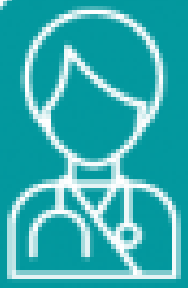

MEDICAL TERMINOLGY FOR HEALTHCARE PROFESSIONS



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Medical Terminology for Healthcare Professions

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ANDREA NELSON AND KATHERINE GREENE

UNIVERSITY OF WEST FLORIDA LIBRARIES
PENSACOLA, FLORIDA

Contents

Introduction

Welcome to ***Medical Terminology for Healthcare Professions***. Medical terminology is a language that is used in healthcare settings. Medical terms are built from Greek and Latin word parts and include **acronyms**, **eponyms**, and modern-day language terms.

Learning a new language can be a daunting task. This book offers methods for breaking down medical words and making them more manageable. To be successful, you will need to be committed to memorizing the word parts, learning the rules, and identifying the rebels. Once you meet that commitment we will show you how to apply the rules to the word parts you have memorized. As you memorize the language components of medical terminology it is important to support that learning with the context of anatomy and physiology. Consider where in the body the medical term is referencing and then how it works within the body. This will build a medical terminology foundation that you can continue to grow in your future healthcare courses.

How Open Educational Resources (OER) work

This book is an adaptation of *Building a Medical Terminology Foundation*, published by Carter and Rutherford at eCampus Ontario with revisions in text and activities for clarification and flow. The anatomy and physiology content of this OER has been adapted from the OpenStax *Anatomy and Physiology* OER by Betts et al. Both books are licensed under a Creative Commons Attribution 4.0 International License and in the spirit of OPEN education we have licensed this OER with the same license.

Building a Medical Terminology Foundation Book Citation:

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Anatomy and Physiology Book Citation:

Betts, J.G., et al. (2013). *Anatomy and Physiology*. OpenStax. http://cnx.org/content/col11496/latest/

Students: This OER book is different from many traditional medical terminology textbooks. Interactive content is built into each chapter that is available only in the online format. If using a PDF copy or EPUB version of this book, you will be directed to a hyperlink to access the interactive content. Further, glossary terms will be bolded in green and their definitions can be found in the glossary at the end of the book. In this book you will work through each body system that includes word parts, whole medical terms, and common abbreviations associated with that particular body system. At the end of each body system chapter is a vocabulary list of associated terms related to that body system. The interactive reinforcement activities require you to click, drag and drop, listen and repeat, flip, and test yourself.

Faculty and teaching staff: While this OER book was curated and created for Healthcare Administration, Health Sciences, and Pre-Professional students, our hope is that you will take this OER and customize it for your program and share again.

Medical Terminology for Healthcare Professions Book Citation:

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***Other formats available upon request

Acknowledgements

Ever since attending an Open Educational Resources (OER) workshop in 2019, I (Andrea) have always wanted to make an OER medical terminology book. I have been searching for years for the right OER book and, finally in Spring of 2021, my co-author (Katherine) found *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford. Their book was just what we had been searching for. We are so grateful for all of their hard work on creating such a wonderful book. By chance in the Fall of 2021 our university signed a contract with *Pressbooks* and the Health Sciences librarian, Cindy Gruwell, was experienced with the process. While the book provided us with an excellent foundation, Katherine and I worked very hard to create a text that would best serve future healthcare students. We are so happy that the creation of this book will save our students here, and elsewhere, on textbook costs while also allowing them to have continued access to this book after their course ends.

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1. Word Parts and Rules

Learning Objectives

- Identify word parts in medical terms.
- Examine the rules for building medical terms.

Word Parts

Medical terms are built from word parts. Those word parts are **prefix**, **word root**, **suffix**, and **combining form vowel**. When a word root is combined with a combining form vowel the word part is referred to as a **combining form**.

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://pressbooks.uwf.edu/medicalterminology/?p=20#h5p-1

Identifying Word Parts in Medical Terms

By the end of this book, you will have identified hundreds of word parts within medical terms. Let's start with some common medical terms that many non-medically trained people may be familiar with.

Examples

Osteoarthritis
Oste/o/arthr/itis – Inflammation of bone and joint.
Oste/o is a **combining form** that means bone

arthr/o is a **combining form** that means joint
-itis is a **suffix** that means inflammation

Intravenous
Intra/ven/ous – Pertaining to within a vein.
Intra- is a **prefix** that means within
ven/o – is a **combining form** that means vein
-ous is a **suffix** that means pertaining to

Notice, when breaking down words that you place slashes between word parts and a slash on each side of a combining form vowel.

Language Review

Before we begin analyzing the rules let's complete a short language review that will assist with pronunciation and spelling.

Short Vowels
a, e, i, o, u, and sometimes y are indicated by lower case.

Long Vowels
A, E, I, O, U are indicated by upper case.

Consonants
Consonants are all of the other letters in the alphabet. b, c, d, f, g, h, j, k, l, m, n, p, q, r, s, t, v, w, x, and z.

Language Rules

Language rules are a good place to start when building a medical terminology foundation. Many medical terms are built from word parts and can be translated **literally**. At first, literal translations sound awkward. Once you build a medical vocabulary and become proficient at using it, the awkwardness will slip away. For example, suffixes will no longer be stated and will be assumed. The definition of *intravenous* then becomes *within the vein*.

Since you are at the beginning of building your medical terminology foundation, stay literal when applicable. It should be noted that as with all language rules there are always exceptions and we refer to those as **rebels**.

Language Rules for Building Medical Terms

1. When combining two **combining forms**, you keep the **combining form vowel**.

2. When combining a **combining form** with a **suffix** that begins with a consonant, you keep the **combining form vowel**.

Examples

Gastr/o/enter/o/logy – The study of the stomach and the intestines

- Following **rule 1,** when we join combining form gastr/o (meaning stomach) with the combining form enter/o (meaning intestines) we keep the combining form vowel o.
- Following **rule 2**, when we join the combining form enter/o (meaning intestines) with the suffix -logy (that starts with a suffix and means the study of) we keep the combining form vowel o.

3. When combining a **combining form** with a **suffix** that begins with a vowel, you drop the **combining form vowel**.
4. A **prefix** goes at the beginning of the word and no **combining form vowel** is used.

Examples

Intra/ven/ous – Pertaining to within the vein

- Following **rule 3**, notice that when combining the combining form ven/o (meaning vein) with the suffix -ous (that starts with a vowel and means pertaining to) we drop the combining form vowel o.
- Following **rule 4**, the prefix intra- (meaning within) is at the beginning of the medical term with no combining form vowel used.

5. When defining a medical word, start with the **suffix** first and then work left to right stating the word parts. You may need to add **filler** words. As long as the filler word does not change the meaning of the word you may use it for the purpose of building a medical vocabulary. Once you start to apply the word in the context of a sentence it will be easier to decide which filler word(s) to choose.

Examples

Intra/ven/ous – Pertaining to within the vein or Pertaining to within a vein.

- Following **rule 5**, notice that I start with the suffix -ous (that means pertaining to) then we work left to right starting with the prefix Intra- (meaning within) and the combining form ven/o (meaning vein).
- Notice that we have used two different definitions that mean the same thing.
- In these examples we do not have the context of a full sentence. For the purpose of building a medical terminology foundation either definition is accepted.

2. Prefixes and Suffixes

Learning Objectives

- Understand the difference between a prefix and a suffix.
- Differentiate prefixes that deal with body parts, color, and direction.
- Distinguish suffixes that deal with procedures.

Prefixes

Prefixes are located at the beginning of a medical term. The prefix alters the meaning of the medical term. It is important to spell and pronounce prefixes correctly.

Many prefixes that you find in medical terms are common to English language prefixes. A good technique to help with memorization is the following:

- Start by reviewing the most common prefixes.
- Consider common English language words that begin with the same prefixes.
- Compare them to the examples of use in medical terms.

Common Prefixes

PREFIX	MEANING	EXAMPLE OF USE IN MEDICAL TERMS
A-, An-	Without; Lacking	**Anemia**
Andr/o-	Male	**Androgen**
Anti-	Against	**Anticholinergic drugs**
Auto-	Self	**Autocrine**
Bio-	Life	**Biology**
Chem/o-	Chemistry	**Chemotherapy**
Contra-	Against	**Contraception**
Cyt/o-	Cell	**Cytokine**
Dis-	Separation; Taking apart	**Dissection**
Dys-	Difficult; Abnormal	**Dyspnea**
Eu-	Good; Well	**Eupnea**
Fibr/o-	Fiber	**Fibrosis**
Gluco-, Glyco-	Glucose; Sugar	**Glycogen**
Gyn/o-, Gynec-	Female	**Gynecology**
Hydr/o-	Water	**Hydrocephalus**
Idio-	Self; One's own	**Idiopathic**
Lyso-, Lys-	Break down; Destruction; Dissolving	**Lysosome**
Mal-	Bad; Abnormal	**Malignant**
Myc/o-	Fungus	**Mycetoma**
Necr/o-	Death	**Necrosis**
Neo-	New	**Neonate**
Oxy-	Sharp; Acute; Oxygen	**Oxytocin**
Pan-, Pant/o-	All or everywhere	**Pancytopenia**
Pharmaco-	Drug; Medicine	**Pharmacist**
Re-	Again; Backward	**Rejuvenation**
Somat/o-, Somatico-	Body; Bodily	**Somatic cell**

Body Part Prefixes

PREFIX	MEANING	EXAMPLE OF USE IN MEDICAL TERMS
Acous/o-	Hearing	**Acoustic meatus**
Aden/o-	Gland	**Adenoid**
Adip/o-	Fat	**Adipocyte**
Adren/o-	Gland	**Adrenal cortex**
Angi/o-	Blood vessel	**Angioplasty**
Arteri/o-	Artery	**Arteriole**
Arthr/o-	Joint	**Arthroplasty**
Bucc/o-	Cheek	**Buccal cavity**
Bronch/i-	**Bronchus**	**Bronchioles**
Burs/o-	**Bursa**	**Bursa**
Carcin/o-	Cancer	**Basal cell carcinoma**
Cardi/o-	Heart	**Cardiology**
Cephal/o-	Head	**Cephalic flexure**
Chol-	Bile	**Cholesterol**
Chondri-	Cartilage	**Chondrosarcoma**
Coron-	Heart	**Coronary arteries**
Cost-	Rib	**Costal cartilage**
Crani/o-	Brain	**Cranium**
Cutane-	Skin	**Cutaneous**
Cyst/o-, Cysti-	Bladder or sac	**Cystoscopy**
Derm-, Dermat/o-	Skin	**Dermatologist**
Duoden/o-	**Duodenum**	**Duodenitis**
Gastr-	Stomach	**Gastrectomy**
Gloss-	Tongue	**Glossectomy**
Hem-, Hema-, Hemat-, Hemo-, Hemat/o-	Blood	**Hematopoiesis**
Hepat/o-, Hepatico-	Liver	**Hepatic portal system**
Hist/o-, Histio-	Tissue	**Histology**
Hyster/o-	Uterus	**Hysterectomy**
Ileo-	**Ileum**	**Ileostomy**
Ischi/o-	**Ischium**	**Ischial tuberosity**
Kerat/o-	Corena (eye or skin)	**Keratin**
Lacrim/o-	Tear (from your eyes)	**Lacrimal fluid**
Lact/o-, Lacti-	Milk	**Lactose**

Laryng/o-	**Larynx**	**Laryngitis**
Lingu/o-	Tongue	**Lingual tonsil**
Lip/o-	Fat	**Lipolysis**
Lymph/o-	Lymph	**Lymphocyte**
Mamm-, Mast/o-	Breast	**Mammary glands**
Mening/o-	**Meninges**	**Meningitis**
Muscul/o-	Muscle	**Musculoskeletal**
My/o-	Muscle	**Myocardium**
Myel/o-	Spinal cord or bone marrow	**Myelin**
Nephr/o-	Kidney	**Nephron**
Neur/i-, Neur/o-	Nerve	**Neuron**
Oculo-	Eye	**Oculomotor nerve**
Onco-	Tumor; Bulk; Volume	**Oncogene**
Onych/o-	Fingernail; Toenail	**Onychodystrophy**
Oo-	Egg; Ovary	**Oocyte**
Oophor/o-	Ovary	**Oophorectomy**
Op-, Opt-	Vision	**Optic nerve**
Ophthalm/o-	Eye	**Ophthalmic artery**
Orchid/o-, Orchio-	Testis	**Orchidectomy**
Orth/o-	Straight; Normal; Correct	**Orthostatic**
Osseo-	Bony	**Osseous tissue**
Ossi-	Bone	**Ossicles**
Ost-, Oste/o-	Bone	**Osteoporosis**
Ot/o-	Ear	**Otolaryngologist**
Ovar/i-, Ovario-, Ovi-, Ovo-	Ovary	**Ovarian follicle**
Phalang-	**Phalanx**	**Phalanges**
Pharyng/o-	Pharynx; Throat	**Pharyngeal tonsil**
Phleb/o-	Vein	**Phlebotomist**
Phren/i-, Phreno-, Phrenico-	Diaphragm	**Phrenic nerve**
Pleur-, Pleur/a-, Pleur/o-	Rib, **pleura**	**Pleural cavity**
Pneum/a- Pneumat/o-	Air; Lung	**Pneumonia**
Proct/o-	Anus; Rectum	**Proctoscopy**

Prostat-	Prostate	**Prostatectomy**
Pseudo-	False	**Pseudostratified**
Psych/o-, Psyche-	Mind	**Psychiatrist**
Radio-	Radiation; Radius	**Radioisotopes**
Ren/o-	Kidney	**Renal cortex**
Retin-	Retina (of the eye)	**Retinitis pigmentosa**
Rhin/o-	Nose	**Rhinoscope**
Salping/o-	Tube	**Salpingo-oophorectomy**
Sarco-	Muscular; Flesh-like	**Sarcomere**
Schiz/o-	Split; Cleft	**Schizophrenia**
Sclera-, Sclero-	Hardness	**Sclerosis**
Sigmoid/o-	Sigmoid colon	**Sigmoidoscopy**
Sperma-, Spermo-, Spermato-	Sperm	**Spermatocyte**
Splen/o-	Spleen	**Splenomegaly**
Sten/o-	Narrowed; Blocked	**Stenosis**
Stern-	**Sternum**	**Sternoclavicular joint**
Stom/a-, Stomat/o-	Mouth	**Stomatitis**
Thorac/o-, Thoracico-	Chest	**Thoracic cavity**
Thromb/o-	Blood clot	**Thrombolytic**
Thyr/o-	Thyroid gland	**Thyroiditis**
Trache/o-	**Trachea**	**Trachealis**
Tympan/o-	Eardrum	**Tympanic membrane**
Ur/o-	Urine	**Urologist**
Vagin-	Vagina	**Vaginal**
Varic/o-	Duct; Blood vessel	**Varicose veins**
Vasculo-	Blood vessel	**Vasculitis**
Ven/o-	Vein	**Venae cavae**
Vertbr-	Vertebra; Spine	**Vertebral column**

Color Prefixes

PREFIX	MEANING	EXAMPLE OF USE IN MEDICAL TERMS
Chlor/o-	Green	**Chlorophyll**
Chrom-, Chromato-	Color	**Chromosome**
Cyano-	Blue	**Cyanosis**
Erythr/o-	Red	**Erythrocyte**
Leuk/o-	White	**Leukocyte**
Melan/o-	Black	**Melanin**

Physical Property and Shape Prefixes

PREFIX	MEANING	EXAMPLE OF USE IN MEDICAL TERMS
Cry/o-	Cold	**Cryotherapy**
Elect-	Electrical activity	**Electrocardiogram**
Kin/o-, Kine-, Kinesi/o-	Movement	**Kinetic energy**
Kyphy/o-	Humped	**Kyphosis**
Rhabd/o-	Rod-shaped; Striated	**Rhabdomyosarcoma**
Phot/o-	Light	**Photoreceptor**
Reticul/o-	Net	**Reticulocytes**
Scoli/o-	Twisted	**Scoliosis**
Therm/o-	Heat	**Thermotherapy**

Direction and Position Prefixes

PREFIX	MEANING	EXAMPLE OF USE IN MEDICAL TERMS
Ab-, Abs-	Away from	**Abductor**
Ad-	Towards	**Adductor**
Ante-	Before; Forward	**Antenatal**
Circum-	Around	**Circumcision**
Cycl-	Circle; Cycle	**Cyclic neutropenia**
De-	Away from; Ending	**Dehydration**
Dia-	Across; Through	**Diagnosis**
Ect/o-, Exo-	Outer; Outside	**Exocrine gland**
End/o-, Ent-, Enter/o-	Within; Inner	**Endocrine gland**
Epi-	Upon; Outside of	**Epidermis**
Ex-, Extra-	Beyond	**Expiration**
Infra-	Beneath; Below	**Infratemporal fossa**
Inter-	Between	**Interstitial fluid**
Intra-	Within	**Intracellular fluid**
Meso-	Middle	**Mesoderm**
Meta-	Beyond; Change	**Metabolism**
Para-	Alongside; Abnormal	**Parathyroid glands**
Path/o-	Disease	**Pathologist**
Peri-	Around	**Pericardium**
Post-	Behind; After	**Postpartum**
Pre-	Before; In front	**Precancerous**
Retro-	Backward; Behind	**Retroperitoneum**
Sub-	Under	**Subcutaneous layer**
Super-	Above	**Superior**
Supra-	Above; Upon	**Supraglottis**
Sy-, Syl-, Sym-, Syn-, Sys-	Together	**Syndrome**
Trans-	Across; Through	**Transdermal**

Quantity Prefixes

PREFIX	MEANING	EXAMPLE OF USE IN MEDICAL TERMS
Bi-	Two	**Biceps**
Brady-	Slow	**Bradycardia**
Diplo-	Double	**Diploid**
Hemi-	Half	**Hemihypertrophy**
Hetero-	Other; Different	**Heterogeneous**
Homo-	Same	**Homozygous genotype**
Hyper-	Above; Beyond; Excessive	**Hypertension**
Hypo-	Under; Deficient	**Hypotension**
Iso-	Equal; Like	**Isointense**
Macro-	Large; Long; Big	**Macrophage**
Mic-, Micro-	Small	**Microglia**
Mon-, Mono-	One	**Monocyte**
Olig/o-	Few; Little	**Oliguria**
Poly-	Many; Excessive	**Polyuria**
Quadri-	Four	**Quadriceps**
Semi-	Half	**Semilunar valves**
Tachy-	Fast	**Tachycardia**
Tetra-	Four	**Tetralogy of Fallot**
Tri-	Three	**Triceps**
Uni-	One	**Unicellular**

Concept Check

- Do you know the difference between the prefixes **inter-**, **infra-**, and **intra-**?
- What color is an erythrocyte? A leukocyte?
- Which prefixes could you use to indicate something is:
    - around something else?

- within something else?
- below something else?

Suffixes

Suffixes are word parts that are located at the end of words. Suffixes can alter the meaning of medical terms. It is important to spell and pronounce suffixes correctly.

Suffixes in medical terms are common to English language suffixes. Suffixes are not always explicitly stated in the definition of a word. It is common that suffixes will not be explicitly stated when defining a medical term in the workplace. However, when transcribing or reading medical reports the suffix is always clearly written. In order to properly spell and pronounce medical terms, it is helpful to learn the suffixes.

Common Suffixes

SUFFIX	MEANING	EXAMPLE OF USE IN MEDICAL TERMS
-ac	Pertaining to	**Cardiac**
-blast, -blasto, -blastic	Bud; Germ	**Myeloblast**
-cyte, -cytic	Cell	**Thrombocyte**
-dynia	Pain; Swelling	**Thoracodynia**
-eal, -ial	Pertaining to	**Esophageal**
-ectasis	Expansion; Dilation	**Atelectasis**
-emia	Blood condition	**Anemia**
-ia	Condition	**Hemophilia**
-iasis	Condition; Formation of	**Psoriasis**
-ism	Condition	**Hypothyroidism**
-ites, -itis	Inflammation	**Arthritis**
-ity	Pertaining to	**Immunity**
-ium	Structure or tissue	**Epithelium**
-lysis, -lytic	Break down; Destruction; Dissolving	**Osteolytic**
-malacia	Softening	**Osteomalacia**
-megaly	Enlargement	**Acromegaly**
-oid	Resembling	**Arachnoid trabeculae**
-oma	Tumor	**Angiosarcoma**
-osis	Condition; Usually abnormal	**Endometriosis**
-ous	Pertaining to	**Aqueous**
-pathy	Disease	**Lymphadenopathy**
-penia	Deficiency; Lack of	**Thrombocytopenia**
-phagia, -phagy	Eating; Swallowing	**Dysphagia**
-phasia	Speech	**Aphasia**
-plasia, -plastic	Growth	**Hyperplasia**
-plegia	Paralysis	**Hemiplegia**
-pnea	Breathing	**Sleep apnea**
-poiesis	Production	**Hemopoiesis**
-ptosis	Falling; Drooping	**Apoptosis**
-rrhage, -rrhagic	Bleeding	**Hemorrhage**
-rrhea	Flow or discharge	**Diarrhea**

-sclerosis	Hardening	**Arteriosclerosis**
-sis	Condition	**Agranulocytosis**
-stasis	Level; Unchanging	**Homeostasis**
-trophy	Growth	**Hypertrophy**
-uria	In the urine	**Anuria**

Procedure Suffixes

SUFFIX	MEANING	EXAMPLE OF USE IN MEDICAL TERMS
-centesis	Surgical puncture to remove fluid	**Thoracentesis**
-desis	Surgical binding	**Pleurodesis**
-ectomy	Cut out; Removal	**Mastectomy**
-gram	Record; Picture	**Electrocardiogram**
-graph	Instrument used to create a record or picture	**Electrocardiograph**
-graphy	To record or take a picture	**Echocardiography**
-meter	Device used for measuring	**Sphygmomanometer**
-opsy	Visual examination	**Biopsy**
-ostomy	Opening	**Colostomy**
-otomy	Incision	**Laparotomy**
-pexy	Surgical fixation	**Oophoropexy**
-plasty	Surgical reconstruction	**Vertebroplasty**
-scope	For examining	**Endoscope**
-scopy	Examine	**Endoscopy**

Concept Check

- Do you know the difference between the suffixes **-gram**, **-graph**, and **-graphy?**
- Which suffixes denote a condition or disease?

Word parts and definitions from "Appendix A: Word Parts and What They Mean" by MedlinePlus and is under public domain.

Definitions of medical term examples from:

- *Anatomy and Physiology* (on OpenStax), by Betts et al. and is used under a CC BY 4.0 international license. Download and access this book for free at https://openstax.org/books/anatomy-and-physiology/pages/1-introduction
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- *NCI Dictionary of Cancer Terms* by the National Cancer Institute and is used under public domain.

3. Body Terminology

Learning Objectives

- Assess medical language learning to the context of anatomy and physiology
- Investigate the basic architecture and levels of organization of the human body
- Evaluate the anatomical position, regional terms, directional terms, body planes, and body quadrants for anatomical positioning
- Recall body cavities and the functions of associated membranes

As you memorize the language components of medical terminology, it is important to support that learning within the context of anatomy and physiology. Proceeding through the body system chapters, you will learn word parts, whole medical terms, and common abbreviations. It is important to put into context where in the body the medical term is referencing, and then consider how it works within the body.

Anatomy focuses on structure and **physiology** focuses on function. Much of the study of physiology centers on the body's tendency toward **homeostasis**.

Consider the structures of the body in terms of fundamental levels of organization that increase in complexity: subatomic particles, atoms, molecules, organelles, cells, tissues, organs, organ systems, organisms, and biosphere (Figure 3.1).

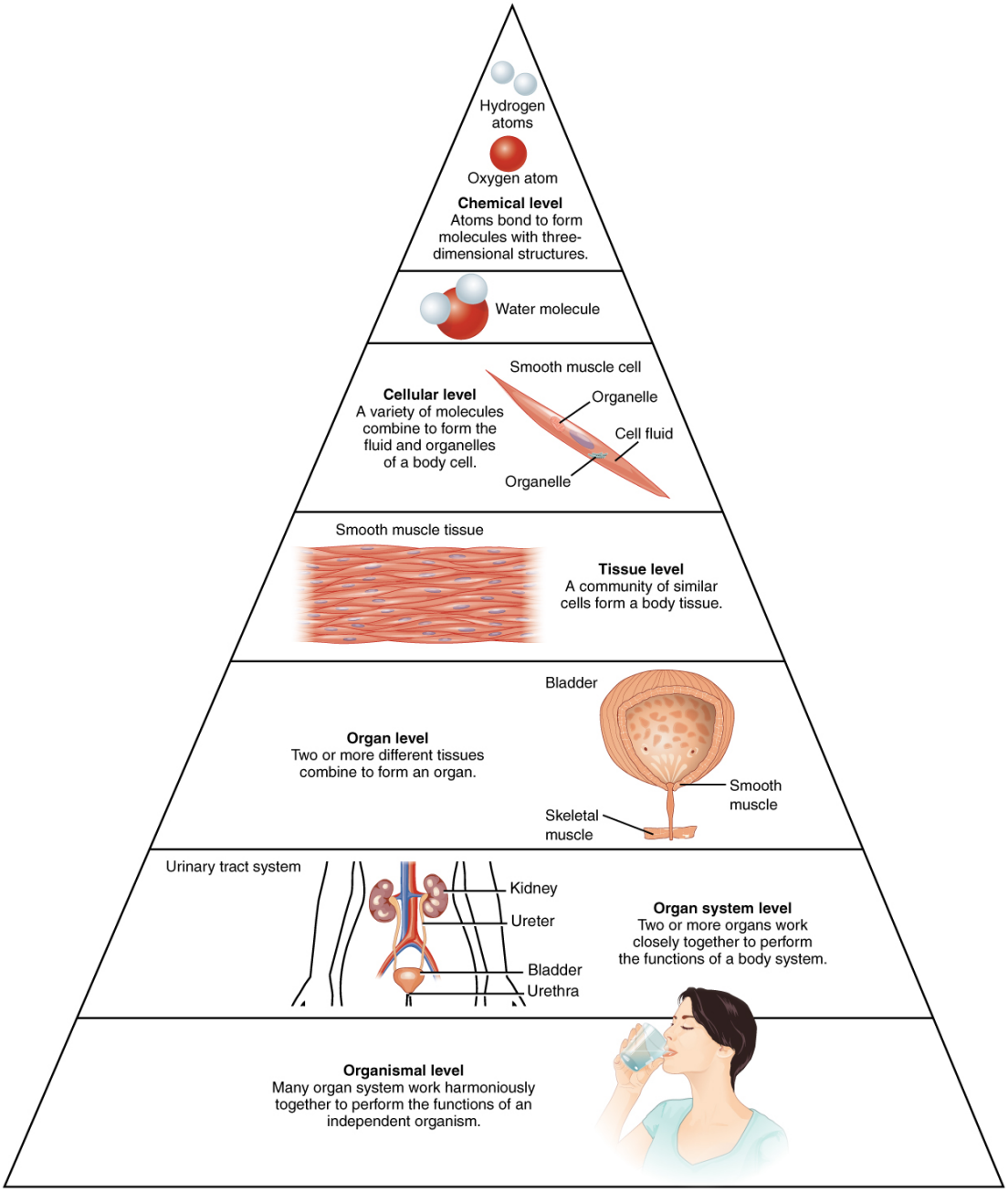

Figure 3.1 Levels of Structural Organization of the Human Body. The organization of the body often is discussed in terms of six distinct levels of increasing complexity, from the smallest chemical building blocks to a unique human organism. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

The Levels of Organization

All matter in the universe is composed of one or more unique pure substances called **elements**. Familiar examples are hydrogen, oxygen, carbon, nitrogen, calcium, and iron.

- The smallest unit of any of these pure substances (elements) is an **atom**.
    - Atoms are made up of subatomic particles such as the proton, electron, and neutron.

- Two or more atoms combine to form a **molecule**, such as the water molecules, proteins, and sugars found in living things.
    - **Molecules** are the chemical building blocks of all body structures.
- A **cell** is the smallest independently functioning unit of a living organism.
    - Even bacteria, which are extremely small, independently-living organisms, have a cellular structure. Each bacterium is a single cell. All living structures of human anatomy contain cells, and almost all functions of human physiology are performed in cells or are initiated by cells
    - A human cell typically consists of flexible membranes that enclose cytoplasm, a water-based cellular fluid, together with a variety of tiny functioning units called **organelles**. In humans, as in all organisms, cells perform all functions of life.
- A **tissue** is a group of many similar cells (though sometimes composed of a few related types) that work together to perform a specific function.
- An **organ** is an anatomically distinct structure of the body composed of two or more tissue types. Each organ performs one or more specific physiological functions.

An **organ system** is a group of organs that work together to perform major functions or meet the physiological needs of the body.

Did you know?

Organs are very collaborative and work with multiple body systems. For example, the heart (cardiovascular system) and lungs (respiratory system) work together to deliver oxygen throughout the body and remove carbon dioxide from the body.

Consider the breakdown into eleven distinct organ systems of the human body (Figure 3.2 and Figure 3.3). Assigning organs to organ systems can be imprecise since organs that "belong" to one system can also have functions integral to another system. In fact, most organs contribute to more than one system.

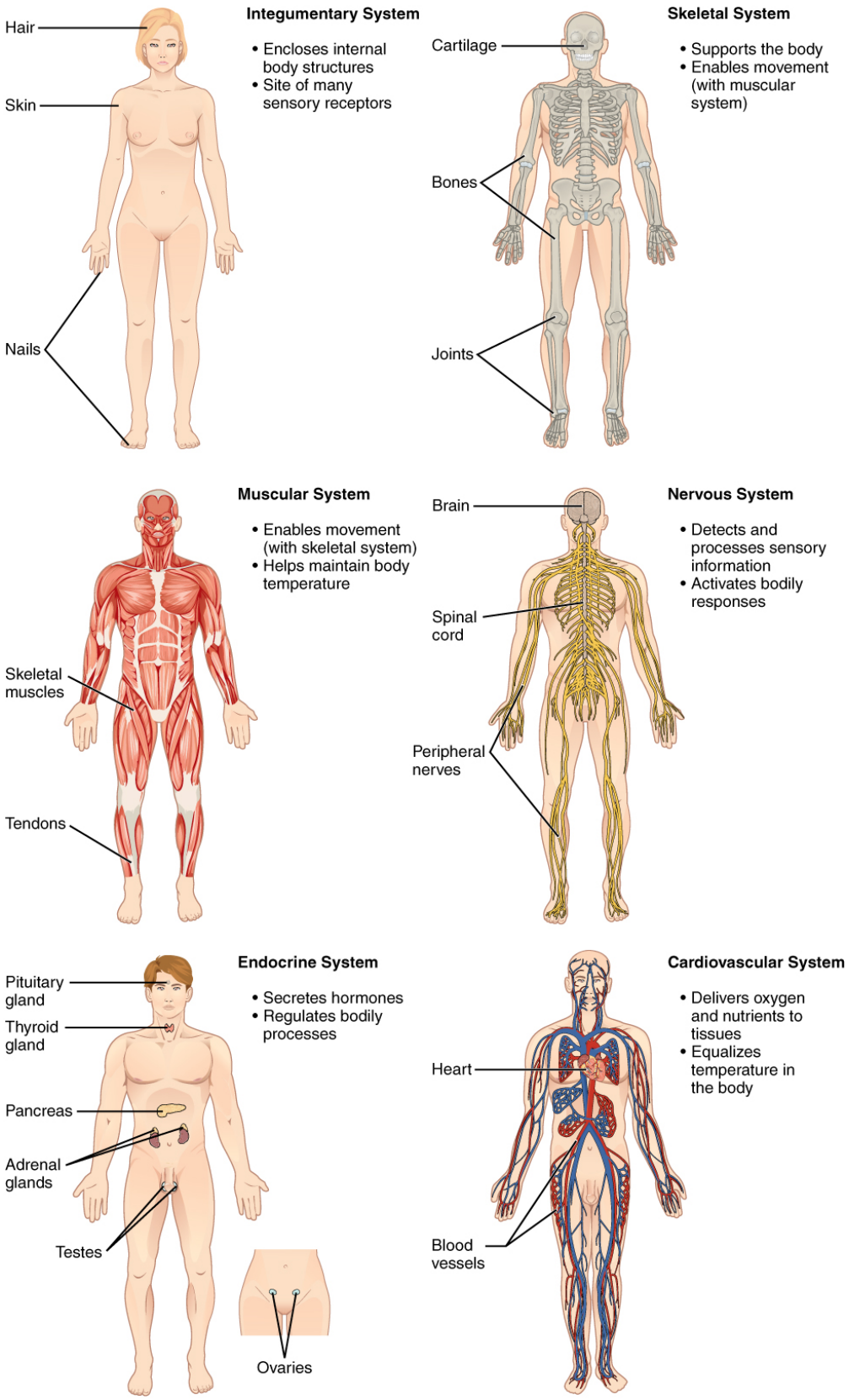

Figure 3.2. Organ Systems of the Human Body. Organs that work together are grouped into organ systems. From Betts et al., 2013. Licensed under CC BY 4.0 *[Image description.]*

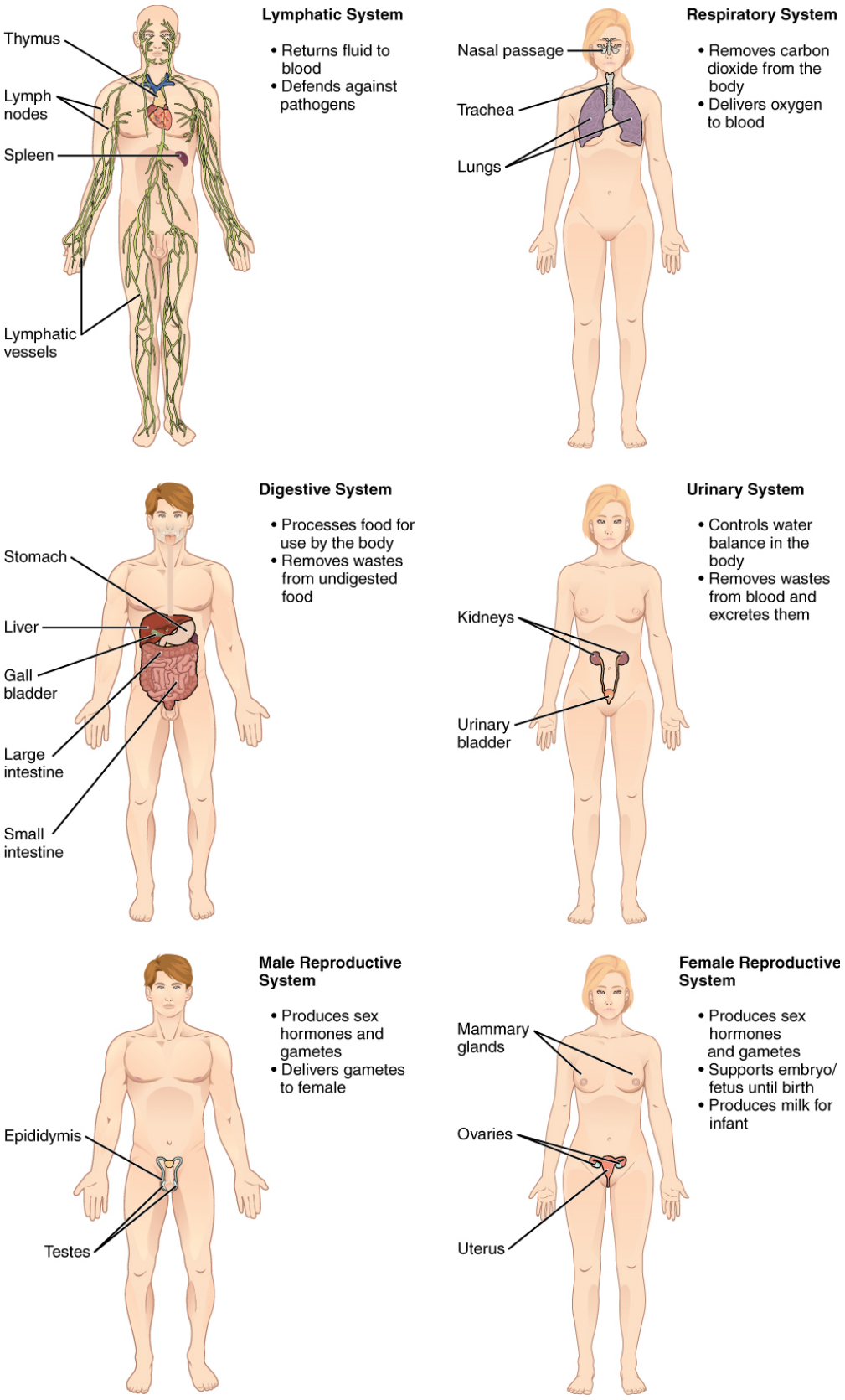

Figure 3.3. Organ Systems of the Human Body (continued). Organs that work together are grouped into organ systems. From Betts et al., 2013. Licensed under CC BY 4.0 [Image description.]

The **organism** level is the highest level of organization. An organism is a living being that has a cellular structure and that can independently perform all physiologic functions necessary for life. In multicellular organisms, including humans, all cells, tissues, organs, and organ systems of the body work together to maintain the life and health of the organism.

Watch this video:

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Media 3.1. Introduction to Anatomy & Physiology: Crash Course A&P #1 [Online video]. Copyright 2015 by CrashCourse.

Anatomical Position

Anatomists and healthcare providers use terminology for the purpose of precision and to reduce medical errors. For example, is a scar "above the wrist" located on the forearm two or three inches away from the hand? Or is it at the base of the hand? Is it on the palm-side or back-side? By using precise anatomical terminology, we eliminate ambiguity. Anatomical terms derive from ancient Greek and Latin words.

To further increase precision, anatomists standardize the way in which they view the body. Just as maps are normally oriented with north at the top, the standard body "map," also known as the **anatomical position**, is that of the body standing upright with the feet at shoulder width and parallel, toes forward. The upper limbs are held out to each side, and the palms of the hands face forward as illustrated in Figure 3.4.

Using this standard position reduces confusion. It does not matter how the body being described is oriented, the terms are used as if it is in anatomical position. For example, a scar in the "anterior (front) carpal (wrist) region" would be present on the palm side of the wrist. The term "anterior" would be used even if the hand were palm down on a table.

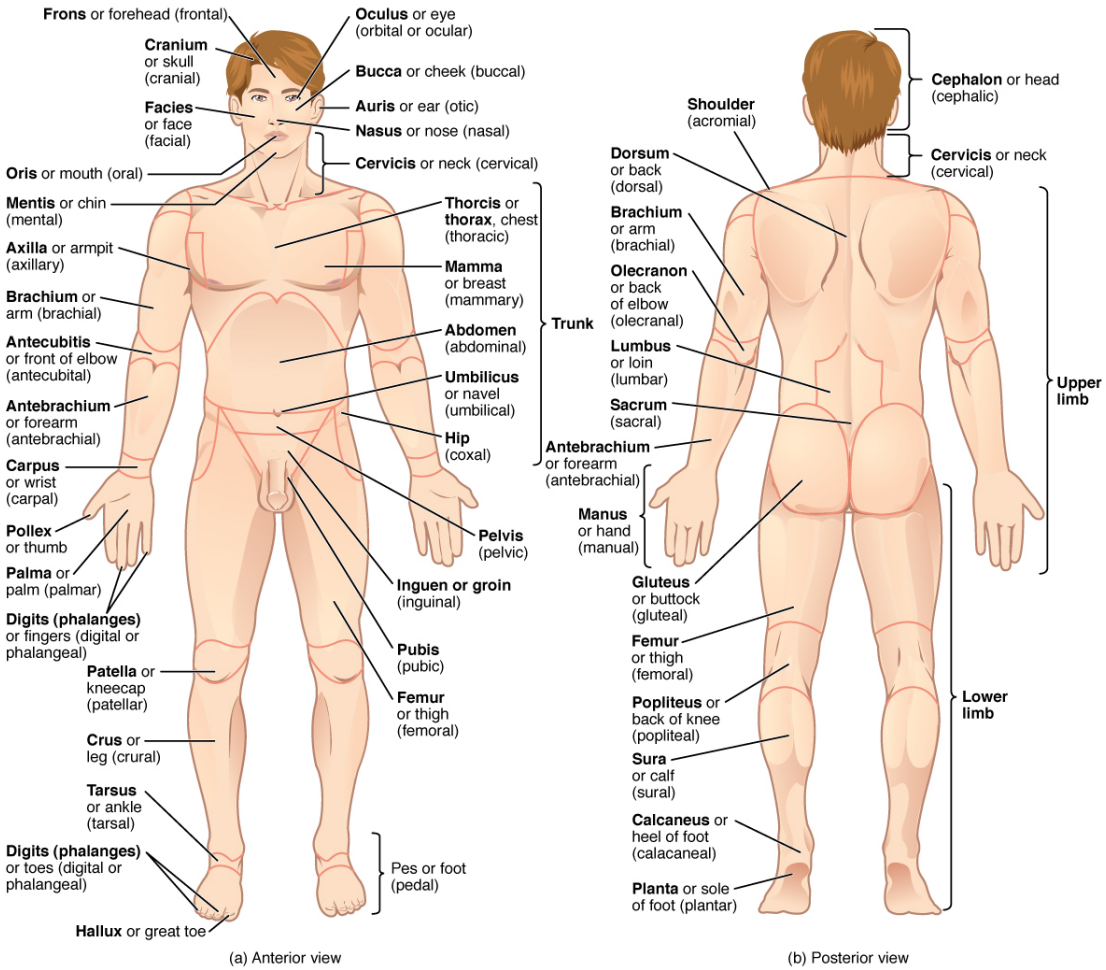

Figure 3.4. Regions of the Human Body. The human body is shown in anatomical position in an (a) anterior view and a (b) posterior view. The regions of the body are labeled in boldface. From Betts et al., 2013. Licensed under CC BY 4.0 [Image description.]

A body that is lying down is described as either **prone** or **supine**. These terms are sometimes used in describing the position of the body during specific physical examinations or surgical procedures.

Did you know?

Terminology is used for the purpose of precision and reduction of medical error.

Regional Terms

The human body's numerous regions have specific terms to help increase precision. Notice that the term "brachium" or "arm" is reserved for the "upper arm" and "antebrachium" or "forearm" is used rather than "lower arm." Similarly, "femur" or "thigh" is correct, and "leg" or "crus" is reserved for the portion of the lower limb between the knee and the ankle. You will be able to describe the body's regions using the terms from the anatomical position.

Directional Terms

Directional terms are essential for describing the relative locations of different body structures (Figure 3.5). For instance, an anatomist might describe one band of tissue as "inferior to" another or a physician might describe a tumor as "superficial to" a deeper body structure. Commit these terms to memory to avoid confusion when you are studying or describing the locations of particular body parts.

- **Anterior** (or **ventral**) describes the front or direction toward the front of the body. The toes are anterior to the foot.
- **Posterior** (or **dorsal**) describes the back or direction toward the back of the body. The popliteus is posterior to the patella.
- **Superior** (or **cranial**) describes a position above or higher than another part of the body proper. The orbits are superior to the oris.
- **Inferior** (or **caudal**) describes a position below or lower than another part of the body proper; near or toward the tail (in humans, the coccyx, or lowest part of the spinal column). The pelvis is inferior to the abdomen.
- **Lateral** describes the side or direction toward the side of the body. The thumb (pollex) is lateral to the digits.
- **Medial** describes the middle or direction toward the middle of the body. The hallux is the medial toe.
- **Proximal** describes a position in a limb that is nearer to the point of attachment or the trunk of the body. The brachium is proximal to the antebrachium.
- **Distal** describes a position in a limb that is farther from the point of attachment or the trunk of the body. The crus is distal to the femur.
- **Superficial** describes a position closer to the surface of the body. The skin is superficial to the bones.
- **Deep** describes a position farther from the surface of the body. The brain is deep to the skull.

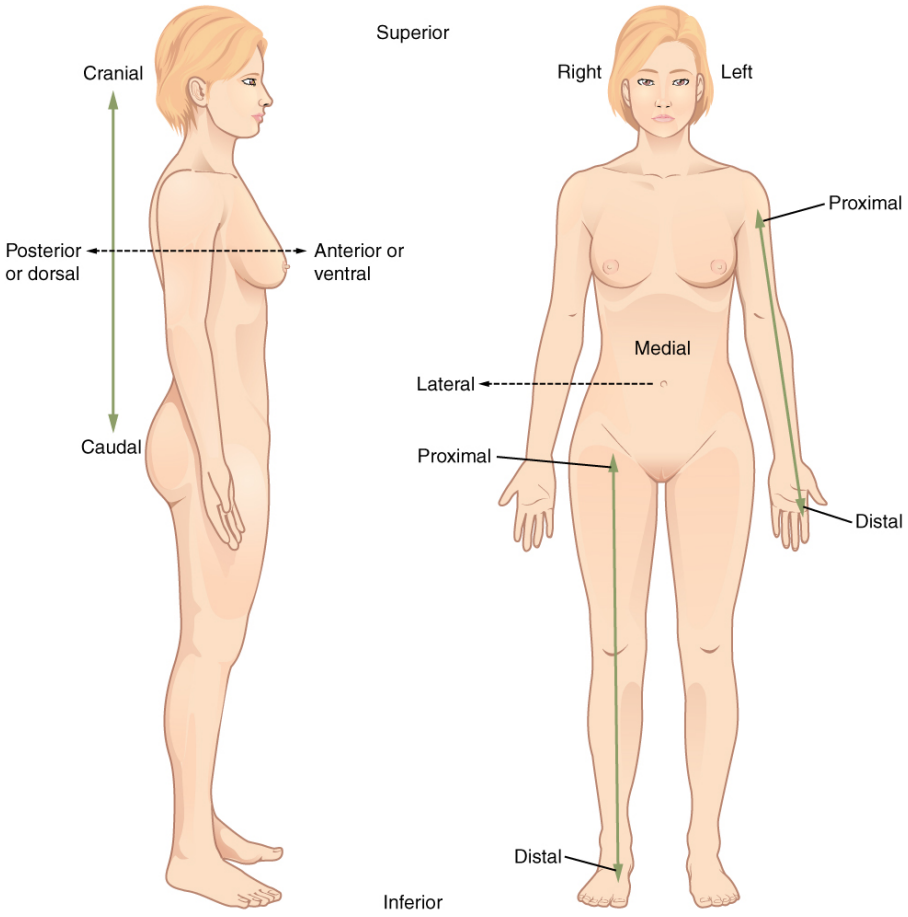

Figure 3.5. Directional Terms Applied to the Human Body. Paired directional terms are shown as applied to the human body. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Practice the Directional Terms

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Concept Check

- Find a partner and take turns choosing two body parts on your or your partner's body.
- Using directional terms, describe the location of those body parts relative to one another.

Body Planes

A section is a two-dimensional surface of a three-dimensional structure that has been cut. Modern medical imaging devices enable clinicians to obtain "virtual sections" of living bodies. We call these scans. Body sections and scans can be correctly interpreted, however, only if the viewer understands the plane along which the section was made. A plane is an imaginary two-dimensional surface that passes through the body. There are three planes commonly referred to in anatomy and medicine:

- The **sagittal plane** is the plane that divides the body or an organ vertically into right and left sides. If this vertical plane runs directly down the middle of the body, it is called the midsagittal or median plane. If it divides the body into unequal right and left sides, it is called a parasagittal plane or, less commonly, a longitudinal section.
- The **frontal plane** is the plane that divides the body or an organ into an anterior (front) portion and a posterior (rear) portion. The frontal plane is often referred to as a coronal plane ("corona" is Latin for "crown").
- The **transverse plane** is the plane that divides the body or organ horizontally into upper and lower portions. Transverse planes produce images referred to as cross-sections.

Can You Locate the Planes?

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Body Cavities and Serous Membranes

The body maintains its internal organization by means of membranes, sheaths, and other structures that separate compartments. The **dorsal (posterior) cavity** and the **ventral (anterior) cavity** are the largest body compartments (Figure 3.6). These cavities contain and protect delicate internal organs, and the ventral cavity allows for significant

changes in the size and shape of the organs as they perform their functions. The lungs, heart, stomach, and intestines, for example, can expand and contract without distorting other tissues or disrupting the activity of nearby organs.

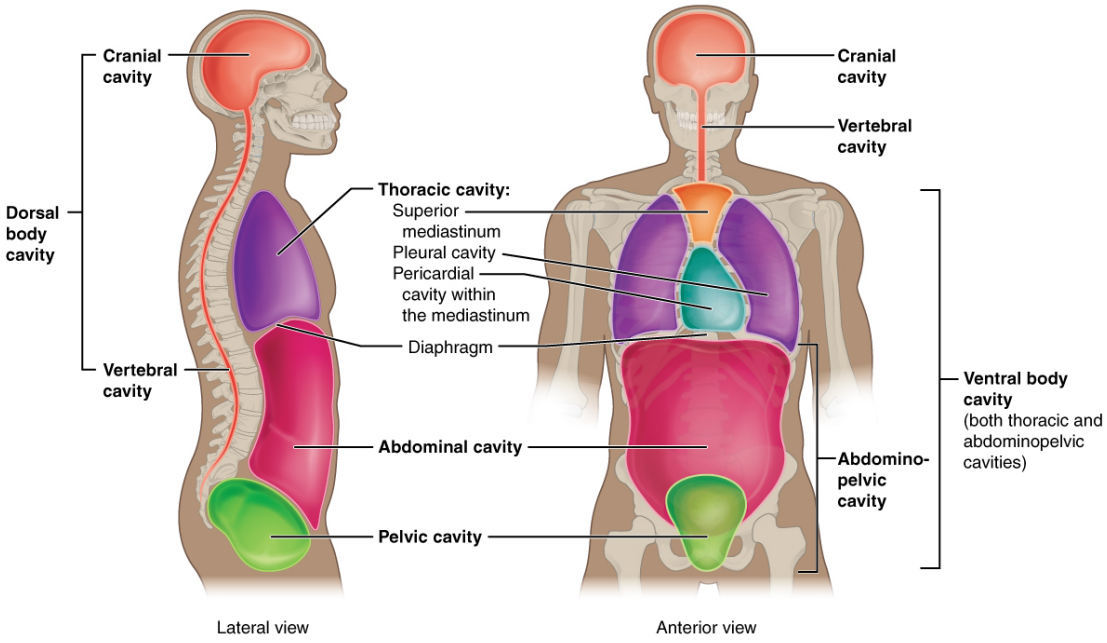

Figure 3.6. Dorsal and Ventral Body Cavities. The ventral cavity includes the thoracic and abdominopelvic cavities and their subdivisions. The dorsal cavity includes the cranial and spinal cavities. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Subdivisions of the Posterior (Dorsal) and Anterior (Ventral) Cavities

The posterior (dorsal) and anterior (ventral) cavities are each subdivided into smaller cavities.

The posterior (dorsal) cavity has two main subdivisions:

- The **cranial cavity** houses the brain.
  - Protected by the bones of the skulls and **cerebrospinal** fluid.
- The **spinal cavity** (or vertebral cavity) encloses the spinal cord.
  - Protected by the vertebral column and **cerebrospinal** fluid.

The anterior (ventral) cavity has two main subdivisions:

- The **thoracic cavity** is the more superior subdivision of the anterior cavity, and it is enclosed by the rib cage.
  - The thoracic cavity contains the lungs and the heart, which are located in the mediastinum.
  - The diaphragm forms the floor of the thoracic cavity and separates it from the more inferior abdominopelvic cavity.
- The **abdominopelvic cavity** is the largest cavity in the body.
  - No membrane physically divides the abdominopelvic cavity.
  - The abdominal cavity houses the digestive organs, the pelvic cavity, and the reproductive organs.

Practice Locating Cavities

> *An interactive H5P element has been excluded from this version of the text. You can view it online here:*
> *https://pressbooks.uwf.edu/medicalterminology/?p=36#h5p-4*

Abdominal Regions and Quadrants

To promote clear communication, for instance about the location of a patient's abdominal pain or a suspicious mass, healthcare providers typically divide up the cavity into either nine regions or four quadrants.

Practice locating the quadrants

> *An interactive H5P element has been excluded from this version of the text. You can view it online here:*
> *https://pressbooks.uwf.edu/medicalterminology/?p=36#h5p-5*

Tissue Membranes

A **tissue membrane** is a thin layer or sheet of cells that covers the outside of the body (for example, skin), the organs (for example, pericardium), internal passageways that lead to the exterior of the body (for example, abdominal mesenteries), and the lining of the movable joint cavities. There are two basic types of tissue membranes: connective tissue and epithelial membranes (Figure 3.7).

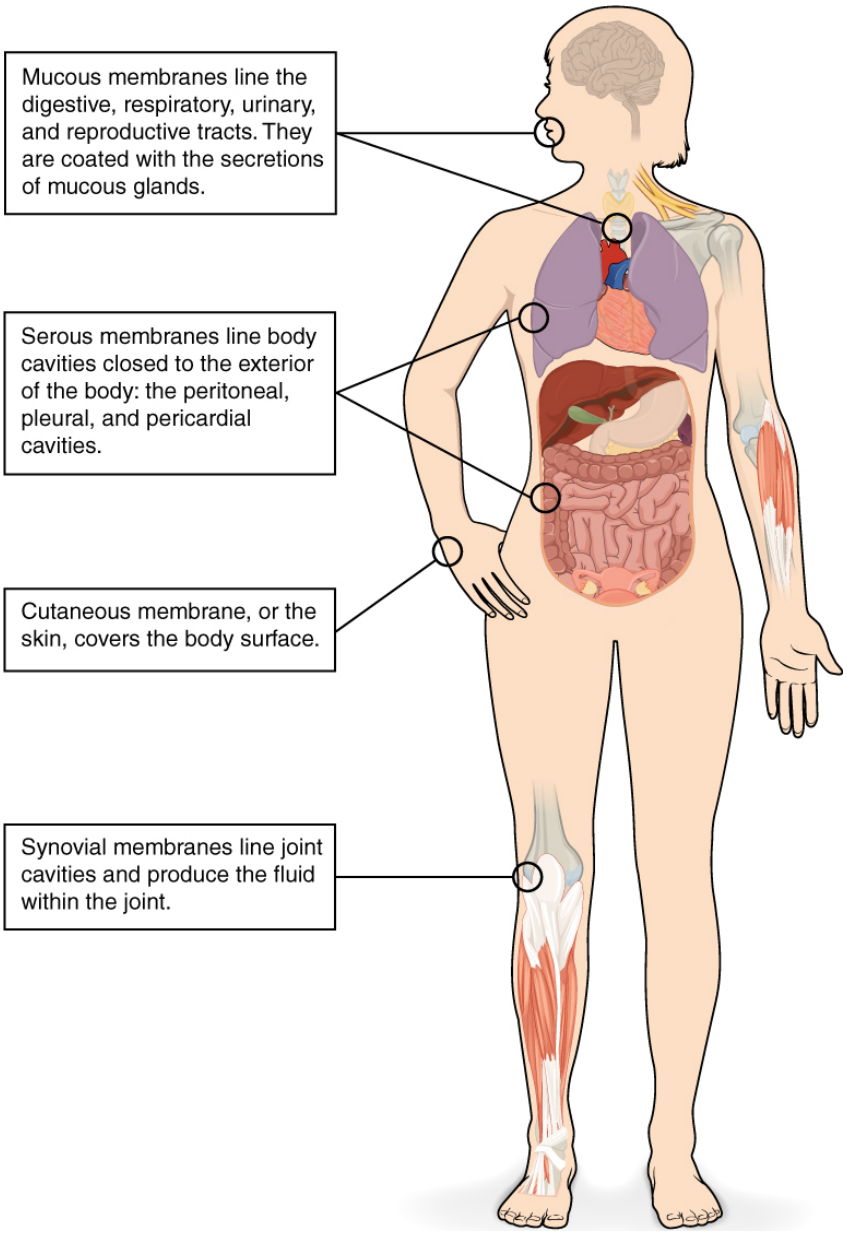

Figure 3.7. Tissue Membranes. The two broad categories of tissue membranes in the body are (1) connective tissue membranes, which include synovial membranes, and (2) epithelial membranes, which include mucous membranes, serous membranes, and the cutaneous membrane, in other words, the skin. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Connective Tissue Membranes

The **connective tissue membrane** is formed solely from connective tissue.

- These membranes encapsulate organs, such as the kidneys, and line our movable joints.

A **synovial membrane** is a type of connective tissue membrane that lines the cavity of a freely movable joint.

- For example, synovial membranes surround the joints of the shoulder, elbow, and knee.

Did you know?

- Synovial membranes line cavities that hold synovial fluid.
- Synovial fluid lubricates the joints for movement.

Epithelial Membranes

The **epithelial membrane** is composed of epithelium attached to a layer of connective tissue.

- For example, your skin.

The **mucous membrane** is also a composite of connective and epithelial tissues.

- Sometimes called mucosae, these epithelial membranes line the body cavities and hollow passageways that open to the external environment and include the digestive, respiratory, excretory, and reproductive tracts.
- Mucus, produced by the epithelial exocrine glands, covers the epithelial layer.
- The underlying connective tissue, called the **lamina propria** (literally "own layer"), helps support the fragile epithelial layer.

The skin is an epithelial membrane also called the **cutaneous membrane**.

- It is a stratified squamous epithelial membrane resting on top of connective tissue. The apical surface of this membrane is exposed to the external environment and is covered with dead, keratinized cells that help protect the body from desiccation and pathogens.

Membranes of the Anterior (Ventral) Body Cavity

A **serous membrane** (also referred to as serosa) is an epithelial membrane composed of mesodermally derived epithelium called the mesothelium that is supported by connective tissue (Figure 3.8). These membranes line the **coelomic** cavities of the body and they cover the organs located within those cavities. They are essentially membranous bags, with mesothelial lining the inside and connective tissue on the outside.

- **Parietal layers:** line the walls of the body cavity.
- **Visceral layer:** covers the organs (the viscera).
- Between the parietal and visceral layers is a very thin, fluid-filled **serous space.**

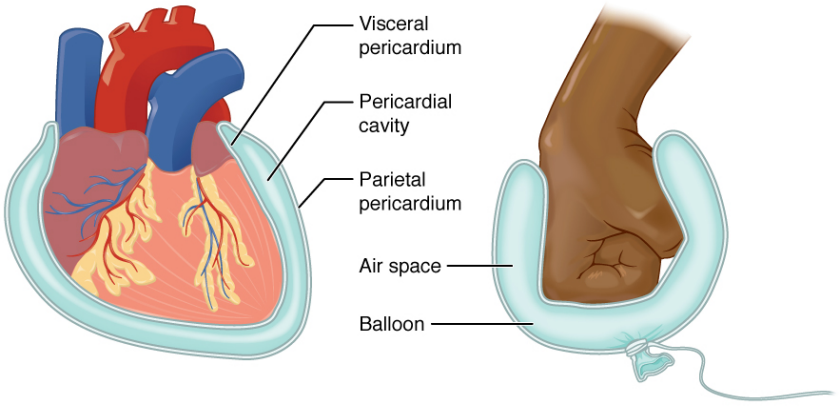

Figure 3.8. Serous Membrane. Serous membrane lines the pericardial cavity and reflects back to cover the heart—much the same way that an underinflated balloon would form two layers surrounding a fist. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

There are three serous cavities and their associated membranes. Serous membranes provide additional protection to the viscera they enclose by reducing friction that could lead to inflammation of the organs.

- **Pleura**: surrounds the lungs in the pleural cavity and reduces friction between the lungs and the body wall.
- **Pericardium:** surrounds the heart in the pericardial cavity and reduces friction between the heart and the wall of the pericardium.
- **Peritoneum:** surrounds several organs in the abdominopelvic cavity. The peritoneal cavity reduces friction between the abdominal and pelvic organs and the body wall.

Practice Body Terminology

An interactive H5P element has been excluded from this version of the text. You can view it online here:
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Body Terminology Vocabulary

Anatomical position

That of the body standing upright, with the feet at shoulder width and parallel, toes forward. The upper limbs are held out to each side, and the palms of the hands face forward.

Anterior (ventral)

Describes the front or direction toward the front of the body.

Cerebrospinal fluid (CSF)

A colorless fluid produced by the brain that cushions the brain and spinal cord within the posterior (dorsal) cavity.

Coelomic

Cavities that do not open to the outside.

Connective tissue

Type of tissue that serves to hold in place, connect, and integrate the body's organs and systems.

Cutaneous membrane

Epithelial tissue made up of stratified squamous epithelial cells that cover the outside of the body; skin.

Deep

Describes a position farther from the surface of the body.

Distal

A position in a limb that is farther from the point of attachment or the trunk of the body.

Epithelial membrane

Epithelium attached to a layer of connective tissue.

Frontal plane

Two-dimensional, vertical plane that divides the body or organ into anterior and posterior portions.

Homeostasis

The state of steady internal conditions maintained by living things.

Inferior (caudal)

A position below or lower than another part of the body proper.

Lateral

Describes the side or direction toward the side of the body.

Medial

Describes the middle or direction toward the middle of the body.

Mucous membrane

Epithelial membranes that line the body cavities and hollow passageways that open to the external environment.

Parietal layer

Outermost layer of the pleura that connects to the thoracic wall, mediastinum, and diaphragm.

Pericardium

Membrane that separates the heart from other mediastinal structures; consists of two distinct, fused sublayers: the fibrous pericardium and the parietal pericardium.

Peritoneum

Serous membrane that lines the abdominopelvic cavity and covers the organs found there.

Pleura

The membrane that wraps around the outside of your lungs and lines the inside of your chest cavity.

Posterior (dorsal)

Describes the back or direction toward the back of the body.

Prone

A face-down orientation.

Proximal

A position in a limb that is nearer to the point of attachment or the trunk of the body.

Sagittal plane

Two-dimensional, vertical plane that divides the body or organ into right and left sides.

Serous membrane

One of the thin membranes that cover the walls and organs in the thoracic and abdominopelvic cavities.

Serous space

The very thin, fluid-filled space between the parietal and visceral layers.

Superficial

Describes a position nearer to the surface of the body.

Superior (cranial)
A position above or higher than another part of the body proper.
Supine
A face-up orientation.
Synovial membrane
Thin layer that lines the inner surface of the joint cavity at a synovial joint; produces the synovial fluid.
Tissue membrane
Thin layer or sheet of cells that covers the outside of the body, organs, and internal cavities.
Visceral layer
Innermost layer of the pleura that is superficial to the lungs and extends into the lung fissures.

Test Yourself

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https://pressbooks.uwf.edu/medicalterminology/?p=36#h5p-6

References

CrashCourse. (2015, January 6). *Introduction to anatomy & physiology: Crash Course A&P #1* [Video]. YouTube. https://youtu.be/uBGl2BujkPQ

Image Descriptions

Figure 3.1 image description: This illustration shows biological organization as a pyramid. The chemical level is at the apex of the pyramid where atoms bond to form molecules with three-dimensional structures. An example is shown with two white hydrogen atoms bonding to a red oxygen atom to create water. The next level down on the pyramid is the cellular level, as illustrated with a long, tapered, smooth muscle cell. At this level, a variety of molecules combine to form the interior fluid and organelles of a body cell. The next level down is the tissue level. A community of similar cells forms body tissue. The example given here is a section of smooth muscle tissue, which contains many smooth muscle cells closely bound side by side. The next level down is the organ level, as illustrated with the bladder and urethra. The bladder contains smooth muscle while the urethra contains skeletal muscle. These are both examples of muscle tissues. The next level down is the organ system level, as illustrated by the entire urinary system containing the kidney, ureters, bladder, and urethra. At this level, two or more organs work closely together to perform the functions of a body system. At the base of the pyramid is the organismal level illustrated with a woman drinking water. At this level, many organ systems work harmoniously together to perform the functions of an independent organism. [Return to Figure 3.1].

Figure 3.2 image description: This illustration shows eight silhouettes of a human female, each showing the components of a different organ system. The integumentary system encloses internal body structures and is the site of many sensory receptors. The integumentary system includes the hair, skin, and nails. The skeletal system supports the body and, along with the muscular system, enables movement. The skeletal system includes cartilage, such as that at the

tip of the nose, as well as the bones and joints. The muscular system enables movement, along with the skeletal system, but also helps to maintain body temperature. The muscular system includes skeletal muscles, as well as tendons that connect skeletal muscles to bones. The nervous system detects and processes sensory information and activates bodily responses. The nervous system includes the brain, spinal cord, and peripheral nerves, such as those located in the limbs. The endocrine system secretes hormones and regulates bodily processes. The endocrine system includes the pituitary gland in the brain, the thyroid gland in the throat, the pancreas in the abdomen, the adrenal glands on top of the kidneys, and the testes in the scrotum of males as well as the ovaries in the pelvic region of females. The cardiovascular system delivers oxygen and nutrients to the tissues as well as equalizes temperature in the body. The cardiovascular system includes the heart and blood vessels. [Return to Figure 3.2].

Figure 3.3 image description: The lymphatic system returns fluid to the blood and defends against pathogens. The lymphatic system includes the thymus in the chest, the spleen in the abdomen, the lymphatic vessels that spread throughout the body, and the lymph nodes distributed along the lymphatic vessels. The respiratory system removes carbon dioxide from the body and delivers oxygen to the blood. The respiratory system includes the nasal passages, the trachea, and the lungs. The digestive system processes food for use by the body and removes wastes from undigested food. The digestive system includes the stomach, the liver, the gallbladder (connected to the liver), the large intestine, and the small intestine. The urinary system controls water balance in the body and removes and excretes waste from the blood. The urinary system includes the kidneys and the urinary bladder. The reproductive system of males and females produce sex hormones and gametes. The male reproductive system is specialized to deliver gametes to the female while the female reproductive system is specialized to support the embryo and fetus until birth and produce milk for the infant after birth. The male reproductive system includes the two testes within the scrotum as well as the epididymis which wraps around each testis. The female reproductive system includes the mammary glands within the breasts and the ovaries and uterus within the pelvic cavity. [Return to Figure 3.3]

Figure 3.4 image description: This illustration shows an anterior and posterior view of the human body. The cranial region encompasses the upper part of the head while the facial region encompasses the lower half of the head beginning below the ears. The eyes are referred to as the ocular region. The cheeks are referred to as the buccal region. The ears are referred to as the auricle or otic region. The nose is referred to as the nasal region. The chin is referred to as the mental region. The neck is referred to as the cervical region. The trunk of the body contains, from superior to inferior, the thoracic region encompassing the chest, the mammary region encompassing each breast, the abdominal region encompassing the stomach area, the coxal region encompassing the beltline, and the pubic region encompassing the area above the genitals. The umbilicus, or navel, is located at the center of the abdomen. The pelvis and legs contain, from superior to inferior, the inguinal or groin region between the legs and the genitals, the pubic region surrounding the genitals, the femoral region encompassing the thighs, the patellar region encompassing the knee, the crural region encompassing the lower leg, the tarsal region encompassing the ankle, the pedal region encompassing the foot and the digital/phalangeal region encompassing the toes. The great toe is referred to as the hallux. The regions of the upper limbs, from superior to inferior, are the axillary region encompassing the armpit, the brachial region encompassing the upper arm, the antecubital region encompassing the front of the elbow, the antebrachial region encompassing the forearm, the carpal region encompassing the wrist, the palmar region encompassing the palm, and the digital/phalangeal region encompassing the fingers. The thumb is referred to as the pollux. The posterior view contains, from superior to inferior, the cervical region encompassing the neck, the dorsal region encompassing the upper back, and the lumbar region encompassing the lower back. The regions of the back of the arms, from superior to inferior, include the cervical region encompassing the neck, acromial region encompassing the shoulder, the brachial region encompassing the upper arm, the olecranal region encompassing the back of the elbow, the antebrachial region encompasses the back of the arm, and the manual region encompassing the palm. The posterior regions of the legs, from superior to inferior, include the gluteal region encompassing the buttocks, the femoral region encompassing the thigh, the popliteal region encompassing the back of the knee, the sural region encompassing the back of the lower leg, and the plantar region encompassing the sole. Some regions are combined into larger regions. These include the trunk, which is a combination of the thoracic, mammary, abdominal, naval, and coxal regions. The cephalic region is a combination of all of the head

regions. The upper limb region is a combination of all of the arm regions. The lower limb region is a combination of all of the leg regions. [Return to Figure 3.4].

Figure 3.5 image description: This illustration shows two diagrams: one of a side view of a female and the other of an anterior view of a female. Each diagram shows directional terms using double-sided arrows. The cranial-distal arrow runs vertically behind the torso and lower abdomen. The cranial arrow is pointing toward the head while the caudal arrow is pointing toward the tail bone. The posterior/anterior arrow is running horizontally through the back and chest. The posterior or dorsal arrow is pointing toward the back while the anterior, or ventral arrow, is pointing toward the abdomen. On the anterior view, the proximal/distal arrow is on the right arm. The proximal arrow is pointing up toward the shoulder while the distal arrow is pointing down toward the hand. The lateral-medial arrow is a horizontal arrow on the abdomen. The medial arrow is pointing toward the navel while the lateral arrow is pointing away from the body to the right. Right refers to the right side of the woman's body from her perspective while left refers to the left side of the woman's body from her perspective. [Return to Figure 3.5].

Figure 3.6 image description: This illustration shows a lateral and anterior view of the body and highlights the body cavities with different colors. The cranial cavity is a large, bean-shaped cavity filling most of the upper skull where the brain is located. The vertebral cavity is a very narrow, thread-like cavity running from the cranial cavity down the entire length of the spinal cord. Together the cranial cavity and vertebral cavity can be referred to as the dorsal body cavity. The thoracic cavity consists of three cavities that fill the interior area of the chest. The two pleural cavities are situated on both sides of the body, anterior to the spine and lateral to the breastbone. The superior mediastinum is a wedge-shaped cavity located between the superior regions of the two thoracic cavities. The pericardial cavity within the mediastinum is located at the center of the chest below the superior mediastinum. The pericardial cavity roughly outlines the shape of the heart. The diaphragm divides the thoracic and abdominal cavities. The abdominal cavity occupies the entire lower half of the trunk, anterior to the spine. Just under the abdominal cavity, anterior to the buttocks, is the pelvic cavity. The pelvic cavity is funnel-shaped and located inferior and anterior to the abdominal cavity. Together the abdominal and pelvic cavity can be referred to as the abdominopelvic cavity while the thoracic, abdominal, and pelvic cavities together can be referred to as the ventral body cavity. [Return to Figure 3.6].

Figure 3.7 image description: This illustration shows the silhouette of a human female from an anterior view. Several organs are showing in her neck, thorax, abdomen, left arm, and right leg. Text boxes point out and describe the mucous membranes in several different organs. The topmost box points to the mouth and trachea. It states that mucous membranes line the digestive, respiratory, urinary, and reproductive tracts. They are coated with the secretions of mucous glands. The second box points to the outside edge of the lungs as well as the large intestine and states that serous membranes line body cavities that are closed to the exterior of the body, including the peritoneal, pleural, and pericardial cavities. The third box points to the skin of the hand. It states that the cutaneous membrane, also known as the skin, covers the body surface. The fourth box points to the right knee. It states that synovial membranes line joint cavities and produce the fluid within the joint.[Return to Figure 3.7]

Figure 3.8 image description: This diagram shows the pericardium on the left next to an analogy of a hand punching a balloon on the right. The pericardium is a two-layered sac that surrounds the entire heart except where the blood vessels emerge on the heart's superior side. The pericardium has two layers because it folds over itself in the shape of the letter U. The inner layer that borders the heart is the visceral pericardium while the outer layer is the parietal pericardium. The space between the two layers is called the pericardial cavity. The heart sits in the cavity much like a fist punching into a balloon. The balloon surrounds the lower part of the fist with a two-layered sac, with the top of the balloon, where it contacts the fist, being analogous to the visceral pericardium. The bottom of the balloon, where it is tied off, is analogous to the parietal pericardium. The air within the balloon is analogous to the pericardial cavity. [Return to Figure 3.8].

Unless otherwise indicated, this chapter contains material adapted from *Anatomy and Physiology* (on

4. Sensory Systems

Learning Objectives

- Examine the anatomy of the sensory systems
- Determine the main functions of the sensory systems
- Differentiate the medical terms of the sensory systems and common abbreviations
- Discover the medical specialties associated with the sensory systems
- Recognize common diseases, disorders, and procedures related to the sensory systems

Sensory Systems Word Parts

Click on prefixes, combining forms, and suffixes to reveal a list of word parts to memorize for the Sensory Systems.

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Introduction to the Sensory Systems

Ask anyone what the senses are, and they are likely to list the five major senses as **taste, smell, touch, hearing, and sight**. However, these are not all of the senses. The most obvious omission from this list is **balance**. Touch can be further subdivided into pressure, vibration, stretch, and hair-follicle position based on the type of **mechanoreceptors** that perceive these touch sensations. Other overlooked senses include temperature perception by **thermoreceptors** and pain perception by nociceptors.

Within the realm of physiology, senses can be classified as either general or special. A **general sense** is one that is distributed throughout the body and has receptor cells within the structures of other organs. Mechanoreceptors in the skin, muscles, or walls of blood vessels are examples of this type. General senses often contribute to the sense of touch, as described above, or to **proprioception** and **kinesthesia**, or to a **visceral** sense, which is most important to autonomic functions. A **special sense** is one that has a specific organ devoted to it, namely the eye, inner ear, tongue, or nose.

Gustation (Taste) and Olfaction (Smell)

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Media 4.1 Taste & Smell: Crash Course A&P #16 [Online video]. Copyright 2015 from CrashCourse.

Practice Medical Terms Related to the Sensory Systems

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Gustation (Taste)

Gustation is the special sense associated with the tongue. The surface of the tongue, along with the rest of the oral cavity, is lined by a stratified squamous epithelium. Raised bumps called papillae contain the structures for gustatory transduction. There are **four types of papillae**, based on their appearance:

- circumvallate
- foliate
- filiform
- fungiform

Within the structure of the papillae are taste buds that contain specialized gustatory receptor cells for the transduction of taste stimuli. These receptor cells are sensitive to the chemicals contained within foods that are ingested, and they release **neurotransmitters** based on the amount of the chemical in the food. Neurotransmitters from the gustatory cells can activate sensory neurons in the facial, glossopharyngeal, and vagus cranial nerves.

Only a few recognized **submodalities** exist within the sense of taste, or gustation. Until recently, only four tastes were recognized: **sweet**, **salty**, **sour**, and **bitter**. Research at the turn of the 20th century led to the recognition of the fifth

taste, **umami**, during the mid-1980s. Very recent research has suggested that there may also be a sixth taste for **fats**, or lipids.

Olfaction (Smell).

Like taste, **olfaction** is also responsive to chemical stimuli. The olfactory receptor neurons are located in a small region within the superior nasal cavity. The nasal epithelium, including the olfactory cells, can be harmed by airborne toxic chemicals. Scent receptor messages travel to the cerebrum, specifically to the primary olfactory cortex that is located in the inferior and medial areas of the temporal lobe and additionally to the hypothalamus, where smells become associated with long-term memory and emotional response.

Did you know?

The human body can detect over 10,000 odors.

Concept Check

- Which parts of the brain are active with recording and associating scents with memories and emotions?
- Recall and list the four types of papillae (taste buds) found on the tongue.

Audition (Hearing), Equilibrium (Balance), and Somatosensation (Touch)

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Media 4.2 Hearing & Balance: Crash Course A&P #17 [Online video]. Copyright 2015 by CrashCourse.

Audition (Hearing)

Hearing, or **audition**, is the **transduction** of sound waves into a neural signal that is made possible by the structures of the ear (see Figure 4.1).

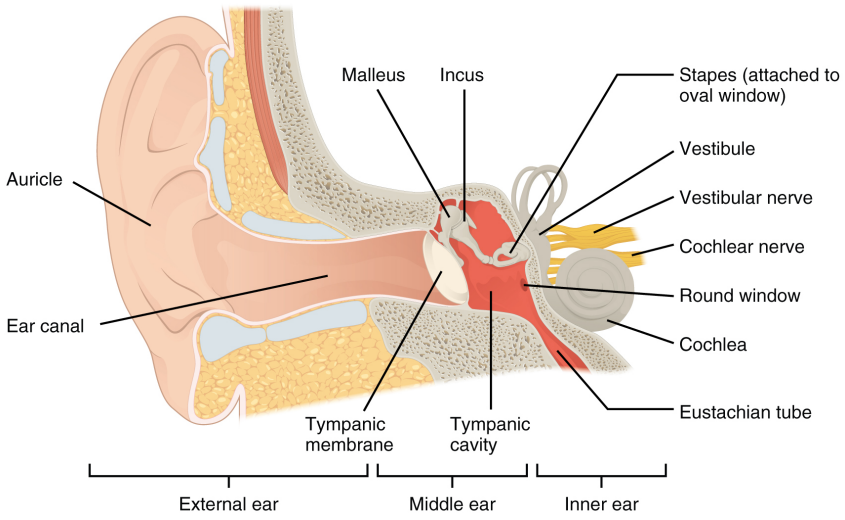

Figure 4.1 Structures of the Ear. The external ear contains the auricle, ear canal, and tympanic membrane. The middle ear contains the ossicles and is connected to the pharynx by the Eustachian tube. The inner ear contains the cochlea and vestibule, which are responsible for audition and equilibrium, respectively. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

- The **external ear** consists of the auricle, sometimes referred to as the pinna, ear canal, and tympanic membrane.
  - The C-shaped curves of the auricle direct sound waves toward the **auditory canal**. The canal enters the skull

through the external auditory meatus of the **temporal bone**. At the end of the auditory canal is the **tympanic membrane**, which vibrates after it is struck by sound waves.

- The **middle ear** consists of the ossicles, oval window, and tympanic membrane.
  - The three **ossicles** are the malleus, incus, and stapes, which are Latin names that roughly translate to hammer, anvil, and stirrup. The malleus is attached to the tympanic membrane and articulates with the incus. The incus, in turn, articulates with the stapes. The stapes is then attached to the inner ear, where the sound waves will be transduced into a neural signal. Vibrations of the ossicles travel through the **oval window**, moving fluid in a wave-like motion. The frequency of the fluid waves matches the frequencies of the sound waves. The middle ear is connected to the pharynx through the Eustachian tube, which helps equilibrate air pressure across the **tympanic membrane**. The tube is normally closed but will pop open when the muscles of the pharynx contract during swallowing or yawning.
- The **inner ear** is often described as a **bony labyrinth**, as it is composed of a series of canals embedded within the temporal bone.
  - It consists of the **cochlea that is responsible for hearing** and the **vestibule that is responsible for balance.** The neural signals from these two regions are relayed to the brain stem through separate fiber bundles. However, these two distinct bundles travel together from the inner ear to the brain stem as the **vestibulocochlear** nerve. Sound is transduced into neural signals within the cochlear region of the inner ear, which contains the sensory neurons of the spiral ganglia. These ganglia are located within the spiral-shaped cochlea of the inner ear. The cochlea is attached to the stapes through the oval window.

The image below is a cross-sectional view of the cochlea that shows the scala vestibuli and scala tympani run along both sides of the cochlear duct (Figure 4.2). The cochlear duct contains several organs of Corti, which transduce the wave motion of the two scalas into neural signals. The organs of Corti lie on top of the basilar membrane, which is the side of the cochlear duct located between the organs of Corti and the scala tympani. As the fluid waves move through the scala vestibuli and scala tympani, the basilar membrane moves at a specific spot, depending on the frequency of the waves. Higher frequency waves move the region of the basilar membrane that is close to the base of the cochlea. Lower frequency waves move the region of the basilar membrane that is near the tip of the cochlea.

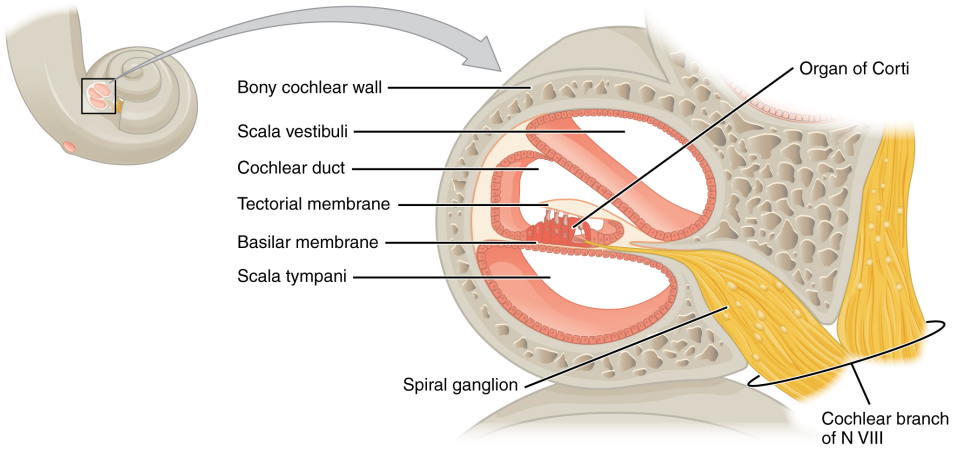

Figure 4.2 Cross Section of the Cochlea. The three major spaces within the cochlea are highlighted. The scala tympani and scala vestibuli lie on either side of the cochlear duct. The organ of Corti, containing the mechanoreceptor hair cells, is adjacent to the scala tympani, where it sits atop the basilar membrane. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

The cochlea encodes auditory stimuli for frequencies between 20 and 20,000 hertz (Hz), which is the range of sound that human ears can detect. The unit of Hz measures the frequency of sound waves in terms of cycles produced per

second. Frequencies as low as 20 Hz are detected by hair cells at the apex, or tip, of the cochlea. Frequencies in the higher ranges of 20 kHz are encoded by hair cells at the base of the cochlea, close to the round and oval windows. Most auditory stimuli contain a mixture of sounds at a variety of frequencies and intensities (represented by the amplitude of the sound wave). The hair cells along the length of the cochlear duct, which are each sensitive to a particular frequency, allow the cochlea to separate auditory stimuli by frequency, just as a prism separates visible light into its component colors.

Did you know?

Sound travels at a speed of 1,130 feet per second.

Equilibrium (Balance)

Along with audition, the **inner ear** is responsible for **encoding** information about **equilibrium**. The cells that sense head position, head movement, and body motion are located within the vestibule of the inner ear. Head position is sensed by otolith organs, whereas head movement is sensed by the semicircular canals (see Figure 4.3). The neural signals generated in the vestibular ganglion are transmitted through the vestibulocochlear nerve to the brainstem and cerebellum.

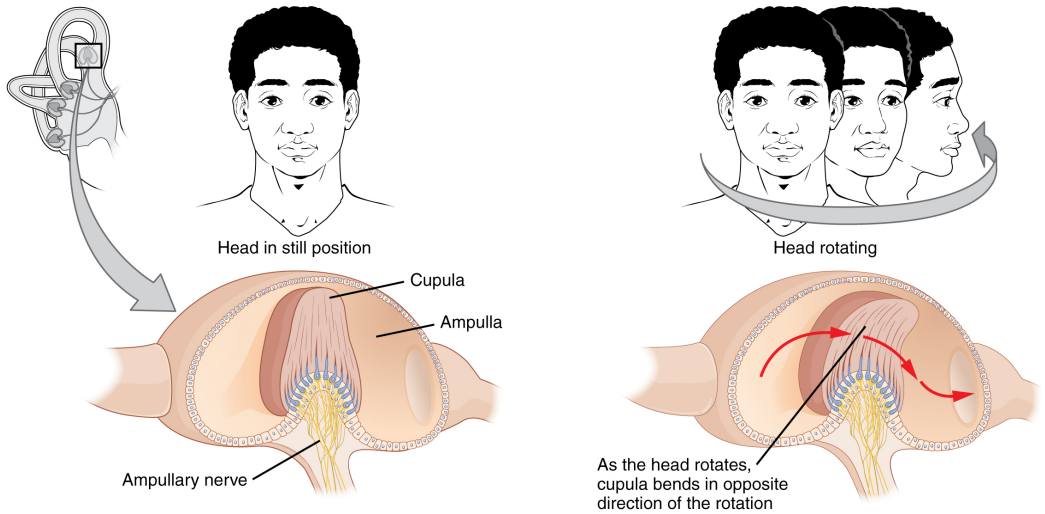

Figure 4.3 Rotational Coding by Semicircular Canals. Rotational movement of the head is encoded by the hair cells in the base of the semicircular canals. As one of the canals moves in an arc with the head, the internal fluid moves in the opposite direction, causing the cupula and stereocilia to bend. The movement of two canals within a plane results in information about the direction in which the head is moving, and activation of all six canals can give a very precise indication of head movement in three dimensions. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Somatosensation (Touch)

Somatosensation is considered a general sense, as opposed to the special senses discussed in this section. Somatosensation is the group of **sensory modalities** that are associated with touch, **proprioception**, and **interoception**. These modalities include pressure, vibration, light touch, tickle, itch, temperature, pain, proprioception, and kinesthesia. This means that its receptors are not associated with a specialized organ, but are instead spread throughout the body in a variety of organs. Many of the somatosensory receptors are located in the skin, but receptors are also found in muscles, tendons, joint capsules, ligaments, and in the walls of visceral organs.

The two types of somatosensory signals that are transduced by free nerve endings are pain and temperature. Temperature receptors are stimulated when local temperatures differ from body temperature. Some thermoreceptors are sensitive to just cold and others to just heat. **Nociception** is the sensation of potentially damaging stimuli. Mechanical, chemical, or thermal stimuli beyond a set threshold will elicit painful sensations. Stressed or damaged tissues release chemicals that activate receptor proteins in the nociceptors.

For example, the sensation of heat associated with spicy foods involves capsaicin, the active molecule in hot peppers. Capsaicin molecules bind to a transmembrane ion channel in nociceptors that is sensitive to temperatures above 37°C (98.6°F). The dynamics of capsaicin binding with this transmembrane ion channel are unusual in that the molecule remains bound for a long time. Because of this, it will decrease the ability of other stimuli to elicit pain sensations through the activated nociceptor. For this reason, capsaicin can be used as a topical analgesic, such as in products such as Icy Hot™.

Did you know?

With the aging process, humans lose sensory receptors cells, including cells that detect pain and temperature changes.

Concept Check

- What structure exists within the ear to assist with maintaining **equilibrium**?
- What are the medical terms used to describe the sense of taste and touch?

Ear Anatomy Labeling Activity

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Vision (Sight)

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Media 4.3 Vision: Crash Course A&P #18 *[Online video]. Copyright 2015 by* CrashCourse.

Vision is the special sense of sight that is based on the transduction of light stimuli received through the eyes. The eyes are located within either orbit in the skull. The bony orbits surround the eyeballs, protecting them and anchoring the soft tissues of the eye (see Figure 4.4). The eyelids, with lashes at their leading edges, help to protect the eye from abrasions by blocking particles that may land on the surface of the eye.

The inner surface of each lid is a thin membrane known as the palpebral conjunctiva. The conjunctiva extends over the **sclera**, connecting the eyelids to the eyeball. Tears are produced by the lacrimal gland, located beneath the lateral edges of the nose. Tears produced by this gland flow through the lacrimal duct to the medial corner of the eye where the tears flow over the conjunctiva, washing away foreign particles.

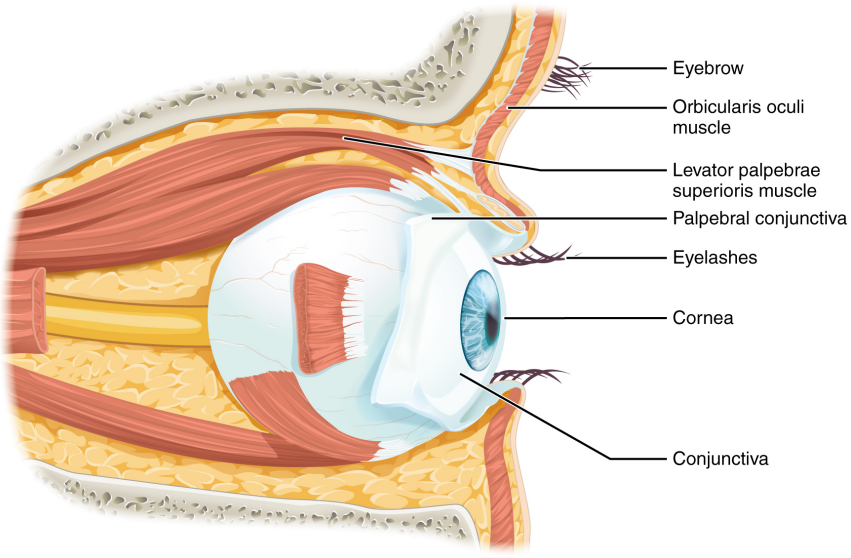

Figure 4.4 The Eye in the Orbit. The eye is located within the orbit and surrounded by soft tissues that protect and support its function. The orbit is surrounded by cranial bones of the skull. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Movement of the eye within the orbit is accomplished by the contraction of six extraocular muscles that originate from the bones of the orbit and insert into the surface of the eyeball. Four of the muscles are arranged at the cardinal points around the eye and are named for those locations. They are the:

- superior rectus
- medial rectus
- inferior rectus
- lateral rectus.

When each of these muscles contracts, the eye moves toward the contracting muscle. For example, when the superior rectus contracts, the eye rotates to look up.

The eye itself is a hollow sphere composed of three layers of tissue:

- The **outermost layer** is the fibrous tunic, which includes the white sclera and clear cornea. The sclera accounts for five-sixths of the surface of the eye, most of which is not visible, though humans are unique compared with many other species in having so much of the "white of the eye" visible (see Figure 4.5). The transparent cornea covers the anterior tip of the eye and allows light to enter the eye.
- The **middle layer** of the eye is the vascular tunic, which is mostly composed of the choroid, ciliary body, and iris. The choroid is a layer of highly vascularized connective tissue that provides a blood supply to the eyeball. The choroid is posterior to the ciliary body, a muscular structure that is attached to the lens by zonule fibers. These two structures bend the lens, allowing it to focus light on the back of the eye. Overlaying the ciliary body, and visible in the anterior eye, is the iris—the colored part of the eye. The iris is a smooth muscle that opens or closes the pupil, which is the hole at the center of the eye that allows light to enter. The iris constricts the pupil in response to bright light and dilates the pupil in response to dim light.
- The **innermost layer** of the eye is the neural tunic, or retina, which contains the nervous tissue responsible for photoreception.

The eye is also divided into two cavities:

- The **anterior cavity**
  - The anterior cavity is the space between the cornea and lens, including the iris and ciliary body. It is filled with a watery fluid called the aqueous humor.
- The **posterior cavity**
  - The posterior cavity is the space behind the lens that extends to the posterior side of the interior eyeball, where the retina is located. The posterior cavity is filled with a more viscous fluid called the vitreous humor.

The **retina** is composed of several layers and contains specialized cells for the initial processing of visual stimuli. The photoreceptors (rods and cones) change their membrane potential when stimulated by light energy. The change in membrane potential alters the number of neurotransmitters that the photoreceptor cells release onto bipolar cells in the outer synaptic layer. It is the bipolar cell in the retina that connects a photoreceptor to a retinal ganglion cell (RGC) in the inner synaptic layer. There, amacrine cells additionally contribute to retinal processing before an action potential is produced by the RGC. The axons of RGCs, which lie at the innermost layer of the retina, collect at the optic disc and leave the eye at the optic nerve (see Figure 4.5). Because these axons pass through the retina, there are no photoreceptors at the very back of the eye where the optic nerve begins. This creates a "blind spot" in the retina and a corresponding blind spot in our visual field.

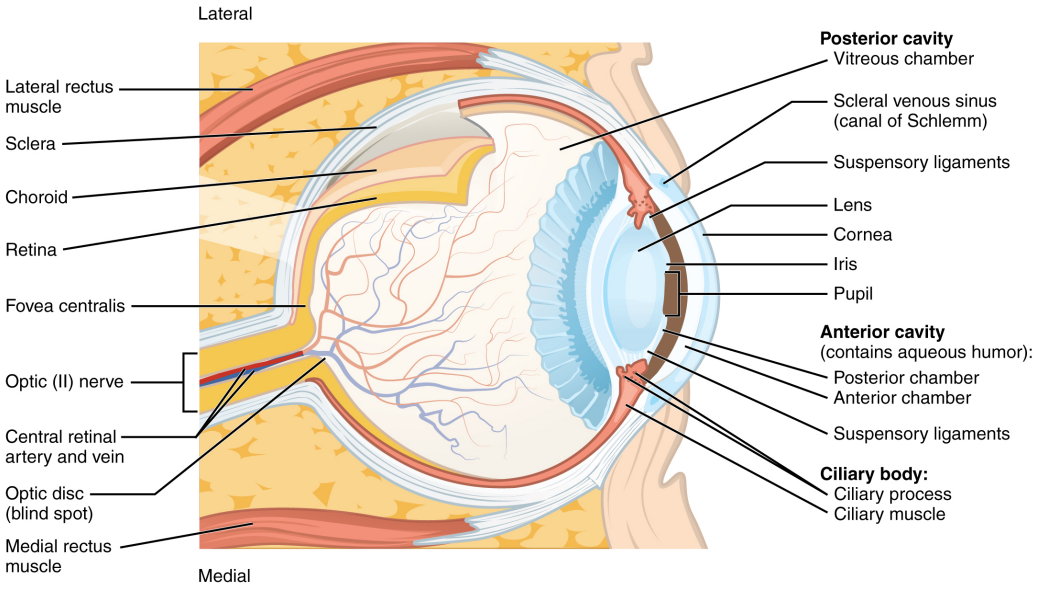

Figure 4.5. Structure of the Eye. The sphere of the eye can be divided into anterior and posterior chambers. The wall of the eye is composed of three layers: the fibrous tunic, vascular tunic, and neural tunic. Within the neural tunic is the retina, with three layers of cells and two synaptic layers in between. The center of the retina has a small indentation known as the fovea. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Photoreceptors in the retina (rods and cones) are located behind the axons, RGCs, bipolar cells, and retinal blood vessels. A significant amount of light is absorbed by these structures before the light reaches the photoreceptor cells. At the exact center of the retina is a small area known as the fovea. At the fovea, the retina lacks the supporting cells and blood vessels, and only contains photoreceptors. Therefore, **visual acuity** is greatest at the fovea. This is because the fovea is where the least amount of incoming light is absorbed by other retinal structures (see Figure 4.5). As one moves in either direction from this central point of the retina, visual acuity drops significantly.

Example: Visual Acuity (VA) between the fovea and peripheral retina.

The difference in visual acuity between the fovea and peripheral retina is easily evidenced by looking directly at a word in the middle of this paragraph. The visual stimulus in the middle of the field of view falls on the fovea and is in the sharpest focus. **Without moving your eyes off that word, notice that words at the beginning or end of the paragraph are not in focus.** The images in your peripheral vision are focused by the peripheral retina and have vague, blurry edges and words that are not as clearly identified. As a result, a large part of the neural function of the eyes is concerned with moving the eyes and head so that important visual stimuli are centered on the fovea.

There are three types of **cone opsins** that are sensitive to different wavelengths of light and provide us with **color vision**. By comparing the activity of the three different cones, the brain can extract color information from visual stimuli (see Figure 4.6). For example, a bright blue light that has a wavelength of approximately 450 nm would activate the **"red"** cones minimally, the **"green"** cones marginally, and the **"blue"** cones predominantly. The relative activation of the three different cones is calculated by the brain, which perceives the color as blue. However, cones cannot react to low-intensity light, and rods do not sense the color of light. Therefore, our low-light vision is, in essence, in **grayscale**. In other words, in a dark room, everything appears as a shade of gray. If you think that you can see colors in the dark, it is most likely because your brain knows what color something is and is relying on that memory.

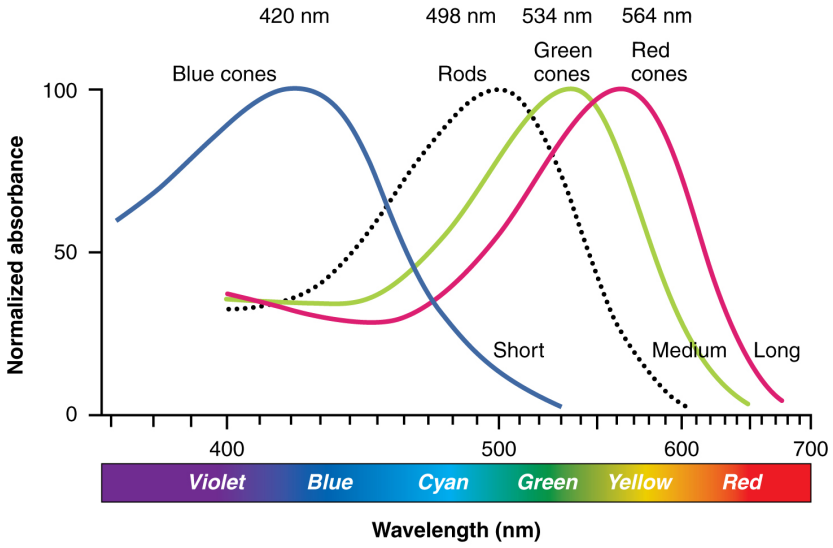

Figure 4.6 Comparison of Color Sensitivity of Photopigments. Comparing the peak sensitivity and absorbance spectra of the four photopigments suggests that they are most sensitive to particular wavelengths. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Anatomy Labeling Activity

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Practice Terms Related to the Sensory Systems

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Common Abbreviations for the Sensory Systems

Many terms and phrases related to the sensory systems are abbreviated. Learn these common abbreviations by expanding the list below.

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Diseases and Disorders of the Sensory Systems

Olfactory Diseases and Disorders

Anosmia

Blunt force trauma to the face, such as that common in many car accidents, can lead to the loss of the olfactory nerve, and subsequently, loss of the sense of smell. This condition is known as **anosmia**. When the frontal lobe of the brain moves relative to the ethmoid bone, the olfactory tract axons may be sheared apart. Professional fighters often experience anosmia because of repeated trauma to the face and head. In addition, certain pharmaceuticals, such as antibiotics, can cause anosmia by killing all the olfactory neurons at once. If no axons are in place within the olfactory nerve, then the axons from newly formed olfactory neurons have no guide to lead them to their connections within the olfactory bulb. There are temporary causes of anosmia, as well, such as those caused by inflammatory responses related to respiratory infections or allergies.

Loss of the sense of smell can result in food tasting bland. A person with an impaired sense of smell may require additional spice and seasoning levels for food to be tasted. Anosmia may also be related to some presentations of mild depression, because the loss of enjoyment of food may lead to a general sense of despair. The ability of olfactory neurons to replace themselves decreases with age, leading to age-related anosmia. This explains why some older adults salt their food more than younger people do. However, this increased sodium intake can increase blood volume and blood pressure, increasing the risk of cardiovascular diseases in older adults.

Ears, Nose, and Throat Diseases and Disorders

Otitis Media

Otitis Media is known as inflammation of the middle ear canal that involves the eardrum. It is commonly seen in younger children due to bacterial and viral infections. Signs and symptoms include fever, cough and cold symptoms, hearing loss, irritability, and **otalgia**. Treatment involves symptomatic control as well as antibiotic (amoxicillin) use if necessary (Centers for Disease Control and Prevention, n.d.-a; MedlinePlus, 2021).

Otitis Externa

Otitis Externa is inflammation of the external ear canal. It is known as swimmer's ear because it is associated with its exposure to water. Its clinical presentation and management are the same as otitis media (Centers for Disease Control and Prevention, n.d.-b).

Conductive Hearing Loss

Conductive hearing loss occurs when something disrupts sound through the mid and outer ear, such as physical damage

to the eardrum (perforation). Hearing loss can be managed with pharmacotherapy, surgery, or a combination of the two (National Institute on Aging, n.d.).

Sensorineural Hearing Loss

Sensorineural hearing loss results from damage to the neural structures. This type of hearing loss is usually permanent (National Institute on Aging, n.d.).

Tinnitus

Tinnitus is a condition in which a person hears ringing, roaring, or buzzing in their ears. It may be a symptom of earwax blocking the ear canal, hearing loss, hormonal changes in women, or a brain tumor. Although there is no cure, several treatments are available (National Institute on Deafness and Other Communication Disorders, 2017).

Otosclerosis

Otosclerosis is the hardening of the ear due to new bone formation of the inner ear ossicles. Its etiology may be related to prior measles infection, stress fractures to the tissue surrounding the inner ear, or immune disorders. Mild otosclerosis can be surgically treated (National Institute on Deafness and Other Communication Disorders, 2018).

Rhinitis

Rhinitis is inflammation of the nasal cavity mucosal lining which can lead to congestion and **rhinorrhea**. Potential causes include allergy, bacterial or viral infection, and exposure to chemicals. Treatment regimens include symptom management, saline sprays, and oral antihistamines (Akhouri & House, 2021).

Dacryostenosis

Dacryostenosis, also known as nasolacrimal obstruction, is an obstruction of the nasolacrimal duct. It prevents tears from draining from the eyes into the ducts and, thus, individuals have excessive tearing. Its etiology is congenital and the result of the duct not forming properly. This condition is managed via observation, as it resolves over time (usually within 1 year) (Pezzoli & Patel, 2021).

Eye Diseases and Disorders

Blindness

The term “blindness” may cover a broad spectrum of visual disability, from limited visibility to total blindness. The parameters for legal blindness are visual field is 20 degrees or narrower and/or visual acuity is 20/200 or less in both eyes even after correction (Lee & Mesfin, 2021). Many of the conditions described below lead to visual disability, low vision, and legal blindness.

Cataract

A cataract is a clouding of the normally clear lens of your eye. For people who have cataracts, it is like seeing through cloudy lenses or windows. Age-related cataracts are the most common type, although cataracts can develop as a result of a congenital condition or due to trauma. Treatment usually involves surgery to remove the clouding of the lens (Nizami & Gulani, 2021).

Conjunctivitis

Conjunctivitis is a condition involving inflammation of the conjunctiva. Common causes include allergens and bacterial and viral pathogens. The cause of conjunctivitis determines if it is transmissible from one individual to another; conjunctivitis caused by the adenovirus, for example, is highly contagious, whereas conjunctivitis caused by pollen is not. Management involves treating the underlying cause of conjunctivitis (Ryder & Benson, 2021).

Diabetic Retinopathy

Diabetic retinopathy is a disease of the retina caused by diabetes mellitus. The retinal veins dilate, leading to swelling as fluid leaks from blood vessels into the retina. It is estimated that 77% of patients with type 1 diabetes and 25% of patients with type 2 diabetes have diabetic retinopathy. Management involves controlling the patient's diabetes (Shukla & Tripathy, 2021).

Glaucoma

Glaucoma is a condition in which increased pressure in the eye leads to progressive vision loss. It is the second most common cause of permanent blindness in the United States. The most common form of glaucoma is primary open-angle glaucoma. This form is associated with elevated pressure caused by a backup of fluid in the eye. Management depends on the type of glaucoma and the severity of the case. Glaucoma-related vision loss cannot be reversed (Dietze et al., 2021).

Macular Degeneration/ Age-related Macular Degeneration (AMD)

Macular degeneration is the progressive damage of a portion of the retina known as the macula. Severe central vision is lost with peripheral vision retained. Macular degeneration is the leading cause of blindness in people over the age of 60 years (Ruia & Kaufman, 2021).

Nystagmus

Nystagmus is a condition whereby involuntary repetitive movements of one or both eyes make it impossible to fixate on a single object (Sekhon et al., 2020).

Retinal Detachment

Retinal detachment occurs when the retina gets pulled away or separated from its normal position. Signs and symptoms include flashing lights, floaters, and vision loss. Treatment generally involves surgery. If left untreated, a retinal detachment can lead to blindness (Blair & Czyz, 2021).

Strabismus

Strabismus is a condition where the affected eye rotates due to mismatched eye coordination. Each eye is focused differently as described below:

- **Esotropia:** the convergence of one or both eyes medially.
- **Exotropia:** the deviation of one eye laterally.
- **Hypertropia:** the deviation of one eye superiorly.
- **Hypotropia:** the deviation of one eye inferiorly.

If not managed, the brain may reject input from one eye, resulting in **amblyopia.** Also known as lazy eye, amblyopia is caused when there is an imbalance of stimuli from the brain to the eyes (one eye receives more than the other). It usually occurs in childhood and requires early intervention to rectify this condition (New York State Department of Health, 2012).

Medical Terms in Context

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Medical Specialties and Procedures Related to the Sensory Systems

Several medical specialties support the sensory systems. An **optometrist** is an eye specialist that examines and evaluates for ocular pathology and prescribes corrective lenses. An **ophthalmologist** evaluates and manages eye pathology as well as performs surgery. An **otorhinolaryngologist** (ENT) is a physician that specializes in ears, nose, and throat treatment and conditions. An **audiologist** evaluates and manages individuals with hearing loss.

Sensory Systems Vocabulary

Acoustic neuroma
A benign tumor of the vestibular nerve in the internal auditory canal.
Anisocoria
Condition of unequal pupil size.
Anosmia
Loss of the sense of smell.
Aphakia
Condition of no lens.
Audiologist
Specialist who studies, diagnoses, and treats hearing-related issues.
Audiology
Medical specialty that studies hearing and hearing impairment.
Audiometry
The testing of the acuity of the sense of hearing.
Binocular
The use of both eyes to create one composite image.
Blepharitis
Inflammation of eyelids.
Blepharoplasty
Surgical repair of the eyelid.
Blepharoptosis
Drooping of the upper eyelid.
Cataract
A condition in which the lens of the eye becomes cloudy.
Conjunctivitis
Inflammation or infection of the conjunctiva; also called pinkeye.
Dacryocystitis
Inflammation of the tear (lacrimal) sac.
Dacryocystorhinostomy
Creation of an artificial opening between the lacrimal sac and the nose (to restore drainage).
Diplopia
Double vision.
Endophthalmitis
Inflammation within the eye.
Epistaxis
Nosebleed.
Hyperopia
Farsightedness.
Iridectomy
Excision of part of the iris.
Iritis
Inflammation of the iris.
Keratitis
Inflammation of the cornea.
Keratomalacia

Degeneration of the cornea.

Keratoplasty

Surgical replacement of the cornea.

Kinesthesia

Sense of body movement based on sensation in the skeletal muscles, tendons, joints, and the skin.

Labyrinthitis

Inflammation of the inner ear (labyrinth).

Mastoidectomy

Excision of the mastoid bone.

Mastoiditis

Inflammation of the mastoid bone.

Mechanoreceptor

A sensory neuron that responds to mechanical pressure.

Myopia

Nearsightedness.

Myringoplasty

Surgical repair of the tympanic membrane.

Nasopharyngeal

Pertaining to the nose and pharynx (throat).

Nociceptors

Sensory neurons that respond to pain.

Ophthalmia neonatorum

Conjunctivitis in newborns (severe).

Ophthalmologist

A doctor who has special training in diagnosing and treating eye problems.

Ophthalmology

A surgical specialty focused on the structure, function, and surgery of the eye.

Ophthalmopathy

Disease of the eye.

Ophthalmoplegia

Paralysis of one or more eye muscles.

Ophthalmoscope

Instrument used to view the inside of the eye.

Ophthalmoscopy

An exam of the fundus of the eye using a magnifying lens and light.

Optometrist

A specialist who diagnoses, treats, and manages diseases and disorders of the eye.

Optometry

The professional practice of eye and vision care that involves measuring vision.

Otalgia

Pain in the ear.

Otorhinolaryngologist

A doctor who has special training in diagnosing and treating diseases of the ear, nose, and throat.

Otomycosis

Fungal infection of the external ear.

Otosclerosis

Hardening of the ear.

Otoscope

Instrument used to view the ear.

Otoscopy

Process of viewing the ear canal and eardrum.

Pharyngitis

Inflammation of the pharynx.

Photophobia

A condition in which the eyes are more sensitive than normal to light.

Proprioception

Sense of position and movement of the body.

Retinoblastoma

Cancer that forms in the tissues of the retina.

Retinopathy

Disease of the retina.

Retinoscopy

Process of determining the refractive state of the eye.

Rhinitis

Inflammation of the mucous membranes of the nose.

Rhinorrhea

Excess nasal drainage; also called a “runny nose.”

Sinusitis

Inflammation of the sinuses.

Stapedectomy

Excision of the stapes.

Stye

Infection of an oil gland of the eyelid (hordeolum).

Thermoreceptors

Specialized neurons that respond to changes in temperature.

Tonometer

Instrument used to measure pressure (within the eye).

Tonometry

Process of measuring pressure (within the eye).

Tonsillitis

Inflammation of the tonsils.

Tympanic membrane

Ear drum.

Tympanoplasty

Surgical repair of the tympanic membrane.

Visceral (sense)

Sense associated with the internal organs.

Visual acuity

Sharpness of vision.

Xerophthalmia

Condition of dry eye.

Test Yourself

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://pressbooks.uwf.edu/medicalterminology/?p=164#h5p-107

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Image Descriptions

Figure 4.1 image description: This image shows the structure of the ear with the major parts labeled. The ear is divided up into 3 parts from left to right: external ear, middle ear, and inner ear. Labels for each part read: external ear (auricle, ear canal), middle ear (tympanic membrane, malleus, incus, tympanic cavity), inner ear (stapes, vestibule, vestibular nerve, cochlear nerve, cochlea, round window, eustachian tube). [Return to Figure 4.1].

Figure 4.2 image description: This diagram shows the structure of the cochlea in the inner ear. Labels read (from top, counterclockwise): bony cochlear wall, scala vestibuli, cochlear duct, tectorial membrane, basilar membrane, scala tympani, spiral ganglion, cochlear branch of N VIII, organ of Corti. [Return to Figure 4.2].

Figure 4.3 image description: The left panel of this image shows a person's head in a still position. Underneath this, the ampullary nerve is shown. Labels read: cupula, ampulla, ampullary nerve). The right panel shows a person rotating his head, and below that, the direction of movement of the cupula is shown. Label reads: as the head rotates, cupula bends in opposite direction of the rotation. [Return to Figure 4.3].

Figure 4.4 image description: This diagram shows the lateral view of the eye. The major parts are labeled. Labels read (from top): eyebrow, orbicularis oculi muscle, levator palpebrae superioris muscle, palpebral conjunctiva, eyelashes, cornea, conjunctiva. [Return to Figure 4.4].

Figure 4.5 image description: This diagram shows a lateral and medial view of the eyeball. The major parts are labeled. Labels read (from top, clockwise): posterior cavity (vitreous chamber, scleral venous sinus (canal of Schlemm), suspensory ligaments, lens, cornea, iris, pupil); anterior cavity (contains aqueous humor, posterior chamber, anterior chamber, suspensory ligaments); Ciliary body (ciliary process and muscle), medial rectus muscle, optic disc (blind spot), central retinal artery and vein, fovea centralis, retina, choroid, sclera, lateral rectus muscle. [Return to Figure 4.5].

Figure 4.6 image description: This graph shows the normalized absorbance versus wavelength for different cell types in the eye. The Y-axis is normalized absorbance, and the X-axis is the wavelength (nm) with the colors violet, blue, cyan, green, yellow, and red across the bottom. The lines in the graph indicate blue cones which peak at 420 nm, rods that peak at 498 nm, green cones which peak at 534 nm, and red cones which peak at 564 nm. Blue cones line is labeled as short, green cones as medium, and red cones as long. [Return to Figure 4.6].

5. Integumentary System

Learning Objectives

- Examine the anatomy of the integumentary system
- Determine the main functions of the integumentary system
- Differentiate integumentary system medical terms and common abbreviations
- Discover medical specialties associated with the integumentary system
- Recognize common diseases, disorders, and procedures related to the integumentary system

Integumentary System Word Parts

Click on prefixes, combining forms, and suffixes to reveal a list of word parts to memorize for the Integumentary System.

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https://pressbooks.uwf.edu/medicalterminology/?p=55#h5p-7

Introduction to the Integumentary System

The integumentary system refers to the skin and its accessory structures. In the adult human body, the skin makes up about 16% of body weight and covers an area of 1.5 to 2 m^2.

In fact, the skin and accessory structures are the largest organ system in the human body. The skin protects your inner organs, and it is in need of daily care and protection to maintain its health.

Did you know?

The skin and accessory structures are the largest organ system in the human body.

Watch this video:

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Media 5.1. *The Integumentary System, Part 1 – Skin Deep: Crash Course A&P #6* [Video]. *Copyright 2015 by CrashCourse*.

Practice Medical Terms Related to the Integumentary System

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Anatomy (Structures) of the Integumentary System

The skin and its accessory structures make up the integumentary system, which provides the body with overall protection. The skin is made of multiple layers of cells and tissues, which are held to underlying structures by connective tissue (Figure 5.1). The deeper layer of skin is well **vascularized**. It also has numerous sensory **autonomic**, and **sympathetic** nerve fibers ensuring communication to and from the brain.

The skin is composed of two main layers:

1. The **epidermis**
2. The **dermis**
    1. Beneath the dermis lies the **hypodermis**, also known as the subcutaneous layer.

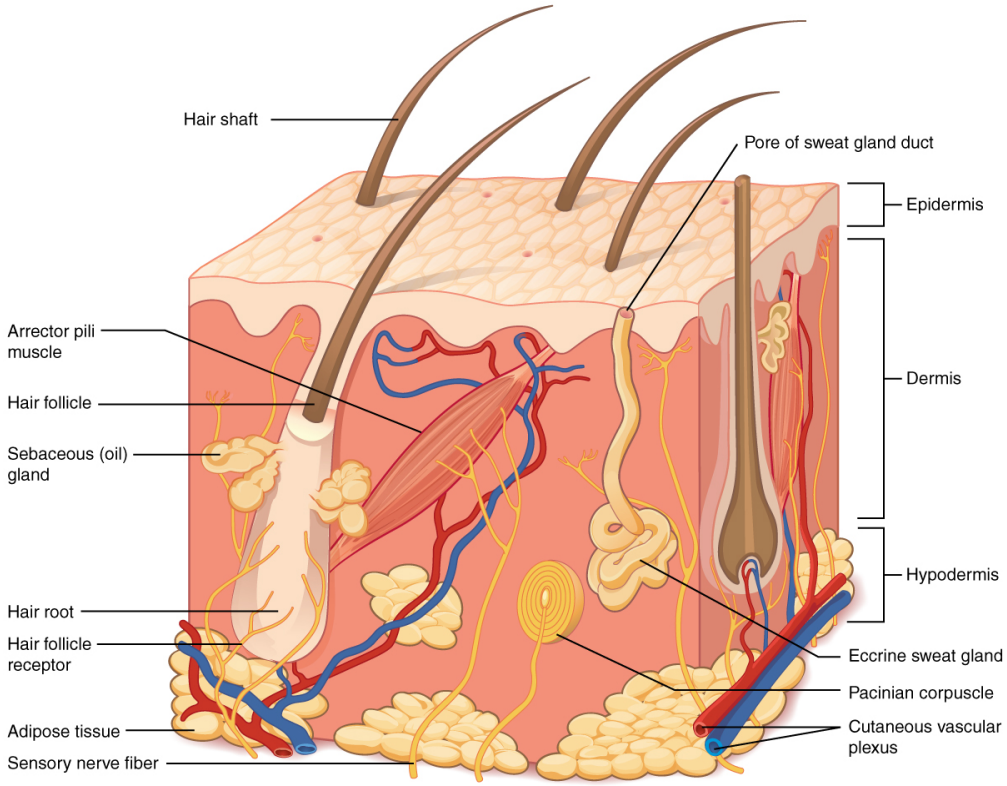

Figure 5.1 Layers of Skin. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Concept Check

- On the diagram above find the two layers of the skin: **epidermis** and **dermis**.
- The literal breakdown for **hypodermis** is "below the dermis." On the diagram above, where can you locate it?
- Can you find a **hair follicle**, **hair root**, and **hair shaft**?
- Keep reading to find out what the **arrector pili muscle** does when you are frightened.

Epidermis

The **epidermis** is composed of keratinized, stratified squamous epithelium. It is made of four or five layers of epithelial cells, depending on its location in the body. It is **avascular**.

- **Thin skin** has four layers of cells. From deep to superficial, these layers are the **stratum basale,** stratum spinosum, stratum granulosum, and stratum corneum. Most of the skin can be classified as thin skin.
- **Thick skin** is found only on the palms of the hands and the soles of the feet. It has a fifth layer, called the stratum lucidum, located between the stratum corneum and the stratum granulosum (see Figure 5.2).

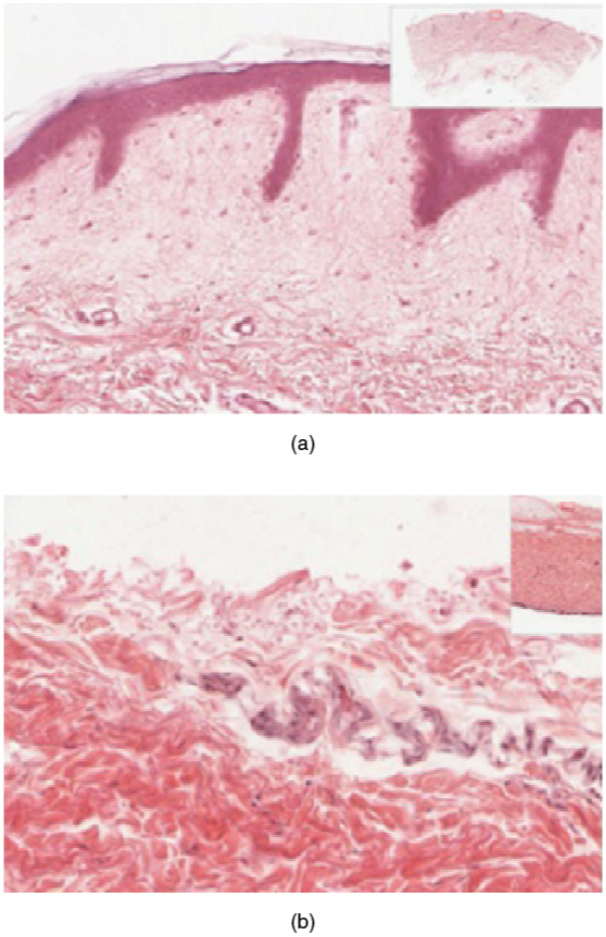

Figure 5.2 Thin Skin versus Thick Skin. These slides show cross-sections of the epidermis and dermis of (a) thin and (b) thick skin. Note the significant difference in the thickness of the epithelial layer of the thick skin. From the top, LM × 40, LM × 40. (Micrographs provided by the Regents of University of Michigan Medical School © 2012). From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

The cells in all of the layers except the stratum basale are called **keratinocytes**. **Keratin** is an intracellular fibrous protein that gives hair, nails, and skin their hardness and water-resistant properties. The keratinocytes in the stratum corneum are dead and regularly slough away, being replaced by cells from the deeper layers (see Figure 5.3).

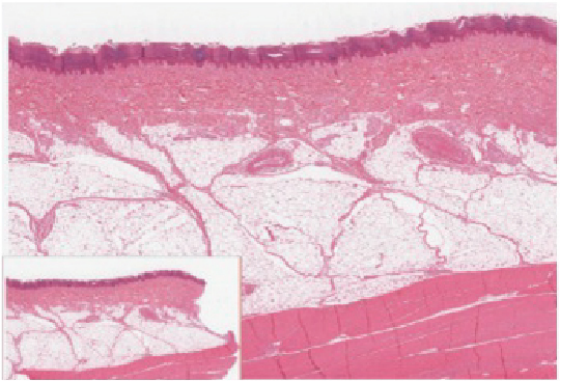

Figure 5.3 Epidermis. The epidermis is epithelium composed of multiple layers of cells. The basal layer consists of cuboidal cells, whereas the outer layers are squamous, keratinized cells, so the whole epithelium is often described as being keratinized stratified squamous epithelium. LM × 40. (Micrograph provided by the Regents of University of Michigan Medical School © 2012). From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Dermis

The dermis contains blood and lymph vessels, nerves, and other structures, such as hair follicles and sweat glands. The dermis is made of two layers (papillary layer and reticular layer) of connective tissue that compose an interconnected mesh of elastin and collagenous fibers, produced by fibroblasts (see Figure 5.4).

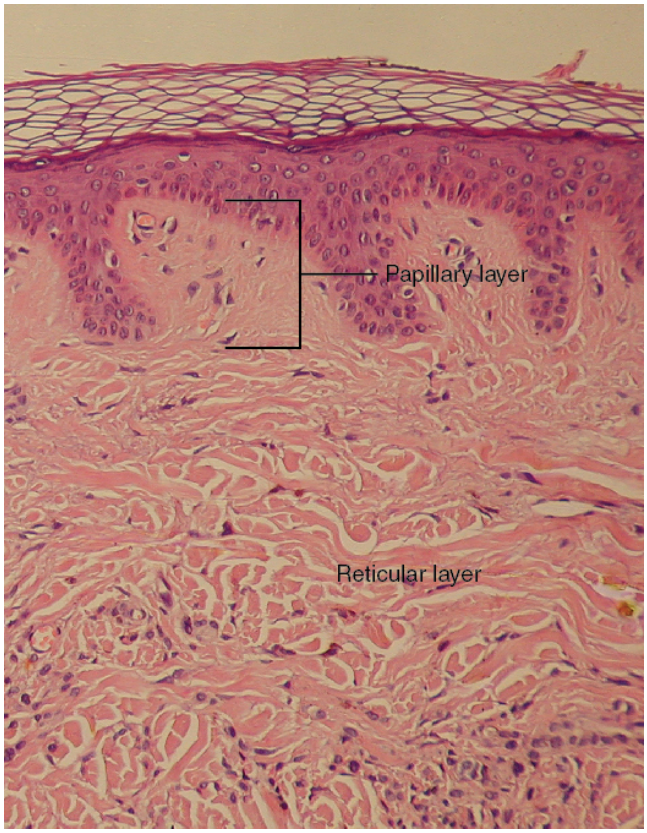

Figure 5.4 Layers of the Dermis. This stained slide shows the two components of the dermis—the papillary layer and the reticular layer. Both are made of connective tissue with fibers of collagen extending from one to the other, making the border between the two somewhat indistinct. The dermal papillae extending into the epidermis belong to the papillary layer, whereas the dense collagen fiber bundles below belong to the reticular layer. LM × 10. *(credit: modification of work by "kilbad"/Wikimedia Commons). From Betts et al., 2013. Licensed under* CC BY 4.0. *[Image description.]*

Papillary Layer

The papillary layer is made of loose, areolar connective tissue, which means the collagen and elastin fibers of this layer form a loose mesh. This superficial layer of the dermis projects into the stratum basale of the epidermis to form finger-like dermal papillae (see Figure 5.4). Within the papillary layer are fibroblasts, a small number of **adipocytes**, and an abundance of small blood vessels. In addition, the papillary layer contains **phagocytes** that help fight bacteria or other infections that have breached the skin. The layer also contains lymphatic capillaries, nerve fibers, and **Meissner corpuscles**.

Reticular Layer

Underlying the papillary layer is the much thicker reticular layer, composed of dense, irregular connective tissue. The layer is well **vascularized** and has a rich sensory and **sympathetic** nerve supply. The reticular layer appears **reticulated**

due to a tight meshwork of fibers. Elastin fibers provide some elasticity to the skin, enabling movement. Collagen fibers provide structure and tensile strength, with strands of collagen extending into both the papillary layer and the hypodermis. In addition, collagen binds water to keep the skin hydrated. Collagen injections and Retin-A creams help restore skin turgor by either introducing collagen externally or stimulating blood flow and repair of the dermis, respectively.

Hypodermis (Subcutaneous Layer)

The **hypodermis**, also known as the subcutaneous layer, serves to connect the skin to the underlying **fascia** of the bones and muscles. It is not strictly a part of the skin, although the border between the hypodermis and **dermis** can be difficult to distinguish. The hypodermis consists of well-vascularized, loose, areolar connective tissue and **adipose** tissue, which functions as a mode of fat storage and provides insulation and cushioning for the integument.

Practice Labeling the Layers of the Skin

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https://pressbooks.uwf.edu/medicalterminology/?p=55#h5p-9

Physiology (Function) of the Integumentary System

The skin and accessory structures perform a variety of essential functions, such as protecting the body from invasion by microorganisms, chemicals, and other environmental factors; preventing dehydration; acting as a sensory organ; modulating body temperature and electrolyte balance; and synthesizing vitamin D. The underlying hypodermis has important roles in storing fats, forming a “cushion” over underlying structures, and providing insulation from cold temperatures.

Protection

The skin protects the body from wind, water, and UV sunlight. It acts as a protective barrier against water loss and it also is the first line of defense against abrasive activity such as grit, microbes, or harmful chemicals. Sweat excreted

from sweat glands deters microbes from over-colonizing the skin surface by generating dermcidin, which has antibiotic properties.

Sensory Function

The skin acts as a sense organ because the epidermis, dermis, and hypodermis contain specialized sensory nerve structures that detect touch, surface temperature, and pain. These receptors are more concentrated on the tips of the fingers, which are most sensitive to touch, especially the **Meissner corpuscle**, which responds to light touch, and the **Pacinian corpuscle**, which responds to vibration. Merkel cells, seen scattered in the stratum basale, are also touch receptors. In addition to these specialized receptors, there are sensory nerves connected to each hair follicle, pain and temperature receptors scattered throughout the skin, and motor nerves innervate the arrector pili muscles and glands. This rich innervation helps us sense our environment and react accordingly,

Thermoregulation

The integumentary system helps regulate body temperature through its tight association with the **sympathetic nervous system**. The sympathetic nervous system is continuously monitoring body temperature and initiating appropriate motor responses.

- When the **body becomes warm** sweat glands, accessory structures to the skin, secrete water, salt, and other substances to cool the body.
    - Even when the body does not appear to be noticeably sweating, approximately 500 mL of sweat are secreted a day.
- If the **body becomes excessively warm** due to high temperatures, vigorous activity, or a combination of the two, sweat glands will be stimulated by the sympathetic nervous system to produce large amounts of sweat.
    - When the sweat evaporates from the skin surface, the body is cooled as body heat is dissipated.
    - In addition to sweating, arterioles in the dermis dilate so that excess heat carried by the blood can dissipate through the skin and into the surrounding environment (Figure 5.5).
    - This accounts for the skin redness that many people experience when exercising.
- When **body temperatures drop**, the arterioles constrict to minimize heat loss, particularly in the ends of the digits and tip of the nose.
    - This reduced circulation can result in the skin taking on a whitish hue.
    - Although the temperature of the skin drops as a result, passive heat loss is prevented, and internal organs and structures remain warm.
    - If the temperature of the skin drops too much (such as environmental temperatures below freezing), the conservation of body core heat can result in **frostbite**.

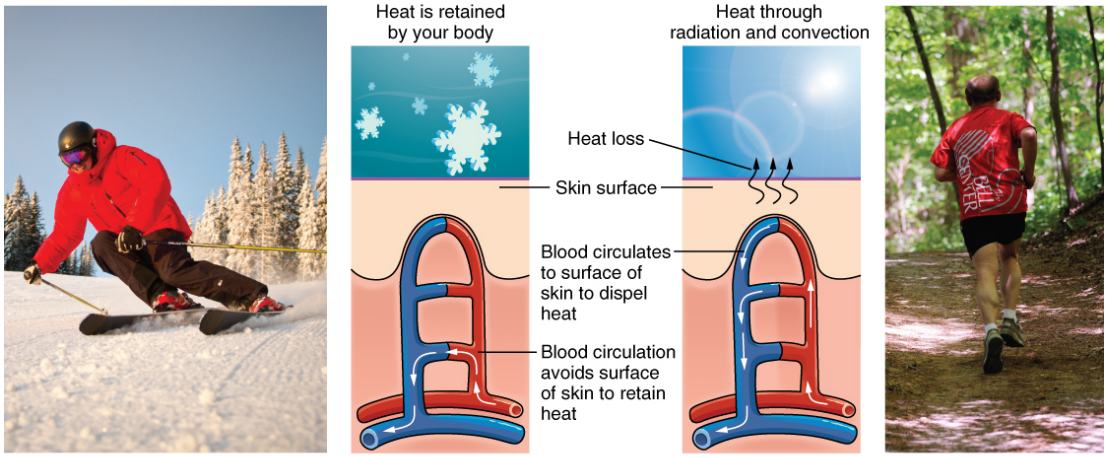

Figure 5.5 Thermoregulation. During strenuous physical activities, such as skiing (a) or running (c), the dermal blood vessels dilate and sweat secretion increases (b). These mechanisms prevent the body from overheating. In contrast, the dermal blood vessels constrict to minimize heat loss in response to low temperatures (b). (credit a: "Trysil"/Flickr; credit c: Ralph Daily). From Betts et al., 2013. Licensed under CC BY 4.0. *[Image description.]*

Concept Check

Can you describe the **thermoregulation** process between the integumentary system and the sympathetic system?

- What happens when the body temperature is too warm?
- What happens when the body temperature is too cold?

Vitamin D Synthesis

The epidermal layer of human skin synthesizes Vitamin D when exposed to UV radiation. In the presence of sunlight, a form of Vitamin D_3 called cholecalciferol is synthesized from a derivative of the steroid cholesterol in the skin. The liver converts cholecalciferol to calcidiol, which is then converted to calcitriol (the active chemical form of the vitamin) in the kidneys.

- Vitamin D is essential for the normal absorption of calcium and phosphorus, which are required for healthy bones.
- The absence of sun exposure can lead to a lack of vitamin D in the body. In children, this can cause **rickets**. Vitamin D deficiency in elderly individuals may lead to **osteomalacia**.

- In present-day society, Vitamin D is added as a supplement to many foods, including milk and orange juice, compensating for the need for sun exposure. In addition to its essential role in bone health, Vitamin D is essential for general immunity against bacterial, viral, and fungal infections.

Did you know?

Vitamin D is essential for general immunity against bacterial, viral, and fungal infections.

Watch this video:

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Media 5.2. The Integumentary System, Part 2 – Skin Deeper: Crash Course A&P #7 [Online video]. Copyright 2015 by CrashCourse.

Accessory Structures

Accessory structures of the skin include hair, nails, sweat glands, and sebaceous glands. These structures embryologically originate from the epidermis and can extend down through the dermis into the **hypodermis**.

Hair

Hair is a keratinous filament growing out of the **epidermis**. It is primarily made of dead, keratinized cells. Strands of hair originate in an epidermal penetration of the dermis called the hair follicle. The hair shaft is the part of the hair not anchored to the follicle, and much of this is exposed at the skin's surface. The rest of the hair, which is anchored in the follicle, lies below the surface of the skin and is referred to as the hair root. The hair root ends deep in the dermis at

the hair bulb and includes a layer of mitotically active basal cells called the hair matrix. The hair bulb surrounds the hair papilla, which is made of connective tissue and contains blood capillaries and nerve endings from the dermis (see Figure 5.6).

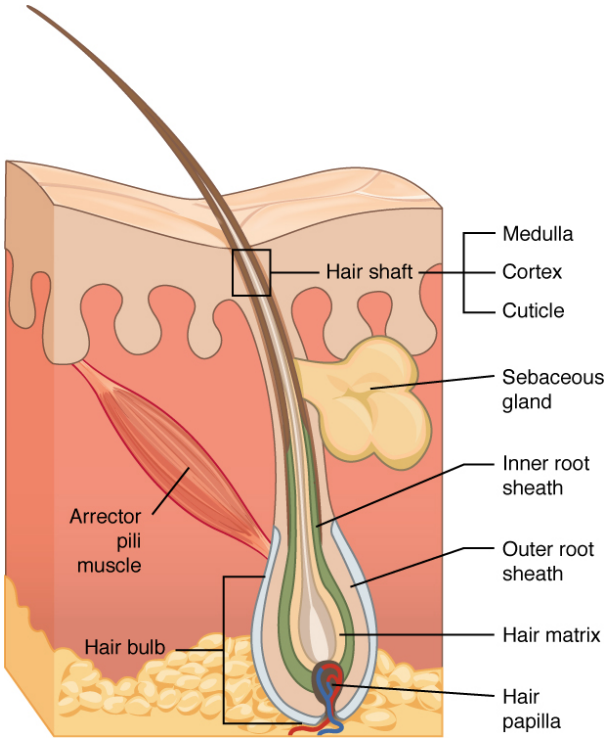

Figure 5.6 Hair. Hair follicles originate in the epidermis and have many different parts. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Hair Function

Hair serves a variety of functions, including protection, sensory input, thermoregulation, and communication. For example:

- Hair on the head **protects** the skull from the sun.
- Hair in the nose and ears, and around the eyes (eyelashes) **defends** the body by trapping and excluding dust particles that may contain allergens and microbes.
- Hair of the eyebrows **prevents** sweat and other particles from dripping into and bothering the eyes.

Hair also has a **sensory function** due to sensory innervation by a hair root plexus surrounding the base of each hair follicle. Hair is extremely sensitive to air movement or other disturbances in the environment, much more so than the skin surface. This feature is also useful for the **detection** of the presence of insects or other potentially damaging substances on the skin surface.

Each hair root is connected to a smooth muscle called the arrector pili that contracts in response to nerve signals from the sympathetic nervous system, making the external hair shaft "stand up." The primary purpose for this is to trap a layer of air to add insulation. This is visible in humans as goosebumps. Of course, this is much more obvious in organisms with a heavier coat than most humans, such as when a frightened cat raises its fur.

Did you know?

When frightened, the arrector pili muscle is responsible for your hair standing on end. The same is true when a cat's fur is raised.

Hair Growth, Loss, and Color

Hair grows and is eventually shed and replaced by new hair. Hair typically grows at the rate of 0.3 mm per day. On average, 50 hairs are lost and replaced per day. Hair loss occurs if there is more hair shed than what is replaced and can happen due to hormonal or dietary changes. Hair loss can also result from the aging process, or the influence of hormones. Similar to the skin, hair gets its color from the pigment melanin, produced by **melanocytes** in the hair papilla. Different hair color results from differences in the type of melanin. As a person ages, the melanin production decreases, and hair tends to lose its color and becomes gray and/or white.

Nails

The **nail bed** is a specialized structure of the epidermis that is found at the tips of our fingers and toes. The nail body is formed on the nail bed and protects the tips of our fingers and toes as they are the farthest extremities and the parts of the body that experience the maximum mechanical stress (see Figure 5.7). The nail body forms a back-support for picking up small objects with the fingers. The nail body is composed of densely packed dead **keratinocytes**.

The epidermis in this part of the body has evolved a specialized structure upon which nails can form. The nail body forms at the nail root, which has a matrix of proliferating cells from the stratum basale that enables the nail to grow continuously. The lateral nail fold overlaps the nail on the sides, helping to anchor the nail body. The nail fold that meets the proximal end of the nail body forms the nail cuticle, also called the eponychium.

The nail bed is rich in blood vessels, making it appear pink, except at the base where a thick layer of epithelium over the nail matrix forms a crescent-shaped region called the **lunula** (the "little moon"). The area beneath the free edge of the nail, furthest from the cuticle, is called the hyponychium. It consists of a thickened layer of stratum corneum.

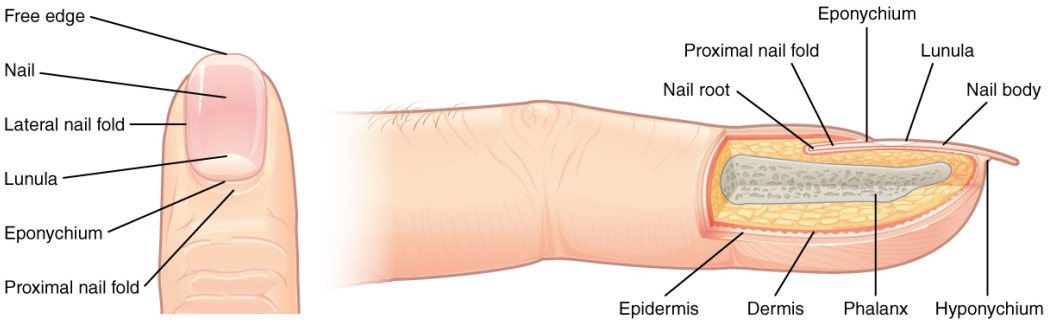

Figure 5.7 Nails. The nail is an accessory structure of the integumentary system. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Sweat Glands

Sudoriferous Glands

When the body becomes warm, sudoriferous glands produce sweat to cool the body. Sweat glands develop from epidermal projections into the dermis and are classified as merocrine glands; that is, the secretions are secreted by **exocytosis** through a duct without affecting the cells of the gland. There are two types of sweat glands, each secreting slightly different products.

An **eccrine sweat gland** is a type of gland that produces hypotonic sweat for thermoregulation as described previously. These glands are found all over the skin's surface but are especially abundant on the palms of the hand, the soles of the feet, and the forehead (Figure 5.8). They are coiled glands lying deep in the dermis, with the duct rising up to a pore on the skin surface where the sweat is released. This type of sweat, released by **exocytosis**, is hypotonic and composed mostly of water, with some salt, antibodies, traces of metabolic waste, and dermcidin, an antimicrobial peptide. **Eccrine glands** are a primary component of thermoregulation in humans and thus help to maintain **homeostasis**.

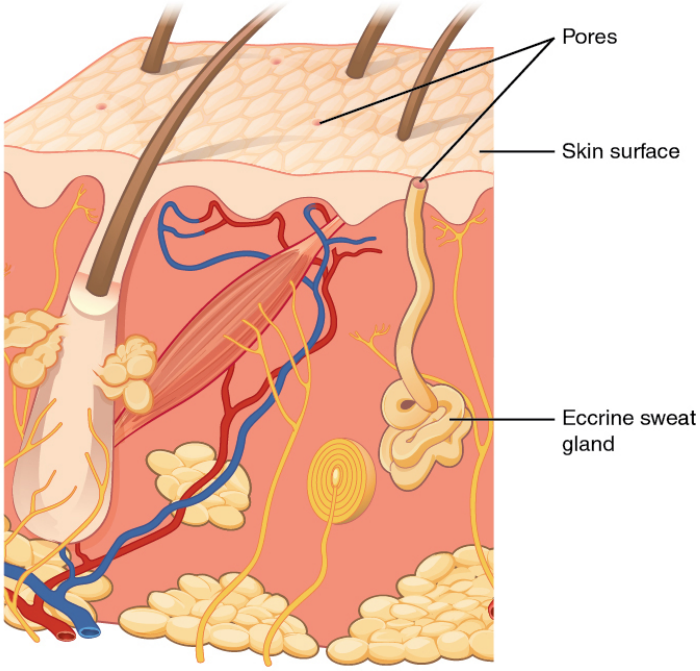

Figure 5.8 Eccrine Gland. Eccrine glands are coiled glands in the dermis that release sweat that is mostly water. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

An **apocrine sweat gland** is usually associated with hair follicles in densely hairy areas, such as armpits and genital regions. Apocrine sweat glands are larger than eccrine sweat glands and lie deeper in the dermis, sometimes even reaching the hypodermis, with the duct normally emptying into the hair follicle. In addition to water and salts, apocrine sweat includes organic compounds that make the sweat thicker and subject to bacterial decomposition and subsequent smell. The release of this sweat is under both nervous and hormonal control and plays a role in the poorly understood human pheromone response. Most commercial antiperspirants use an aluminum-based compound as their primary active ingredient to stop sweat. When the antiperspirant enters the sweat gland duct, the aluminum-based compounds precipitate due to a change in **pH** and form a physical block in the duct, which prevents sweat from coming out of the pore.

Sebaceous Glands

A **sebaceous gland** is a type of oil gland that is found all over the body and helps to lubricate and waterproof the skin and hair. Most sebaceous glands are associated with hair follicles. They generate and excrete sebum, a mixture of lipids, onto the skin surface, thereby naturally lubricating the dry and dead layer of keratinized cells of the stratum corneum, keeping it pliable. The fatty acids of sebum also have antibacterial properties and prevent water loss from the skin in low-humidity environments. The secretion of sebum is stimulated by hormones, many of which do not become active until puberty. Thus, sebaceous glands are relatively inactive during childhood.

Did you know?

Aluminum-based compounds due to a change in pH form a physical block in the sweat gland duct. This prevents sweating.

Practice Terms Related to the Integumentary System

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Common Abbreviations for the Integumentary System

Many terms and phrases related to the integumentary system are abbreviated. Learn these common abbreviations by expanding the list below.

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https://pressbooks.uwf.edu/medicalterminology/?p=55#h5p-11

Changes Due to Aging

All systems in the body accumulate subtle and some not-so-subtle changes as a person ages. Among these changes are reductions in cell division, metabolic activity, blood circulation, hormonal levels, and muscle strength (see Figure 5.9). In the skin, these changes are reflected in decreased mitosis in the stratum basale, leading to a thinner epidermis. The dermis, which is responsible for the elasticity and resilience of the skin, exhibits a reduced ability to regenerate, which leads to slower wound healing. The hypodermis, with its fat stores, loses structure due to the reduction and redistribution of fat, which in turn contributes to the thinning and sagging of skin.

Figure 5.9 Aging. Generally, skin, especially on the face and hands, starts to display the first noticeable signs of aging, as it loses its elasticity over time. (credit: Janet Ramsden). From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

The accessory structures also have lowered activity, generating thinner hair and nails, and reduced amounts of sebum and sweat. A reduced sweating ability can cause some elderly to be intolerant to extreme heat. Other cells in the skin, such as **melanocytes** and dendritic cells, also become less active, leading to a paler skin tone and lowered immunity. Wrinkling of the skin occurs due to the breakdown of its structure, which results from decreased collagen and elastin production in the dermis, weakening of muscles lying under the skin, and the inability of the skin to retain adequate moisture.

Did you know?

A reduced sweating ability can cause some older adults to be intolerant to extreme heat.

Diseases and Disorders of the Integumentary System

The integumentary system is susceptible to a variety of diseases, disorders, and injuries. These range from annoying but relatively benign bacterial or fungal infections that are categorized as disorders, to skin cancer and severe burns, which can be fatal. In this section, you will learn several of the most common skin conditions.

Most **cancers** are identified by the organ or tissue in which the cancer originates. In general, cancers result from an

accumulation of DNA mutations. These mutations can result in cell populations that do not die when they should and uncontrolled cell proliferation that leads to tumors. Although many tumors are **benign**, some **metastasize**. Cancers are characterized by their ability to metastasize. One common form of cancer is skin cancer.

Sun Damage

Melanin synthesis peaks about 10 days after initial sun exposure, which is why pale-skinned individuals tend to suffer sunburns of the epidermis initially. Dark-skinned individuals can also get sunburns but are more protected than are pale-skinned individuals. Too much sun exposure can eventually lead to wrinkling due to the destruction of the cellular structure of the skin, and in severe cases, can cause sufficient DNA damage to result in skin cancer. When there is an irregular accumulation of melanocytes in the skin, freckles appear. Moles are larger masses of melanocytes, and although most are benign, they should be monitored for changes that might indicate the presence of cancer (see Figure 5.10).

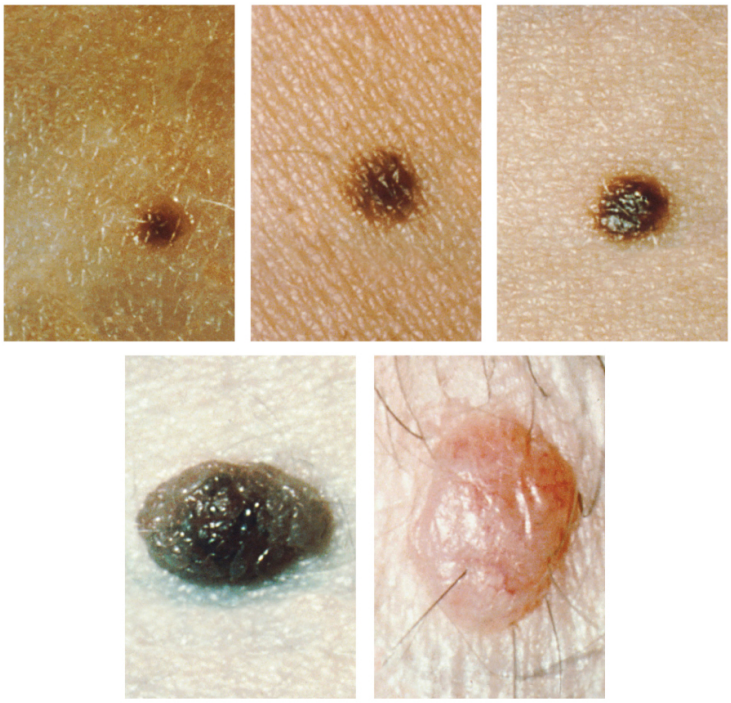

Figure 5.10 Moles. Moles range from benign accumulations of melanocytes to melanomas. These structures populate the landscape of our skin. (credit: the National Cancer Institute). From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Basal Cell Carcinoma (BCC)

Basal cell carcinoma is a form of cancer that affects the mitotically active stem cells in the stratum basale of the epidermis. It is the most common of all cancers that occur in the United States and is frequently found on the head, neck, arms, and back, which are the most susceptible to long-term sun exposure. Although UV rays are the main culprit, exposure to other agents, such as radiation and arsenic, can also lead to this type of cancer. Wounds on the skin due

to open sores, tattoos, burns, et cetera may be predisposing factors. Basal cell carcinomas start in the stratum basale and usually spread along this boundary. At some point, they begin to grow toward the surface and become an uneven patch, bump, growth, or scar on the skin surface (see Figure 5.11). Like most cancers, basal cell carcinomas respond best to treatment when caught early. Treatment options include surgery, freezing (cryosurgery), and topical ointments.

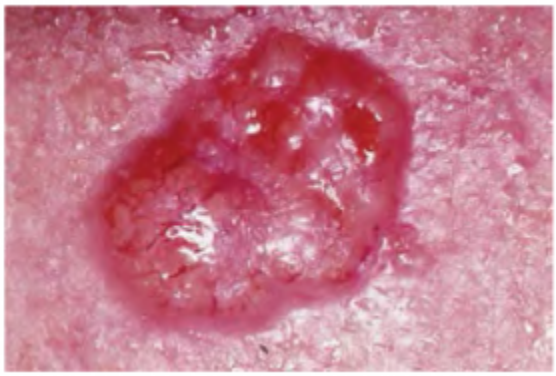

Figure 5.11 Basal Cell Carcinoma. Basal cell carcinoma can take several different forms. Similar to other forms of skin cancer, it is readily cured if caught early and treated. (credit: John Hendrix, MD). From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Squamous Cell Carcinoma (SCC)

Squamous cell carcinoma is cancer that affects the keratinocytes of the stratum spinosum and presents as lesions commonly found on the scalp, ears, and hands (see Figure 5.12). It is the second most common skin cancer. The American Cancer Society reports that two of 10 skin cancers are squamous cell carcinomas, and it is more aggressive than basal cell carcinoma. If not removed, these carcinomas can **metastasize**. Surgery and radiation are used to cure squamous cell carcinoma.

Figure 5.12 Squamous Cell Carcinoma Squamous cell carcinoma presents here as a lesion on a nose. (credit: the National Cancer Institute). From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Melanoma

Melanoma is cancer characterized by the uncontrolled growth of melanocytes, the pigment-producing cells in the epidermis. Typically, a melanoma develops from a mole. It is the most fatal of all skin cancers, as it is highly metastatic and can be difficult to detect before it has spread to other organs. Melanomas usually appear as asymmetrical brown and black patches with uneven borders and a raised surface (see Figure 5.13). Treatment typically involves surgical excision and immunotherapy.

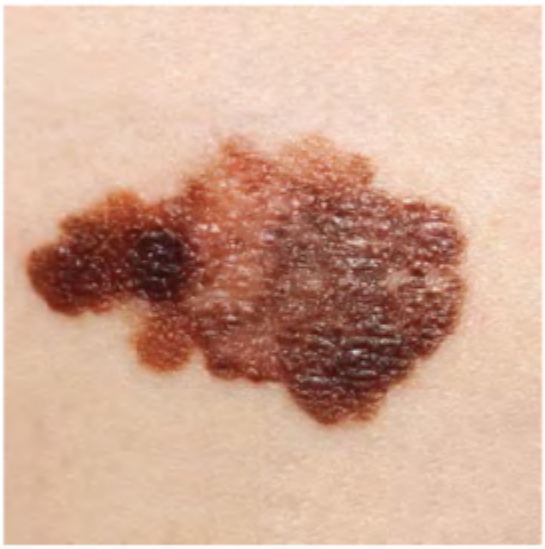

Figure 5.13 Melanoma. Melanomas typically present as large brown or black patches with uneven borders and a raised surface. (credit: the National Cancer Institute). From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

ABCDE for Early Diagnosis

Doctors often give their patients the following ABCDE mnemonic to help with the diagnosis of early-stage melanoma. If you observe a mole on your body displaying these signs, consult a doctor:

- **A**symmetry: the two sides are not symmetrical
- **B**orders: the edges are irregular in shape
- **C**olor: the color is varied shades of brown or black
- **D**iameter: it is larger than 6 mm (0.24 in)
- **E**volving: its shape has changed

Some specialists cite the following additional signs for the most serious form, nodular melanoma:

- Elevated: it is raised on the skin surface
- Firm: it feels hard to the touch
- Growing: it is getting larger

Albinism

Albinism is a genetic disorder that affects (completely or partially) the coloring of skin, hair, and eyes. This is primarily due to the inability of melanocytes to produce melanin. Individuals with albinism tend to appear white or very pale due to the lack of melanin in their skin and hair. Recall that melanin helps protect the skin from the harmful effects of UV radiation. Individuals with albinism tend to need more protection from UV radiation, as they are more prone to sunburns and skin cancer. They also tend to be more sensitive to light and have vision problems due to the lack of pigmentation on the retinal wall.

Treatment of this disorder usually involves addressing the symptoms, such as limiting UV light exposure to the skin and eyes. In **vitiligo**, the melanocytes in certain areas lose their ability to produce melanin, possibly due to an autoimmune reaction. This leads to a loss of color in patches (see Figure 5.14). Neither albinism nor vitiligo directly affects the lifespan of an individual.

Figure 5.14 Vitiligo. Individuals with vitiligo experience depigmentation that results in lighter colored patches of skin. The condition is especially noticeable on darker skin. (credit: Klaus D. Peter). From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Changes in Skin Coloration

Other changes in the appearance of skin coloration can be indicative of diseases associated with other body systems.

- Liver disease or liver cancer can cause the accumulation of bile and the yellow pigment bilirubin, leading to the skin appearing **yellow** or **jaundiced**.
- Tumors of the pituitary gland can result in the secretion of large amounts of melanocyte-stimulating hormone (MSH), which results in a **darkening** of the skin.
- Addison's disease can stimulate the release of excess amounts of adrenocorticotropic hormone (ACTH), which can give the skin a **deep bronze** color

- A sudden drop in oxygenation can affect skin color, causing the skin to initially turn **ashen** (white).
- After a prolonged reduction in oxygen levels, dark red deoxyhemoglobin becomes dominant in the blood, making the skin appear **blue**, a condition referred to as **cyanosis**. This happens when the oxygen supply is restricted, as when someone is experiencing difficulty in breathing because of asthma or a heart attack. However, in these cases, the effect on skin color has nothing to do with the skin's pigmentation.

Skin Disorders

Two common skin disorders are **eczema** and **acne**. Eczema is an inflammatory condition and occurs in individuals of all ages. Acne involves the clogging of pores, which can lead to infection and inflammation and is often seen in adolescents. Other disorders include seborrheic dermatitis (on the scalp), psoriasis, fungal infections, cold sores, impetigo, scabies, hives, and warts.

Eczema

Eczema is an allergic reaction that manifests as dry, itchy patches of skin that resemble rashes (see Figure 5.15). It may be accompanied by swelling of the skin, flaking, and in severe cases, bleeding. Symptoms are usually managed with moisturizers, corticosteroid creams, and immunosuppressants.

Figure 5.15 Eczema. Eczema is a common skin disorder that presents as a red, flaky rash. (credit: "Jambula"/Wikimedia Commons). From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Acne

Acne is a skin disturbance that typically occurs on areas of the skin that are rich in sebaceous glands (face and back). It is most common along with the onset of puberty due to associated hormonal changes, but can also occur in infants and continue into adulthood. Hormones, such as androgens, stimulate the release of sebum. Overproduction and accumulation of sebum along with keratin can block hair follicles. This plug is initially white. The sebum, when oxidized by exposure to air, turns black. Acne results from infection by acne-causing bacteria (*Propionibacterium* and

Staphylococcus), which can lead to redness and potential scarring due to the natural wound healing process (see Figure 5.16).

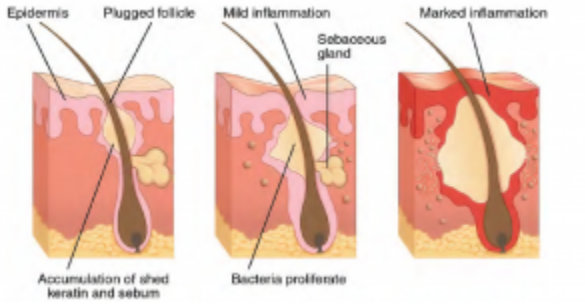

Figure 5.16. Acne. Acne is a result of over-productive sebaceous glands, which leads to the formation of blackheads and inflammation of the skin. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Ringworm

Tinea or dermatophytosis is often referred to as ringworm. Ringworm presents as a circular rash that is itchy and red and can be found on various parts of the body. It is referred to by the location that it is found:

- Tinea pedis – feet (commonly referred to as athlete's feet)
- Tinea capitis – scalp
- Tinea barbae – beard
- Tinea manuum – hands
- Tinea unguium – toenails and fingernails (also called onychomycosis)
- Tinea corporis – body parts such as arms and legs (Center for Disease Control and Prevention, n.d.-a)

To learn more about ringworm, visit the Center for Disease Control and Prevention's web page on fungal infections.

Psoriasis

Psoriasis is a chronic autoimmune disorder that results in patches of thick red skin with the appearance of silvery scales. These patches can be found on elbows, knees, scalp, low back, face, feet, fingernails, toenails, and even the mouth. Psoriasis can be confused with other skin diseases, so a dermatologist is the best physician to diagnose psoriasis. Treatments may include creams, ointments, ultraviolet light therapy, and medication (Center for Disease Control and Prevention, n.d.-b). To learn more, visit the Center for Disease Control and Prevention's web page on psoriasis.

Injuries

Because the skin is the part of our bodies that meets the world most directly, it is especially vulnerable to injury. Injuries include **burns, wounds**, **scars,** and **calluses**. They can be caused by sharp objects, heat, or excessive pressure or friction to the skin.

Skin injuries set off a healing process that occurs in several overlapping stages.

- The first step to repairing damaged skin is the **formation of a blood clot** that helps stop the flow of blood and scabs over time. Many different types of cells are involved in wound repair, especially if the surface area that needs repair is extensive.
- Before the basal stem cells of the stratum basale can recreate the epidermis, fibroblasts mobilize and divide rapidly to **repair the damaged tissue** by collagen deposition, forming granulation tissue.
- Blood capillaries follow the fibroblasts and help **increase blood circulation and oxygen** supply to the area.
- Immune cells, such as macrophages, roam the area and **engulf any foreign matter** to reduce the chance of infection.

Burns

A burn results when the skin is damaged by intense heat, radiation, electricity, or chemicals. The damage results in the death of skin cells, which can lead to a massive loss of fluid. Dehydration, electrolyte imbalance, and renal and circulatory failure follow, which can be fatal. Burn patients are treated with **intravenous** fluids to offset **dehydration**, as well as intravenous nutrients that enable the body to repair tissues and replace lost proteins. Another serious threat to the lives of burn patients is **infection**. Burned skin is extremely susceptible to bacteria and other **pathogens** due to the loss of protection by intact layers of skin.

Burn Classification

Burns are sometimes measured in terms of the size of the total surface area affected. This is referred to as the *rule of nines*, which associates specific anatomical areas with a percentage that is a factor of nine (see Figure 5.17).

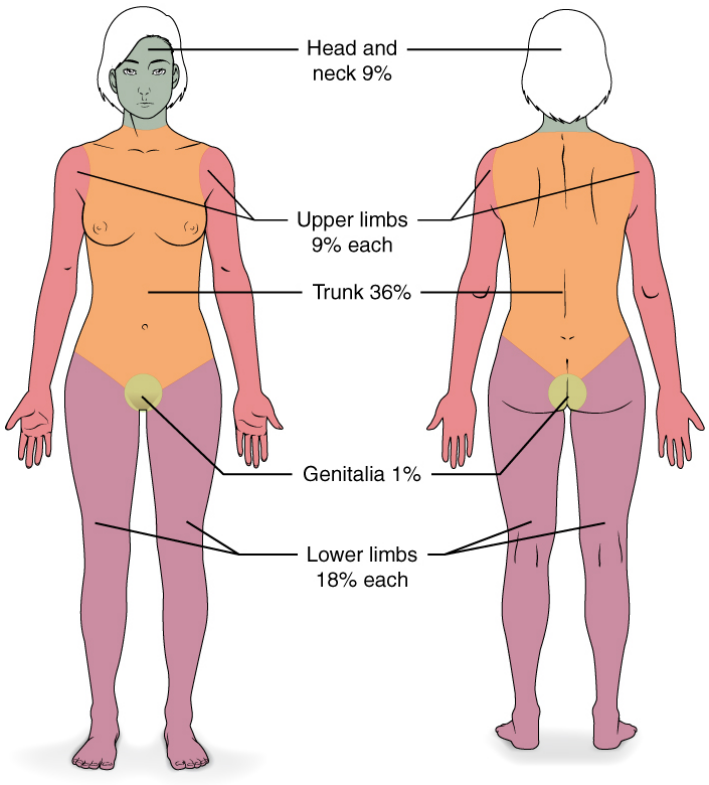

Figure 5.17 Calculating the Size of a Burn. The size of a burn will guide decisions made about the need for specialized treatment. Specific parts of the body are associated with a percentage of body area. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Burns are also classified by the degree of their severity:

- A **first-degree** burn is a superficial burn that affects only the epidermis. Although the skin may be painful and swollen, these burns typically heal on their own within a few days. Mild sunburn fits into the category of a first-degree burn.
- A **second-degree** burn goes deeper and affects both the epidermis and a portion of the dermis. These burns result in swelling and a painful blistering of the skin. It is important to keep the burn site clean and sterile to prevent infection. If this is done, the burn will heal within several weeks.
- A **third-degree** burn fully extends into the epidermis and dermis, destroying the tissue and affecting the nerve endings and sensory function. These are serious burns that may appear white, red, or black; they require medical attention and will heal slowly without it.
- A **fourth-degree** burn is even more severe, affecting the underlying muscle and bone.

Oddly, third and fourth-degree burns are usually not as painful because the nerve endings themselves are damaged. Full-thickness burns cannot be repaired by the body, because the local tissues used for repair are damaged and require **debridement**, or amputation in severe cases, followed by grafting of the skin from an unaffected part of the body, or from skin grown in tissue culture for grafting purposes. Skin grafts are required when the damage from trauma or infection cannot be closed with sutures or staples.

Scars and Keloids

Most cuts or wounds, with the exception of ones that only scratch the epidermis, lead to **scar** formation. Scarring occurs in cases in which there is repair of skin damage, but the skin fails to regenerate the original skin structure. Fibroblasts generate scar tissue in the form of collagen, and the bulk of repair is due to the basket-weave pattern generated by collagen fibers and does not result in regeneration of the typical cellular structure of skin. Instead, the tissue is fibrous in nature and does not allow for the regeneration of accessory structures, such as hair follicles, sweat glands, or sebaceous glands.

Sometimes, there is an overproduction of scar tissue, because the process of collagen formation does not stop when the wound is healed; this results in a **keloid**. In contrast, scars that result from acne and chickenpox have a sunken appearance and are called atrophic scars.

Scarring of skin after wound healing is a natural process and does not need to be treated further. Application of mineral oil and lotions may reduce the formation of scar tissue. However, modern cosmetic procedures, such as dermabrasion, laser treatments, and filler injections have been invented as remedies for severe scarring. All of these procedures try to reorganize the structure of the epidermis and underlying collagen tissue to make it look more natural.

Bedsores and Stretch Marks

Skin and its underlying tissue can be affected by excessive pressure. One example of this is called a bedsore. Bedsores, also called **decubitus ulcers**, are caused by constant, long-term, unrelieved pressure on certain body parts that are bony, reducing blood flow to the area and leading to **necrosis**. Bedsores are most common in elderly patients who have debilitating conditions that cause them to be immobile. Most hospitals and long-term care facilities have the practice of turning the patients every few hours to prevent the incidence of bedsores. If left untreated, bedsores can be fatal if they become infected.

The skin can also be affected by pressure associated with rapid growth. A stretch mark results when the dermis is stretched beyond its limits of elasticity, as the skin stretches to accommodate the excess pressure. Stretch marks usually accompany rapid weight gain during puberty and pregnancy. They initially have a reddish hue but lighten over time. Other than for cosmetic reasons, treatment of stretch marks is not required. They occur most commonly over the hips and abdomen.

Calluses

When you wear shoes that do not fit well and are a constant source of abrasion on your toes, you tend to form a callus at the point of contact. This occurs because the basal stem cells in the stratum basale are triggered to divide more often to increase the thickness of the skin at the point of abrasion to protect the rest of the body from further damage. This is an example of a minor or local injury, and the skin manages to react and treat the problem independently of the rest of the body. Calluses can also form on your fingers if they are subject to constant mechanical stress, such as long periods of writing, playing string instruments, or video games. A corn is a specialized form of callus. Corns form from abrasions on the skin that result from an elliptical-type motion.

Medical Terms in Context

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Medical Specialties and Procedures Related to the Integumentary System

A dermatologist is a medical doctor with specialized training in treating diseases, disorders, and injuries related to the integumentary system and its accessory structures. There are many dermatologic subspecialties, such as cosmetic dermatology, dermatopathology, and pediatric dermatology. To learn more, visit the American Academy of Dermatology Association's webpage on dermatology as a career.

Dermatologists can be specially trained to perform a procedure called Mohs surgery. Mohs surgery excises skin cancers in thin layers until all cancer is removed from the tissue (Prickett & Ramsey, 2021).

Integumentary System Vocabulary

Abscess
An enclosed collection of pus in tissues, organs, or confined spaces in the body.
Adipocyte
Fat cell.
Adipose tissue
Fat tissue.
Autonomic
Involuntary or unconscious.
Avascular
Without blood vessels.
Bacteria
Single-cell microorganisms that reproduce by cell division and may cause infection by invading body tissue.
Benign
Non-cancerous.
Biopsy
The removal of cells or tissues for examination by a pathologist.
Cancer
Abnormal cells in the body that divide uncontrollably.

Cauterize

To destroy tissue using a hot or cold instrument, an electrical current, or a chemical that burns or dissolves the tissue to kill tumors or stop bleeding.

Cellulitis

An infection of the skin and subcutaneous tissue, characterized by tenderness, fever, and blisters.

Contusion

Injury resulting in a bruise.

Cyanosis

A condition in which the oxygen supply is restricted, causing the skin to look blue.

Cyst

Closed sac containing fluid or semisolid material.

Debridement

Excision of damaged tissues and cell debris from a wound or burn to prevent infection and promote healing.

Dehydration

A net loss of water that results in insufficient water in blood and other tissues.

Dermabrasion

A procedure to remove superficial scars using sandpaper or revolving wire brushes.

Dermatitis

Inflammation of the skin.

Dermatofibroma

Fibrous tumor of the skin.

Dermatologist

Medical doctor who specializes in diagnosing and treating skin disorders.

Dermatology

Study of disorders of the skin.

Dermis

The layer of skin that is made of dense, irregular connective tissue that houses blood vessels, hair follicles, sweat glands, and other structures.

Diaphoresis

Sweating.

Eczema

Non-infectious, inflammatory disease presenting as redness, blisters, scabs, and itching.

Edema

Swelling due to excessive liquid in the tissues.

Epidermis

The outer, protective layer of the skin.

Excisional skin surgery

A surgical procedure used to remove moles, cysts, skin cancer, and other skin growths using local anesthesia.

Exocytosis

A form of active transport in which a cell exports material using vesicular transport.

Fascia

Fibrous tissue.

Frostbite

A condition in which conservation of the body core heat results in the skin freezing.

Gangrene

Death of tissue due to blood supply loss.

Hidradenitis

Inflammation of a sweat gland.

Hypodermis

Also known as the subcutaneous layer; the layer of the skin below the dermis that is composed mainly of loose connective and fatty tissues.

Incision

A cut made in the body to perform surgery.

Infection

The invasion and growth of bacteria, viruses, yeast, fungi, or other microorganisms in the body.

Intradermal

Within the skin.

Intravenous

Into or within the vein.

Jaundiced

Yellow-colored.

Keloid

A raised or hypertrophic scar.

Keratinocytes

Cells that manufacture and store the protein keratin.

Keratosis

Any growth of horny tissue.

Laceration

Torn, ragged-edged wound.

Lesion

An area of abnormal tissue.

Meissner corpuscle

A specialized sensory nerve structure that responds to light touch.

Melanocyte

A cell that produces the pigment melanin.

Metastasis

The process in which cancer spreads from one part of the body to another.

Necrosis

Accidental cell death.

Nevus

A benign growth on the skin that is formed by a cluster of melanocytes.

Nodule

A growth or lump that may be malignant or benign.

Onychocryptosis

An ingrown nail.

Onychomycosis

A fungal infection of the nail.

Onychophagia

Nail-biting.

Osteomalacia

A softening of adult bones due to Vitamin D deficiency.

Pacinian corpuscle

A specialized sensory nerve structure that responds to vibration.

Pallor

Unnatural paleness of the skin.

Paronychia

Infection of the skin around the nail.

Pathogen

An organism that causes a disease.

Percutaneous

Passing through the skin, as an injection or a topical medicine.

Phagocytes

Cells that engulf and absorb bacteria and cell particles.

Pruritus

Itching.

Reticulated

Net like.

Rhytidoplasty

Excision of wrinkles of the skin.

Rickets

A painful condition in children where bones are misshapen due to a lack of calcium, causing bow-leggedness.

Scar

A collagen-rich skin formed after the process of wound healing that differs from normal skin.

Staphylococcus aureus

A bacteria that is commonly found in minor skin infections, as well as in the nose of some healthy people.

Stratum basale

The deepest layer of the epidermis.

Streptococcus

The bacteria that causes strep throat.

Subcutaneous

Beneath the skin.

Sympathetic nervous system

The division of the nervous system involved in our fight-or-flight responses. It continuously monitors body temperature and initiates appropriate motor responses.

Tinea

A group of fungal skin diseases of the hair, skin, and nail tissues.

Transdermal

Absorbed through the unbroken skin.

Vascularized

Tissue that has numerous blood vessels.

Virus

A simple microorganism that may cause infection by invading body tissue.

Test Yourself

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https://pressbooks.uwf.edu/medicalterminology/?p=55#h5p-14

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Image Descriptions

Figure 5.1 image description: This illustration shows a cross-section of skin tissue. The outermost layer is called the epidermis and occupies one-fifth of the cross-section. Several hairs are emerging from the surface. The epidermis dives around one of the hairs, forming a follicle. The middle layer is called the dermis, which occupies four-fifths of the cross-section. The dermis contains an arrector pili muscle connected to one of the follicles. The dermis also contains an eccrine sweat gland, composed of a bunch of tubules. One tubule travels up from the bunch, through the epidermis, opening onto the surface of a pore. There are two string-like nerves traveling vertically through the dermis. The right nerve is attached to a Pacinian corpuscle, which is a yellow structure consisting of concentric ovals similar to an onion. The lowest level of the skin, the hypodermis, contains fatty tissue, arteries, and veins. Blood vessels travel from the hypodermis and connect to hair follicles and arrector pili muscle in the dermis. [Return to Figure 5.1].

Figure 5.2 image description: Part A is a micrograph showing a cross-section of thin skin. The topmost layer is a thin, translucent layer with irregular texture and areas where cells are sloughing off. The deepest layer is dark purple and extends into the third layer with finger-like projections. The third light purple layer contains thin bands of fibers and small, dark cells. The fourth, and deepest layer, is darker than the third layer but is still light purple. It contains thick fiber bands that are loosely packed. Part B is a magnified view of the epidermis of thick skin. It shows the topmost layer is five times thicker than the topmost layer of thin skin. The topmost layer of thick skin is also denser and less translucent than the topmost layer of thin skin. [Return to Figure 5.2].

Figure 5.3 image description: The outer layer of cells in this micrograph is the thinnest layer and stained deep purple due to the full keratinization of dead cells. The next layer occupies one-quarter of the micrograph, is lightly stained, and is a dense collection of cells. The third layer from the top is mostly white, with lightly stained, loosely-packed strands radiating in random directions. The bottom-most layer is densely-packed, with thick bands of highly organized muscle tissue that are darkly stained. [Return to Figure 5.3].

Figure 5.4 image description: This micrograph shows layers of skin in a cross-section. The papillary layer of the dermis extends between the downward fingers of the darkly stained epidermis. The papillary layer appears finer than the reticular layer, consisting of smaller, densely-packed fibers. The reticular layer is three times thicker than the papillary layer and contains larger, thicker fibers. The fibers seem more loosely packed than those of the papillary layer, with some separated by empty spaces. Both layers of the dermis contain cells with darkly stained nuclei. [Return to Figure 5.4].

Figure 5.5 image description: Part A is a photo of a man skiing with several snow-covered trees in the background. Part B is a diagram with a right and left half. The left half is titled " Heat is retained by the body," while the right half is titled "Heat loss through radiation and convection." Both show blood flowing from an artery through three capillary

beds within the skin. The beds are arranged vertically, with the topmost bed located along the boundary of the dermis and epidermis. The bottommost bed is located deep in the hypodermis. The middle bed is evenly spaced between the topmost and bottommost beds. In each bed, oxygenated blood (red) enters the bed on the left and deoxygenated blood (blue) leaves the bed on the right. The left diagram shows a picture of snowflakes above the capillary beds, indicating that the weather is cold. Blood is only flowing through the deepest of the three capillary beds, as the upper beds are closed off to reduce heat loss from the outer layers of the skin. The right diagram shows a picture of the sun above the capillary beds, indicating that the weather is hot. Blood is flowing through all three capillary beds, allowing heat to radiate out of the blood, increasing heat loss. Part C is a photo of a man running through a forested trail on a summer day. [Return to Figure 5.5].

Figure 5.6 image description: A cross-section of the skin containing a hair follicle. The follicle is teardrop-shaped. Its enlarged base, labeled the hair bulb, is embedded in the hypodermis. The outermost layer of the follicle is the epidermis, which invaginates from the skin surface to envelop the follicle. Within the epidermis is the outer root sheath, which is only present on the hair bulb. It does not extend up the shaft of the hair. Within the outer root sheath is the inner root sheath. The inner root sheath extends about half of the way up the hair shaft, ending midway through the dermis. The hair matrix is the innermost layer. The hair matrix surrounds the bottom of the hair shaft where it is embedded within the hair bulb. The hair shaft, in itself, contains three layers: the outermost cuticle, a middle layer called the cortex, and an innermost layer called the medulla. [Return to Figure 5.6].

Figure 5.7 image description: The anatomy of the fingernail region. The top image shows a dorsal view of a finger. The proximal nail fold is the part underneath where the skin of the finger connects with the edge of the nail. The eponychium is a thin, pink layer between the white proximal edge of the nail (the lunula), and the edge of the finger skin. The lunula appears as a crescent-shaped white area at the proximal edge of the pink-shaded nail. The lateral nail folds are where the sides of the nail contact the finger skin. The distal edge of the nail is white and is called the free edge. An arrow indicates that the nail grows distally out from the proximal nail fold. The lower image shows a lateral view of the nail bed anatomy. In this view, one can see how the edge of the nail is located just proximal to the nail fold. This end of the nail, from which the nail grows, is called the nail root. [Return to Figure 5.7].

Figure 5.8 image description: An illustration of an eccrine sweat gland embedded in a cross-section of skin tissue. The eccrine sweat gland is a bundle of white tubes embedded in the dermis. A single white tube travels up from the bundle and opens onto the surface of the epidermis. The opening is called a pore. There are several pores on the small block of skin portrayed in this diagram. [Return to Figure 5.8].

Figure 5.9 image description: This figure consists of two photos. One photo shows a young woman on the phone. Her skin is smooth and unwrinkled. The other photo shows an elderly woman in the same posture while on the phone. The skin of her hands and forearms is wrinkled. [Return to Figure 5.9].

Figure 5.10 image description: Five photos of moles. The three upper photos show moles that are small, flat, and dark brown. The bottom left photo shows a dark black mole that is raised above the skin. The bottom right photo shows a large, raised, reddish mole with protruding hairs. [Return to Figure 5.10].

Figure 5.11 image description: This photo shows an enlarged view of a basal cell carcinoma, a large, pink, irregular bump on the skin. The carcinoma is marked with irregular, dark-red stripes that resemble tiny blood vessels. The surrounding skin is the same pink color as the carcinoma, but without the red striping or raised appearance. [Return to Figure 5.11].

Figure 5.12 image description: This photo shows a man's nose. The squamous cell carcinoma is located just above the tip of the nose and appears as a deep red, irregularly-shaped sore that spans almost the entire bridge of his nose. [Return to Figure 5.12].

Figure 5.13 image description: This photo shows a patch of fair skin containing a large melanoma. The melanoma is dark brown and splotchy in appearance. [Return to Figure 5.13].

Figure 5.14 image description: This photo shows the back of a man's neck. There is a large, discolored patch of skin at the base of his hairline. The discolored area extends over the ears onto the cheeks, toward the front of the face. The man's head and facial hair are mostly gray, but white patches of hair are seen above the discolored skin. [Return to Figure 5.14].

Figure 5.15 image description: This photo shows a person with eczema on the ventral skin of the forearms. The person is white, but their light skin is mottled with many red marks, giving it the appearance of a rash. In some areas, the skin is breaking and peeling. [Return to Figure 5.15].

Figure 5.16 image description: Three diagrams show the progression of acne in three steps from left to right. All three depict a cross-section of skin containing a hair follicle. In the left diagram, the follicle has a swollen area about halfway up the hair shaft, just above a sebaceous gland. The follicle is plugged with sebum, depicted as a yellowish substance. In the middle diagram, the follicle has become more swollen, as a label indicates that bacteria are reproducing within the blockage. The surrounding epidermis becomes inflamed as a result of the bacterial infection. In the rightmost image, the blockage has swollen to about five times its original size and has broken the surrounding epidermis, which is now red and inflamed. [Return to Figure 5.16].

Figure 5.17 image description: This diagram depicts the percentage of the total body area burned when a victim suffers complete burns to regions of the body. Complete burning of the face, head, and neck account for 19% of the total body area. Burning of the chest, abdomen, and entire back above the waist accounts for 36% of the total body area. Anterior and posterior surfaces of the arms and hands account for 18% of the total body area (9% for each arm). The anterior and posterior surface of both legs, along with the buttocks, accounts for 36% of the total body area (18% for each leg). Finally, the anterior and posterior surfaces of the genitalia account for 1% of the total body area. [Return to Figure 5.17].

6. Skeletal System

Learning Objectives

- Examine the anatomy of the skeletal system
- Determine the main functions of the skeletal system
- Differentiate the medical terms of the skeletal system
- Discover common diseases, disorders, and procedures related to the skeletal system
- Recognize common medical specialties associated with the skeletal system

Skeletal System Word Parts

Click on prefixes, combining forms, and suffixes to reveal a list of word parts to memorize for the Skeletal System.

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://pressbooks.uwf.edu/medicalterminology/?p=153#h5p-86

Introduction to the Skeletal System

The **skeletal system** forms the framework of the body. It is the body system composed of bones, cartilage, and ligaments. Each bone serves a particular function and varies in size, shape, and strength. Bones are weight-bearing structures in your body and can therefore change in thickness as you gain or lose weight. The skeletal system performs the following critical functions for the human body:

- supports the body
- facilitates movement
- protects internal organs
- produces blood cells
- stores and releases minerals and fat

Watch this video:

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Media 6.1. The Skeletal System: Crash Course A&P #19 [Online video]. Copyright 2015 by CrashCourse.

Practice Medical Terms Related to the Skeletal System

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://pressbooks.uwf.edu/medicalterminology/?p=153#h5p-87

Anatomy (Structures) of the Skeletal System

The skeletal system includes all of the bones, cartilages, and ligaments of the body that support and give shape to the body and body structures. The **skeleton** consists of the bones of the body. For adults, there are 206 bones in the skeleton. Younger individuals have higher numbers of bones because some bones fuse together during childhood and adolescence to form an adult bone. The primary functions of the skeleton are to provide a rigid, internal structure that can support the weight of the body against the force of gravity, and to provide a structure upon which muscles can act to produce movements of the body.

In addition to providing for support and movements of the body, the skeleton has protective and storage functions. It protects the internal organs, including the brain, spinal cord, heart, lungs, and pelvic organs. The bones of the skeleton serve as the primary storage site for important minerals such as calcium and phosphate. The bone marrow found within bones stores fat and houses the blood-cell-producing tissue of the body.

The skeleton is subdivided into two major divisions: the **axial** and **appendicular**.

The Axial Skeleton

The **axial skeleton** forms the vertical, central axis of the body and includes all bones of the head, neck, chest, and back (see Figure 6.1). It serves to protect the brain, spinal cord, heart, and lungs. It also serves as the attachment site for

muscles that move the head, neck, and back, and for muscles that act across the shoulder and hip joints to move their corresponding limbs.

The axial skeleton of the adult consists of 80 bones, including the **skull**, the **vertebral column**, and the **thoracic cage**. The skull is formed by 22 bones. Also associated with the head are an additional seven bones, including the **hyoid bone** and the **ear ossicles** (three small bones found in each middle ear). The vertebral column consists of 24 bones, each called a **vertebra**, plus the **sacrum** and **coccyx**. The thoracic cage includes the 12 pairs of **ribs** and the **sternum**, the flattened bone of the anterior chest.

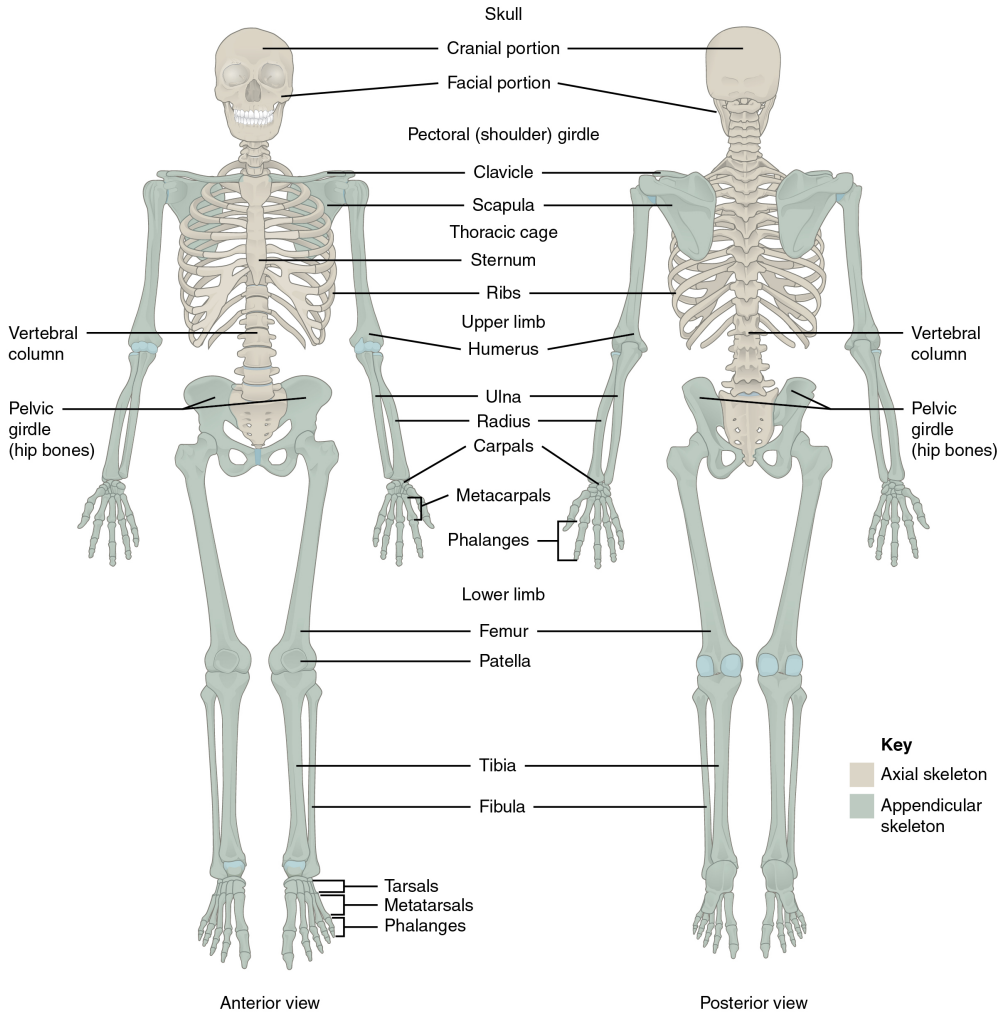

Figure 6.1 Axial and Appendicular Skeleton. The axial skeleton supports the head, neck, back, and chest and thus forms the vertical axis of the body. It consists of the skull, vertebral column (including the sacrum and coccyx), and the thoracic cage, formed by the ribs and sternum. The appendicular skeleton is made up of all bones of the upper and lower limbs. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

The **cranium** or skull supports the face and protects the brain. It is subdivided into the bones of the skull and the bones of the face.

Bones of the Skull

- **Frontal** – forms the forehead
- **Parietal** – the upper lateral sides of the cranium
- **Occipital** – the posterior skull and base of the cranial cavity
- **Temporal** – the lower lateral sides of the cranium
- **Sphenoid** -the 'keystone' bone that forms part of the base of the skull and eye sockets
- **Ethmoid** – forms part of the nose and orbit and base of the cranium
- **Auditory ossicles** – the small bones of the middle ear
- **External auditory meatus** – the external opening of the ear and temporal bone

Bones of the Face

- **Zygomatic** – the cheekbone
- **Maxillary** – the upper jaw and hard palate
- **Palatine** – the lateral walls of the nose
- **Lacrimal** – the walls of the orbit
- **Inferior conchae** – the lower lateral wall of the nasal cavity
- **Vomer –** the bone that separates the left and right nasal cavity
- **Mandible** – the lower jaw bone (the only movable bone of the skull)
- **Hyoid –** the bone located between the mandible and larynx, not connected to other bones

Did you know?

The axial skeleton has 80 bones and includes bones of the skull (and face), vertebral column, and thoracic cage.

Bones of the Vertebral Column

The vertebral column is also known as the spinal column or spine (see Figure 6.2). It consists of a sequence of vertebrae (singular = vertebra), each of which is separated and united by an **intervertebral disc**. Together, the vertebrae and intervertebral discs form the vertebral column. It is a flexible column that supports the head, neck, and body and allows for their movements. It also protects the spinal cord, which passes down the back through openings in the vertebrae.

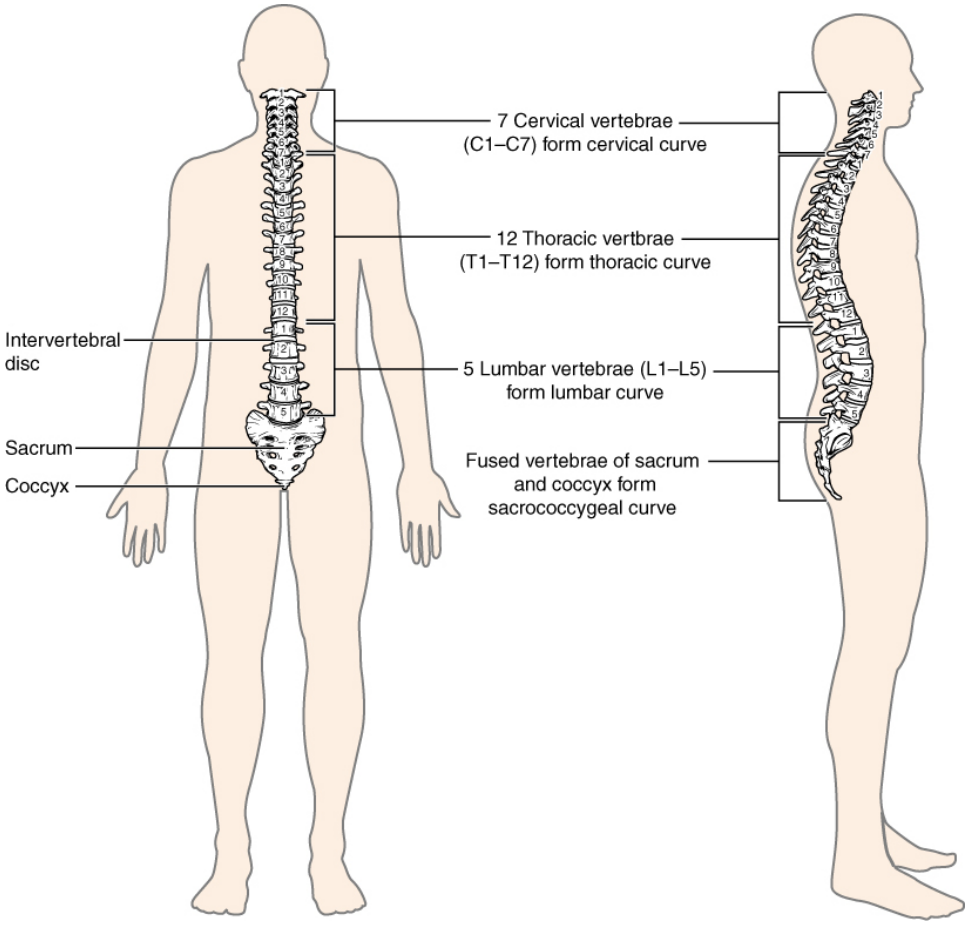

Figure 6.2 Vertebral Column. The adult vertebral column consists of 24 vertebrae, plus the sacrum and coccyx. The vertebrae are divided into three regions: cervical C1–C7 vertebrae, thoracic T1–T12 vertebrae, and lumbar L1–L5 vertebrae. The vertebral column is curved, with two primary curvatures (thoracic and sacrococcygeal curves) and two secondary curvatures (cervical and lumbar curves). From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Types of Vertebrae

- **Cervical** – C1 to C7, the first 7 vertebrae in the neck region
- **Thoracic** – T1 to T12, the next 12 vertebrae that form the outward curvature of the spine
- **Lumbar** – L1 to L5, the next 5 vertebrae that form the inner curvature of the spine
- **Sacrum** – the triangular-shaped bone at the base of the spine
- **Coccyx** – the tailbone

Bones of the Thoracic Cavity

The thoracic cage (rib cage) forms the thorax (chest) portion of the body. It consists of the 12 pairs of ribs with their costal cartilages and the sternum (see Figure 6.3). The ribs are anchored posteriorly to the 12 thoracic vertebrae (T1–T12). The thoracic cage protects the heart and lungs.

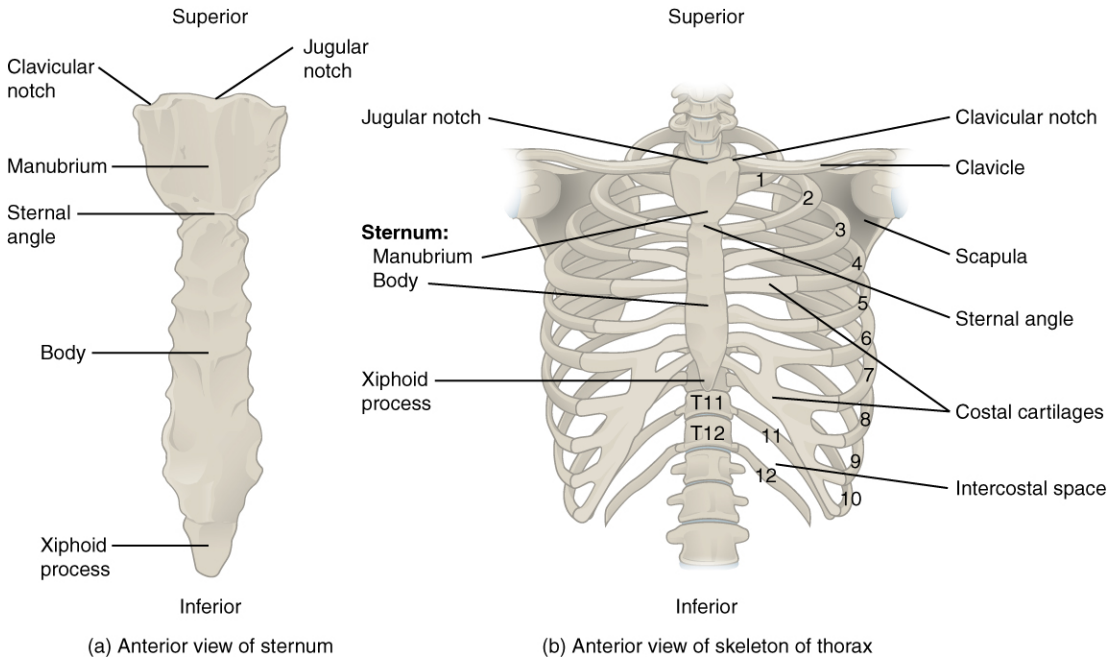

Figure 6.3 Thoracic Cage. The thoracic cage is formed by the (a) sternum and (b) 12 pairs of ribs with their costal cartilages. The ribs are anchored posteriorly to the 12 thoracic vertebrae. The sternum consists of the manubrium, body, and xiphoid process. The ribs are classified as true ribs (1–7) and false ribs (8–12). The last two pairs of false ribs are also known as floating ribs (11–12). From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Ribs

There are 12 sets of **ribs** and can be divided as such:

- 7 **true ribs** – they are attached to the front of the sternum
- 3 **false ribs** – they are attached to the cartilage that joins the sternum
- 2 **floating ribs** – they are not attached to the front of the sternum

Sternum

The **sternum**, also known as the breast bone, is divided into 3 parts:

- **manubrium** – the upper portion of the breast bone
- **body** – the middle portion of the breast bone
- **xiphoid process** – the lower portion of the breast bone and is made up of cartilage

Concept Check

- What is the medical term for the upper jaw bone and the lower jaw bone?
- What medical term is used for the bones of the inner ear?
- How many bones make up the cervical region of the vertebral column?

The Appendicular Skeleton

The **appendicular skeleton**includes all bones of the upper and lower limbs, plus the bones that attach each limb to the axial skeleton. There are 126 bones in the appendicular skeleton of an adult.

Bones of the Pectoral Girdle

- **Scapula** – the shoulder blades
- **Clavicle** – the collarbone, which connects the sternum to the scapula
- **Acromion** – the extension that forms the bony point of the shoulder

Bones of the Upper Limbs

The bones of the upper limbs include the bones of the arms, wrists, and hands.

Bones of the Arm

- **Humerus** – the bone in the upper arm
- **Radius** – the bone that runs thumb-side of the forearm
- **Ulna** – the bone that runs on the side of the little finger of the forearm (Figure 6.4)

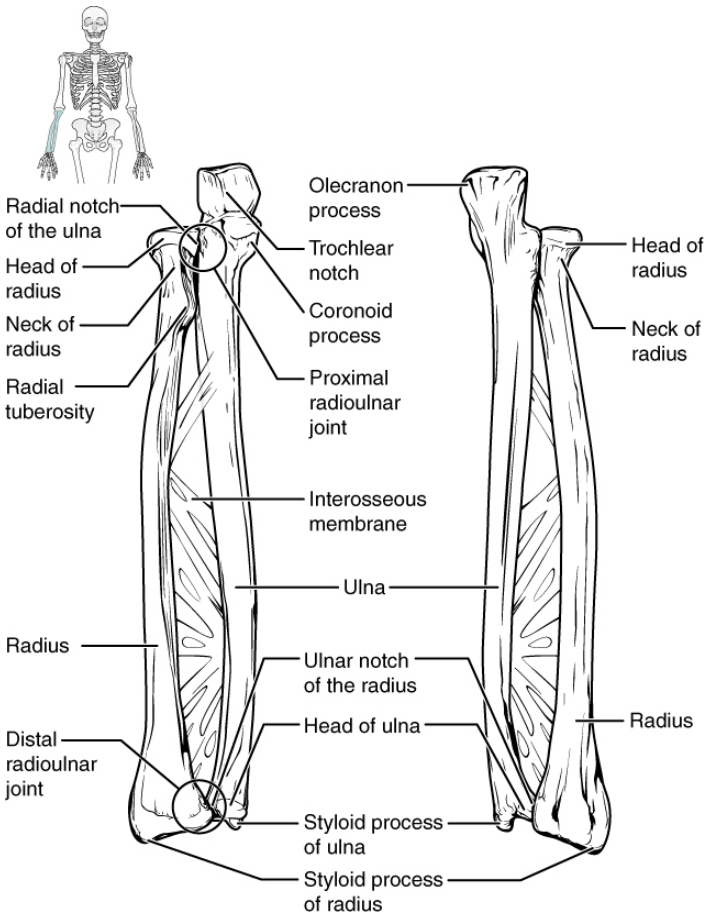

Figure 6.4 Ulna and Radius. The ulna is located on the medial side of the forearm, and the radius is on the lateral side. These bones are attached by an interosseous membrane. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Bones of the Wrist and Hand

- **Carpals** – the wrist bones
- **Metacarpals** – the bones in the palm
- **Phalanges** – the finger and toe bones

Each phalanx has three bones: the distal, medial, and proximal. The exception is the thumb and big toe which has two bones: the distal and proximal (Figure 6.5). There are 30 bones in each upper limb. Can you count them on your limb?

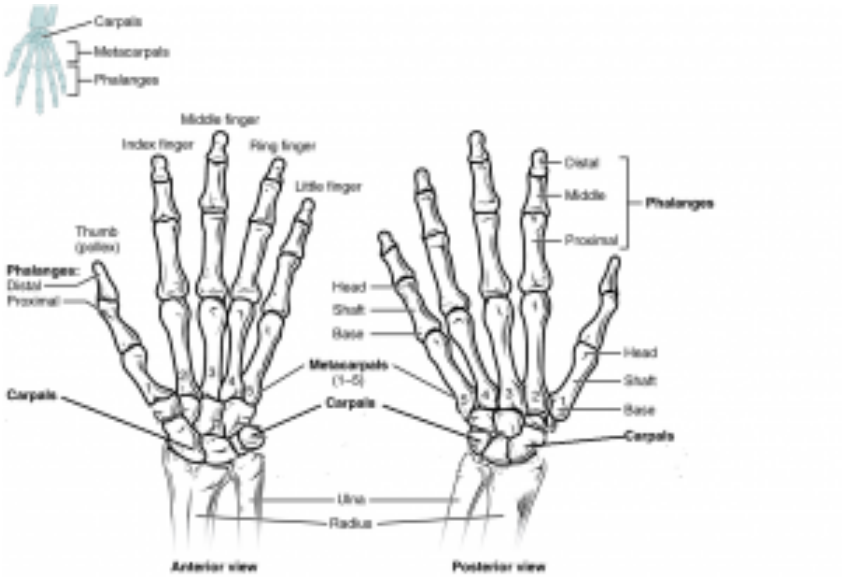

Figure 6.5 Bones of the Hands. The eight carpal bones form the base of the hand. These are arranged into proximal and distal rows of four bones each. The metacarpal bones form the palm. The thumb and fingers consist of the phalanx bones. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Did you know?

The appendicular skeleton has 126 bones. It is divided into the bones of the upper limbs and lower limbs that attach each limb to the skeleton.

Bones of the Pelvic Region

The bones of the pelvic region protect the reproductive, urinary, and excretory organs.

- **Pelvic girdle** – the hip or coxal bone; it is formed by the fusion of three bones during adolescence
- **Illium** – the largest part of the hip bone
- **Ischium** – the lower portion of pelvic girdle
- **Pubis** – the anterior portion of pelvic girdle
- **Pelvis** – consists of four bones: the left and right hip bones as well as the sacrum and coccyx
- **Acetabulum** – the large socket in the pelvic bones that holds the head of the femur

The shape of the pelvic girdle is different for males than females. In the male, it is a funnel shape. In the female, it is shaped like a basin to accommodate the fetus during pregnancy.

Bones of the Lower Limbs

The bones of the lower limb include bones of the leg and the feet.

Bones of the Leg

- **Femur** – the thigh bone and is also referred to as the upper leg bone; it is the longest and strongest bone in the human body
- **Patella** – the kneecap
- **Tibia** – the shin bone; it is a medial bone and the main weight-bearing bone of the lower leg
- **Fibula** – the smaller of the lower leg bones (see Figure 6.6)

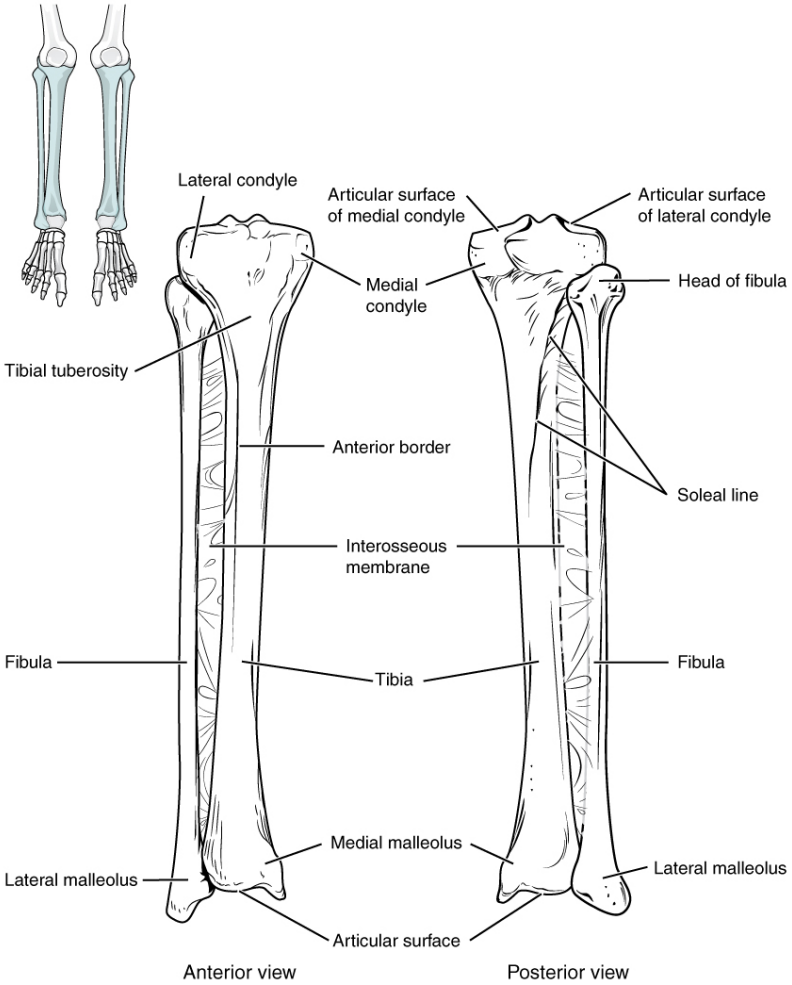

Figure 6.6 Tibia and Fibula. The tibia is the larger, weight-bearing bone located on the medial side of the leg. The fibula is the slender bone of the lateral side of the leg and does not bear weight. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Bones of the Ankles and Feet

- **Tarsals** – the ankle bones (7 total)
- **Malleolus** – the bony protrusions of the ankle bones
- **Talus** – the superior ankle bones
- **Calcaneus** – the heel bones
- **Metatarsals** – the foot bones
- **Phalanges** – the bones of the toes (see Figure 6.7)

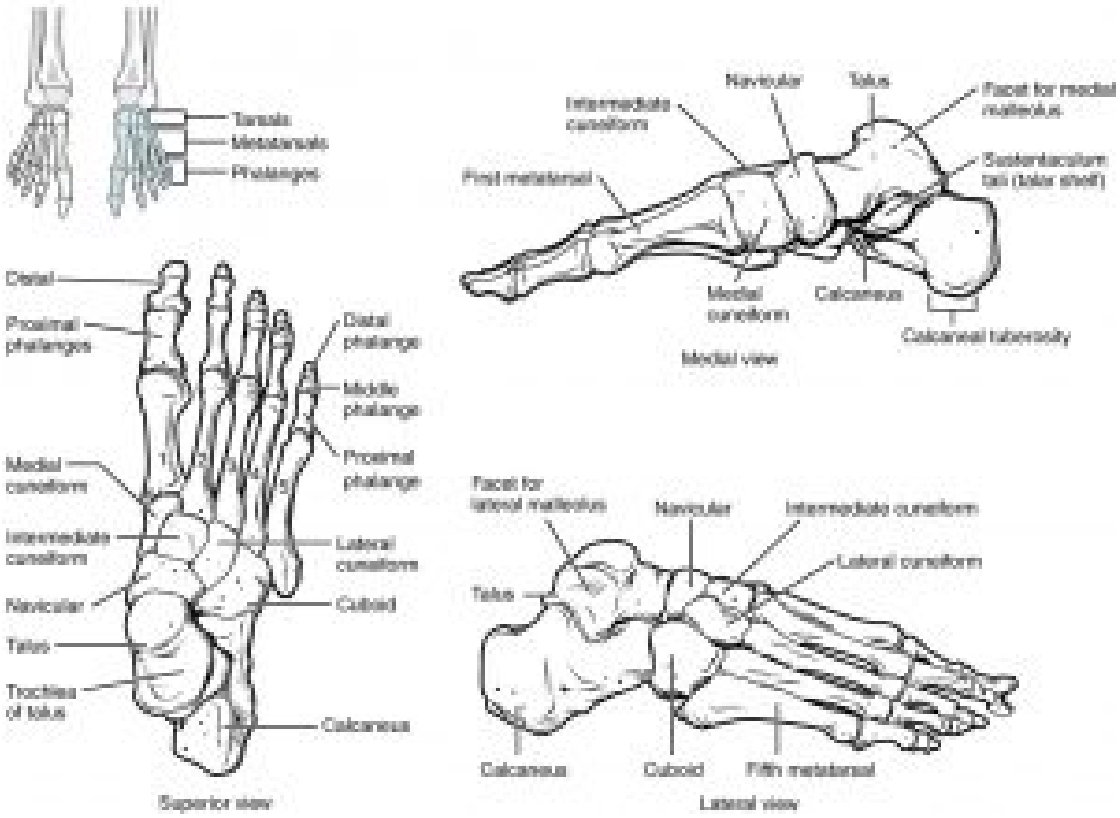

Figure 6.7 Bones of the Foot. The bones of the foot are divided into three groups. The posterior foot is formed by the seven tarsal bones. The mid-foot has five metatarsal bones. The toes contain the phalanges. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Did you know?

The femur is the longest and strongest bone of the body and accounts for approximately one-quarter of a person's total height.

Concept Check

Answer the following questions:

- Is the humerus the same as the funny bone?
- What is the medical term for the kneecap?

Anatomy Labeling Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://pressbooks.uwf.edu/medicalterminology/?p=153#h5p-88

Physiology (Function) of the Skeletal System

The bones of the skeletal system are comprised of an inner spongy tissue referred to as bone marrow. There are two types of bone marrow: red and yellow. The red bone marrow produces the red blood cells, and it does so by a process called **hematopoiesis**. The yellow bone marrow contains adipose tissues which can be a source of energy. The bones of the skeletal system also store minerals such as calcium and phosphate. These minerals are important for the physiological processes in the body and are released into the bloodstream when levels are low in the body.

Joints

Watch this video:

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Media 6.2. Joints: Crash Course A&P #20 [Online video]. Copyright 2015 by CrashCourse.

Most bones connect to at least one other bone in the body. The area where bones meet bones or where bones meet cartilage are called **articulations**. Joints can be classified based on their ability to move. At **movable** joints, the articulating surfaces of the adjacent bones can move smoothly against each other. However, other joints may be connected by connective tissue or cartilage. These joints are designed for stability and provide for little or no movement. Importantly, joint stability and movement are related to each other. This means that stable joints allow for little or no mobility between the adjacent bones. Conversely, joints that provide the most movement between bones are the least stable.

Based on the **function of joints**, there are 3 types of joints:

- **Synarthrosis** joints allow no movement.
  - For example, joints of the skull
- **Amphiarthrosis** joints allow some movement.
  - For example, joints of the pubic symphysis
- **Diarthrosis** joints allow for free movement.
  - For example, joints of the knee

Structures associated with joints are:

- **Cartilage –** the elastic connective tissue that is found at the ends of bones, nose tip, et cetera
- **Synovial membrane –** the lining or covering of synovial joints
- **Synovial fluid –** the lubricating fluid found between synovial joints
- **Ligaments** – the tough, elastic connective tissue that connects bone to bone
- **Tendons** – the fibrous connective tissue that attaches muscle to bone
- **Bursa** – the closed, fluid-filled sacs that work as a cushion
- **Meniscus** – C-shaped cartilage that acts as shock absorbers between bones

Did you know?

The left and right hip bones are connected by an amphiarthrosis joint.

Body Movements

Synovial joints are movable joints and provide most of the body movements. Body movement occurs when the bones, joints, and muscles work together.

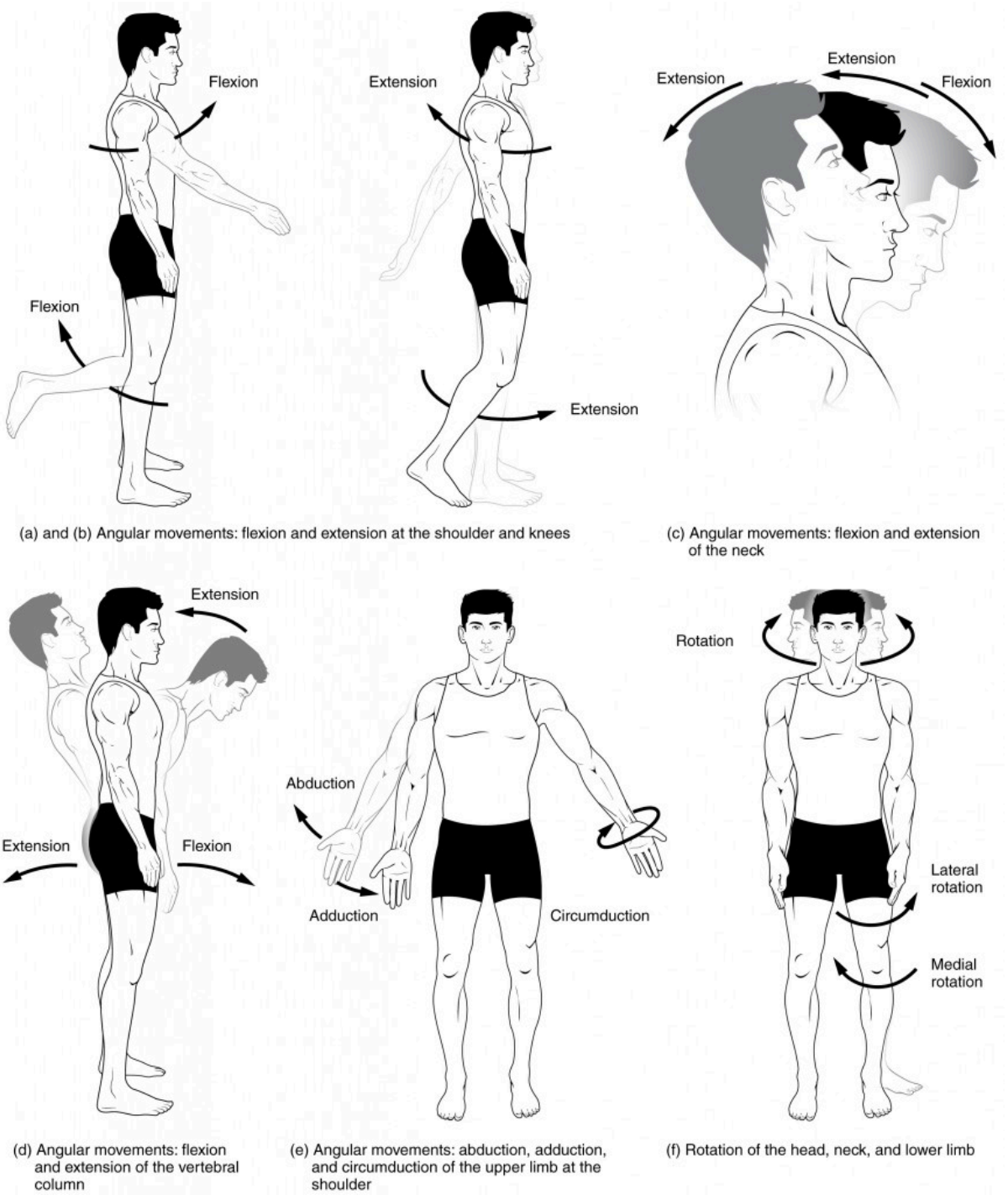

Figure 6.8 Movements of the Body, Part 1. Synovial joints give the body many ways in which to move. (a) and (b) Flexion and extension motions are in the sagittal (anterior and posterior) plane of motion. These movements take place at the shoulder, hip, elbow, knee, wrist, metacarpophalangeal, metatarsophalangeal, and interphalangeal joints. (c) and (d) Anterior bending of the head or vertebral column is flexion, while any posterior-going movement is extension. (e) Abduction and adduction are motions of the limbs, hand, fingers, or toes in the coronal (medial and lateral) plane of movement. Moving the limb or hand laterally away from the body, or spreading the fingers or toes, is abduction. Adduction brings the limb or hand toward or across the midline of the body or brings the fingers or toes together. Circumduction is the movement of the limb, hand, or fingers in a circular pattern, using the sequential combination of flexion, adduction, extension, and abduction motions. Adduction/abduction and circumduction take place at the shoulder, hip, wrist, metacarpophalangeal, and metatarsophalangeal joints. (f) Turning of the head side to side or twisting of the body is rotation. Medial and lateral rotation of the upper limb at the shoulder or lower limb at the hip involves turning the anterior surface of the limb toward the midline of the body (medial or internal rotation) or away from the midline (lateral or external rotation). From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Flexion and Extension

Flexion and **extension** are movements that take place within the sagittal plane and involve anterior or posterior movements of the body or limbs. For the vertebral column, **flexion** (anterior flexion) is an anterior (forward) bending of the neck or body, while **extension** involves a posterior-directed motion, such as straightening from a flexed position or bending backward. **Lateral flexion** is the bending of the neck or body toward the right or left side. These movements of the vertebral column involve both the joints as well as the associated intervertebral disc.

In the limbs, flexion decreases the angle between the bones (bending of the joint), while extension increases the angle and straightens the joint (see Figures 6.8(a-d)). You will discover in the muscular system chapter that the associated muscles to these movements are flexor and extensor.

Abduction and Adduction

Abduction and **adduction** motions occur within the coronal plane and involve medial-lateral motions of the limbs, fingers, toes, or thumb. For example, abduction is raising the arm at the shoulder joint, moving it laterally away from the body, while adduction brings the arm down to the side of the body (see Figure 6.8(e)). In the muscular system chapter, you will discover that the associated muscles to these movements are the abductor and adductor.

Circumduction

Circumduction is the movement of a body region in a circular manner, in which one end of the body region being moved stays relatively stationary while the other end describes a circle. It involves the sequential combination of flexion, adduction, extension, and abduction at a joint (see Figure 6.8(e)).

Rotation

Rotation can occur within the vertebral column, at a **pivot joint**, or at a **ball-and-socket joint**. Rotation of the neck or body is the twisting movement produced by the summation of the small rotational movements available between adjacent vertebrae. At a pivot joint, one bone rotates in relation to another bone.

Rotation can also occur at the **ball-and-socket joints** of the shoulder and hip. Here, the humerus and femur rotate around their long axis, which moves the anterior surface of the arm or thigh either toward or away from the midline of the body (see Figure 6.8(f)).

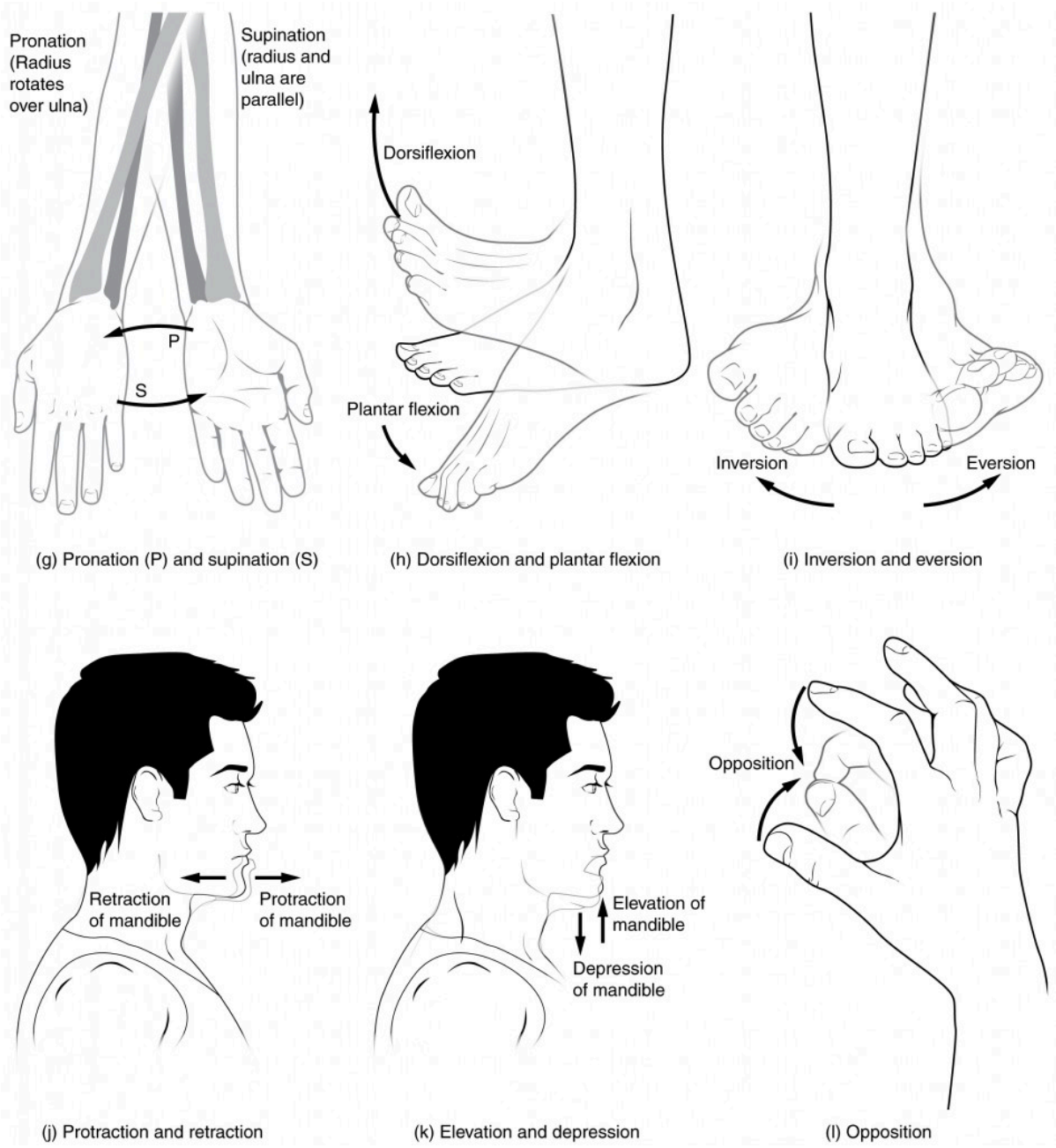

Figure 6.9 Movements of the Body, Part 2. (g) Supination of the forearm turns the hand to the palm forward position in which the radius and ulna are parallel, while forearm pronation turns the hand to the palm backward position in which the radius crosses over the ulna to form an "X." (h) Dorsiflexion of the foot at the ankle joint moves the top of the foot toward the leg, while plantar flexion lifts the heel and points the toes. (i) Eversion of the foot moves the bottom (sole) of the foot away from the midline of the body, while foot inversion faces the sole toward the midline. (j) Protraction of the mandible pushes the chin forward, and retraction pulls the chin back. (k) Depression of the mandible opens the mouth, while elevation closes it. (l) Opposition of the thumb brings the tip of the thumb into contact with the tip of the fingers of the same hand and reposition brings the thumb back next to the index finger. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Supination and Pronation

Supination and pronation are movements of the forearm. In the anatomical position, the upper limb is held next to the

body with the palm facing forward. This is the **supinated position** of the forearm. In this position, the radius and ulna are parallel to each other. When the palm faces backward, the forearm is in the **pronated position**, and the radius and ulna form an X-shape.

Pronation is the movement that allows the palm to face backward while in supination the palm faces forward. It helps to remember that supination is the motion you use when scooping up soup with a spoon (see Figure 6.9(g)).

Dorsiflexion and Plantar Flexion

Dorsiflexion and **plantar flexion** are movements at the ankle joint, which is a hinge joint. Lifting the front of the foot, so that the top of the foot moves (upward) toward the anterior leg is dorsiflexion, while lifting the heel of the foot from the ground or pointing the toes downward is plantar flexion. These are the only movements available at the ankle joint (see Figure 6.9(h)).

Inversion and Eversion

Inversion and eversion are complex movements that involve the multiple plane joints among the tarsal bones of the posterior foot (intertarsal joints) and thus are not motions that take place at the ankle joint. **Inversion** is the turning of the foot to angle the bottom of the foot toward the midline, while **eversion** turns the bottom of the foot away from the midline. The foot has a greater range of inversion than eversion motion. These are important motions that help to stabilize the foot when walking or running on an uneven surface and aid in the quick side-to-side changes in direction used during active sports such as basketball, racquetball, or soccer (see Figure 6.9(i)).

Protraction and Retraction

Protraction and **retraction** are anterior-posterior movements of the scapula or mandible. Protraction of the scapula occurs when the shoulder is moved forward, as when pushing against something or throwing a ball. Retraction is the opposite motion, with the scapula being pulled posteriorly and medially, toward the vertebral column. For the mandible, protraction occurs when the lower jaw is pushed forward, to stick out the chin, while retraction pulls the lower jaw backward (see Figure 6.9(j)).

Depression and Elevation

Depression and **elevation** are downward and upward movements of the scapula or mandible. The upward movement of the scapula and shoulder is elevation, while a downward movement is depression. These movements are used to shrug your shoulders. Similarly, elevation of the mandible is the upward movement of the lower jaw used to close the mouth or bite on something, and depression is the downward movement that produces the opening of the mouth (see Figure 6.9(k)).

Concept Check

- Discuss the joints involved and movements required for you to cross your arms together in front of your chest.
- Differentiate between **pronation** and **supination**.

Practice Skeletal System Movement Terms

An interactive H5P element has been excluded from this version of the text. You can view it online here:
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Medical Terms in Context

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Diseases and Disorders of the Skeletal System

Osteoporosis

The National Institute of Health's Osteoporosis and Related Bone Diseases National Resource Center describes **osteoporosis** as bone loss that causes bones to become weak and thin over time. This weakness can lead to fractures from simple movements and occur often in the wrist, shoulder, spine, and hip (National Institute of Arthritis and Musculoskeletal and Skin Diseases, n.d.-b). To learn more, please visit the National Institute of Health's web page on osteoporosis.

Arthritis

Arthritis often presents as **edema**, **arthralgia**, and **ankylosis** (National Institute of Arthritis and Musculoskeletal and Skin Diseases, n.d.-a). Common types of arthritis are **osteoarthritis** (OA), rheumatoid arthritis (RA), Gout and lupus. To learn more about arthritis visit this web page from the National Institute of Arthritis and Musculoskeletal and Skin Diseases.

Osteoarthritis

Osteoarthritis is the most common form of arthritis and according to the Centers for Disease Control and Prevention (CDC), affects over 32.5 million adults in the United States. The breakdown of cartilage and bone occurs over time when joints are exposed to heavy workloads either through occupation, obesity, and/or prior injury to a joint. Common signs and symptoms are pain, stiffness, and aching that worsens over time. While there is no cure, symptoms can be managed through exercise, medications, and in severe cases, joint replacements (Centers for Disease Control and Prevention, n.d.-a).

Rheumatoid Arthritis

The CDC describes rheumatoid arthritis (RA) as an autoimmune and inflammatory disease. Autoimmune diseases are disorders in which the immune system overreacts and begins to attack itself. In the case of RA, inflammation of the joint tissues of the hands, wrists, and knees is painful and debilitating. Treatments may include immunosuppressive drugs and anti-inflammatory drugs (Betts et al., 2013). RA can also affect other tissues throughout the body and cause problems in organs such as the lungs, heart, and eyes. RA can affect children; in this case, it is referred to as **juvenile rheumatoid arthritis** (Centers for Disease Control and Prevention, n.d.-b).

Gout

Gout is an inflammatory arthritis caused by the buildup of uric acid crystals in a joint. Gout has periods of **flares** and **remission** and is commonly treated through lifestyle changes and medication. While any joint can be affected, it is

common in the lower extremities and most often in the big toe (Centers for Disease Control and Prevention, n.d.-c). To learn more about the causes and treatments please visit the Arthritis Foundation's web page about gout.

Myasthenia Gravis

The National Institute of Neurological Disorders and Strokes describes **myasthenia gravis** as a "**chronic** autoimmune neuromuscular disease that causes weakness in the skeletal muscles" (Office of Communications and Public Liaison, 2020). To learn more, read the National Institute of Neurological Disorders and Stroke's myasthenia gravis fact sheet.

Fibromyalgia

Fibromyalgia is a challenging disease to diagnose since symptoms manifest differently and are similar to other diseases. Signs and symptoms may include widespread pain, chronic fatigue, gastrointestinal problems, and headaches. It is not known what causes fibromyalgia. A doctor may need to order tests to rule out other conditions before making a diagnosis of fibromyalgia (National Institute of Arthritis and Musculoskeletal and Skin Diseases, n.d.-c). To learn more about the diagnosis and treatment for fibromyalgia, please read this handout from the National Institute of Arthritis and Musculoskeletal and Skin Diseases (pdf).

Osteomyelitis

Osteomyelitis is a bone infection caused when staphylococcus bacteria travel through the bloodstream from an infection in one part of the body to the bone. Staphylococcus bacteria are found on the skin, and they can transfer to the bone through a wound and/or surgical contamination. The risk increases as people age or if their immune system is compromised (Momodu & Savaliya, 2021). To learn more, visit the Mayo Clinic's web page on osteomyelitis.

Disorders of the Curvature of the Spine

Developmental anomalies, pathological changes, or obesity can enhance the normal vertebral column curves, resulting in the development of abnormal or excessive curvatures (see Figure 6.10). Disorders associated with the curvature of the spine include:

- **Kyphosis:** Also referred to as humpback, it is an excessive posterior curvature of the thoracic region. This can develop when osteoporosis causes weakening and erosion of the anterior portions of the upper thoracic vertebrae, resulting in their gradual collapse (see Figure 6.11).
- **Lordosis:** Also referred to as swayback, it is an excessive anterior curvature of the lumbar region and is most commonly associated with obesity or late pregnancy. The accumulation of body weight in the abdominal region results in an anterior shift in the line of gravity that carries the weight of the body. This causes an anterior tilt of the pelvis and a pronounced enhancement of the lumbar curve.
- **Scoliosis:** An abnormal, lateral curvature, accompanied by twisting of the vertebral column. Scoliosis is the most common vertebral abnormality among girls. The cause is usually unknown, but it may result from weakness of the

back muscles, defects such as differential growth rates in the right and left sides of the vertebral column, or differences in the length of the lower limbs. When present, scoliosis tends to get worse during adolescent growth spurts. Although most individuals do not require treatment, a back brace may be recommended for growing children. In extreme cases, surgery may be required.

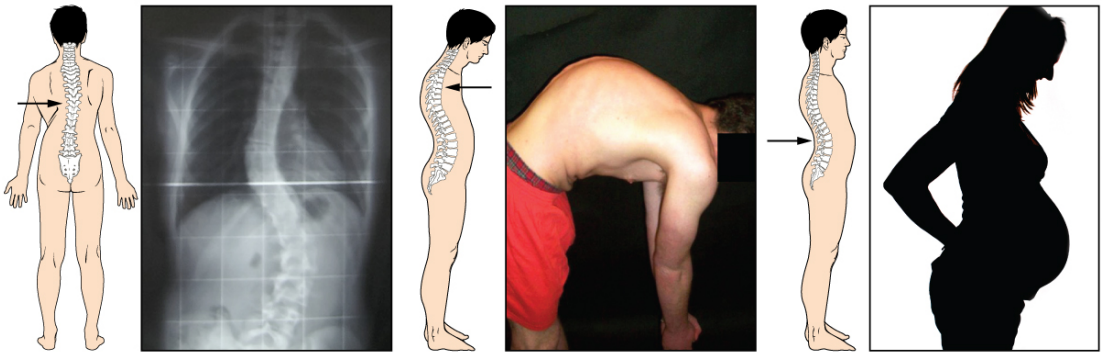

Figure 6.10 Abnormal Curvatures of the Vertebral Column. (a) Scoliosis is an abnormal lateral bending of the vertebral column. (b) An excessive curvature of the upper thoracic vertebral column is called kyphosis. (c) Lordosis is an excessive curvature in the lumbar region of the vertebral column. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

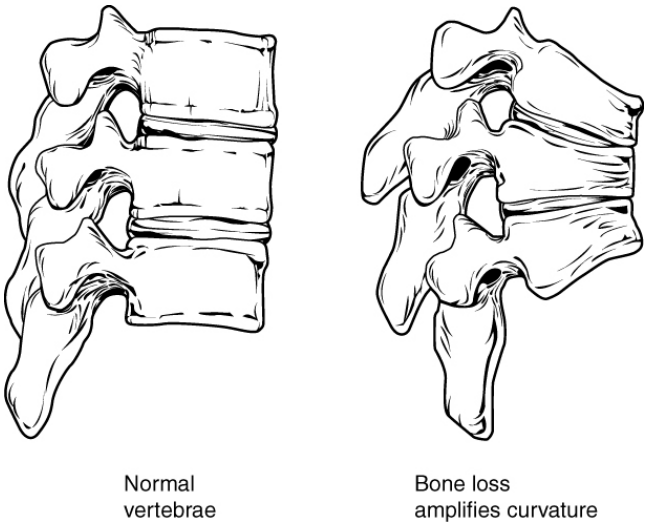

Figure 6.11. Osteoporosis. Osteoporosis is an age-related disorder that causes the gradual loss of bone density and strength. When the thoracic vertebrae are affected, there can be a gradual collapse of the vertebrae. This results in kyphosis, an excessive curvature of the thoracic region. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Fractures

A **fracture** is a broken bone. It will heal whether or not a physician resets it in its anatomical position. If the bone

is not reset correctly, the healing process will keep the bone in its deformed position. **Crepitation or crepitus** is the creaking or popping sound that is heard when fractured bones move against each other. Fractures are classified by their complexity, location, and other features (see Figure 6.12). Some fractures may be described using more than one term because they may have the features of more than one type (e.g., an open transverse fracture).

Types of fractures include:

- **Closed or simple** – bones are broken but do not protrude the skin
- **Open or compound** – bones are broken and pierce through the skin
- **Transverse** – bone is broken straight across
- **Spiral** – the bone has twisted apart
- **Comminuted –** bones are broken and crushed into pieces
- **Greenstick –** bones are partially broken; occurs mainly in children
- **Oblique** – bones are broken at an angle
- **Coles** – bones are broken at the wrist or distal radius
- **Stress** – a small crack in the bone

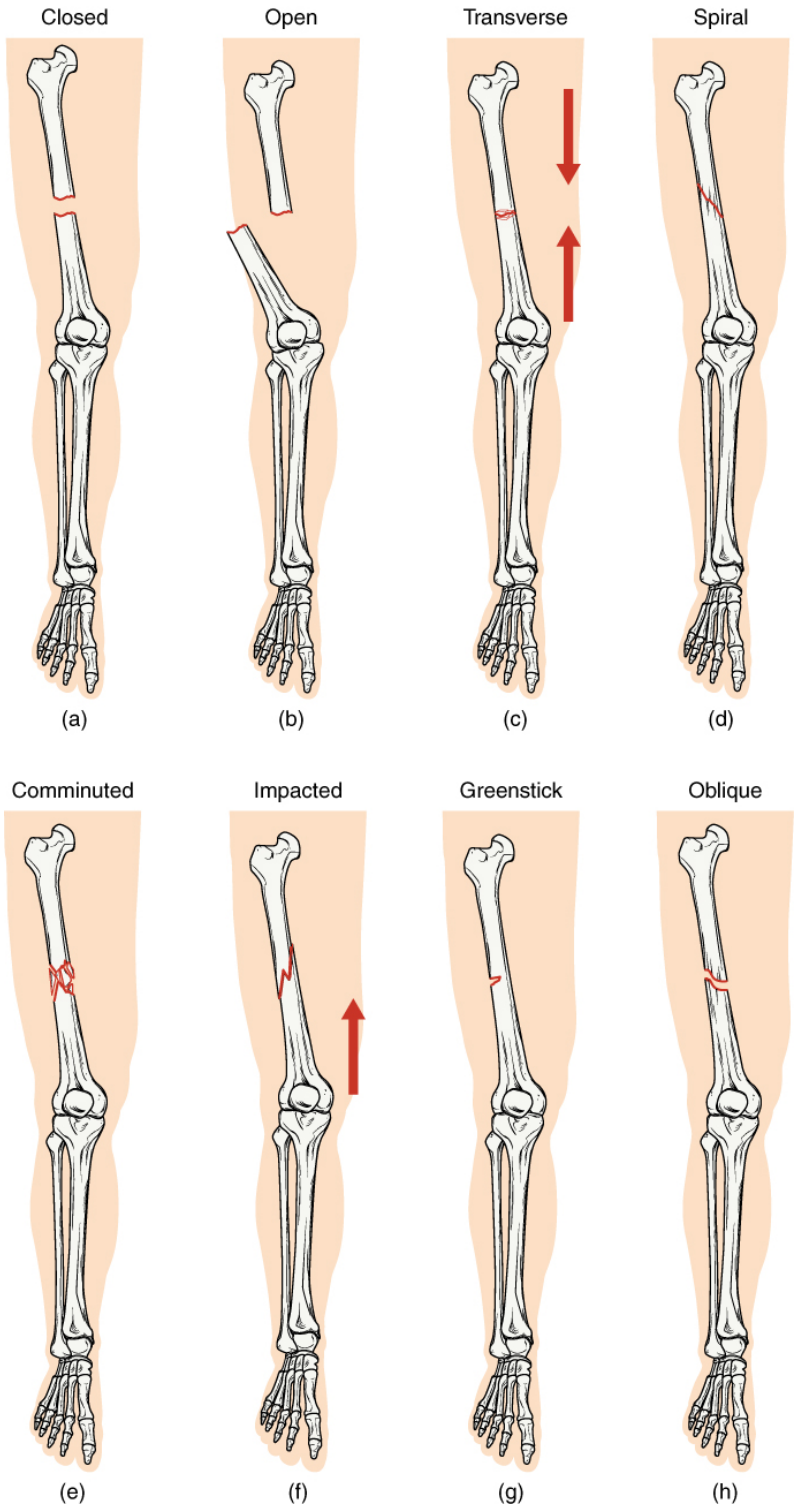

Figure 6.12. Types of Fractures. Compare healthy bone with different types of fractures: (a) closed fracture, (b) open fracture, (c) transverse fracture, (d) spiral fracture, (e) comminuted fracture, (f) impacted fracture, (g) greenstick fracture, and (h) oblique fracture. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Bone Cancer

There are three types of primary bone cancers: osteosarcoma, Ewing Sarcomas, and chondrosarcoma. These are considered primary cancers because they originate in the bones. Osteosarcoma and Ewing Sarcomas primarily affect children, teenagers, and young adults. Chondrosarcoma primarily affects older adults (National Cancer Institute, n.d.-a). To learn more, visit the American Cancer Society's web page on bone cancer.

Medical Specialties and Procedures Related to the Skeletal System

Orthopedic Surgeon

Orthopedic surgeons are medical doctors who have specialized training in the prevention, diagnosis, treatment, and surgery of disorders and diseases related to the musculoskeletal systems (Bureau of Labor Statistics, 2021a). For more details, please visit the American College of Surgeons' page on Orthopedic Surgery.

Rheumatologist

Rheumatologists are medical doctors who specialize in the diagnosis and treatment of disorders of the joints, muscles, and bones. They diagnose and treat diseases such as arthritis, musculoskeletal disorders, osteoporosis, plus autoimmune diseases like ankylosing spondylitis, a chronic spinal inflammatory disease, and rheumatoid arthritis (Fowler et al., 2013). For more details, please follow the link to the American College of Rheumatology's page on rheumatology.

Doctor of Chiropractic (DC)/Chiropractor

Chiropractors are required to have a Doctor of Chiropractic (D.C.) degree, which is a 4-year postgraduate professional degree, and a state license. Chiropractors focus on spinal adjustments, nutrition, and preventing injury without the use of pharmaceuticals or surgical procedures (Bureau of Labor Statistics, 2021b). To learn more, visit the Bureau of Labor Statistics' website.

Physical Therapist

A physical therapist is a licensed professional who develops individualized treatment plans for their clients. These plans can include exercises, hands-on therapy, and equipment, such as canes or wheelchairs. Although current licensure laws require that those entering the field have a doctor of physical therapy degree, physical therapists who began working before those requirements went into effect may have a bachelor's or master's degree (Bureau of Labor Statistics, 2021c). To learn more, please visit the American Physical Therapy Association website.

Diagnostic Procedures

Common diagnostic procedures related specifically to the skeletal system include x-rays, bone mineral density testing, and arthroscopy.

- **X-rays** are common diagnostic tests used to confirm or rule out fractures and broken bones. The radiation dose is low so it is considered a safe diagnostic test (MedlinePlus, 2021).
- **Dual x-ray absorptiometry (BMD)**, also called a **bone mineral density** test, is a test to determine osteoporosis by measuring the amount of bone mineral in a particular amount of bone (National Cancer Institute, n.d.-b).
- **Arthroscopy** is a procedure that involves a small incision and the insertion into the joint of an arthroscope, a pencil-thin instrument that allows for visualization of the joint interior. Small surgical instruments are also inserted via additional incisions. These tools allow a surgeon to remove or repair a torn meniscus or to reconstruct a ruptured cruciate ligament.

Practice Terms Related to the Skeletal System

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Skeletal System Vocabulary

Abduction
Moving the limb or hand laterally away from the body, or spreading the fingers or toes.
Adduction
Movement that brings the limb or hand toward or across the midline of the body, or brings the fingers or toes together.
Amphiarthrosis
A slightly mobile joint.
Ankylosis
Fixation and immobility of a joint.
Appendicular skeleton
All bones of the upper and lower limbs, plus the girdle bones that attach each limb to the axial skeleton.
Arthralgia
Joint pain.
Arthritis
Chronic inflammation of the synovial joints.
Arthrocentesis
Surgical puncture to aspirate fluid from a joint.
Arthrodesis
Surgical fixation of a joint.
Arthrography

Process of recording a joint.

Arthroplasty

Joint replacement surgery.

Arthroscopy

Process of viewing a joint using an endoscope.

Articulations

Where two bone surfaces meet.

Autoimmune diseases/disorders

Disorders in which the immune system overreacts and begins to attack itself.

Axial skeleton

The central, vertical axis of the body, including the skull, vertebral column, and thoracic cage.

Bradykinesia

Condition of slow movement.

Bursitis

Inflammation of a bursa near a joint.

Chondromalacia

Degeneration of cartilage.

Chronic

A condition that lasts a long time with periods of remission and exacerbation.

Craniotomy

An operation in which a piece of the skull is removed.

Diarthrosis

Freely mobile joints.

Diskectomy

Excision of the intervertebral disk.

Discitis

Inflammation of the intervertebral disk.

Dyskinesia

Abnormal involuntary movements of the extremities, trunk, or jaw.

Edema

Swelling due to excessive liquid in the tissues.

Eversion

Foot movement in which the bottom of the foot is turned laterally, away from the midline.

Extension

Movement in the sagittal plane that increases the angle of a joint (straightens the joint).

Flexion

Movement in the sagittal plane that decreases the angle of a joint (bends the joint).

Hematopoiesis

The production of blood cells.

Hyperkinesia

Excessive movement of muscles of the body as a whole.

Hypertrophy

The enlargement of muscles.

Inversion

Foot movement in which the bottom of the foot is turned toward the midline.

Kyphosis

An excessive posterior curvature of the thoracic region; also called humpback.

Lordosis

Excessive anterior curvature of the lumbar vertebral column region; also called swayback.

Lumbar

Pertaining to the lumbar region of the spine (L1 to L5).

Lumbosacral

Pertaining to the region of the back that includes the lumbar vertebrae, sacrum, and nearby structures.

Muscular dystrophy

A general term for the group of inherited myopathies that are characterized by wasting and weakness of the skeletal muscle.

Osteitis

Inflammation of bone.

Osteoarthritis

The most common type of arthritis; associated with aging and "wear and tear" of the articular cartilage.

Osteoblast

The cell responsible for forming new bone.

Osteochondritis

Inflammation of bone and cartilage.

Osteocyte

Bone cell.

Osteomalacia

A softening of adult bones due to Vitamin D deficiency.

Osteomyelitis

Inflammation of bone and bone marrow.

Osteonecrosis

Abnormal condition of bone death (lack of blood supply).

Osteopenia

Abnormally low bone mass or bone mineral density.

Osteopetrosis

Abnormal condition of porous bones.

Osteoporosis

A disease characterized by a decrease in bone mass that occurs when the rate of bone resorption exceeds the rate of bone formation.

Osteosarcoma

Malignant tumor of bone.

Pelvic

Pertaining to the pelvis.

Pronation

Forearm motion that moves the palm of the hand from the palm forward to the palm backward position.

Rotation

Movement of a bone around a central axis or around its long axis.

Sarcopenia

Age-related muscle atrophy.

Scoliosis

Lateral curvature of the spine.

Spondyloarthritis

Inflammation of the joints of the spine.

Spondylosis

A degenerative spinal disease that can involve any part of the vertebra, intervertebral disk, and surrounding soft tissue.

Supination

Forearm motion that moves the palm of the hand from the palm backward to the palm forward position.

Synarthrosis

An immobile or nearly immobile joint.

Synovectomy

Excision of the synovial membrane.

Synovial sarcoma

Malignant tumor of the synovial membrane.

Tendinitis

Inflammation of the tendon.

Tenosynovitis

Inflammation of the synovial membrane of a tendon.

Vertebroplasty

A procedure used to repair a bone in the spine that has a break caused by cancer, osteoporosis, or trauma.

Test Yourself

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https://pressbooks.uwf.edu/medicalterminology/?p=153#h5p-92

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Image Descriptions

Figure 6.1 image description: This diagram shows the human skeleton and identifies the major bones. The left panel shows the anterior view (from the front) and the right panel shows the posterior view (from the back). Labels read (from the top of the skull): skull (cranial portion, facial portion), pectoral shoulder girdle, clavicle, scapula, thoracic cage (sternum, ribs), upper limb (humerus, ulna, radius, carpals, metacarpals, phalanges), vertebral column, pelvic girdle (hip bones), lower limb (femur, patella, tibia, fibula, tarsals, metatarsals, phalanges). [Return to Figure 6.1].

Figure 6.2 image description: This image shows the structure of the vertebral column. The left panel shows the front view of the vertebral column. Labels and the right panel show the side view of the vertebral column. labels read (from top): 7 cervical vertebrae (C1-C7) form cervical curve, 12 thoracic vertebrae (T1-T12) form the thoracic curve, intervertebral disc, 5 lumbar vertebrae (L1-L5) form lumbar curve, Fused vertebrae of sacrum and coccyx form a sacrococcygeal curve, sacrum, coccyx. [Return to Figure 6.2].

Figure 6.3 image description: This figure shows the skeletal structure of the rib cage. The left panel shows the anterior view of the sternum. Labels read (from top): clavicular notch, jugular notch, manubrium, sternal angle, body, xiphoid process. The right panel shows the anterior panel of the sternum including the entire rib cage. Labels read (from top): jugular notch, clavicular notch, clavicle, sternum (manubrium, body, xiphoid process), scapula, sternal angle, costal cartilages, intercostal space. Ribs are numbered 1-12 from the top. [Return to Figure 6.3].

Figure 6.4 image description: This diagram labels the bones of the lower arm (excluding the hands). Labels read (from top): olecranon process, head of radius, radial notch of the ulna, trochlear notch, coronoid process, radial tuberosity, proximal radioulnar joint, neck of radius, radius, interosseous membrane, ulna, ulnar notch of the radius, head of the ulna, distal radioulnar joint, styloid process of ulna, styloid process of radius. [Return to Figure 6.4].

Figure 6.5 image description: This diagram shows an anterior and posterior view of the hands with corresponding labels. Anterior view labels read (from top): middle finger, ring finger, index finger, little finger, thumb, phalanges (distal, proximal), metacarpals, carpals, ulna, radius. Posterior view labels read (from top): Phalanges (distal, middle, proximal), head shaft and base of the proximal phalanx, head shaft and base of the metatarsal, metatarsals 1-5, carpals, ulna, radius. [Return to Figure 6.5].

Figure 6.6 image description: This image shows the structure of the tibia and the fibula. The left panel shows the anterior view. Labels read (from top): lateral condyle, medial condyle, tibial tuberosity, anterior border, interosseous membrane, fibula, tibia, medial malleolus, lateral malleolus, articular surface. The right panel shows the posterior view. Labels read (from top): the articular surface of medial and lateral condyles, medial condyle, head of the fibula, soleal line, interosseous membrane, tibia, fibula, medial malleolus, lateral malleolus, articular surface. [Return to Figure 6.6].

Figure 6.7 image description: This figure shows the bones of the foot. The left panel shows the superior view. Labels

read (from toes): distal, proximal phalanges, distal phalange, middle phalange, proximal phalanx, medial cuneiform, intermediate and lateral cuneiforms, navicular, cuboid, talus, trochlea of talus, calcaneus. The top right panel shows the medial view. Labels read (from left to right starting at toe): first metatarsal, medial cuneiform, intermediate cuneiform, navicular, talus, calcaneus, facet for medial malleolus, sustentaculum tali (talar shelf), calcaneal tuberosity. The bottom right panel shows the lateral view. Labels read (from left at the heel, to right): calcaneus, talus, facet for lateral malleolus, cuboid, navicular, intermediate and lateral cuneiforms, fifth metatarsal. [Return to Figure 6.7].

Figure 6.8 image description: This multi-part image shows different types of movements that are possible by different joints in the body. Labels read (from the top, left): a and b angular movements: flexion and extension at the shoulders and knees, c) angular movements: flexion and extension of the neck (arrows pointing left and right to indicate movement). Labels (from the bottom, left) read d) angular movements: flexion and extension of the vertical column, e) angular movements abduction, adduction, and circumduction of the upper limb at the shoulder, f) rotation of the head, neck, and lower limb. [Return to Figure 6.8].

Figure 6.9 image description: This multi-part image shows different types of movements that are possible by different joints in the body. The top left image shows a hand and forearm in the pronation and supination positions. The top middle image shows a foot in the dorsiflexion and plantar flexion positions. The top right image shows a foot in the inversion and eversion positions. The bottom left image shows the retraction and protraction of a man's mandible. The bottom middle image shows the elevation and depression of a man's mandible. The bottom right image shows a hand in the opposition position. [Return to Figure 6.9].

Figure 6.10 image description: This image shows the changes to the abnormal curves of the vertebral columns in different diseases. The left panel shows the change in the curve of the vertebral column in scoliosis, the middle panel shows the change in the curve of the vertebral column in kyphosis, and the right panel shows the change in the curve of the vertebral column in lordosis. [Return to Figure 6.10].

Figure 6.11 image description: This figure shows the changes to the spine in osteoporosis. The left panel shows the structure of normal vertebrae and the right panel shows the curved vertebrae in osteoporosis. [Return to Figure 6.11].

Figure 6.12 image description: In this illustration, each type of fracture is shown on the right femur from an anterior view. In the closed fracture, the femur is broken in the middle of the shaft with the upper and lower halves of the bone completely separated. However, the two halves of the bones are still aligned in that the broken edges are still facing each other. In an open fracture, the femur is broken in the middle of the shaft with the upper and lower halves of the bone completely separated. Unlike the closed fracture, in the open fracture, the two bone halves are misaligned. The lower half is turned laterally and it has protruded through the skin of the thigh. The broken ends no longer line up with each other. In a transverse fracture, the bone has a crack entirely through its width, however, the broken ends are not separated. The crack is perpendicular to the long axis of the bone. Arrows indicate that this is usually caused by compression of the bone in a superior-inferior direction. A spiral fracture travels diagonally through the diameter of the bone. In a comminuted fracture, the bone has several connecting cracks at its middle. The bone could splinter into several small pieces at the site of the comminuted fracture. In an impacted fracture, the crack zig zags throughout the width of the bone like a lightning bolt. An arrow indicates that these are usually caused by an impact that pushes the femur up into the body. A greenstick fracture is a small crack that does not extend through the entire width of the bone. The oblique fracture shown here is traveling diagonally through the shaft of the femur at about a thirty degree angle. [Return to Figure 6.12].

7. Muscular System

Learning Objectives

- Examine the anatomy of the muscular system
- Determine the main functions of the muscular system
- Differentiate the medical terms of the muscular system and common abbreviations
- Discover common diseases, disorders, and procedures related to the muscular system
- Recognize the medical specialties associated with the muscular system

Muscular System Word Parts

Click on prefixes, combining forms, and suffixes to reveal a list of word parts to memorize for the Muscular System.

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https://pressbooks.uwf.edu/medicalterminology/?p=156#h5p-93

Introduction to the Muscular System

When most people think of muscles, they think of the muscles that are visible just under the skin, particularly of the limbs. These are skeletal muscles, so-named because most of them move the skeleton, but there are two additional types of muscles: the smooth muscle and the cardiac muscle. The body has over 600 muscles which contribute significantly to the body's weight.

Watch this video:

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Media 7.1 Muscles, Part 2 – Organismal Level: Crash Course A&P #22 [Online video]. Copyright 2015 by CrashCourse.

Medical Terms Related to the Muscular System

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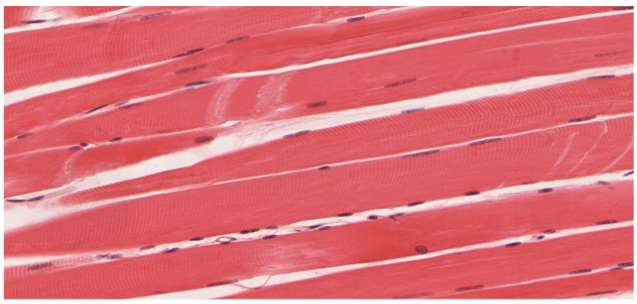
Anatomy (Structures) of the Muscular System

Muscle is one of the four primary tissue types of the body, and it is made up of specialized cells called fibers. The body contains three types of muscle tissue: **skeletal muscle**, **cardiac muscle**, and **smooth muscle** (see Figure 7.1). All three muscle tissues have some properties in common; they all exhibit a quality called **excitability** as their plasma membranes can change their electrical states (from polarized to depolarized) and send an electrical wave called an action potential along the entire length of the membrane. **Fascia** is fibrous connective tissue that encloses muscles.



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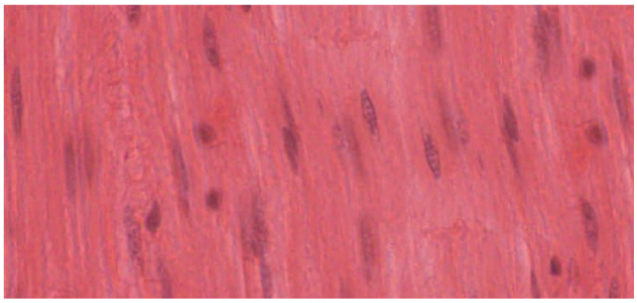

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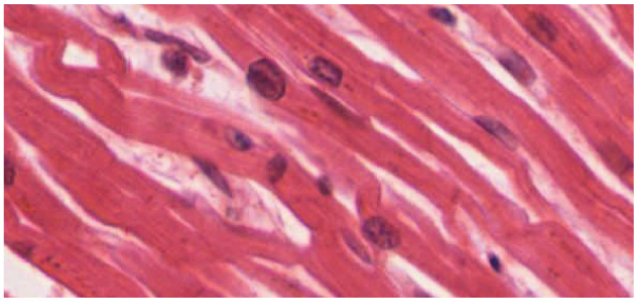


(c)

Figure 7.1 The Three Types of Muscle Tissue. The body contains three types of muscle tissue: (a) skeletal muscle, (b) smooth muscle, and (c) cardiac muscle. (Micrographs provided by the Regents of University of Michigan Medical School © 2012). From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Three Types of Muscle Tissues

- **Skeletal** – closely associated with the skeletal system. Also known as striated muscles, they are responsible for voluntary muscle movement, such as swallowing, et cetera.
- **Smooth** – mainly associated with the walls of the internal organs. Also known as visceral muscles, they are responsible for involuntary muscle movement, such as breathing, et cetera.
- **Cardiac** – heart muscle or myocardium. Its appearance is similar to a skeletal muscle and is responsible for the pumping of blood. It gives the heart beat.

Skeletal Muscle

Skeletal muscles act not only to produce movement but also to stop movement, such as resisting gravity to maintain posture. Small, constant adjustments of the skeletal muscles are needed to hold a body upright or balanced in any position. Muscles also prevent excess movement of the bones and joints, maintaining skeletal stability and preventing skeletal structure damage or deformation.

Skeletal muscles are located throughout the body at the openings of internal tracts to control the movement of various substances. These muscles allow functions, such as swallowing, urination, and defecation, to be under voluntary control. Skeletal muscles also protect internal organs (particularly abdominal and pelvic organs) by acting as an external barrier or shield to external trauma and by supporting the weight of the organs.

Skeletal muscles contribute to the maintenance of **homeostasis** in the body by generating heat. This heat is very noticeable during exercise, when sustained muscle movement causes body temperature to rise, and in cases of extreme cold when shivering produces random skeletal muscle contractions to generate heat.

Did you know?

The gluteus maximus is the largest muscle and the heart is the hardest working muscle.

Smooth Muscle

Smooth muscle, so named because the cells do not have striations, is present in the walls of hollow organs like the urinary bladder, uterus, stomach, intestines, and in the walls of passageways, such as the arteries and veins of the circulatory system, and the tracts of the respiratory, urinary, and reproductive systems. Smooth muscle is also present in the eyes, where it functions to change the size of the iris and alter the shape of the lens; and in the skin where it causes hair to stand erect in response to cold temperature or fear.

Cardiac Muscle

Cardiac muscle tissue is only found in the heart. Highly coordinated contractions of cardiac muscle pump blood into the vessels of the circulatory system. Similar to skeletal muscle, cardiac muscle is striated and organized into **sarcomeres**, possessing the same banding organization as skeletal muscle (see Figure 7.1). Cardiac muscle fibers cells also are extensively branched and are connected to one another at their ends by intercalated discs. An **intercalated disc** allows the cardiac muscle cells to contract in a wave-like pattern so that the heart can work as a pump.

Concept Check

- Compare and contrast the three types of muscle tissues.
- Where in the body do you find each of the muscle types?

Physiology (Function) of the Muscular System

The main function of the muscular system is to assist with **movement**. Muscles work as **antagonistic** pairs. As one muscle contracts, the other muscle relaxes. This contraction pulls on the bones and assists with movement. Contraction is the shortening of the muscle fibers while relaxation lengthens the fibers. This sequence of relaxation and contraction is influenced by the nervous system.

Muscles also work to keep the **posture** of the body. This is done through muscle contraction where the trunk is kept straight either when sitting or standing.

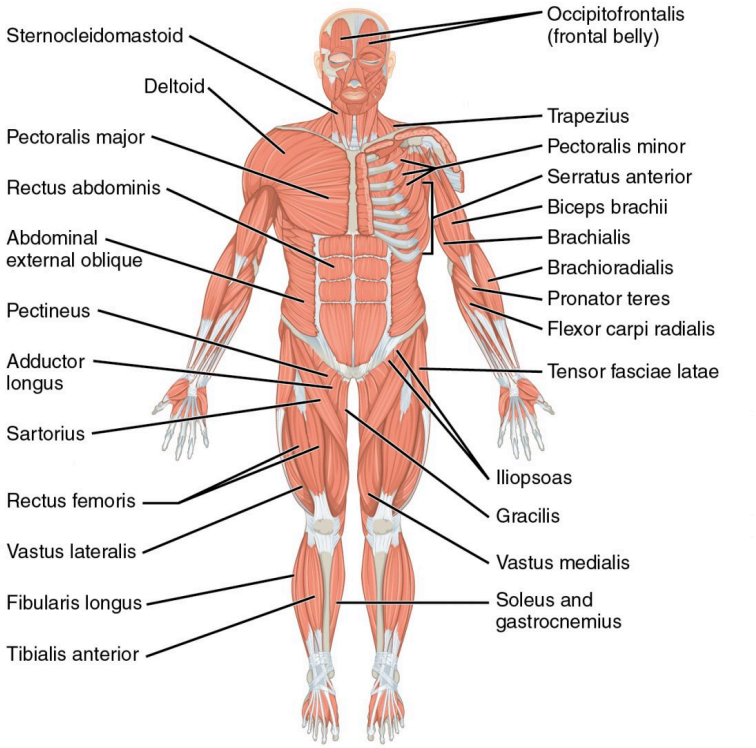
Did you know?

If all the muscles in the jaw worked together, it could close the teeth with a force as great as 200 pounds on the molars (Science Reference Section, 2019).

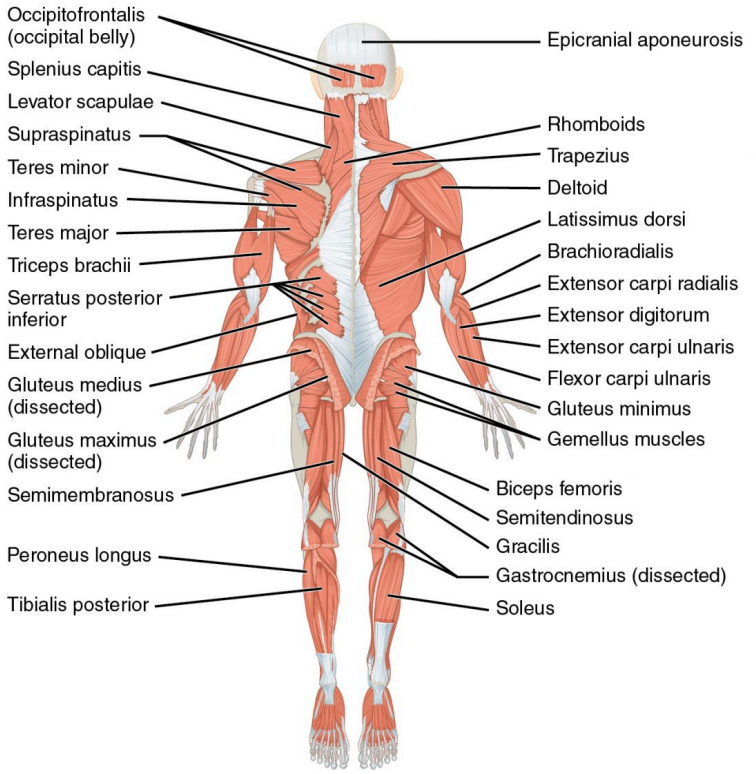
Naming of Muscles

There are many **nomenclatures** for naming muscles. Some of these include:

- **divisions** – biceps, triceps, quadriceps
- **size** – maximus (largest), minimus (smallest)
- **shape** – deltoid (triangular), trapezius (trapezoid)
- **action** – flexor (to flex), adductor (towards midline of the body)



Major muscles of the body.
Right side: superficial; left side: deep (anterior view)



Major muscles of the body.
Right side: superficial; left side: deep (posterior view)

Figure 7.2. Overview of the Muscular System. On the anterior and posterior views of the muscular system above, superficial muscles (those at the surface) are shown on the right side of the body while deep muscles (those underneath the superficial muscles) are shown on the left half of the body. For the legs, superficial muscles are shown in the anterior view while the posterior view shows both superficial and deep muscles. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Table 7.1. Understanding a Muscle Name from the Latin. Adapted from Betts et al., 2013. Licensed under CC BY 4.0.

EXAMPLE	WORD	LATIN ROOT 1	LATIN ROOT 2	MEANING	TRANSLATION
abductor digiti minimi	abductor	ab = away from	duct = to move	a muscle that moves away from	A muscle that moves the little finger or toe away
	digiti	digitus = digit	n/a	refers to a finger or toe	
	minimi	minimus = mini, tiny	n/a	little	
adductor digiti minimi	adductor	ad = to, toward	duct = to move	a muscle that moves towards	A muscle that moves the little finger or toe toward
	digiti	digitus = digit	n/a	refers to a finger or toe	
	minimi	minimus = mini, tiny	n/a	little	

Common Abbreviations for the Muscular System

Many terms and phrases related to the muscle system are abbreviated. Learn these common abbreviations by expanding the list below.

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Diseases and Disorders of the Muscle System

Duchenne Muscular Dystrophy

Duchenne Muscular Dystrophy (DMD) is caused by the inability of the body to make dystrophin (a muscle protein). This causes the muscles to become weak as the person ages. This disease primarily affects boys. Signs and symptoms typically present before the age of six and may include a delay of motor milestones and progressive weakness in the lower extremities and pelvis. Since all muscles are affected, the person will eventually require a wheelchair and assistance with breathing (National Human Genome Research Institute, 2013). To learn more, please visit the Genetic and Rare Diseases Information Center's web page on Duchenne Muscular Dystrophy.

Cerebral Palsy

Cerebral palsy (CP) is caused by an interruption to the normal development of a person's brain leading to weakness with muscles. Depending on the area of the brain that is affected, signs and symptoms will vary in the type and severity between individuals. Balance and coordination are often challenging due to the inability to control muscles (Centers for Disease Control and Prevention, n.d.). To learn more, please visit the Centers for Disease Control and Prevention's web page on cerebral palsy.

Carpal Tunnel Syndrome

Carpal tunnel syndrome may present with pain, numbness, or weakness to the hand(s) caused by pressure on the median nerve. Some causes for this pressure are repetitive movements, trauma or injury to the wrist, or fluid retention related to pregnancy or menopause (National Institute of Neurological Disorders and Stroke, 2020). To learn more, visit the National Institute of Neurological Disorders and Stroke web page on carpal tunnel.

Paralysis

Paralysis is the loss of strength and control of the muscles in parts of the body. Paralysis can be localized where it affects specific areas such as the face, feet, vocal cords, et cetera, or it can be generalized where it affects a larger area of the body. There are various types of generalized paralysis, including:

- **Paresis** – a partial paralysis wherein there is a moderate degree of muscular weakness
- **Paraplegia** – paralysis that affects the lower extremities and lower portions of the trunk
- **Quadriplegia** – affects all four limbs
- **Hemiplegia** – affects one side of the body. For example, the arm and leg on the same side of the body (National Library of Medicine, 2021)

To learn more about paralysis, please visit the Cleveland Clinic's web page on paralysis.

Sprain and Strain

A **sprain** is an injury to a joint whereby a ligament is stretched or torn. Joints can be sprained as a result of falling, twisting, or being hit. Sprains most often occur in the ankle, although other joints can be affected. Signs and symptoms of a sprain include pain, swelling, bruising, and an inability to use the joint (National Institute of Arthritis and Musculoskeletal and Skin Diseases, n.d.).

A **strain** is an injury to a muscle or a tendon caused by stretching or tearing. Tendons or muscles can be strained as a result of an injury, lifting heavy objects incorrectly, or overstress, and they can develop suddenly or over time. Signs and symptoms of a strain include pain, muscle spasms, swelling, cramping, and difficulty moving the muscle (National Institute of Arthritis and Musculoskeletal and Skin Diseases, n.d.).

Medical Terminology in Context

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Medical Specialties and Procedures Related to Muscular System

Orthopedic Surgeon

Orthopedic surgeons are medical doctors who have specialized training in the prevention, diagnosis, treatment, and surgery of disorders and diseases related to the musculoskeletal systems (Bureau of Labor Statistics, 2021). For more details, please visit the American College of Surgeons' web page on orthopedic surgery.

Massage Therapist

Massage therapists manipulate muscles and other soft tissues through touch to relieve pain, aid the injury-healing process, and reduce stress. Massage therapists generally have a postsecondary degree, although requirements vary by state (Bureau of Labor Statistics, 2021b). To learn more about massage therapy, visit the American Massage Therapy Association's web page.

Diagnostic Procedures

Electromyography (EMG) is a procedure that assesses the electrical signals muscles send while at rest and when they are used. During the test, a needle electrode is placed into the muscle, and a machine records the muscle activity. EMG can be used to diagnose myasthenia gravis, muscular dystrophy, and other conditions affecting the muscles (MedlinePlus, 2021a). To learn more, please visit the Medline Plus web page on electromyography.

Magnetic Resonance Imaging (MRI) is a test that uses radio waves and a magnetic field to view internal organs and structures. MRI tests are used to diagnose a variety of conditions, such as torn ligaments or tumors. They are also used to view the brain and spinal cord (Medline Plus, 2021b).

Range of Motion Testing is a diagnostic procedure used to determine the amount of movement around a specific joint.

Practice Terms Related to the Muscular System

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https://pressbooks.uwf.edu/medicalterminology/?p=156#h5p-125

Muscular System Vocabulary

Antagonistic
In opposition to each other.
Bradykinesia
Condition of slow movement.
Cardiac muscle
Involuntary and found only in the heart. Highly coordinated contractions pump blood into the vessels of the circulatory system.
Dyskinesia
Abnormal involuntary movements of the extremities, trunk, or jaw.
Electromyogram
Record of the electricity of the muscle.
Electromyography (EMG)

Recording of muscle electrical activity in response to a nerve's stimulation of the muscle.

Fibromyalgia

A common nonarticular rheumatic syndrome characterized by muscle pain.

Hemiplegia

Paralysis on one side of the body.

Hemostasis

The process by which the body seals a ruptured blood vessel to prevent further blood loss.

Hyperkinesia

Excessive movement of muscles of the body as a whole.

Hypertrophy

The enlargement of muscles.

Magnetic Resonance Imaging (MRI)

A procedure in which radio waves and a powerful magnet linked to a computer are used to create detailed pictures of areas inside the body.

Muscular dystrophy

A general term for the group of inherited myopathies that are characterized by wasting and weakness of the skeletal muscle.

Myalgia

Pain in a muscle or group of muscles.

Myasthenia Gravis

A disease in which antibodies made by a person's immune system prevent certain nerve-muscle interactions, causing weakness in the arms and legs, vision problems, and drooping eyelids or head.

Myeloma

Cancer that arises in plasma cells.

Paraplegia

Paralysis that affects both legs and lower part of the body.

Paresis

Partial paralysis wherein there is still some control of the muscles.

Polymyositis

An inflammatory disease of the muscles closest to the center of the body.

Quadriplegia

Paralysis of all four limbs.

Rhabdomyolysis

Necrosis or disintegration of skeletal muscle.

Skeletal muscle

The muscles responsible for voluntary muscle movement; also called striated muscle.

Smooth muscle

The muscles responsible for involuntary muscle movement; also called visceral muscle.

Sprain

The stretching or tearing of the supporting ligaments.

Strain

An overstretching or overexertion of a muscle or tendon.

Tendinitis

Inflammation of the tendon.

Test Yourself

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https://pressbooks.uwf.edu/medicalterminology/?p=156#h5p-97

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Image Descriptions

Figure 7.1 image description: The top panel shows a micrographic view of skeletal muscle. The middle panel shows a micrographic view of smooth muscle. The bottom panel shows a micrographic view of cardiac muscle. [Return to Figure 7.1].

Figure 7.2 image description: The top panel shows the anterior view of the human body with the major muscles

labeled. Labels read (from the top, head): occipitofrontalis (frontal belly), sternocleidomastoid, trapezius, deltoid, pectoralis minor, serratus anterior, pectoralis major, arm muscles: biceps brachii, brachialis, brachioradialis, pronator teres, flexor carpi radialis, abdominal: rectus abdominis, abdominal external oblique, lower body: tensor fasciae latae, iliopsoas, pectineus, adductor longus, sartorius, gracilis, rectus femoris, vastus lateralis, vastus medialis, fibularis longus, tibialis anterior. The bottom panel shows the posterior view of the human body with the major muscles labeled. Labels read (from the top, head, left side): epicranial aponeurosis, occipitofrontalis, splenius capitis, levator scapulae, rhombus, trapezius, supraspinatus, teres minor, infraspinatus, teres major, triceps brachii, serratus posterior inferior, external oblique, lower body: gluteus medius, gluteus maximus, semimembranosus, peroneus longus, tibialis posterior, (right side, from top) trapezius, deltoid, latissimus dorsi, arm: brachioradialis, extensor carpi radialis, extensor digitorum, extensor carpi ulnaris, flexor carpi ulnaris, lower body: gluteus minimus, gemellus muscles, biceps femoris, semitendinosus, gracilis, gastrocnemius, soleus. [Return to Figure 7.2].

8. Nervous System

Learning Objectives

- Examine the anatomy of the nervous system
- Determine the main functions of the nervous system
- Differentiate the medical terms of the nervous system and common abbreviations
- Recognize the medical specialties associated with the nervous system
- Discover common diseases, disorders, and procedures related to the nervous system

Nervous System Word Parts

Click on prefixes, combining forms, and suffixes to reveal a list of word parts to memorize for the Nervous System.

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https://pressbooks.uwf.edu/medicalterminology/?p=181#h5p-108

Introduction to the Nervous System

The picture you have in your mind of the nervous system probably includes the **brain**, the **nervous tissue** contained within the cranium, and the **spinal cord**, the extension of nervous tissue within the vertebral column. That suggests it is made of two organs—and you may not even think of the spinal cord as an organ—but the nervous system is a very complex structure. Within the brain, many different and separate regions are responsible for many different and separate functions. It is as if the nervous system is composed of many organs that all look similar and can only be differentiated using tools such as the **microscope** or **electrophysiology**.

Watch this video:

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Media 8.1 The Nervous System, Part 1: Crash Course A&P #8 [Online video]. Copyright 2015 by CrashCourse.

Practice Medical Terms Related to the Nervous System

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Anatomy (Structures) of the Nervous System

The Central and Peripheral Nervous Systems

The nervous system can be divided into two major regions: the central and peripheral nervous systems. The **central nervous system (CNS)** is the brain and spinal cord, and the **peripheral nervous system (PNS)** is everything else (see Figure 8.1). The brain is contained within the cranial cavity of the skull, and the spinal cord is contained within the vertebral cavity of the vertebral column. It is a bit of an oversimplification to say that the CNS is what is inside these two cavities and the peripheral nervous system is outside of them, but that is one way to start to think about it. In actuality, there are some elements of the peripheral nervous system that are within the cranial or vertebral cavities. The peripheral nervous system is so named because it is on the periphery—meaning beyond the brain and spinal cord. Depending on different aspects of the nervous system, the dividing line between central and peripheral is not necessarily universal.

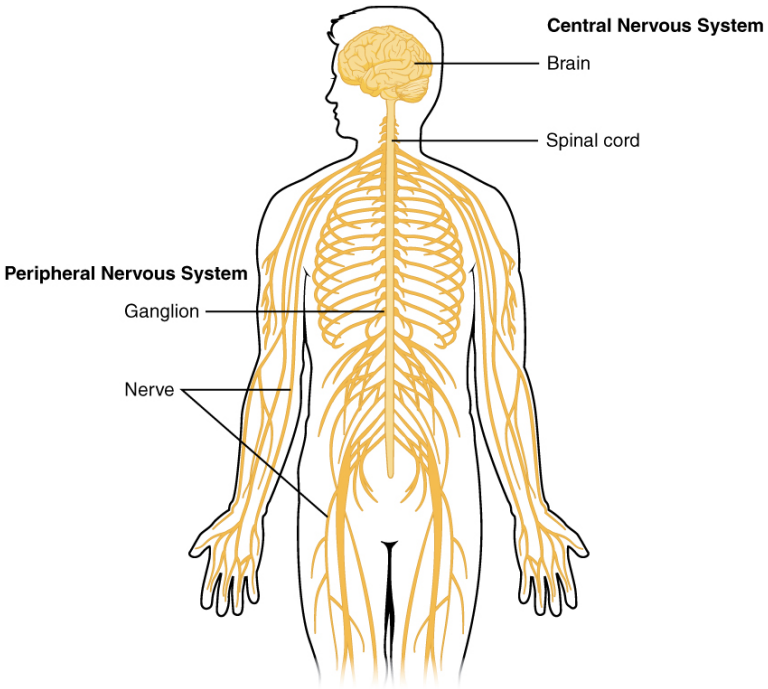

Figure 8.1 Central and Peripheral Nervous System. The structures of the PNS are referred to as ganglia and nerves, which can be seen as distinct structures. The equivalent structures in the CNS are not obvious from this overall perspective and are best examined in prepared tissue under the microscope. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Nervous tissue, present in both the CNS and PNS, contains two basic types of cells: neurons and glial cells. **Neurons** are the primary type of cell that most anyone associates with the nervous system. They are responsible for the computation and communication that the nervous system provides. They are electrically active and release chemical signals to target cells. Glial cells, or **glia**, are known to play a supporting role for nervous tissue. Ongoing research pursues an expanded role that glial cells might play in signaling, but neurons are still considered the basis of this function. Neurons are important, but without glial support, they would not be able to perform their function. A glial cell is one of a variety of cells that provide a framework of tissue that supports the neurons and their activities. The neuron is the more functionally important of the two, in terms of the communicative function of the nervous system. To describe the functional divisions of the nervous system, it is important to understand the structure of a neuron.

Neurons are cells and therefore have a **soma,** or cell body, but they also have extensions of the cell; each extension is generally referred to as a process. There is one important process that every neuron has called an **axon**, which is the fiber that connects a neuron with its target. Another type of process that branches off from the soma is the dendrite. **Dendrites** are responsible for receiving most of the input from other neurons.

Looking at nervous tissue, some regions predominantly contain cell bodies and regions that are largely composed of just axons. These two regions within nervous system structures are often referred to as **gray matter** (the regions with many cell bodies and dendrites) or **white matter** (the regions with many axons). Figure 8.2 demonstrates the appearance of these regions in the brain and spinal cord. The colors ascribed to these regions are what would be seen in "fresh," or unstained, nervous tissue. Gray matter is not necessarily gray. It can be pinkish because of blood content, or even slightly tan, depending on how long the tissue has been preserved. White matter is white because axons are insulated by a lipid-rich substance called myelin. Lipids can appear as white ("fatty") material, much like the fat on a raw piece of chicken or beef. Gray matter may have that color ascribed to it because next to the white matter, it is just darker—hence, gray.

The distinction between **gray matter** and **white matter** is most often applied to central nervous tissue, which has

large regions that can be seen with the unaided eye. When looking at peripheral structures, often a microscope is used and the tissue is stained with artificial colors. That is not to say that central nervous tissue cannot be stained and viewed under a microscope, but unstained tissue is most likely from the CNS—for example, a frontal section of the brain or cross-section of the spinal cord.

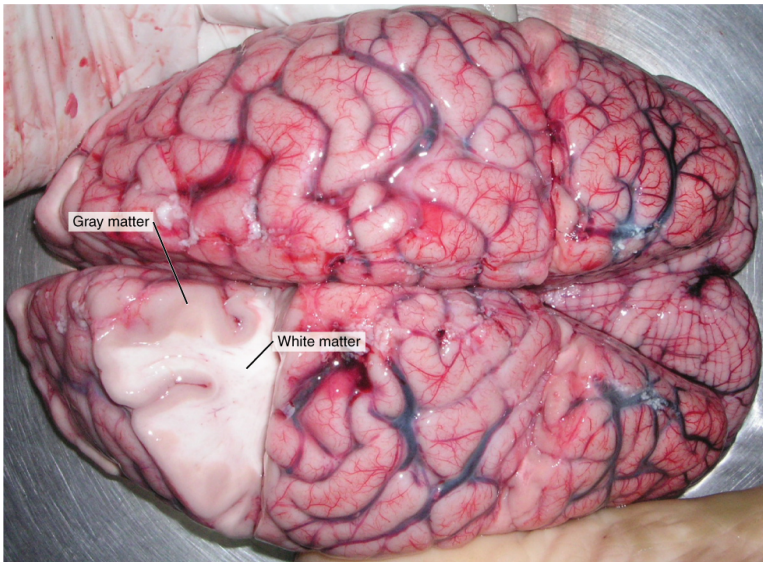

Figure 8.2 Gray Matter and White Matter. A brain removed during an autopsy, with a partial section removed, shows white matter surrounded by gray matter. Gray matter makes up the outer cortex of the brain. (credit: modification of work by "Suseno"/Wikimedia Commons). From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Did you know?

The brain has over 100 billion neurons.

The Adult Brain

The adult brain is separated into four major regions: the cerebrum, the diencephalon, the brain stem, and the cerebellum. The cerebrum is the largest portion and contains the cerebral cortex and subcortical nuclei. It is divided into two halves by the longitudinal fissure.

The Cerebrum

The iconic gray mantle of the human brain, which appears to make up most of the mass of the brain, is the **cerebrum** (see Figure 8.3). The wrinkled portion is the cerebral cortex, and the rest of the structure is beneath that outer covering. There is a large separation between the two sides of the cerebrum called the **longitudinal** fissure. It separates the cerebrum into two distinct halves, a right and left **cerebral hemisphere**. Deep within the cerebrum, the white matter of the corpus callosum provides the major pathway for communication between the two hemispheres of the cerebral cortex.

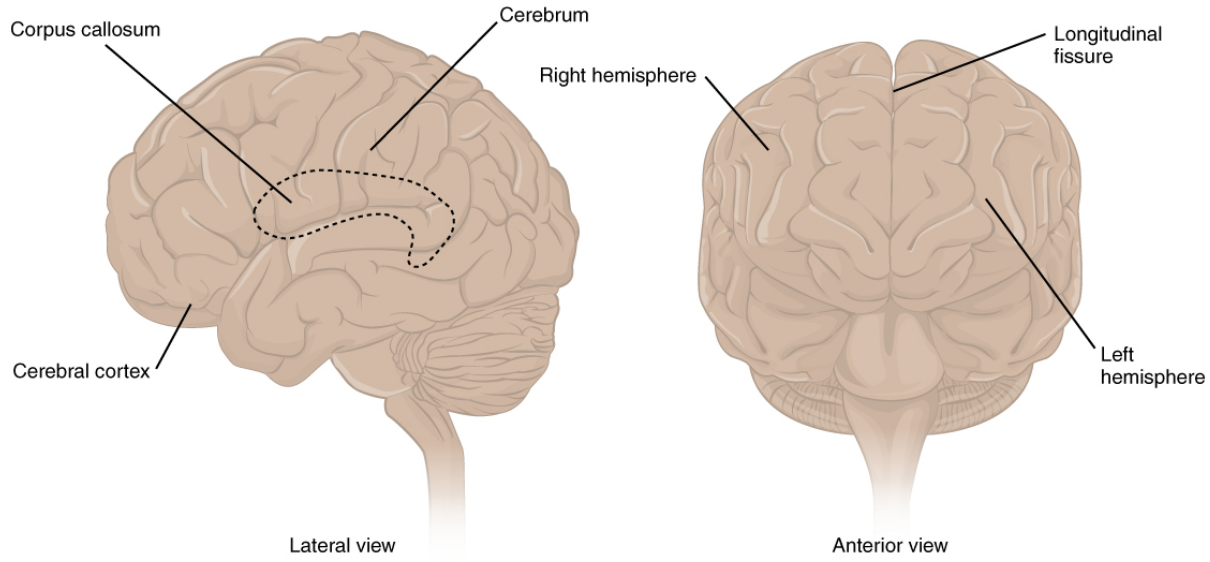

Figure 8.3 The Cerebrum. The cerebrum is a large component of the CNS in humans, and the most obvious aspect of it is the folded surface called the cerebral cortex. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Many of the higher neurological functions, such as memory, emotion, and consciousness, are the result of cerebral function. The complexity of the cerebrum is different across vertebrate species. The cerebrum of the most primitive vertebrates is not much more than the connection for the sense of smell. In mammals, the cerebrum comprises the outer gray matter that is the cortex (from the Latin word meaning “bark of a tree”) and several deep nuclei that belong to three important functional groups. The basal nuclei are responsible for cognitive processing, the most important function being that associated with planning movements. The basal forebrain contains nuclei that are important in learning and memory. The limbic cortex is the region of the cerebral cortex that is part of the limbic system, a collection of structures involved in emotion, memory, and behavior.

Did you know?

The brain is about 75% water and is the fattest organ in the body.

Cerebral Cortex

The cerebrum is covered by a continuous layer of gray matter that wraps around either side of the forebrain—the **cerebral cortex**. This thin, extensive region of wrinkled gray matter is responsible for the higher functions of the nervous system. A gyrus (plural = gyri) is the ridge of one of those wrinkles, and a sulcus (plural = sulci) is the groove between two gyri. The pattern of these folds of tissue indicates specific regions of the cerebral cortex.

The head is limited by the size of the birth canal, and the brain must fit inside the cranial cavity of the skull. Extensive folding in the cerebral cortex enables more gray matter to fit into this limited space. If the gray matter of the cortex were peeled off of the cerebrum and laid out flat, its surface area would be roughly equal to one square meter.

The folding of the cortex maximizes the amount of gray matter in the cranial cavity. During embryonic development, as the **telencephalon** expands within the skull, the brain goes through a regular course of growth that results in everyone's brain having a similar pattern of folds. The surface of the brain can be mapped based on the locations of large gyri and sulci. Using these landmarks, the cortex can be separated into four major regions, or lobes (see Figure 8.4). The lateral sulcus that separates the temporal lobe from the other regions is one such landmark. Superior to the lateral sulcus is the **parietal lobe** and **frontal lobe**, which are separated from each other by the **central sulcus**. The posterior region of the cortex is the **occipital lobe**, which has no obvious anatomical border between it and the parietal or temporal lobes on the lateral surface of the brain. From the medial surface, an obvious landmark separating the parietal and occipital lobes is called the parieto-occipital sulcus. The fact that there is no obvious anatomical border between these lobes is consistent with the functions of these regions being interrelated.

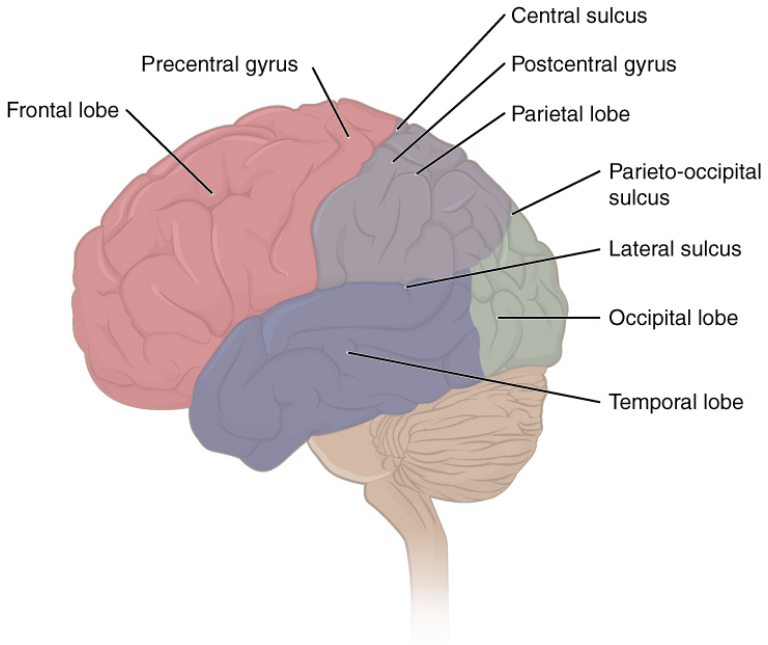

Figure 8.4 Lobes of the Cerebral Cortex. The cerebral cortex is divided into four lobes. Extensive folding increases the surface area available for cerebral functions. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Concept Check

- Identify the two major divisions of the nervous system.
- Describe the **cerebral cortex.**
- What are the halves of the cerebrum known as?

The Diencephalon

The diencephalon is deep beneath the cerebrum and constitutes the walls of the third ventricle. The diencephalon can be described as any region of the brain with "thalamus" in its name. The two major regions of the diencephalon are the thalamus itself and the hypothalamus (see Figure 8.5). There are other structures, such as the epithalamus, which contains the pineal gland, or the subthalamus, which includes the subthalamic nucleus that is part of the basal nuclei.

Thalamus

The **thalamus** is a collection of nuclei that relay information between the cerebral cortex and the periphery, spinal cord, or brainstem. All sensory information, except for the sense of smell, passes through the thalamus before processing by the cortex. For example, the portion of the thalamus that receives visual information will influence what visual stimuli are important, or what receives attention.

The cerebrum also sends information down to the thalamus, which usually communicates motor commands. This involves interactions with the cerebellum and other nuclei in the brainstem. The cerebrum interacts with the basal nuclei, which involves connections with the thalamus. The primary output of the basal nuclei is to the thalamus, which relays that output to the cerebral cortex. The cortex also sends information to the thalamus that will then influence the effects of the basal nuclei.

Hypothalamus

Inferior and slightly anterior to the thalamus is the **hypothalamus**, the other major region of the diencephalon. The hypothalamus is a collection of nuclei that are largely involved in regulating homeostasis. The hypothalamus is the executive region in charge of the **autonomic nervous system** and the endocrine system through its regulation of the anterior pituitary gland. Other parts of the hypothalamus are involved in memory and emotion as part of the limbic system.

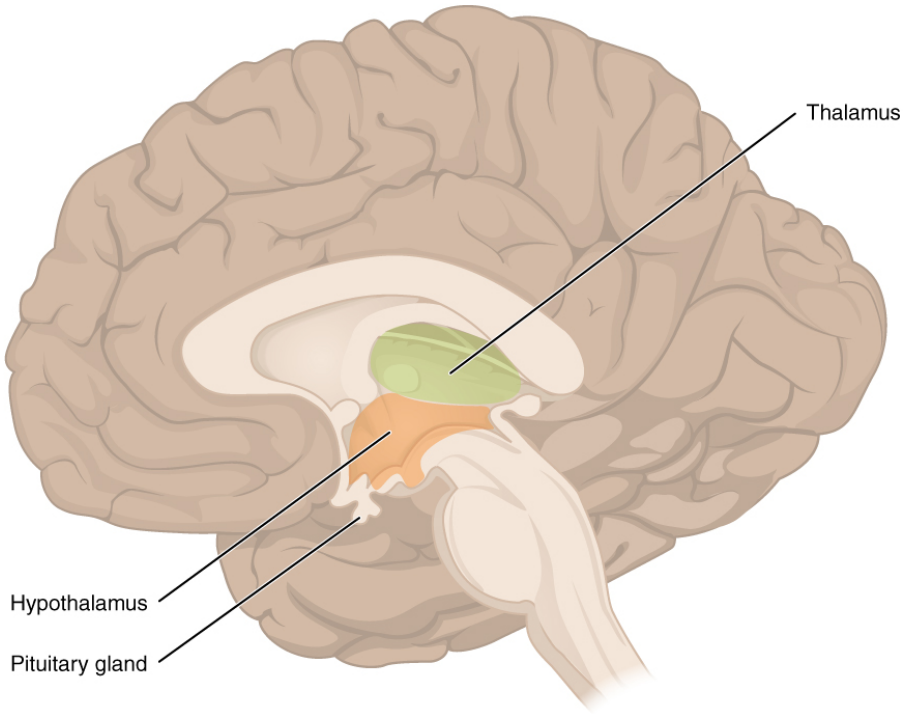

Figure 8.5 The Diencephalon. The diencephalon is composed primarily of the thalamus and hypothalamus, which together define the walls of the third ventricle. The thalami are two elongated, ovoid structures on either side of the midline that make contact in the middle. The hypothalamus is inferior and anterior to the thalamus, culminating in a sharp angle to which the pituitary gland is attached. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Brain Stem

The midbrain and hindbrain (composed of the **pons** and the **medulla**) are collectively referred to as the brain stem (see Figure 8.6). The structure emerges from the ventral surface of the forebrain as a tapering cone that connects the brain to the spinal cord. Attached to the brain stem but considered a separate region of the adult brain is the cerebellum. The midbrain coordinates sensory representations of the visual, auditory, and somatosensory perceptual spaces. The pons is the main connection with the cerebellum. The pons and the medulla regulate several crucial functions, including the cardiovascular and respiratory systems and rates.

The cranial nerves connect through the brain stem and provide the brain with the sensory input and motor output associated with the head and neck, including most of the special senses. The major ascending and descending pathways between the spinal cord and brain, specifically the cerebrum, pass through the brain stem.

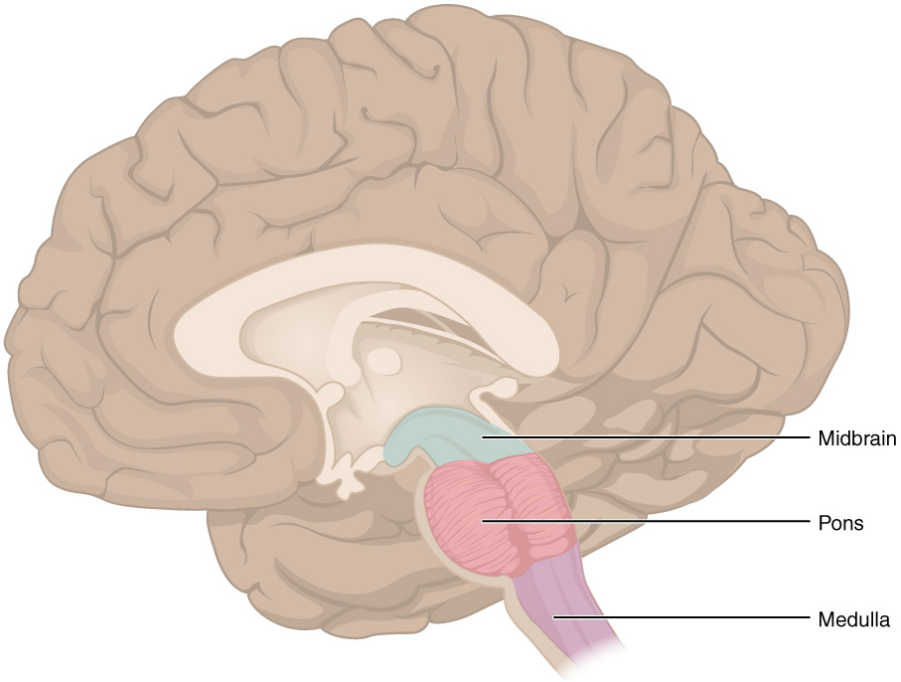

Figure 8.6 The Brain Stem. The brain stem comprises three regions: the midbrain, the pons, and the medulla. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Midbrain

One of the original regions of the embryonic brain, the midbrain is a small region between the thalamus and pons. It is separated into the **tectum** and **tegmentum**, from the Latin words for roof and floor, respectively. The cerebral aqueduct passes through the center of the midbrain, such that these regions are the roof and floor of that canal.

Pons

The word **pons** comes from the Latin word for bridge. It is visible on the anterior surface of the brain stem as the thick bundle of white matter attached to the cerebellum. The pons is the main connection between the cerebellum and the brain stem. The bridge-like white matter is only the anterior surface of the pons; the gray matter beneath that is a

continuation of the tegmentum from the midbrain. Gray matter in the tegmentum region of the pons contains neurons receiving descending input from the forebrain that is sent to the cerebellum.

Medulla

The medulla is the region known as the **myelencephalon** in the embryonic brain. The initial portion of the name, "myel," refers to the significant white matter found in this region—especially on its exterior, which is continuous with the white matter of the spinal cord. The tegmentum of the midbrain and pons continues into the medulla because this gray matter is responsible for processing cranial nerve information. A diffuse region of gray matter throughout the brain stem, known as the reticular formation, is related to sleep and wakefulness, such as general brain activity and attention.

The Cerebellum

The cerebellum, as the name suggests, is the "little brain." It is covered in **gyri** and sulci like the cerebrum and looks like a miniature version of that part of the brain (see Figure 8.7). The cerebellum is largely responsible for comparing information from the cerebrum with sensory feedback from the periphery through the spinal cord. It accounts for approximately 10% of the mass of the brain.

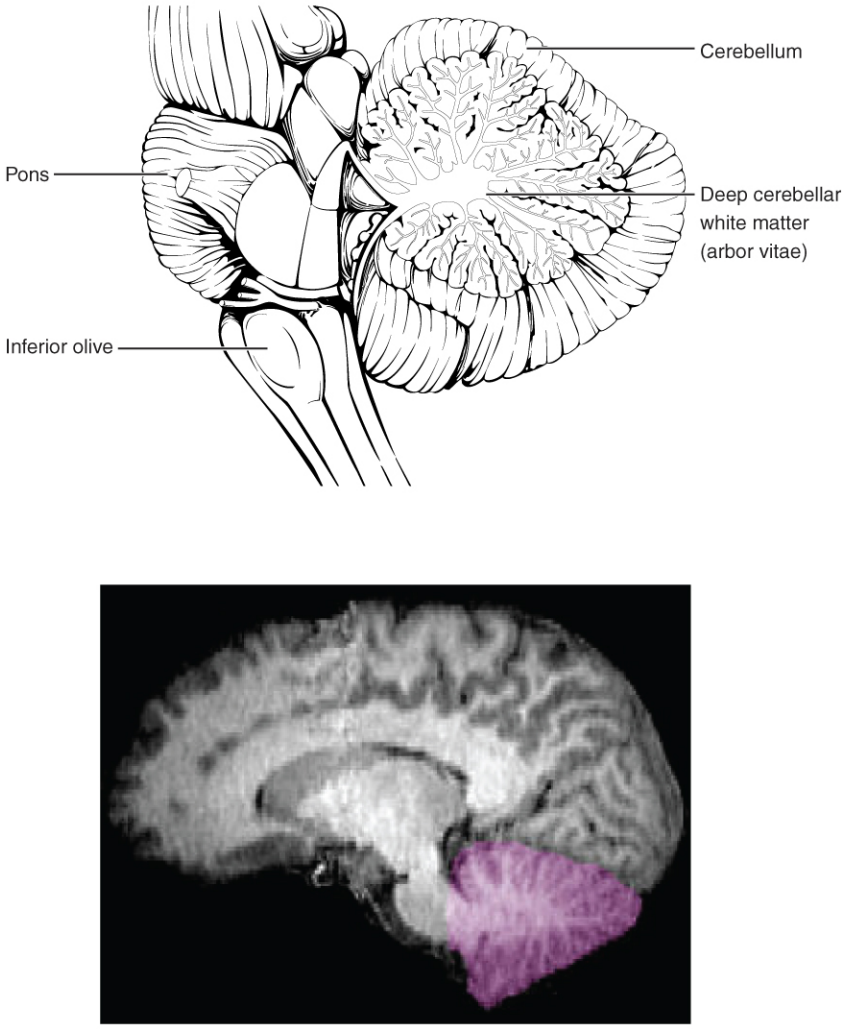

Figure 8.7 The Cerebellum. The cerebellum is situated on the posterior surface of the brain stem. Descending input from the cerebellum enters through the large white matter structure of the pons. Ascending input from the periphery and spinal cord enters through the fibers of the inferior olive. Output goes to the midbrain, which sends a descending signal to the spinal cord. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Concept Check

- What is the primary processing purpose of the **medulla**?
- Identify the structure in the brain responsible for sensory feedback through the spinal cord. Suggest what may happen if this function fails.

The Spinal Cord

The description of the CNS is concentrated on the structures of the brain, but the spinal cord is another major organ of the system. Whereas the brain develops out of expansions of the neural tube into primary and then secondary vesicles, the spinal cord maintains the tube structure and is only specialized into certain regions. As the spinal cord continues to develop in the newborn, anatomical features mark its surface. The anterior midline is marked by the anterior median fissure, and the posterior midline is marked by the posterior median sulcus. Axons enter the posterior side through the dorsal (posterior) nerve root, which marks the posterolateral sulcus on either side. The axons emerging from the anterior side do so through the ventral (anterior) nerve root. Note that it is common to see the terms dorsal (dorsal = "back") and ventral (ventral = "belly") used interchangeably with posterior and anterior, particularly in reference to nerves and the structures of the spinal cord. You should learn to be comfortable with both.

On the whole, the posterior regions are responsible for sensory functions and the anterior regions are associated with motor functions. This comes from the initial development of the spinal cord, which is divided into the basal plate and the alar plate. The basal plate is closest to the ventral midline of the neural tube, which will become the anterior face of the spinal cord and gives rise to motor neurons. The alar plate is on the dorsal side of the neural tube and gives rise to neurons that will receive sensory input from the periphery.

The length of the spinal cord is divided into regions that correspond to the regions of the vertebral column. The name of a spinal cord region corresponds to the level at which spinal nerves pass through the intervertebral foramina. Immediately adjacent to the brain stem are the following divisions of the spinal cord:

- cervical region
- thoracic region
- lumbar region
- sacral region.

The spinal cord is not the full length of the vertebral column because the spinal cord does not grow significantly longer after the first or second year, but the skeleton continues to grow. The nerves that emerge from the spinal cord pass through the intervertebral **foramina** at the respective levels. As the vertebral column grows, these nerves grow with it and result in a long bundle of nerves that resembles a horse's tail and is named the **cauda equina**. The sacral spinal cord is at the level of the upper lumbar vertebral bones. The spinal nerves extend from their various levels to the proper level of the vertebral column.

Did you know?

The bundle of nerve fibers making up the spinal cord is no thicker than the human thumb.

Neurons

Neurons are the cells considered to be the basis of nervous tissue. They are responsible for the electrical signals that communicate information about sensations, and that produce movements in response to those stimuli, along with inducing thought processes within the brain. An important part of the function of neurons is in their structure or shape. The three-dimensional shape of these cells makes the immense number of connections within the nervous system possible.

Parts of a Neuron

As you learned in the first section, the main part of a neuron is the **cell body**, which is also known as the soma (soma = "body"). The cell body contains the nucleus and most of the major organelles. What makes neurons special is that they have many extensions of their cell membranes, which are generally referred to as processes. Neurons are usually described as having one, and only one, axon—a fiber that emerges from the cell body and projects to target cells. That single axon can branch repeatedly to communicate with many **target** cells. It is the axon that **propagates** the nerve impulse, which is communicated to one or more cells. The other processes of the neuron are dendrites, which receive information from other neurons at specialized areas of contact called synapses. The dendrites are usually highly branched processes, providing locations for other neurons to communicate with the cell body. Information flows through a neuron from the dendrites, across the cell body, and down the axon. This gives the neuron a polarity—meaning that information flows in this one direction. Figure 8.8 shows the relationship of these parts to one another.

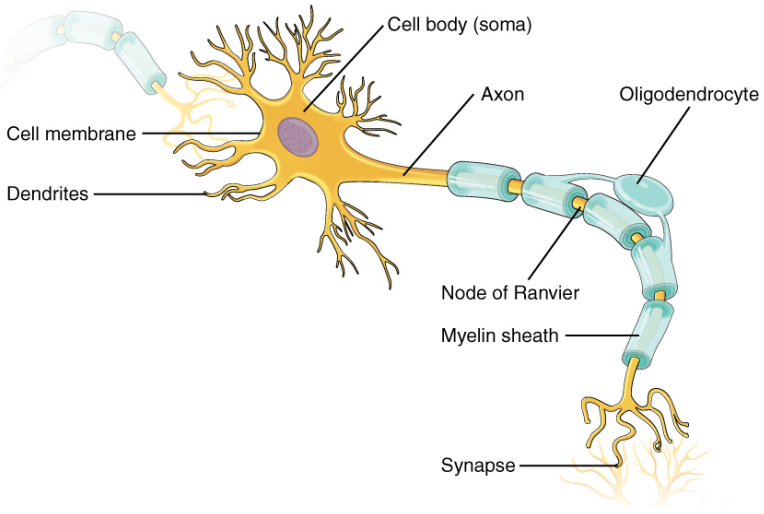

Figure 8.8 Parts of a Neuron. The major parts of the neuron are labeled on a multipolar neuron from the CNS. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Where the axon emerges from the cell body, there is a special region referred to as the **axon hillock**. This is a tapering of the cell body toward the axon fiber. Within the axon hillock, the cytoplasm changes to a solution of limited components called **axoplasm**. Because the axon hillock represents the beginning of the axon, it is also referred to as the initial segment.

Many axons are wrapped by an insulating substance called myelin, which is made from glial cells. Myelin acts as

insulation much like the plastic or rubber that is used to insulate electrical wires. A key difference between **myelin** and the insulation on a wire is that there are gaps in the myelin covering of an axon. Each gap is called a node of Ranvier and is important to the way that electrical signals travel down the axon. The length of the axon between each gap, which is wrapped in myelin, is referred to as an axon segment. At the end of the axon is the axon terminal, where there are usually several branches extending toward the target cell, each of which ends in an enlargement called a synaptic end bulb. These bulbs are what make the connection with the target cell at the synapse.

Types of Neurons

There are many neurons in the nervous system—a number in the trillions. And there are many different types of neurons. They can be classified by many different criteria. The first way to classify them is by the number of processes attached to the cell body. Using the standard model of neurons, one of these processes is the axon, and the rest are dendrites. Because information flows through the neuron from dendrites or cell bodies toward the axon, these names are based on the neuron's polarity (see Figure 8.9).

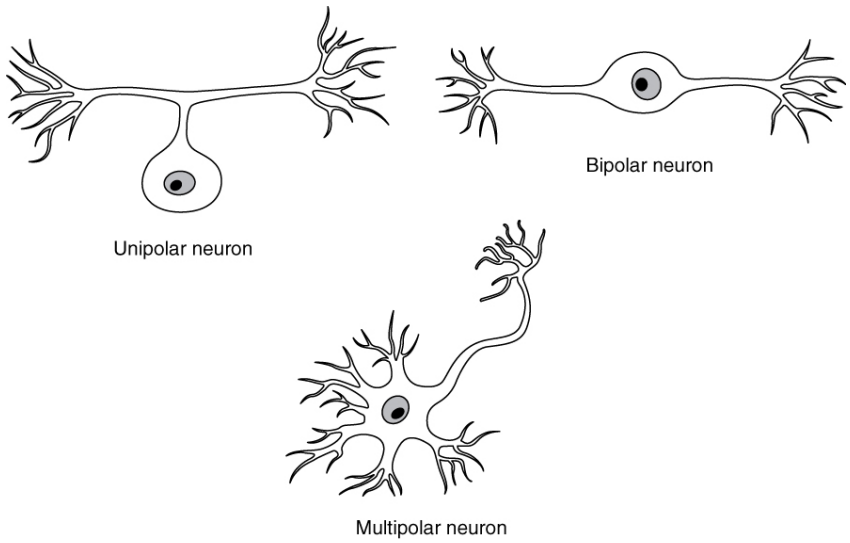

Figure 8.9 Neuron Classification by Shape. Unipolar cells have one process that includes both the axon and dendrite. Bipolar cells have two processes, the axon, and a dendrite. Multipolar cells have more than two processes, the axon, and two or more dendrites. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Unipolar cells have only one process emerging from the cell. True unipolar cells are only found in invertebrate animals, so the unipolar cells in humans are more appropriately called "pseudo-unipolar" cells. Invertebrate unipolar cells do not have dendrites.

Bipolar cells have two processes, which extend from each end of the cell body, opposite to each other. One is the axon and one the dendrite. Bipolar cells are not very common. They are found mainly in the olfactory epithelium (where smell stimuli are sensed), and as part of the retina.

Multipolar neurons are all of the neurons that are not unipolar or bipolar. They have one axon and two or more dendrites (usually many more). With the exception of the unipolar sensory ganglion cells, and the two specific bipolar cells mentioned above, all other neurons are multipolar.

Neurons can also be classified on the basis of where they are found, who found them, what they do, or even what chemicals they use to communicate with each other. Some neurons referred to in this section on the nervous system

are named on the basis of those sorts of classifications (see Figure 8.10). For example, a multipolar neuron that has a very important role to play in a part of the brain called the cerebellum is known as a Purkinje (commonly pronounced per-KIN-gee) cell. It is named after the anatomist who discovered it (Jan Evangilista Purkinje, 1787–1869).

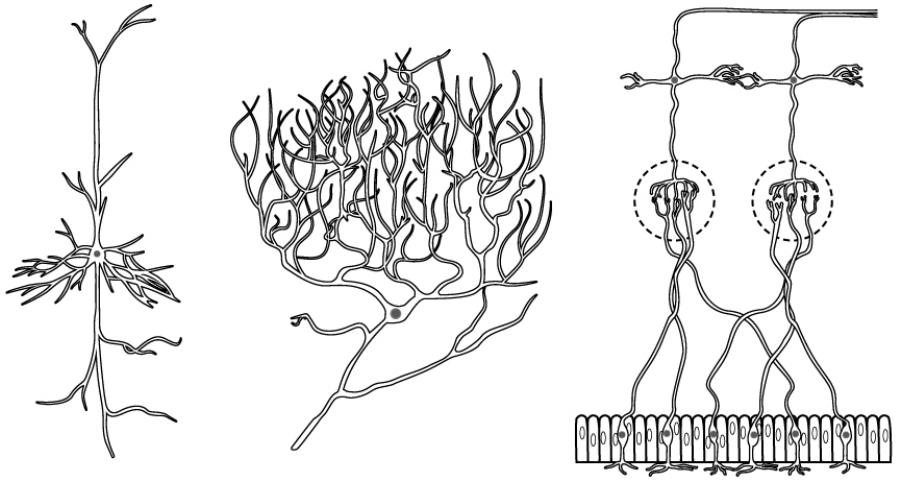

Figure 8.10 Other Neuron Classifications. Three examples of neurons that are classified on the basis of other criteria. (a) The pyramidal cell is a multipolar cell with a cell body that is shaped something like a pyramid. (b) The Purkinje cell in the cerebellum was named after the scientist who originally described it. (c) Olfactory neurons are named for the functional group to which they belong. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Glial Cells

Glial cells, or neuroglia or simply glia, are the other type of cell found in nervous tissue. They are considered to be supporting cells, and many functions are directed at helping neurons complete their function for communication. The name glia comes from the Greek word that means "glue," and was coined by the German pathologist Rudolph Virchow, who wrote in 1856, "This connective substance, which is in the brain, the spinal cord, and the special sense nerves, is a kind of glue (neuroglia) in which the nervous elements are planted." Today, research into nervous tissue has shown that there are many deeper roles that these cells play, and research may find much more about them in the future.

There are six types of glial cells. Four of them are found in the CNS and two are found in the PNS. Table 8.1 outlines some common characteristics and functions.

Table 8.1: Glial Cell Types by Location and Basic Function. From Betts et al., 2013. Licensed under CC BY 4.0.

CNS GLIA	PNS GLIA	BASIC FUNCTION
Astrocyte	Satellite cell	Support
Oligodendrocyte	Schwann cell	Insulation, myelination
Microglia	–	Immune surveillance and phagocytosis
Ependymal cell	–	Creating CSF

Glial Cells of the CNS

One cell providing support to neurons of the CNS is the astrocyte, so named because it appears to be star-shaped under the microscope (astro- = "star"). **Astrocytes** have many processes extending from their main cell body (not axons or dendrites like neurons, just cell extensions). Those processes extend to interact with neurons, blood vessels, or the connective tissue covering the CNS that is called the pia mater (see Figure 8.11). Generally, they are supporting cells for the neurons in the central nervous system. Some ways in which they support neurons in the central nervous system are by maintaining the concentration of chemicals in the extracellular space, removing excess signaling molecules, reacting to tissue damage, and contributing to the **blood-brain barrier** (BBB). The blood-brain barrier is a physiological barrier that keeps many substances that circulate in the rest of the body from getting into the central nervous system, restricting what can cross from circulating blood into the CNS. Nutrient molecules, such as glucose or amino acids, can pass through the BBB, but other molecules cannot. This actually causes problems with drug delivery to the CNS. Pharmaceutical companies are challenged to design drugs that can cross the BBB as well as have an effect on the nervous system.

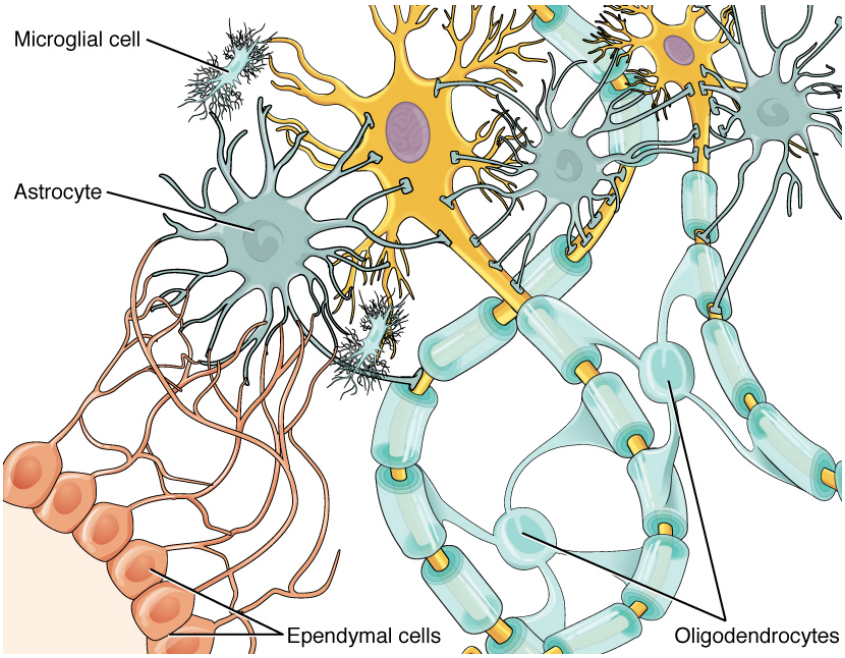

Figure 8.11 Glial Cells of the CNS. The CNS has astrocytes, oligodendrocytes, microglia, and ependymal cells that support the neurons of the CNS in several ways. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Like a few other parts of the body, the brain has a privileged blood supply. Very little can pass through by diffusion. Most substances that cross the wall of a blood vessel into the CNS must do so through an active transport process. Because of this, only specific types of molecules can enter the CNS. Glucose—the primary energy source—is allowed, as are amino acids. Water and some other small particles, like gases and ions, can enter, but most everything else cannot, including white blood cells, which are one of the body's main lines of defense. While this barrier protects the CNS from exposure to toxic or pathogenic substances, it also keeps out the cells that could protect the brain and spinal cord from disease and damage. The BBB also makes it harder for pharmaceuticals to be developed that can affect the nervous system. Aside from finding efficacious substances, the means of delivery is also crucial.

Oligodendrocyte, sometimes called just "oligo," is the glial cell type that insulates axons in the CNS. The name means

"cell of a few branches" (oligo- = "few"; dendro- = "branches"; -cyte = "cell"). There are a few processes that extend from the cell body. Each one reaches out and surrounds an axon to insulate it in myelin.

Microglia are, as the name implies, smaller than most of the other glial cells. Ongoing research into these cells, although not entirely conclusive, suggests that they may originate as white blood cells, called macrophages, that become part of the CNS during early development. While their origin is not conclusively determined, their function is related to what macrophages do in the rest of the body. When macrophages encounter diseased or damaged cells in the rest of the body, they ingest and digest those cells or the pathogens that cause disease. Microglia are the cells in the CNS that can do this in normal, healthy tissue, and they are therefore also referred to as CNS-resident macrophages.

The **ependymal** cell is a glial cell that filters blood to make cerebrospinal fluid (CSF), the fluid that circulates through the CNS. Because of the privileged blood supply inherent in the BBB, the extracellular space in nervous tissue does not easily exchange components with the blood. Ependymal cells line each ventricle, one of four central cavities that are remnants of the hollow center of the neural tube formed during the embryonic development of the brain. They also have cilia on their apical surface to help move the CSF through the ventricular space. The relationship of these glial cells to the structure of the CNS is seen in Figure 8.11.

Glial Cells of the PNS

One of the two types of glial cells found in the PNS is the **satellite** cell. Satellite cells are found in sensory and autonomic ganglia, where they surround the cell bodies of neurons. This accounts for the name, based on their appearance under the microscope. They provide support, performing similar functions in the periphery as astrocytes do in the CNS—except, of course, for establishing the BBB.

The second type of glial cell is the **Schwann** cell, which insulates axons with myelin in the periphery. Schwann cells are different from oligodendrocytes in that a Schwann cell wraps around a portion of only one axon segment and no others. Oligodendrocytes have processes that reach out to multiple axon segments, whereas the entire Schwann cell surrounds just one axon segment. The nucleus and cytoplasm of the Schwann cell are on the edge of the myelin sheath. The relationship of these two types of glial cells to ganglia and nerves in the PNS is seen in Figure 8.12.

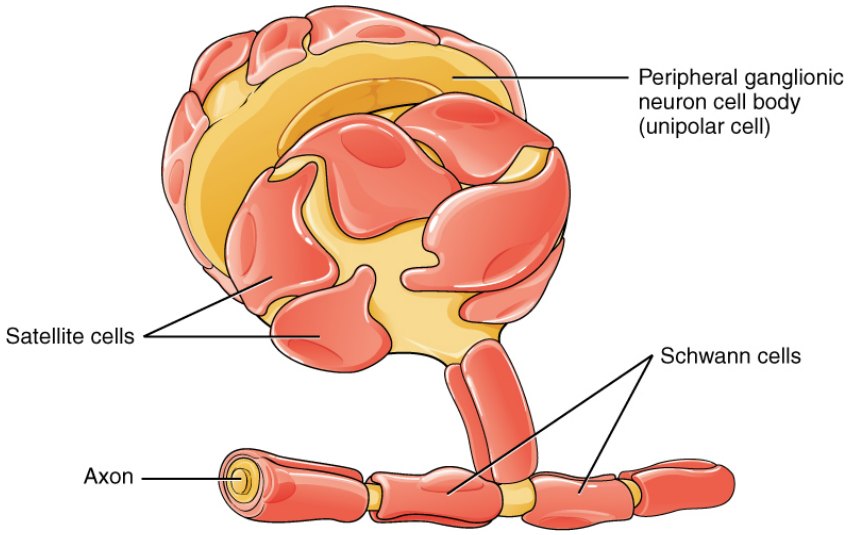

Figure 8.12 Glial Cells of the PNS. The PNS has satellite cells and Schwann cells. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Myelin

The appearance of the myelin sheath can be thought of as similar to the pastry wrapped around a hot dog for "pigs in a blanket" or similar food. The glial cell is wrapped around the axon several times with little to no cytoplasm between the glial cell layers. For **oligodendrocytes**, the rest of the cell is separate from the myelin sheath as a cell process extends back toward the cell body. A few other processes provide the same insulation for other axon segments in the area. For Schwann cells, the outermost layer of the cell membrane contains cytoplasm and the nucleus of the cell as a bulge on one side of the myelin sheath. During development, the glial cell is loosely or incompletely wrapped around the axon. The edges of this loose enclosure extend toward each other, and one end tucks under the other. The inner edge wraps around the axon, creating several layers, and the other edge closes around the outside so that the axon is completely enclosed.

Anatomy Labeling Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://pressbooks.uwf.edu/medicalterminology/?p=181#h5p-110

Physiology (Function) of the Nervous System

The nervous system is involved in receiving information about the environment around us (sensation) and generating responses to that information (motor responses). The nervous system can be divided into regions that are responsible for sensation (sensory functions) and the response (motor functions), but there is a third function that needs to be included. Sensory input needs to be integrated with other sensations, as well as with memories, emotional state, or learning (cognition). Some regions of the nervous system are termed integration or association areas. The process of integration combines sensory perceptions and higher cognitive functions such as memories, learning, and emotion to produce a response.

Sensation

The first major function of the nervous system is sensation—receiving information about the environment to gain input about what is happening outside the body (or, sometimes, within the body). The sensory functions of the nervous system register the presence of a change from homeostasis or a particular event in the environment, known as a stimulus. The senses we think of most are the "big five": taste, smell, touch, sight, and hearing. The stimuli for taste and smell are both chemical substances (molecules, compounds, ions, etc.), touch is physical or mechanical stimuli that interact with the skin, sight is light stimuli, and hearing is the perception of sound, which is a physical stimulus similar to some aspects of touch. There are more senses than just those, but that list represents the major senses. Those five are all senses that receive stimuli from the outside world, and of which there is conscious perception. Additional sensory stimuli might be from the internal environment (inside the body), such as the stretch of an organ wall or the concentration of certain ions in the blood.

Response

The nervous system produces a response on the basis of the stimuli perceived by sensory structures. An obvious response would be the movement of muscles, such as withdrawing a hand from a hot stove, but there are broader uses of the term. The nervous system can cause the contraction of all three types of muscle tissue. For example, skeletal muscle contracts to move the skeleton, cardiac muscle is influenced as heart rate increases during exercise, and smooth muscle contracts as the digestive system moves food along the digestive tract. Responses also include the neural control of glands in the body as well, such as the production and secretion of sweat by the eccrine and merocrine sweat glands found in the skin to lower body temperature.

Responses can be divided into those that are voluntary or conscious (contraction of skeletal muscle) and those that

are involuntary (contraction of smooth muscles, regulation of cardiac muscle, activation of glands). Voluntary responses are governed by the somatic nervous system and involuntary responses are governed by the autonomic nervous system, which are discussed in the next section.

Integration

Stimuli that are received by sensory structures are communicated to the nervous system where that information is processed. This is called integration. Stimuli are compared with, or integrated with, other stimuli, memories of previous stimuli, or the state of a person at a particular time. This leads to the specific response that will be generated. Seeing a baseball pitched to a batter will not automatically cause the batter to swing. The trajectory of the ball and its speed will need to be considered. Maybe the count is three balls and one strike, and the batter wants to let this pitch go by in the hope of getting a walk to first base. Or maybe the batter's team is so far ahead, it would be fun to just swing away.

Controlling the Body

The nervous system can be divided into two parts mostly on the basis of a functional difference in responses. The **somatic nervous system (SNS)** is responsible for conscious perception and voluntary motor responses. Voluntary motor response means the contraction of skeletal muscle, but those contractions are not always voluntary in the sense that you have to want to perform them. Some somatic motor responses are reflexes and often happen without a conscious decision to perform them. If your friend jumps out from behind a corner and yells "Boo!" you will be startled and you might scream or leap back. You didn't decide to do that, and you may not have wanted to give your friend a reason to laugh at your expense, but it is a reflex involving skeletal muscle contractions. Other motor responses become automatic (in other words, unconscious) as a person learns motor skills (referred to as "habit learning" or "procedural memory").

The **autonomic nervous system (ANS)** is responsible for involuntary control of the body, usually for the sake of homeostasis (regulation of the internal environment). Sensory input for autonomic functions can be from sensory structures tuned to external or internal environmental stimuli. The motor output extends to smooth and cardiac muscle as well as glandular tissue. The role of the autonomic system is to regulate the organ systems of the body, which usually means to control homeostasis. Sweat glands, for example, are controlled by the autonomic system. When you are hot, sweating helps cool your body down. That is a homeostatic mechanism. When you are nervous, you might start sweating also. That is not homeostatic, it is the physiological response to an emotional state.

There is another division of the nervous system that describes functional responses. The **enteric nervous system (ENS)** is responsible for controlling the smooth muscle and glandular tissue in your digestive system. It is a large part of the PNS, and is not dependent on the CNS. It is sometimes valid, however, to consider the enteric system to be a part of the autonomic system because the neural structures that make up the enteric system are a component of the autonomic output that regulates digestion. There are some differences between the two, but for our purposes here there will be a good bit of overlap. See Figure 8.13 for examples of where these divisions of the nervous system can be found.

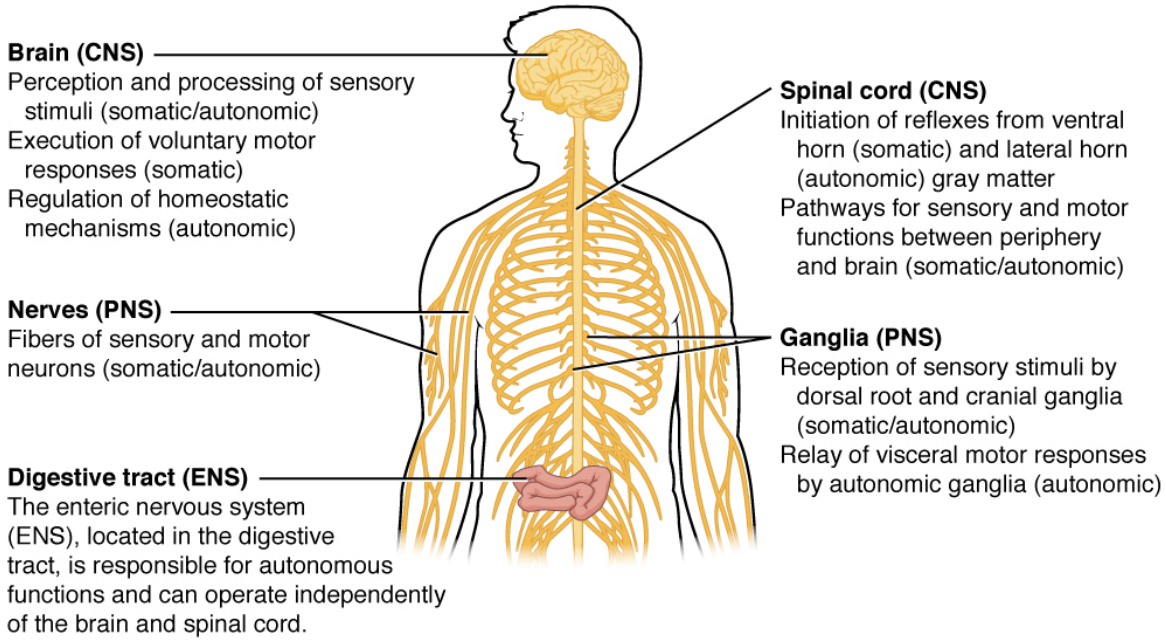

Figure 8.13 Somatic, Autonomic, and Enteric Structures of the Nervous System. Somatic structures include the spinal nerves, both motor and sensory fibers, as well as the sensory ganglia (posterior root ganglia and cranial nerve ganglia). Autonomic structures are found in the nerves also but include the sympathetic and parasympathetic ganglia. The enteric nervous system includes the nervous tissue within the organs of the digestive tract. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Functions of the Cerebral Cortex

The cerebrum is the seat of many of the higher mental functions, such as memory and learning, language, and conscious perception, which are the subjects of subtests of the **mental status** exam. The cerebral cortex is the thin layer of gray matter on the outside of the cerebrum. It is approximately a millimeter thick in most regions and highly folded to fit within the limited space of the cranial vault. These higher functions are distributed across various regions of the cortex, and specific locations can be said to be responsible for particular functions. There is a limited set of regions, for example, that are involved in language function, and they can be subdivided on the basis of the particular part of language function that each governs.

Cognitive Abilities

Assessment of cerebral functions is directed at cognitive abilities. The abilities assessed through the mental status exam can be separated into four groups: orientation and memory, language and speech, sensorium, and judgment and abstract reasoning.

Orientation and Memory

Orientation is the patient's awareness of his or her immediate circumstances. It is awareness of time, not in terms of the clock but of the date and what is occurring around the patient. It is awareness of place, such that a patient should know

where he or she is and why. It is also awareness of who the patient is—recognizing personal identity and being able to relate that to the examiner. The initial tests of orientation are based on the questions, "Do you know what the date is?" or "Do you know where you are?" or "What is your name?" Further understanding of a patient's awareness of orientation can come from questions that address remote memory, such as "Who is the President of the United States?", or asking what happened on a specific date.

Memory is largely a function of the temporal lobe, along with structures beneath the cerebral cortex such as the hippocampus and the amygdala. The storage of memory requires these structures of the medial temporal lobe. A famous case of a man who had both medial temporal lobes removed to treat intractable epilepsy provided insight into the relationship between the structures of the brain and the function of memory.

The prefrontal cortex can also be tested for the ability to organize information. In one subtest of the mental status exam called set generation, the patient is asked to generate a list of words that all start with the same letter, but not to include proper nouns or names. The expectation is that a person can generate such a list of at least 10 words within 1 minute. Many people can likely do this much more quickly, but the standard separates the accepted normal from those with compromised prefrontal cortices.

Language and Speech

Language is, arguably, a very human aspect of neurological function. There are certainly strides being made in understanding communication in other species, but much of what makes the human experience seemingly unique is its basis in language. Any understanding of our species is necessarily reflective, as suggested by the question "What am I?" And the fundamental answer to this question is suggested by the famous quote by René Descartes, "Cogito Ergo Sum" (translated from Latin as "I think, therefore I am"). Formulating an understanding of yourself is largely describing who you are to yourself. It is a confusing topic to delve into, but language is certainly at the core of what it means to be self-aware.

The neurological exam has two specific subtests that address language. One measures the ability of the patient to understand language by asking them to follow a set of instructions to perform an action, such as "touch your right finger to your left elbow and then to your right knee." Another subtest assesses the fluency and coherency of language by having the patient generate descriptions of objects or scenes depicted in drawings, and by reciting sentences or explaining a written passage.

An important example of multimodal integrative areas is associated with language function (see Figure 8.14). Adjacent to the auditory association cortex, at the end of the lateral sulcus just anterior to the visual cortex, is **Wernicke's area**. In the lateral aspect of the frontal lobe, just anterior to the region of the motor cortex associated with the head and neck is Broca's area. Both regions were originally described on the basis of losses of speech and language, which is called **aphasia**. The aphasia associated with Broca's area is known as **expressive aphasia**, which means that speech production is compromised. This type of aphasia is often described as non-fluency because the ability to say some words leads to broken or halting speech. Grammar can also appear to be lost. The aphasia associated with Wernicke's area is known as **receptive aphasia**, which is not a loss of speech production but a loss of understanding of content. Patients, after recovering from acute forms of this aphasia, report not being able to understand what is said to them or what they are saying themselves, but they often cannot keep from talking.

The two regions are connected by white matter tracts that run between the posterior temporal lobe and the lateral aspect of the frontal lobe. **Conduction aphasia** associated with damage to this connection refers to the problem of connecting the understanding of language to the production of speech. This is a very rare condition but is likely to present as an inability to faithfully repeat spoken language.

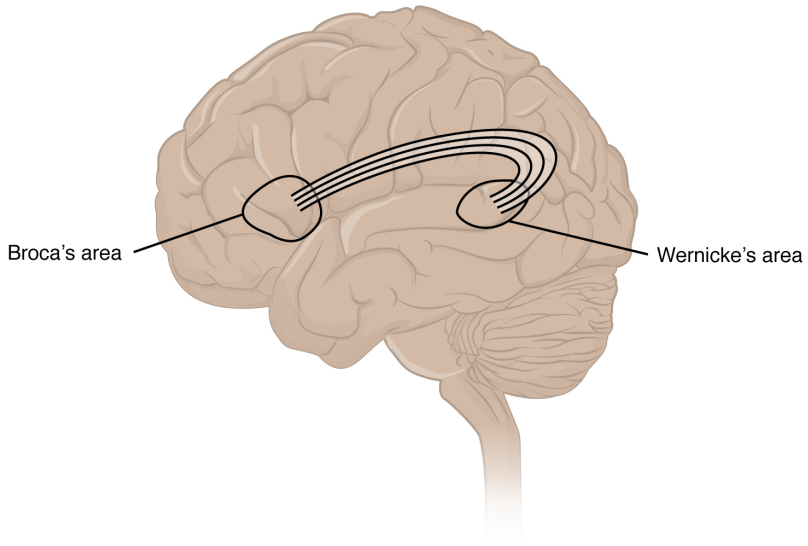

Figure 8.14 Broca's and Wernicke's Areas. Two important integration areas of the cerebral cortex associated with language function are Broca's and Wernicke's areas. The two areas are connected through the deep white matter running from the posterior temporal lobe to the frontal lobe. From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Sensorium

Those parts of the brain involved in the reception and interpretation of sensory stimuli are referred to collectively as the sensorium. The cerebral cortex has several regions that are necessary for sensory perception. Several of the subtests can reveal activity associated with these sensory modalities, such as being able to hear a question or see a picture. Two subtests assess specific functions of these cortical areas.

The first is **praxis**, a practical exercise in which the patient performs a task completely on the basis of verbal description without any demonstration from the examiner. The second subtest for sensory perception is **gnosis**, which involves two tasks. The first task, known as **stereognosis**, involves the naming of objects strictly on the basis of the somatosensory information that comes from manipulating them. The patient keeps their eyes closed and is given a common object, such as a coin, that they have to identify. The patient should be able to indicate the particular type of coin, such as a dime versus a penny, or a nickel versus a quarter, on the basis of the sensory cues involved. For example, the size, thickness, or weight of the coin may be an indication, or to differentiate the pairs of coins suggested here, the smooth or corrugated edge of the coin will correspond to the particular denomination. The second task, **graphesthesia**, is to recognize numbers or letters written on the palm with a dull pointer, such as a pen cap.

Judgment and Abstract Reasoning

Planning and producing responses requires an ability to make sense of the world around us. Making judgments and reasoning in the abstract are necessary to produce movements as part of larger responses. For example, when your alarm goes off, do you hit the snooze button or jump out of bed? Are 10 extra minutes in bed worth the extra rush to get ready for your day? Will hitting the snooze button multiple times lead to feeling more rested or result in a panic as you run late? How you mentally process these questions can affect your whole day.

The prefrontal cortex is responsible for the functions responsible for planning and making decisions. In the mental status exam, the subtest that assesses judgment and reasoning is directed at three aspects of frontal lobe function. First, the examiner asks questions about problem-solving, such as "If you see a house on fire, what would you do?" The patient is also asked to interpret common proverbs, such as "Don't look a gift horse in the mouth." Additionally, pairs of words are compared for similarities, such as apple and orange, or lamp and cabinet.

Everyday Connections

Left Brain, Right Brain

Popular media often refer to right-brained and left-brained people, as if the brain were two independent halves that work differently for different people. This is a popular misinterpretation of an important neurological phenomenon. As an extreme measure to deal with a debilitating condition, the corpus callosum may be sectioned to overcome intractable epilepsy. When the connections between the two cerebral hemispheres are cut, interesting effects can be observed.

The reason for this is that the language functions of the cerebral cortex are localized to the left hemisphere in 95% of the population. Additionally, the left hemisphere is connected to the right side of the body through the corticospinal tract and the ascending tracts of the spinal cord. Motor commands from the precentral gyrus control the opposite side of the body, whereas sensory information processed by the postcentral gyrus is received from the opposite side of the body. For a verbal command to initiate movement of the right arm and hand, the left side of the brain needs to be connected by the corpus callosum. Language is processed in the left side of the brain and directly influences the left brain and right arm motor functions but is sent to influence the right brain and left arm motor functions through the corpus callosum. Likewise, the left-handed sensory perception of what is in the left pocket travels across the corpus callosum from the right brain, so no verbal report on those contents would be possible if the hand happened to be in the pocket.

People who have had their corpus callosum cut can perform two independent tasks at the same time because the lines of communication between the right and left sides of their brains have been removed. Whereas a person with an intact corpus callosum cannot overcome the dominance of one hemisphere over the other, this patient can. If the left cerebral hemisphere is dominant in the majority of people, why would right-handedness be most common?

Common Abbreviations for the Nervous System

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Disease and Disorders

Neurodegenerative Diseases – Alzheimer's disease, Parkinson's disease, Amyotrophic Lateral Sclerosis (ALS), Multiple sclerosis (MS)

A class of disorders that affect the nervous system are the neurodegenerative diseases: Alzheimer's disease, Parkinson's disease, Huntington's disease, amyotrophic lateral sclerosis (ALS), Creutzfeldt–Jakob disease, multiple sclerosis (MS), and other disorders that are the result of nervous tissue degeneration. In diseases like Alzheimer's, Parkinson's, or ALS, neurons die; in diseases like MS, myelin is affected. Some of these disorders affect motor function, and others present with dementia. Some are the result of genetics, such as Huntington's disease, or the result of autoimmunity, such as MS; others are not entirely understood, such as Alzheimer's and Parkinson's diseases.

Several diseases can result from the demyelination of axons. The causes of these diseases are not the same; some have genetic causes, some are caused by pathogens, and others are the result of autoimmune disorders. Though the causes are varied, the results are largely similar. The myelin insulation of axons is compromised, making electrical signaling slower.

Multiple sclerosis (MS) is one such disease. It is an example of an autoimmune disease. The antibodies produced by lymphocytes (a type of white blood cell) mark myelin as something that should not be in the body. This causes inflammation and the destruction of the myelin in the central nervous system. As the insulation around the axons is destroyed by the disease, scarring becomes obvious.

Guillain-Barre (pronounced gee-YAN bah-RAY) syndrome is an example of a demyelinating disease of the peripheral nervous system. It is also the result of an autoimmune reaction, but the inflammation is in peripheral nerves. Sensory symptoms or motor deficits are common, and autonomic failures can lead to changes in the heart rhythm or a drop in blood pressure, especially when standing, which causes dizziness.

Other Nerve Disorders

Infection, trauma, and congenital disorders can all lead to significant signs, as identified through the neurological exam. It is important to differentiate between an acute event, such as stroke, and a chronic or global condition such as blunt force trauma. Responses seen in the neurological exam can help. A loss of language function observed in all its aspects is more likely a global event as opposed to a discrete loss of one function, such as not being able to say certain types of words. A concern, however, is that a specific function—such as controlling the muscles of speech—may mask other language functions. The various subtests within the mental status exam can address these finer points and help clarify the underlying cause of the neurological loss.

Stroke

Damage to the nervous system can be limited to individual structures or can be distributed across broad areas of the brain and spinal cord. Localized, limited injury to the nervous system is most often the result of circulatory problems. The loss of blood flow to part of the brain is known as a **stroke**, or a **cerebrovascular accident (CVA)**. There are two main types of stroke, depending on how the blood supply is compromised: ischemic and hemorrhagic. An **ischemic stroke** is the loss of blood flow to an area because vessels are blocked or narrowed. This is often caused by an embolus, which may be a blood clot or fat deposit. Ischemia may also be the result of thickening of the blood vessel wall, or a drop in

blood volume in the brain known as **hypovolemia**. A **hemorrhagic stroke** is bleeding into the brain because of a damaged blood vessel. Accumulated blood fills a region of the cranial vault and presses against the tissue in the brain (see Figure 8.15).

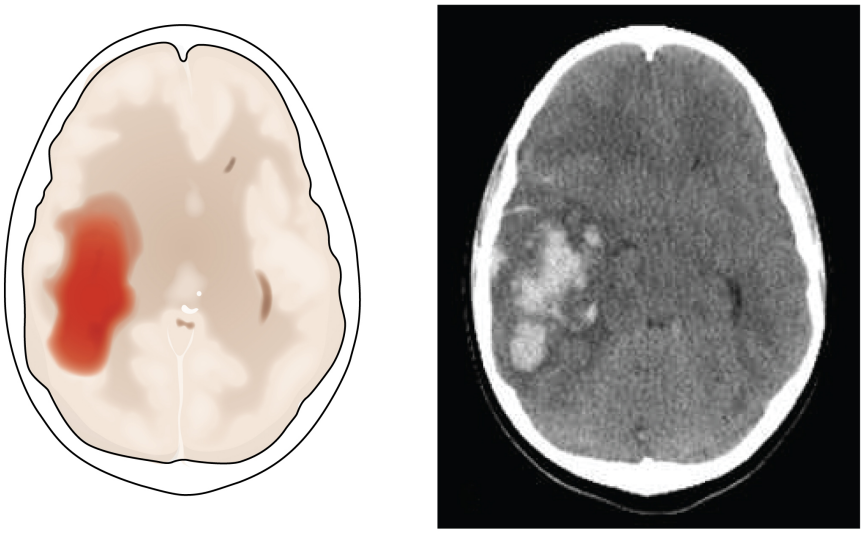

Figure 8.15 Hemorrhagic Stroke. (a) A hemorrhage into the tissue of the cerebrum results in a large accumulation of blood with additional edema in the adjacent tissue. The hemorrhagic area causes the entire brain to be disfigured as suggested here by the lateral ventricles being squeezed into the opposite hemisphere. (b) A CT scan shows an intraparenchymal hemorrhage within the parietal lobe. (credit b: James Heilman). From Betts et al., 2013. Licensed under CC BY 4.0. [Image description.]

Cerebral Palsy

Cerebral palsy (CP) is caused by an interruption to the normal development of a person's brain, leading to weakness with muscles. Depending on the area of the brain that is affected, signs and symptoms will vary in the type and severity between individuals. Balance and coordination are often challenging due to the inability to control muscles (Centers for Disease Control and Prevention, n.d.-a). To learn more about cerebral palsy, please visit the Centers for Disease Control and Prevention.

Traumatic Brain Injury (TBI)

According to the Centers for Disease Control and Prevention, about 166 people in the United States died each day from a traumatic brain injury in 2019. Brain injuries range from mild to severe and include concussions. TBI can be caused by falls, automobile accidents, assaults, and firearm-related suicide (Centers for Disease Control and Prevention, n.d.-b). To learn more about TBI, please visit the Centers for Disease Control and Prevention.

Practice Medical Terms in Context

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Medical Specialties

Neurologist

Neurologists are medical doctors who complete specialized training in the prevention, diagnosis, and treatment of disorders and conditions related to the brain and nervous system (Bureau of Labor Statistics, 2021). For more details visit the American Academy of Neurology.

Procedures Related to the Nervous System

Lumbar Puncture

A lumbar puncture is a procedure in which cerebrospinal fluid (CSF) is withdrawn from the lumbar region of the spinal column. This procedure can be used to diagnose and monitor certain infections, such as meningitis, administer drugs, or reduce spinal fluid pressure (Betts et al., 2013; ClinicalInfo, n.d.).

Electromyography (EMG)

Electromyography (EMG) is a procedure that assesses the electrical signals muscles send while at rest and when they are used. During the test, a needle electrode is placed into the muscle, and a machine records the muscle activity.

EMG can be used to diagnose myasthenia gravis, muscular dystrophy, and other conditions affecting the muscles (MedlinePlus, 2021a). To learn more, please visit the Medline Plus web page on electromyography.

Electroencephalogram (EEG)

With electrodes applied to your scalp, an electroencephalogram (EEG) measures electrical activity in the brain. It's used to help diagnose conditions of the brain, including seizures, altered mental status, and hemorrhage. (Rayi & Murr, 2021). For more information, please visit the Mayo Clinic's web page on electroencephalograms.

Practice Terms Related to the Nervous System

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Nervous System Vocabulary

Afferent nerves

Nerves that carry sensory signals (nerve impulses) toward the central nervous from the periphery.

Aphasia

Loss of language function.

Arachnoid mater

Middle layer of the meninges named for the spider-web–like trabeculae that extend between it and the pia mater.

Astrocyte

Glial cell type of the central nervous system that provides support for neurons and maintains the blood-brain barrier.

Autonomic nervous system (ANS)

Functional division of the nervous system that is responsible for homeostatic reflexes that coordinate control of cardiac and smooth muscle, as well as glandular tissue.

Axon

Single process of the neuron that carries an electrical signal (action potential) away from the cell body toward a target cell.

Axon hillock

Tapering of the neuron cell body that gives rise to the axon.

Axon segment

Single stretch of the axon insulated by myelin and bounded by nodes of Ranvier at either end (except for the first, which is after the initial segment, and the last, which is followed by the axon terminal).

Axon terminal

End of the axon, where there are usually several branches extending toward the target cell.

Axoplasm

Cytoplasm of an axon, which is different in composition than the cytoplasm of the neuronal cell body.

Babinski sign

Dorsiflexion of the foot with extension and splaying of the toes in response to the plantar reflex, normally suppressed by corticospinal input.

Bipolar

Shape of a neuron with two processes extending from the neuron cell body—the axon and one dendrite.

Blood-brain barrier (BBB)

Physiological barrier between the circulatory system and the central nervous system that establishes a privileged blood supply, restricting the flow of substances into the central nervous system.

Brain

The large organ of the central nervous system composed of white and gray matter, contained within the cranium and continuous with the spinal cord.

Brain stem

Region of the adult brain that includes the midbrain, pons, and medulla oblongata and develops from the mesencephalon, metencephalon, and myelencephalon of the embryonic brain.

Broca's area

Region of the frontal lobe associated with the motor commands necessary for speech production.

Brodmann's areas

Mapping of regions of the cerebral cortex based on microscopic anatomy that relates specific areas to functional differences, as described by Brodmann in the early 1900s.

Cauda equina

Bundle of spinal nerve roots that descend from the lower spinal cord below the first lumbar vertebra and lie within the vertebral cavity; has the appearance of a horse's tail.

Caudate

Nucleus deep in the cerebrum that is part of the basal nuclei; along with the putamen, it is part of the striatum.

Central nervous system (CNS)

Anatomical division of the nervous system located within the cranial and vertebral cavities, namely the brain and spinal cord.

Central sulcus

Surface landmark of the cerebral cortex that marks the boundary between the frontal and parietal lobes.

Cephalgia

Pain in the head.

Cerebellum

Region of the adult brain connected primarily to the pons that developed from the metencephalon (along with the pons) and is largely responsible for comparing information from the cerebrum with sensory feedback from the periphery through the spinal cord.

Cerebral angiography

Process of recording the blood vessels of the cerebrum.

Cerebral cortex

Outer gray matter covering the forebrain, marked by wrinkles and folds known as gyri and sulci.

Cerebrum

Region of the adult brain that develops from the telencephalon and is responsible for higher neurological functions such as memory, emotion, and consciousness.

Cerebral hemisphere

One half of the bilaterally symmetrical cerebrum.

Cerebrospinal fluid (CSF)

A colorless fluid produced by the brain that cushions the brain and spinal cord within the posterior (dorsal) cavity.

Cerebral thrombosis

Formation of a blood clot in a blood vessel within the skull.

Choroid plexus

Specialized structure containing ependymal cells that line blood capillaries and filter blood to produce cerebrospinal fluid in the four ventricles of the brain.

Corpus callosum

Large white matter structure that connects the right and left cerebral hemispheres.

Dendrite

One of many branchlike processes that extends from the neuron cell body and functions as a contact for incoming signals (synapses) from other neurons or sensory cells.

Descending tract

Central nervous system fibers carrying motor commands from the brain to the spinal cord or periphery.

Diencephalon

Region of the adult brain that retains its name from embryonic development and includes the thalamus and hypothalamus.

Direct pathway

Connections within the basal nuclei from the striatum to the globus pallidus internal segment and substantia nigra pars reticulata that disinhibit the thalamus to increase cortical control of movement.

Dorsal (posterior) nerve root

Axons entering the posterior horn of the spinal cord.

Dura mater

Tough, fibrous, outer layer of the meninges that is attached to the inner surface of the cranium and vertebral column and surrounds the entire central nervous system.

Efferent nerves

Nerve tissue that carries impulses away from the CNS towards the peripheral that result in motor response (movement).

Electroencephalogram

The record of electrical activity of the brain.

Electroencephalography

Process of recording the electrical activity of the brain.

Embolus

An obstruction such as a blood clot or plaque that blocks the flow of blood in an artery or vein.

Encephalitis

Inflammation of the tissues of the brain.

Encephalomalacia

Softening of the tissues of the brain.

Enteric nervous system (ENS)

Neural tissue associated with the digestive system that is responsible for nervous control through autonomic connections.

Ependymal cell

Glial cell type in the central nervous system responsible for producing cerebrospinal fluid.

Epithalamus

Region of the diencephalon containing the pineal gland.

Foramen magnum

Large opening in the occipital bone of the skull through which the spinal cord emerges and the vertebral arteries enter the cranium.

Frontal lobe

Region of the cerebral cortex directly beneath the frontal bone of the cranium.

Ganglion

Localized collection of neuron cell bodies in the peripheral nervous system.

Ganglionectomy

Excision of a ganglion.

Glial cell

One of the various types of neural tissue cells responsible for maintenance of the tissue, and largely responsible for supporting neurons.

Glioblastoma

A central nervous system tumor composed of developing glial tissue.

Glioma

A tumor that begins in the glial tissue.

Gray matter

Regions of the nervous system containing cell bodies of neurons with few or no myelinated axons; actually may be more pink or tan in color, but called gray in contrast to white matter.

Gyrus

Ridge formed by convolutions on the surface of the cerebrum or cerebellum.

Hemiplegia

Paralysis on one side of the body.

Hemorrhagic stroke

Disruption of blood flow to the brain caused by bleeding within the cranial vault.

Hydrocephalus

The abnormal buildup of cerebrospinal fluid in the ventricles of the brain.

Hyperesthesia

Increased sensitivity to stimuli.

Hypothalamus

A region of the forebrain below the thalamus; has function in both the autonomic and endocrine systems and regulates homeostasis.

Ischemic stroke

Disruption of blood flow to the brain because blood cannot flow through blood vessels as a result of a blockage or narrowing of the vessel.

Integration

Nervous system function that combines sensory perceptions and higher cognitive functions (memories, learning, emotion, etc.) to produce a response.

Initial segment

First part of the axon as it emerges from the axon hillock, where the electrical signals known as action potentials are generated.

Longitudinal fissure

A large separation along the midline between the two cerebral hemispheres.

Lumbar puncture

Procedure used to withdraw cerebrospinal fluid from the lower lumbar region of the vertebral column.

Medulla oblongata

A part of the brain stem responsible for control of heart rate and breathing.

Meninges

The membranes that surround the central nervous system.

Meningioma

A tumor of the meninges.

Meningitis

Inflammation of the meninges, the tough membranes that surround the central nervous system.

Meningocele

Protrusion of the meninges.

Meningomyelocele

Protrusion of the meninges and spinal cord.

Microglia

Smaller than most of the other glial cells; they ingest and digest cells or pathogens that cause disease.

Midbrain

A portion of the brainstem, positioned above the pons, also called mesencephalon, that assists in motor reflexes associated with visual, auditory, and somatosensory stimuli.

Mononeuropathy

Disease affecting a single peripheral nerve.

Motor nerves

Peripheral, efferent, myelinated nerve tissue that stimulates muscle contraction.

Multipolar

Shape of a neuron that has multiple processes—the axon and two or more dendrites.

Myelin sheath

Lipid-rich layer of insulation that surrounds an axon, formed by oligodendrocytes in the central nervous system and Schwann cells in the peripheral nervous system; facilitates the transmission of electrical signals.

Nerves

Bundle of fibers that receives and sends messages between the body and the brain.

Neuralgia

Pain of the peripheral or cranial nerves.

Neuritis

Inflammation of a peripheral or cranial nerve.

Neuroglia

Supportive tissue of the nervous system, including the network of branched cells in the central nervous system (astrocytes, microglia, and oligodendrocytes) and the supporting cells of the peripheral nervous system (Schwann cells and satellite cells), also called glia.

Neurologist

A doctor who has special training in diagnosing and treating disorders of the nervous system.

Neurology

A medical specialty concerned with the study of the structures, functions, and diseases of the nervous system.

Neuroma

Tumor made up of nerve cells.

Neuron

Cells that propagate information via electrochemical impulses.

Neuropathy

A nerve problem that causes pain, numbness, tingling, swelling, or muscle weakness in different parts of the body.

Neurotransmitters

Chemicals that are made by nerve cells and used to communicate with other cells, including other nerve cells and muscle cells.

Node of Ranvier

Gap between two myelinated regions of an axon, allowing for strengthening of the electrical signal as it propagates down the axon.

Nucleus

The cell's central organelle, which contains the cell's DNA.

Occipital lobe

Region of the cerebral cortex directly beneath the occipital bone of the cranium.

Olfaction

The sense of smell.

Oligodendrocyte

Glial cell type in the central nervous system that provides the myelin insulation for axons in tracts.

Paresis

Partial paralysis wherein there is still some control of the muscles.

Paresthesia

Abnormal sensation in the extremities.

Parietal lobe

Region of the cerebral cortex directly beneath the parietal bone of the cranium.

Peripheral nervous system (PNS)

All nervous tissue that is outside of the brain and spinal cord.

Pia mater

Thin, innermost membrane of the meninges that directly covers the surface of the central nervous system.

Poliomyelitis

Acute infection by the poliovirus, especially of the motor neurons in the spinal cord and brainstem.

Polyneuritis

Inflammation of several peripheral nerves at the same time.

Polyneuropathy

Disease of multiple peripheral nerves at the same time.

Pons

The main connection between the cerebellum and the brain stem. It is responsible for regulating several crucial functions, including the cardiovascular and respiratory systems.

Process

In cells, an extension of a cell body; in the case of neurons, this includes the axon and dendrites.

Psychiatrist

A medical doctor who specializes in neuroscience and diagnoses and treats mental disorders.

Psychiatry

The medical science that deals with the origin, diagnosis, prevention, and treatment of mental disorders.

Psychologist

A specialist who can talk with patients and their families about emotional and personal matters.

Psychology

The study of how the mind works and how thoughts and feelings affect behavior.

Psychosis

A severe mental disorder in which a person loses the ability to recognize reality or relate to others.

Quadriplegia

Paralysis of all four limbs.

Radiculopathy

Disease of the nerve roots.

Response

Nervous system function that causes a target tissue (muscle or gland) to produce an event as a consequence to stimuli.

Rhizotomy

Incision into a nerve root.

Satellite cell

Glial cell type in the peripheral nervous system that provides support for neurons in the ganglia.

Schwann cell

Glial cell type in the peripheral nervous system that provides the myelin insulation for axons in nerves.

Sensation

Nervous system function that receives information from the environment and translates it into the electrical signals of nervous tissue.

Soma

In neurons, that portion of the cell that contains the nucleus; the cell body, as opposed to the cell processes (axons and dendrites).

Somatic nervous system (SNS)

Functional division of the nervous system that is concerned with conscious perception, voluntary movement, and skeletal muscle reflexes.

Spinal cord

Organ of the central nervous system found within the vertebral cavity and connected with the periphery through spinal nerves; mediates reflex behaviors.

Stimulus

An event in the external or internal environment that registers as activity in a sensory neuron.

Stroke

Loss of neurological function caused by an interruption of blood flow to a region of the central nervous system, also called cerebrovascular accident (CVA).

Subarachnoid space

Space between the arachnoid mater and pia mater that contains CSF and the fibrous connections of the arachnoid trabeculae.

Subdural hematoma

Accumulation of blood in the subdural space.

Sulcus

Groove formed by convolutions in the surface of the cerebral cortex.

Synapse

Narrow junction across which a chemical signal passes from neuron to the next, initiating a new electrical signal in the target cell.

Synaptic end bulb

Swelling at the end of an axon where neurotransmitter molecules are released onto a target cell across a synapse.

Sympathetic nervous system (SNS)

The division of the nervous system involved in our fight-or-flight responses. It continuously monitors body temperature and initiates appropriate motor responses.

Temporal lobe

Region of the cerebral cortex directly beneath the temporal bone of the cranium.

Thalamus

Major region of the diencephalon that is responsible for relaying information between the cerebrum and the hindbrain, spinal cord, and periphery.

Tract

Bundle of axons in the central nervous system having the same function and point of origin.

Transient ischemic attack (TIA)

Temporary disruption of blood flow to the brain in which symptoms occur rapidly but last only a short time.

Unipolar

Shape of a neuron which has only one process that includes both the axon and dendrite.

Ventricle

Central cavity within the brain where cerebrospinal fluid is produced and circulates.

Wernicke's area

Region at the posterior end of the lateral sulcus in which speech comprehension is localized.

White matter

Regions of the nervous system containing mostly myelinated axons, making the tissue appear white because of the high lipid content of myelin.

Test Yourself

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Image Descriptions

Figure 8.1 image description: This diagram shows a silhouette of a human highlighting the nervous system. The central nervous system is composed of the brain and spinal cord. The brain is a large mass of ridged and striated tissue within the head. The spinal cord extends down from the brain and travels through the torso, ending in the pelvis. Pairs of enlarged nervous tissue, labeled ganglia, flank the spinal cord as it travels through the rib area. The ganglia are part of the peripheral nervous system, along with the many thread-like nerves that radiate from the spinal cord and ganglia through the arms, abdomen, and legs. [Return to Figure 8.1].

Figure 8.2 image description: This photo shows an enlarged view of the dorsal side of a human brain. The right side