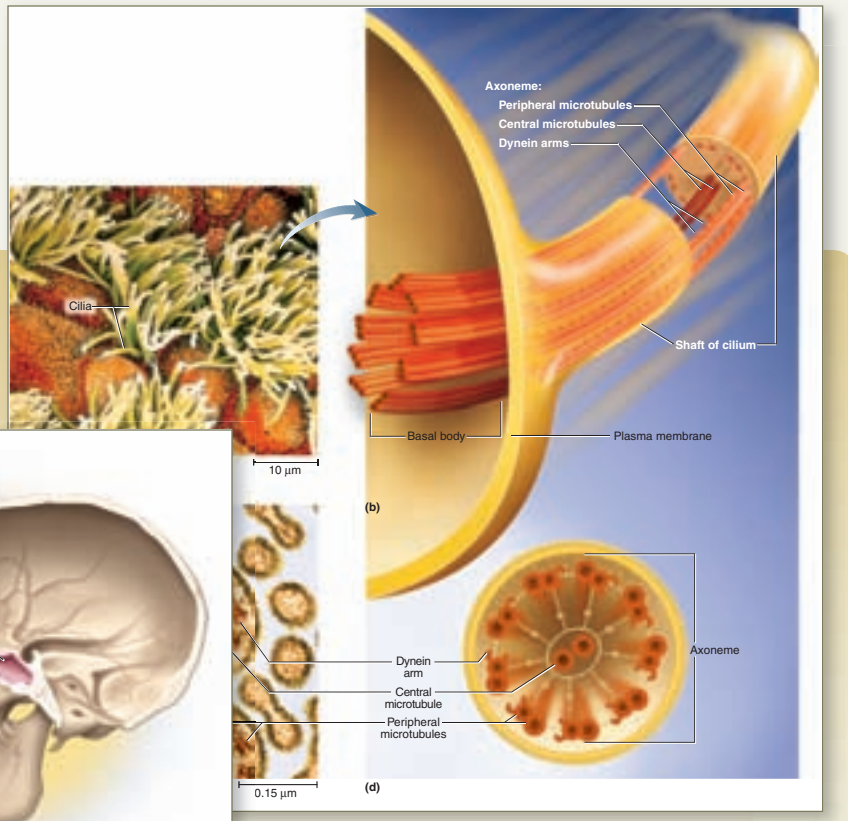
Neurosomas range from 5 to 135 μm in diameter, whereas axons range from 1 to 20 μm in diameter and from a few millimeters to more than a meter long. Such dimensions are more impressive when we scale them up to the size of familiar objects. If the soma of a spinal motor neuron were the size of a tennis ball, its dendrites would form a huge bushy mass that could fill a 30-seat classroom from floor to ceiling. Its axon would be up to a mile long but a little narrower than a garden hose. This is quite a point to ponder. The neuron must assemble molecules and organelles in its "tennis ball" soma and deliver them through its "mile-long garden hose" to the end of the axon. In a process called *axonal transport,* neurons employ *motor proteins* that can carry organelles and macromolecules as they crawl along the cytoskeleton of the nerve fiber to distant destinations in the cell.

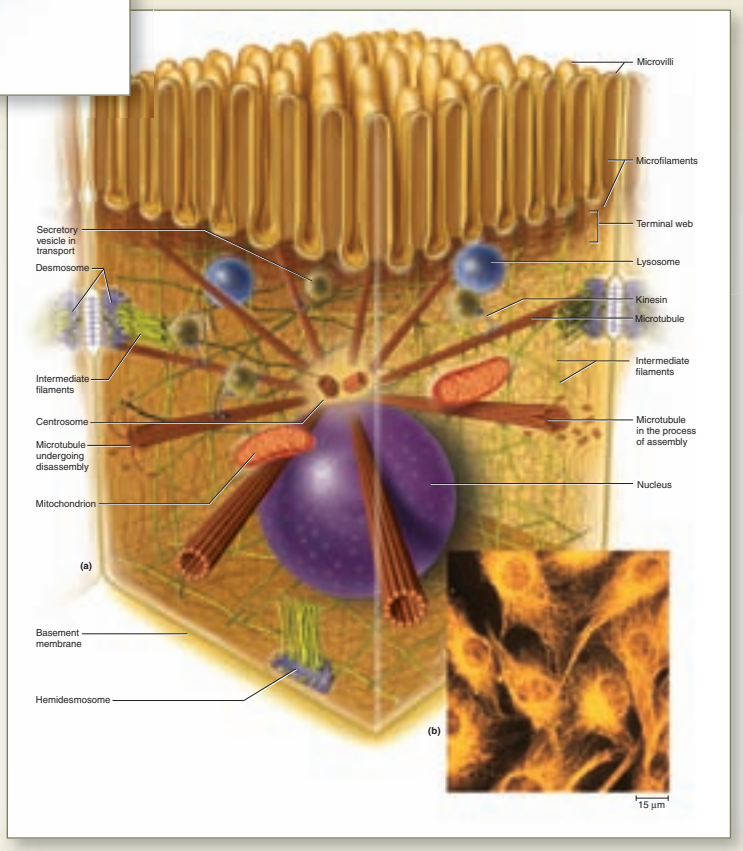
Artwork That Piques Interest and Clarifies Ideas

Saladin's portfolio of stunning illustrations and photos draws in students who regard themselves as "visual learners."

Vivid Illustrations with rich textures and shading and bold, bright colors bring anatomy to life.

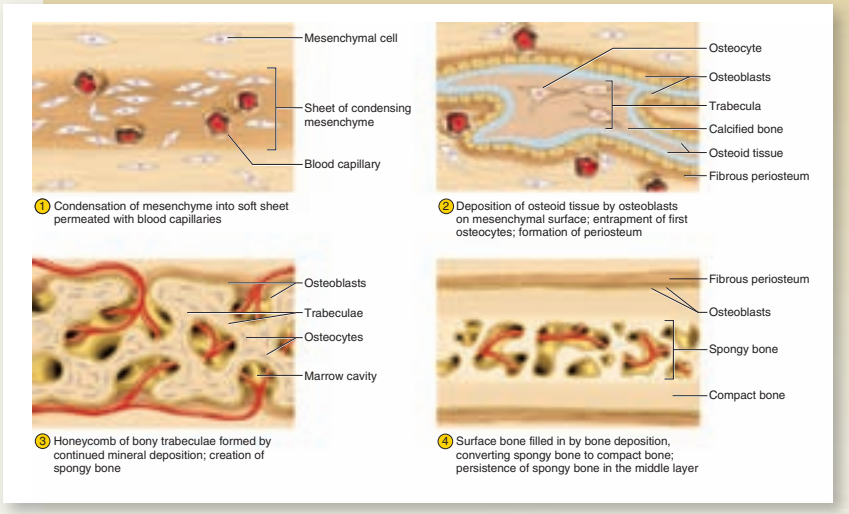






Ken Saladin explains his approach to helping visual learners . . . "The visual appeal of nature is immensely important in motivating one to study it. We certainly see this at work in human anatomy—in the countless students who describe themselves as visual learners; in the millions of laypeople who flock to museums and popular exhibitions such as Body Worlds; and in all those who find anatomy atlases so intriguing. I have illustrated Human Anatomy not only to visually explain concepts, but also to appeal to this sense of the aesthetics of the human body."

Process Figures relate numbered steps in the art with correspondingly numbered text descriptions.



Intramembranous Ossification

Intramembranous[23] (IN-tra-MEM-bruh-nus) **ossification** produces the flat bones of the skull and most of the clavicle (collarbone). Such bones develop within a fibrous sheet similar to the dermis of the skin, so they are sometimes called *dermal bones.* Figure 6.8 shows the stages of the process.

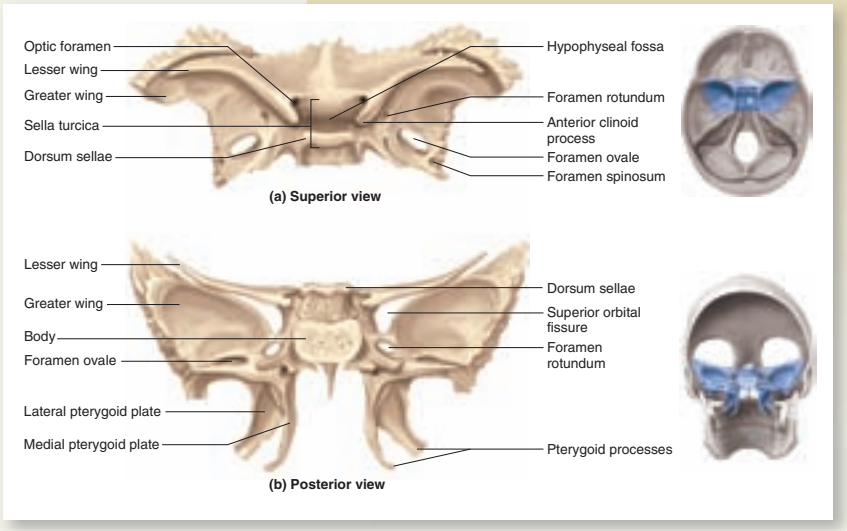
1. An area of the embryonic connective tissue (mesenchyme) condenses into a layer of soft tissue with a dense supply of blood capillaries. The mesenchymal cells enlarge and differentiate into osteogenic cells, and regions of mesenchyme become a network of soft sheets called trabeculae.

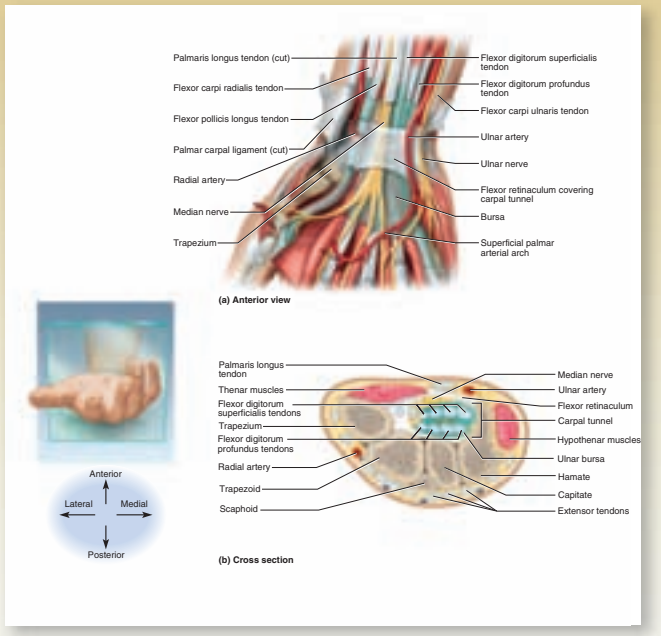
2. Osteogenic cells gather on these trabeculae and differentiate into osteoblasts. These cells deposit an organic matrix called **osteoid**[24] **tissue**—soft collagenous tissue similar to bone except for a lack of minerals (fig. 6.9). As the trabeculae grow thicker, calcium phosphate is deposited in the matrix. Some osteoblasts become trapped in the matrix and are now osteocytes. Mesenchyme close to the surface of a trabecula remains uncalcified, but becomes denser and more fibrous, forming a periosteum.

3. Osteoblasts continue to deposit minerals, producing a honeycomb of bony trabeculae. Some trabeculae persist as permanent spongy bone, while osteoclasts resorb and remodel others to form a marrow cavity in the middle of the bone.

4. Trabeculae at the surface continue to calcify until the spaces between them are filled in, converting the spongy bone to compact bone. This process gives rise to the sandwichlike arrangement typical of mature flat bones.

Orientation Tools clarify the perspective from which a structure is viewed.



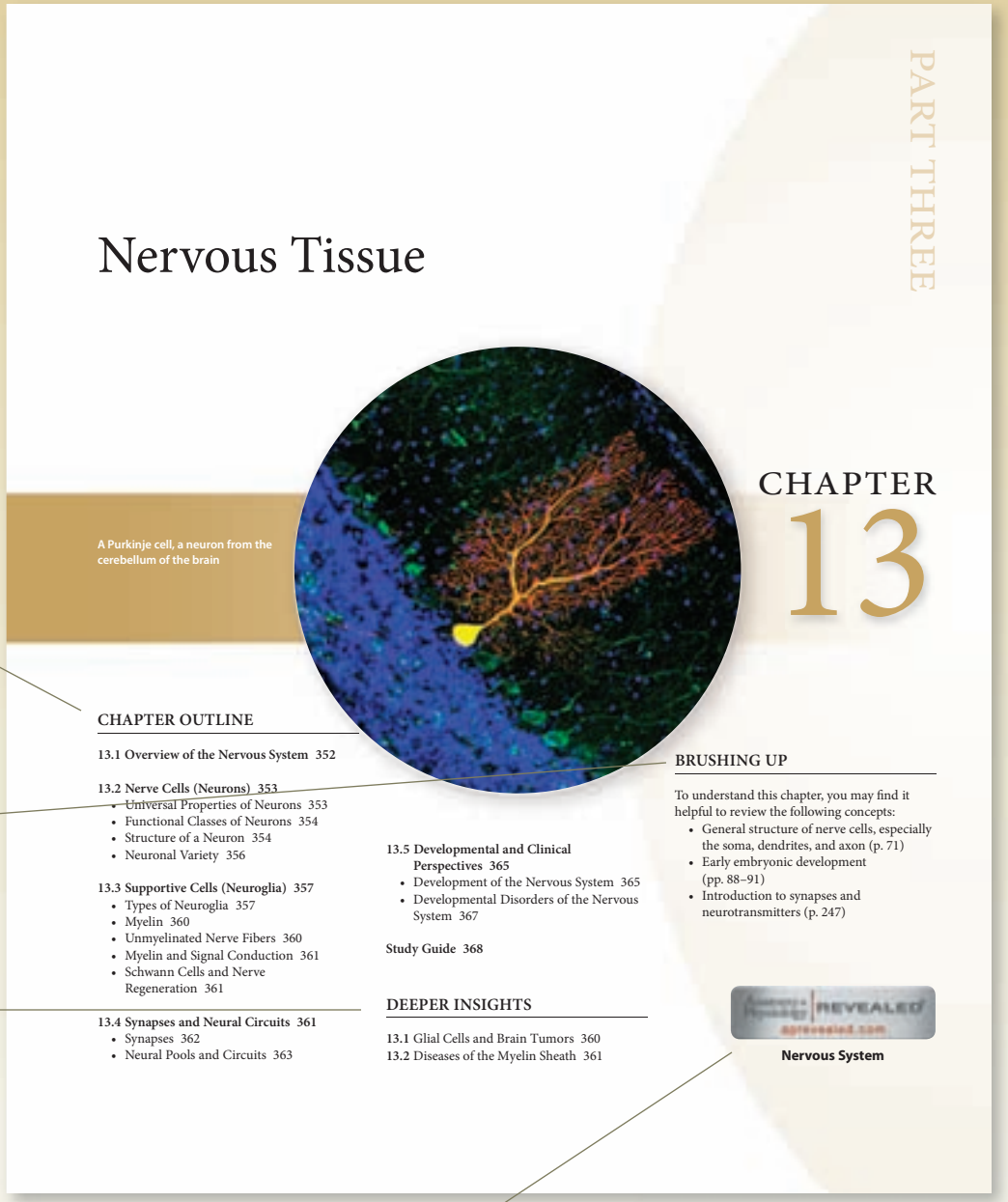


The Art of Teaching—Pedagogical Features

Having taught human anatomy for 32 years, Saladin knows what works in the classroom and brings those approaches to *Human Anatomy.*

Chapters Laid Out for Preview and Review

- Chapters begin with a preview of topics to be covered, as well as a reminder to review previously read material that is relevant to the current chapter.
- Chapters are divided into manageable sections conducive to limited blocks of study time.



PART THREE

Nervous Tissue

A Purkinje cell, a neuron from the cerebellum of the brain

CHAPTER 13

CHAPTER OUTLINE

DEEPER INSIGHTS

BRUSHING UP

To understand this chapter, you may find it helpful to review the following concepts:
- General structure of nerve cells, especially the soma, dendrites, and axon (p. 71)
- Early embryonic development (pp. 88–91)
- Introduction to synapses and neurotransmitters (p. 247)

REVEALED

Nervous System

Chapter Outline provides a content preview and facilitates review and study.

Brushing Up reminds students of the relevance of earlier chapters to the one on which they are newly embarking.

Deeper Insights pique the interest of health-science students by showing the clinical relevance of the core science.

Anatomy & Physiology REVEALED icons indicate which area of this interactive cadaver dissection program corresponds to the chapter topic.

The Bookends of Knowledge

- Each section is a conceptually unified topic framed between a pair of learning "bookends"—a set of learning objectives at the beginning and a set of review and self-testing questions at the end.
- Each section is numbered for easy reference in lecture, assignments, and ancillary materials.

Expected Learning Outcomes give the student a preview of key points to be learned within the next few pages.

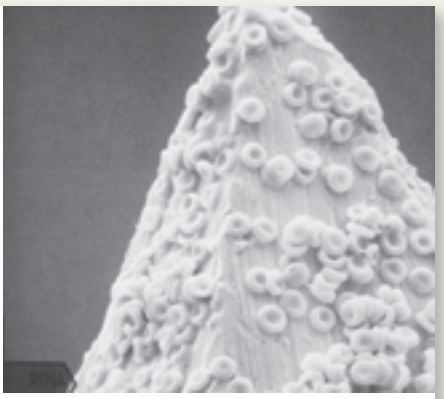
19.2 Erythrocytes

Expected Learning Outcomes

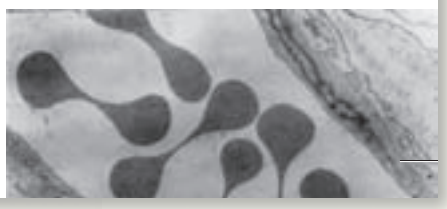
When you have completed this section, you should be able to

- describe the morphology and functions of erythrocytes (RBCs);
- explain some clinical measurements of RBC and hemoglobin quantities;
- describe the structure and function of hemoglobin;
- discuss the formation, life span, death, and disposal of RBCs; and
- explain the chemical and immunologic basis and the clinical significance of blood types.

Erythrocytes, or **red blood cells (RBCs),** have two principal functions: (1) to pick up oxygen from the lungs and deliver it to tissues elsewhere, and (2) to pick up carbon dioxide from the tissues and unload it in the lungs. RBCs are the most abundant formed elements of the blood and therefore the most obvious things one sees upon its



(b)



Before You Go On prompts the student to pause and spot-check his or her mastery of the previous few pages before going on to new material.

wide range of other blood diseases. Efforts are being made to further improve the procedure by stimulating placental stem cells to multiply before the transplant, and by removing placental T cells that may react against the recipient.

AB, and O) and Rh group (with blood types Rh-positive and Rh-negative). These types differ with respect to the chemical composition of glycolipids on the RBC surface; figure 19.6 shows how the ABO types differ in this regard. The glycolipids act as *antigens,* substances capable of evoking an immune reaction. The blood plasma contains *antibodies* that react against incompatible antigens on foreign RBCs.

RBC antigens and plasma antibodies determine the compatibility of donor and recipient blood in transfusions. For example, a person with blood type A has anti-B antibodies in the blood plasma. If this person is mistakenly given a transfusion of type B blood, those antibodies attack the donor RBCs. The RBCs agglutinate—they form clumps that obstruct the circulation in small blood vessels, with devastating consequences for such crucial organs as the brain, heart, lungs, and kidneys. The agglutinated RBCs also rupture *(hemolyze)* and release their hemoglobin. This free hemoglobin is filtered out by the kidneys, clogs the microscopic kidney tubules, and can cause death from renal failure within a week or so. The same can happen if a type B person receives type A blood, or if a type O person receives either type A or type B. Incompatibility of Rh types between the mother and fetus sometimes causes severe anemia in the newborn infant *(hemolytic disease of the newborn).*

Apply What You Know

Why might a court of law be interested even in human blood types that have no connection to disease?

Before You Go On

Answer the following questions to test your understanding of the preceding section:

5. What are the two main functions of RBCs?
6. Define *hematocrit* and *RBC count,* and state some normal clinical values for each.
7. Describe the structure of a hemoglobin molecule. Explain where O_2 and CO_2 are carried on a hemoglobin molecule.
8. Name the stages in the production of an RBC, and state the differences between them.
9. Explain what plasma and RBC components are responsible for blood types, and why blood types are clinically important.

Vocabulary Building

Several features help build a student's level of comfort with medical vocabulary.

Pronunciation Guides Students can't very well remember or spell terms if they can't pronounce them in the first place. Saladin gives simple, intuitive "pro-NUN-see-AY-shun" guides to help students over this hurdle and widen the student's comfort zone for medical vocabulary.

Word Origins Accurate spelling and insight into medical terms are greatly enhanced by a familiarity with commonly used word roots, prefixes, and suffixes.. Footnotes throughout the chapters will help build the student's working lexicon of word elements.

Building Your Medical Vocabulary An exercise at the end of each chapter helps students creatively use their knowledge of new medical word elements.

The **foramen spinosum,** about the diameter of a pencil lead, provides passage for an artery of the meninges. An irregular gash called the **foramen lacerum**[18] (LASS-eh-rum) occurs at the junction of the sphenoid, temporal, and occipital bones. It is filled with cartilage in life and transmits no major vessels or nerves.

In an inferior view of the skull, the sphenoid can be seen just anterior to the basilar part of the occipital bone (see fig. 7.5a). The internal openings of the nasal cavity seen here are called the **posterior nasal apertures,** or **choanae**[19] (co-AH-nee). Lateral to each aperture, the sphenoid bone exhibits a pair of parallel plates—the **medial** and **lateral pterygoid**[20] (TERR-ih-goyd) **plates.** Each plate has a narrow inferior extension called the *pterygoid process*. The plates provide attachment for some of the jaw muscles. The sphenoid sinus occurs within the body of the sphenoid bone.

Ethmoid Bone

The **ethmoid**[21] (ETH-moyd) bone is an anterior cranial bone located between the eyes (fig. 7.12). It contributes to the medial wall of the orbit, the roof and walls of the nasal cavity, and the nasal septum. It is a very porous and delicate bone, with three major portions:

1. The vertical **perpendicular plate,** a thin median plate of bone that forms the superior two-thirds of the nasal septum (see fig. 7.4b). (The lower part is formed by the vomer, discussed

[18] *lacerum* = torn, lacerated
[19] *choana* = funnel
[20] *pterygo* = wing
[21] *ethmo* = sieve, strainer + *oid* = resembling

Building Your Medical Vocabulary

State a medical meaning of each of the following word elements, and give a term in which it is used.

1. cyto-
2. squam-
3. -form
4. poly-
5. -philic
6. phago-
7. endo-
8. glyco-
9. chromo-
10. meta-

Answers in the Appendix

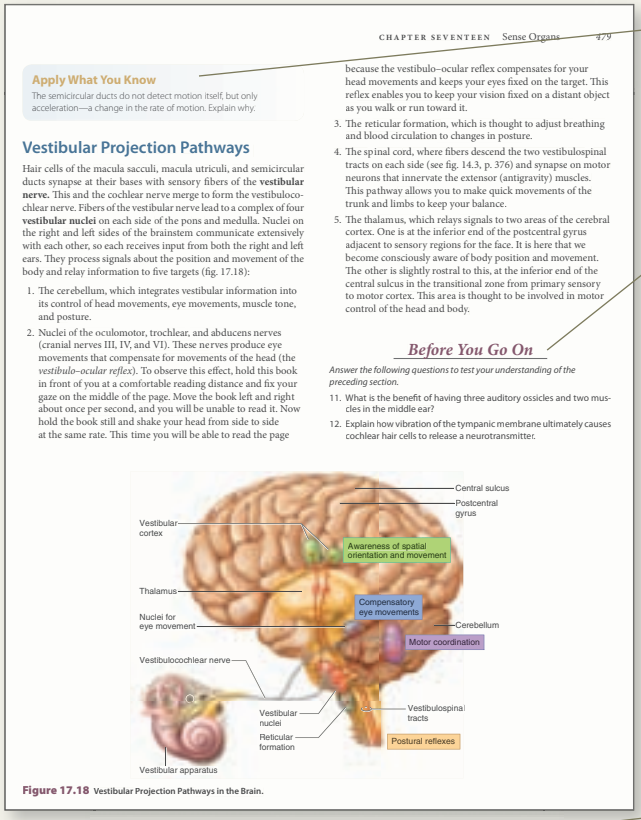
Desktop Experiments

Many chapters offer simple experiments and palpations a student can do at his or her desk, with no equipment, to help visualize chapter concepts.

- **Tactile (Meissner[4]) corpuscles.** These are receptors for light touch and texture. They are tall, ovoid to pear-shaped, and consist of two or three nerve fibers meandering upward through a mass of flattened Schwann cells. They occur in the dermal papillae of the skin and are limited to sensitive hairless areas such as the fingertips, palms, eyelids, lips, nipples, and parts of the genitals. Drag your fingernails lightly across your forearm and then across your palm. The difference in sensation you feel is due to the high density of tactile corpuscles in your palmar skin. Tactile corpuscles enable you to tell the difference between silk and sandpaper, for example, by light strokes of your fingertips.

Self-Assessment Tools

Saladin provides students with abundant opportunities to evaluate their comprehension of concepts. A wide variety of questions from simple recall to analytical evaluation cover all six cognitive levels of Bloom's Taxonomy of Educational Objectives.



CHAPTER SEVENTEEN Sense Organs 479

Apply What You Know

The semicircular ducts do not detect motion itself, but only acceleration—a change in the rate of motion. Explain why.

Vestibular Projection Pathways

Hair cells of the macula sacculi, macula utriculi, and semicircular ducts synapse at their bases with sensory fibers of the **vestibular nerve.** This and the cochlear nerve merge to form the vestibulocochlear nerve. Fibers of the vestibular nerve lead to a complex of four **vestibular nuclei** on each side of the pons and medulla. Nuclei on the right and left sides of the brainstem communicate extensively with each other, so each receives input from both the right and left ears. They process signals about the position and movement of the body and relay information to five targets (fig. 17.18):

1. The cerebellum, which integrates vestibular information into its control of head movements, eye movements, muscle tone, and posture.
2. Nuclei of the oculomotor, trochlear, and abducens nerves (cranial nerves III, IV, and VI). These nerves produce eye movements that compensate for movements of the head (the *vestibulo–ocular reflex*). To observe this effect, hold this book in front of you at a comfortable reading distance and fix your gaze on the middle of the page. Move the book left and right about once per second, and you will be unable to read it. Now hold the book still and shake your head from side to side at the same rate. This time you will be able to read the page because the vestibulo–ocular reflex compensates for your head movements and keeps your eyes fixed on the target. This reflex enables you to keep your vision fixed on a distant object as you walk or run toward it.
3. The reticular formation, which is thought to adjust breathing and blood circulation to changes in posture.
4. The spinal cord, where fibers descend the two vestibulospinal tracts on each side (see fig. 14.3, p. 376) and synapse on motor neurons that innervate the extensor (antigravity) muscles. This pathway allows you to make quick movements of the trunk and limbs to keep your balance.
5. The thalamus, which relays signals to two areas of the cerebral cortex. One is at the inferior end of the postcentral gyrus adjacent to sensory regions for the face. It is here that we become consciously aware of body position and movement. The other is slightly rostral to this, at the inferior end of the central sulcus in the transitional zone from primary sensory to motor cortex. This area is thought to be involved in motor control of the head and body.

Before You Go On

Answer the following questions to test your understanding of the preceding section.

11. What is the benefit of having three auditory ossicles and two muscles in the middle ear?
12. Explain how vibration of the tympanic membrane ultimately causes cochlear hair cells to release a neurotransmitter.

Figure 17.18 Vestibular Projection Pathways in the Brain.

Apply What You Know Questions interjected in the chapter spot-test a student's ability to think of the deeper implications or clinical applications of a point he or she just read.

Before You Go On Tests simple recall and lower-level interpretation of information read within the last few pages

Figure Legend Questions Questions posed in many of the figure legends prompt the student to interpret the art and apply it to the reading.

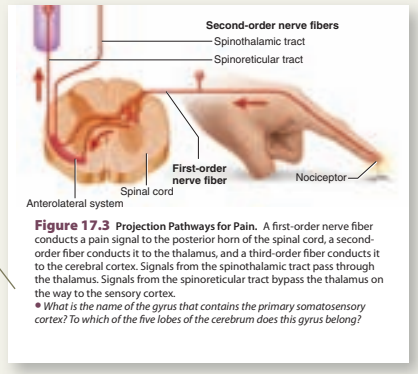
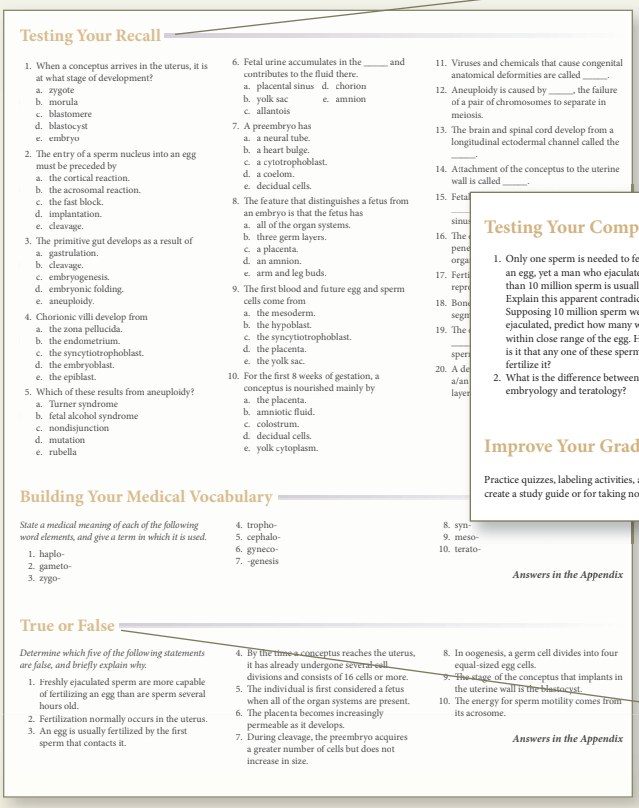


Figure 17.3 Projection Pathways for Pain. A first-order nerve fiber conducts a pain signal to the posterior horn of the spinal cord, a second-order fiber conducts it to the thalamus, and a third-order fiber conducts it to the cerebral cortex. Signals from the spinothalamic tract pass through the thalamus. Signals from the spinoreticular tract bypass the thalamus on the way to the sensory cortex.

• *What is the name of the gyrus that contains the primary somatosensory cortex? To which of the five lobes of the cerebrum does this gyrus belong?*



Testing Your Recall

1. When a conceptus arrives in the uterus, it is at what stage of development?
   a. zygote
   b. morula
   c. blastomere
   d. blastocyst
   e. embryo
2. The entry of a sperm nucleus into an egg must be preceded by
   a. the cortical reaction.
   b. the acrosomal reaction.
   c. the fast block.
   d. implantation.
   e. cleavage.
3. The primitive gut develops as a result of
   a. gastrulation.
   b. cleavage.
   c. embryogenesis.
   d. embryonic folding.
   e. aneuploidy.
4. Chorionic villi develop from
   a. the zona pellucida.
   b. the endometrium.
   c. the syncytiotrophoblast.
   d. the embryoblast.
   e. the epiblast.
5. Which of these results from aneuploidy?
   a. Turner syndrome
   b. fetal alcohol syndrome
   c. nondisjunction
   d. mutation
   e. rubella
6. Fetal urine accumulates in the _____ and contributes to the fluid there.
   a. placental sinus
   b. yolk sac
   c. allantois
   d. chorion
   e. amnion
7. A preembryo has
   a. a neural tube.
   b. a heart bulge.
   c. a cytotrophoblast.
   d. a coelom.
   e. decidual cells.
8. The feature that distinguishes a fetus from an embryo is that the fetus has
   a. all of the organ systems.
   b. three germ layers.
   c. a placenta.
   d. an amnion.
   e. arm and leg buds.
9. The first blood and future egg and sperm cells come from
   a. the mesoderm.
   b. the hypoblast.
   c. the syncytiotrophoblast.
   d. the placenta.
   e. the yolk sac.
10. For the first 8 weeks of gestation, a conceptus is nourished mainly by
    a. the placenta.
    b. amniotic fluid.
    c. colostrum.
    d. decidual cells.
    e. yolk cytoplasm.
11. Viruses and chemicals that cause congenital anatomical deformities are called _____.
12. Aneuploidy is caused by _____, the failure of a pair of chromosomes to separate in meiosis.
13. The brain and spinal cord develop from a longitudinal ectodermal channel called the _____.
14. Attachment of the conceptus to the uterine wall is called _____.

Building Your Medical Vocabulary

State a medical meaning of each of the following word elements, and give a term in which it is used.

1. haplo-
2. gameto-
3. zygo-
4. tropho-
5. cephalo-
6. gyneco-
7. -genesis
8. syn-
9. meso-
10. terato-

Answers in the Appendix

True or False

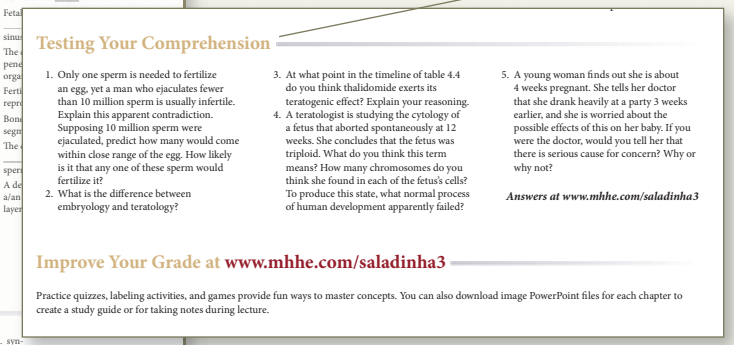
Determine which five of the following statements are false, and briefly explain why.

1. Freshly ejaculated sperm are more capable of fertilizing an egg than are sperm several hours old.
2. Fertilization normally occurs in the uterus.
3. An egg is usually fertilized by the first sperm that contacts it.
4. By the time a conceptus reaches the uterus, it has already undergone several cell divisions and consists of 16 cells or more.
5. The individual is first considered a fetus when all of the organ systems are present.
6. The placenta becomes increasingly permeable as it develops.
7. During cleavage, the preembryo acquires a greater number of cells but does not increase in size.
8. In oogenesis, a germ cell divides into four equal-sized egg cells.
9. The stage of the conceptus that implants in the uterine wall is the blastocyst.
10. The energy for sperm motility comes from its acrosome.

Answers in the Appendix

Testing Your Recall Twenty simple recall questions at the end of each chapter test retention of terminology and basic ideas.

Testing Your Comprehension Clinical application and other interpretive essay questions require the student to apply the chapter's basic science to new clinical or other scenarios.



Testing Your Comprehension

1. Only one sperm is needed to fertilize an egg, yet a man who ejaculates fewer than 10 million sperm is usually infertile. Explain this apparent contradiction. Supposing 10 million sperm were ejaculated, predict how many would come within close range of the egg. How likely is it that any one of these sperm would fertilize it?
2. What is the difference between embryology and teratology?
3. At what point in the timeline of table 4.4 do you think thalidomide exerts its teratogenic effect? Explain your reasoning.
4. A teratologist is studying the cytology of a fetus that aborted spontaneously at 12 weeks. She concludes that the fetus was triploid. What do you think this term means? How many chromosomes do you think she found in each of the fetus's cells? To produce this state, what normal process of human development apparently failed?
5. A young woman finds out she is about 4 weeks pregnant. She tells her doctor that she drank heavily at a party 3 weeks earlier, and she is worried about the possible effects of this on her baby. If you were the doctor, would you tell her that there is serious cause for concern? Why or why not?

Answers at www.mhhe.com/saladinha3

Improve Your Grade at www.mhhe.com/saladinha3

Practice quizzes, labeling activities, and games provide fun ways to master concepts. You can also download image PowerPoint files for each chapter to create a study guide or for taking notes during lecture.

True or False These statements require students not only to evaluate their truth but also to concisely explain why the false statements are untrue or rephrase them in a way that makes them true.

Making It Relevant

Students understandably want to know how the basic science of anatomy relates to their career goals.

Apply What You Know prompts the student to think of the deeper implications or clinical applications of what he or she has just read.

Apply What You Know

Spinal cord injuries commonly result from fractures of vertebrae C5 to C6, but never from fractures of L3 to L5. Explain both observations.

Apply What You Know

Why does it make more functional sense for the collecting ducts to connect to the subclavian veins than it would for them to connect to the subclavian arteries?

Apply What You Know

What effect would you expect from a small brain tumor that blocked the left interventricular foramen?

Deeper Insights are brief side essays on the clinical application of the basic science.

Other Deeper Insight boxes highlight medical history and evolutionary interpretations of human structure and function.

DEEPER INSIGHT 6.1

Radioactivity and Bone Cancer

Radioactivity captured the public imagination when Marie and Pierre Curie and Henri Becquerel shared the 1903 Nobel Prize for its discovery. Not for several decades, however, did anyone realize its dangers. Factories employed women to paint luminous numbers on watch and clock dials with radium paint. As they moistened the paint brushes with their tongues to keep them finely pointed, the women ingested radium. Their bones readily absorbed it and many of the women developed *osteosarcoma,* the most common and deadly form of bone cancer.

Even more horrific, in the wisdom of hindsight, was a deadly health fad in which people drank "tonics" made of radium-enriched water. One famous enthusiast was the champion golfer and millionaire playboy Eben Byers, who drank several bottles of radium tonic each day and praised its virtues as a wonder drug and aphrodisiac. Like the factory women, Byers contracted osteosarcoma. By the time of his death, holes had formed in his skull and doctors had removed his entire up- to halt the spreading ive they could expose amage left him unable e bitter end. His tragic nd put an end to the

DEEPER INSIGHT 4.2

Morning Sickness

A woman's earliest sign of pregnancy is often *morning sickness,* a nausea that sometimes progresses to vomiting. Severe and prolonged vomiting, called *hyperemesis gravidarum,*[17] can necessitate hospitalization for fluid therapy to restore electrolyte and acid–base balance. The physiological cause of morning sickness is unknown; the steroids of pregnancy inhibiting intestinal motili tain whether it is merely an undesirable effect of preg it has a biological purpose. An evolutionary hypothes sickness is an adaptation to protect the embryo fro bryo is most vulnerable to toxins at the same time t ness peaks, and women with morning sickness ten foods and to avoid spicy and pungent foods, which a compounds. Pregnant women tend also to be espe flavors and odors that suggest spoiled food. Women rience morning sickness are more likely to miscarry with birth defects.

which gives rise to the dermis of the skin and subcutaneous tissue.

At 5 weeks, the embryo exhibits a prominent cephalic end and a pair of optic vesicles destine eyes. A large **heart bulge** contains a heart, which since day 22. The **arm buds** and **leg buds,** the

[17] *hyper* = excessive + *emesis* = vomiting + *gravida* = pregnant w

DEEPER INSIGHT 11.3

Hernias

A hernia is any condition in which the viscera protrude through a weak point in the muscular wall of the abdominopelvic cavity. The most common type to require treatment is an *inguinal hernia* (fig. 11.18). In the male fetus, each testis descends from the pelvic cavity into the scrotum by way of a passage called the *inguinal canal* through the muscles of the groin. This canal remains a weak point in the pelvic floor, especially in infants and children. When pressure rises in the abdominal cavity, it can force part of the intestine or bladder into this canal or even into the scrotum. This also sometimes occurs in men who hold their breath while lifting heavy weights. When the diaphragm and abdominal muscles contract, pressure in the abdominal cavity can soar to 1,500 pounds per square inch—more than 100 times the normal pressure and quite sufficient to produce an inguinal hernia, or "rupture." Inguinal hernias rarely occur in women.

Two other sites of hernia are the diaphragm and navel. A *hiatal hernia* is a condition in which part of the stomach protrudes through the diaphragm into the thoracic cavity. This is most common in overweight people over age 40. It may cause heartburn due to the regurgitation of stomach acid into the esophagus, but most cases go undetected. In an *umbilical hernia,* abdominal viscera protrude through the navel.

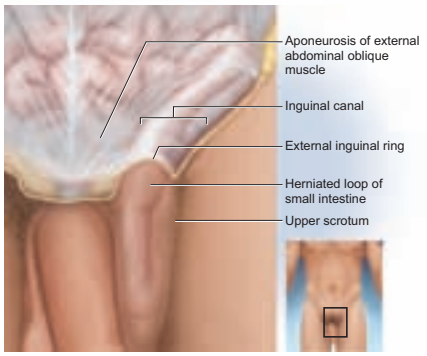


Figure 11.18 Inguinal Hernia. A loop of small intestine has protruded through the inguinal canal into a space beneath the skin.

DEEPER INSIGHT 1.2

Cardiac Tamponade

Being confined by the pericardium can cause a problem for the heart under some circumstances. If a heart wall weakened by disease should rupture, blood spurts from the heart chamber into the pericardial cavity, filling the cavity more and more with each heartbeat. Diseased hearts also sometimes seep serous fluid into the pericardial sac. Either way, the effect is the same: the pericardial sac has little room to expand, so the accumulating fluid puts pressure on the heart, squeezing it and preventing it from refilling between beats. This condition is called *cardiac tamponade.* If the heart chambers cannot refill, then cardiac output declines and a person may die of catastrophic circulatory failure. A similar situation occurs if serous fluid or air accumulates in the pleural cavity, causing collapse of a lung.

"The clinical applications and evolutionary medicine sections are...nice feature(s) that provide interesting supplemental information."

—Ben F. Brammell
Morehead State University