



Medical Terminology

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WISCONSIN



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Introduction

Learning a new language can be a daunting task. In this resource, we offer a method for breaking down medical words that takes that daunting task and makes it manageable. What is required from you is a commitment 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 health-care courses.

How this open educational resource (OER) works.

The introductory anatomy and physiology content of this OER has been adapted from the [OpenStax Anatomy and Physiology OER](#) by Betts, et al., which is licensed under a [Creative Commons Attribution 4.0 International License](#). Following OpenStax's leadership and in the spirit of OPEN education we have licensed this OER with the same license.

This book was then adapted in 2021 from the eCampusOntario's version of [Building a Medical Terminology Foundation](#) by K. Carter and M. Rutherford which is licensed under a [Creative Commons Attribution 4.0 International License](#). The Lakeshore Technical College team modified this version of the textbook based on the Wisconsin Technical College System course competencies for Medical Terminology. We later added on faculty contributors from Gateway Technical College and Milwaukee Area Technical College as well as a librarian project manager from Western Technical College.

Students: this OER is different than many traditional medical terminology textbooks. The interactive content is built into each chapter. In this resource 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 was curated and created for Medical Terminology students in a technical college system, our hope is that you will take this OER and customize it for your program and share again.

Let us know that you are using this textbook

Please respond to our quick [textbook adoption survey](#) to let us know that you are using this resource. Help us continue to make high-quality educational materials accessible by letting us know you've adopted! Our future grant funding is based on faculty adoptions and the number of students we impact.

Suggest a correction

Please respond to our [suggest a correction survey](#) to submit suggestions for improvements to the Medical Terminology textbook and ancillary materials. We appreciate your feedback.

Wisconsin Technical College System (WTCS) Project Team Timeline & Next Steps

A small cross-functional team consisting of faculty, librarians, and instructional designers from across the WTCS has been meeting since April 2020 to create a WTCS Medical Terminology course using open educational resources. The team adapted the textbook, created a printable student companion guide, and built a Canvas course shell with additional activities and assessments.

Here is the link to the Student Companion: [OER Medical Terminology Student Companion](#)

Here is a link to the Canvas Course Shell: [Medical Terminology Canvas Course Shell](#)

We have a small group of faculty that are piloting the resources in the Fall 2022 term. Their feedback will inform edits or revisions for the next edition of the book.

Book Citations

Medical Terminology Book Citation:

Grimm S., Allee, C., Belitz, H., Gotz, T., Randolph, M., Strachota, E., and Zielinski L. (2022). *Medical Terminology*. Wisconsin Technical College System. <https://nicoletcollege.pressbooks.pub/lcmedicalterminology/>
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Building a Medical Terminology Foundation Book Citation:

Carter K. & Rutherford M. (2020). *Building a Medical Terminology Foundation*. eCampusOntario. <https://ecampusontario.pressbooks.pub/medicalterminology/>

Anatomy and Physiology Book Citation:

Betts, J.G., Young, K.A., Wise, J.A., Johnson, E., Poe, B., Kruse, D. H., Korol, O., Johnson, J.E., Womble, M. & DeSaix, P. (2013). *Anatomy and Physiology*. OpenStax. <http://cnx.org/content/col11496/latest/>

Acknowledgments

In Fall of 2020, this OER textbook was adapted to be used by the Wisconsin Technical College System for their Medical Terminology course. A team of instructors and librarians from across the 16 technical colleges collaborated to get this open education resource (OER) book adapted specifically for Wisconsin Technical College students so they could take the Medical Terminology course with no additional textbook costs!

Two teams worked virtually during the COVID-19 Pandemic and beyond to adapt and edit the textbook to support WTCS curriculum.

Team 1, consisted of:

- Heidi Belitz, Lakeshore Technical College
- Stacey Grimm, Lakeshore Technical College
- Coleen Allee, Lakeshore Technical College
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Team 2, consisted of:

- Traci Gotz, Gateway Technical College
- Micheal Randolph, Gateway Technical College
- Elaine Strachota, Milwaukee Area Technical College
- Laurie Zielinski, Milwaukee Area Technical College
- Ellen Range, Western Technical College

We also want to acknowledge the contributions of the individuals who edited this book before we got our hands on it. Thanks and gratitude to:

- Kimberlee Carter B.Ed., M.A., Conestoga College ITAL
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Wisconsin Land Acknowledgment

We acknowledge and honor the inherent sovereignty of the 12 tribal nations in Wisconsin that are pictured on the map below.

We take time to call out the need for each of us to learn about the tribal nations in our communities, create meaningful collaboration and partnership, and lift up the voices of native people. Also as educators, we need to work to decolonize our curriculum and engage in antiracist pedagogy. To learn more about the tribal nations within Wisconsin, please see [The Ways: Great Lakes Native Culture and Language webpage](#).

Seats of Government: American Indian Nations in Wisconsin



Seats of Government: American Indian Nations in Wisconsin:
<https://dpi.wi.gov/amind/tribalnationswi>

I. Identifying Word Parts in Medical Terms

Welcome to **Medical Terminology**. Medical terminology is a language that is used in health care settings. Medical terms are built from Greek and Latin word parts and in addition include **acronyms**, such as “laser” (light amplification by stimulated emission of radiation), **eponyms**, such as West Nile Virus (named after a geographical location where the virus was identified) or Alzheimer disease (named after the person who discovered it) and **modern-day language terms**, such as “nuclear medicine scanner”, which is derived from the English language.

Word Parts

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

Word Root

The word root contains the fundamental meaning of the word. It is the core part of the word. Each medical term contains at least one word root.

Examples:

- In the word: play/er (*play* is the word root)
- In the medical term: arthr/itis (*arthr* – meaning “joint” – is the word root)

Some words contain more than one word root. The order is generally dictated by common practice. As you practice throughout this course, you will learn more about how to determine the order of word roots.

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.

Examples

- In the word: re/play (“re” is the prefix)
- In the medical term: intra/ven/ous (“intra” is the prefix)

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.

Prefixes often indicate:

- **Number:** such as bi- meaning two
- **Position:** such as sub-, meaning under
- **Direction:** such as intra-, meaning within
- **Time:** such as brady-, meaning slow
- **Negation:** such as a- and an-, meaning without

Suffixes

Suffixes are word parts that are located at the end of words. Suffixes can alter the meaning of medical terms. In order to properly spell and pronounce medical terms, it is helpful to learn the suffixes.

Examples

- In the word: king/dom (“-dom” is the suffix)
- In the medical term: hepat/itis (“-itis” is the suffix)

When defining a medical term you often begin with the meaning of the suffix. For example: hepat/itis would be defined as “inflammation of the liver.”

Suffixes often indicate:

- **Procedures:** such as -scopy, meaning visual examination
- **Conditions:** such as -itis, meaning inflammation
- **Diseases:** such as -oma, meaning tumor

Combining Vowel

The combining vowel is a word part – most often an o – that helps pronunciation.

The combining vowel is placed to connect two word roots or to connect a word root and a suffix. Do NOT place a combining vowel to connect a prefix and a word root. Not all medical terms will have combining vowels.

Table 1.1 Combining Vowel Guidelines

Guideline	Example
1. When connecting a word root and a suffix, a combining vowel is used if the suffix DOES NOT begin with a vowel	arthr/o/pathy
2. When connecting a word root and a suffix, a combining vowel is usually NOT USED if the suffix BEGINS with a vowel	hepat/ic
3. When connecting two word roots, a combining vowel is usually used even if vowels are present at the junction	oste/o/arthr/itis
4. When connecting a prefix and a word root, a combining vowel is NOT USED	sub/hepat/ic



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

<https://nicolecollege.pressbooks.pub/lcmedicalterminology/?p=20#h5p-1>

Categories of Medical Terms

All medical terms are divided into two basic categories:

1. **terms built from word parts**
2. **terms NOT built from word parts**

Table: 1.2 Categories of Medical Terms

Category	Origin	Example	Learning Method
Terms Built from Word Parts	Word parts of Greek and Latin origin combined to create literal translations	1. cytogenic 2. dysplasia	1. Analyzing terms 2. Defining terms 3. Building terms
Terms NOT built from Word Parts	1. Eponyms 2. Acronyms 3. Modern Language 4. Terms from Greek and Latin word parts that cannot be easily translated to find their meanings	1. Parkinson's Disease 2. AIDS (acquired immunodeficiency syndrome) 3. posttraumatic stress disorder 4. orthopedics	1. Recalling terms 2. Matching terms 3. Defining terms

Medical terms are also further divided into:

1. **Disease and Disorder** – These are terms that describe any harmful deviation from the normal structural or functional state of an organism, generally associated with certain signs and symptoms. It does not include physical

- injury. An example of a disease is bronchopneumonia, which is a diseased state of the bronchi and lungs.
2. **Diagnostic/Procedural** – These are terms related to the process of identifying a disease, condition, or injury from its signs and symptoms. An example of a diagnostic term is transrectal ultrasound, which is an ultrasound procedure used to diagnose prostate cancer.
 3. **Therapeutic** – These are terms regarding treating or curing of diseases. An example of a therapeutic term is nebulizer, which is a device that creates a mist used to deliver medication for respiratory treatment.
 4. **Anatomical** – These are terms used to describe specific areas and movement of the body as well as the relation of body parts to each other. An example of an anatomical term is medial, which describes the middle or direction toward the middle of the body.

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**.

By the end of this resource, you will have identified hundreds of word parts within medical terms. Here are 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

When breaking down words place slashes between word parts and a slash on each side of a combining vowel. Notice how the term is defined by beginning with the meaning of the suffix, then shifts to the beginning of the term with the meaning of the word parts in the order they appear.

Pronunciation

Special marking above vowels indicate the proper pronunciation of the vowel. When you see a macron (or straight line) above the vowel, that means the vowel sound is long. A u-shaped symbol above a vowel indicates a short vowel sound. CAPITAL letters indicate where to place the emphasis when pronouncing a word. The table below provides examples, try pronouncing them aloud.

Table 1.3 Combining Vowels Tips

Guidelines	Examples
1. Words are distorted minimally to indicate the proper phonetic sound.	doctor (dōk-tōr)
	prorate (prō-rāt)
2. The macron (line above the letter) indicated a long vowel sound.	As in the: ā in play ē in be ī in wine ō in go ū in mule
	medical (mēd-ī-cāl)
3. A u-shaped mark above the vowel indicates a short sound.	As in the: ā in mad ě in bet ĩ in tip ǒ in mop ŭ in cup
4. Primary emphasis is indicated by capital letters.	debride (di-BRĒD) dehydration (dē-hī-DRĀ-shōn)

Review

Table 1.4 Combining Vowels Tips

Combining Vowel Tip	Example
1. Use a combining vowel when connecting a word root to a suffix that begins with a consonant.	arthr/o/pathy
2. DO NOT use a combining vowel if the suffix begins with a vowel.	hepat/ic
3. Use a combining vowel when connection two word roots, even if vowels are present at the conjunction.	oste/o/arthr/itis
4. DO NOT use a combining vowel when connect a prefix and a word root.	sub/hepat/ic

Table 1.5 Word Parts and Combining Forms

Part	Definition	Example
Word Root	Core of the word	hepat /itis
Suffix	Attached to the end of a word root to alter its meaning	hepat/ itis
Prefix	Attached to the beginning of the word root to alter its meaning	sub /hepatic
Combining Vowel	Typically an "o" used to assist pronunciation	hepat/ o /magaly
Combining Form	Word root with a combining vowel	hepat/o

Table 1.6 Medical Terminology Learning Techniques

<u>Technique</u>	<u>Instructions</u>	<u>Example</u>
Analyze	<ol style="list-style-type: none"> 1. Divide into word parts 2. Label the word parts 3. Underline and label each combining form 	<ol style="list-style-type: none"> 1. oste/o/arthr/o/pathy 2. oste =WR/ o= CV/ arthr = WR/ o = CV/ pathy = S 3. oste/o/arthr/o/pathy
Define	<ol style="list-style-type: none"> 1. Define each word part in the term 2. Begin defining the suffix meaning and then move to the beginning of the term 	<ol style="list-style-type: none"> 1. oste = bone, arthr = joint, pathy= disease 2. Disease of the bone and joint
Build	<ol style="list-style-type: none"> 1. Place word parts together to add terms 2. Add combining vowels 	<ol style="list-style-type: none"> 1. Disease of the bone and joint = oste/ /arthr/ /pathy 2. oste/o/arthr/o/pathy

2. Medical Language Related to the Body as a Whole

WTCS Learning Objectives

- Use the anatomic reference system to identify the anatomic position of the body
- Use the anatomic reference system to identify the body planes
- Use the anatomic reference system to identify the body cavities
- Use the anatomic reference system to identify the directional terms
- Use the anatomic reference system to identify the divisions of the body
- Describe the structural organization of the body
- Apply the rules of medical language
- Identify meanings of key word components

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 2.1).

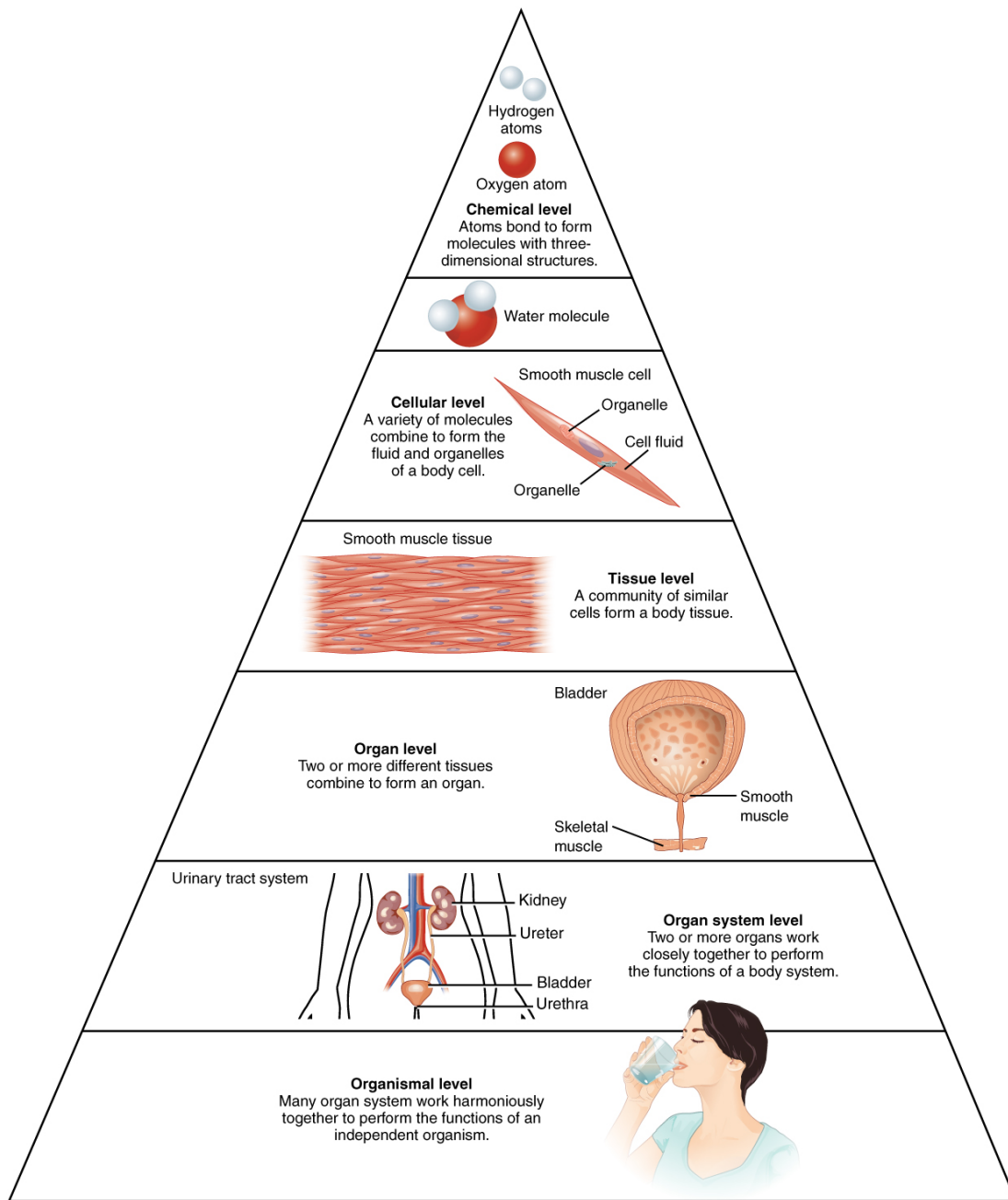


Figure 2.1 Levels of Structural Organization of the Human Body. The organization of the body often is discussed in terms of six distinct levels of increasing complexity, from the smallest chemical building blocks to a unique human organism. From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

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.

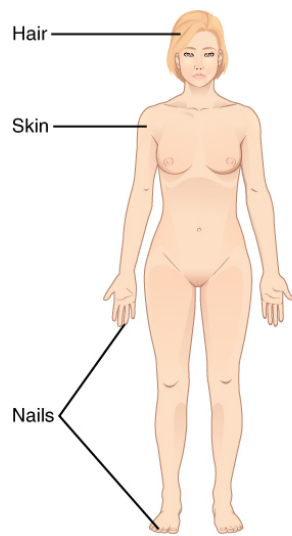
- Two or more atoms combine to form a **molecule**, such as the water molecules, proteins, and sugars found in living things.
 - **Molecules** are the chemical building blocks of all body structures.
- A **cell** is the smallest independently functioning unit of a living organism.
 - Even bacteria, which 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?

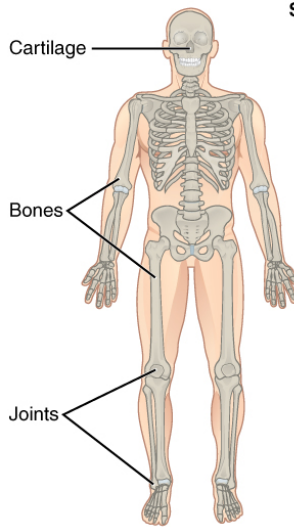
- Organs are very collaborative and work with multiple body systems.
- For example, the heart (cardiovascular system) and lungs (respiratory system) work together to deliver oxygen throughout the body and remove carbon dioxide from the body.

Consider the breakdown into eleven distinct organ systems in the human body (Figure 2.2 and Figure 2.3). 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.



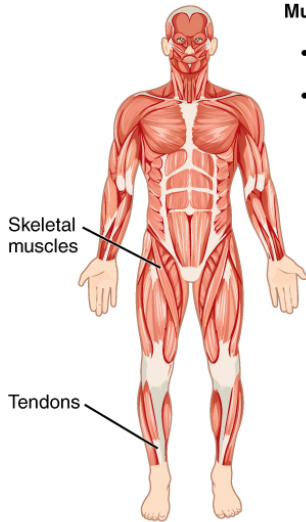
Integumentary System

- Encloses internal body structures
- Site of many sensory receptors



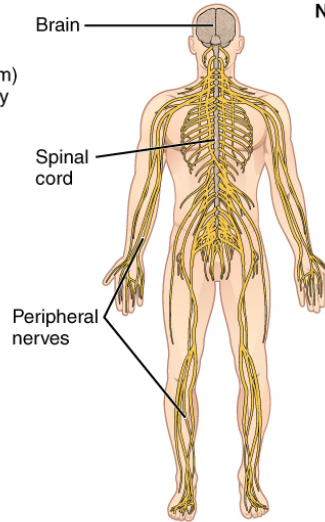
Skeletal System

- Supports the body
- Enables movement (with muscular system)



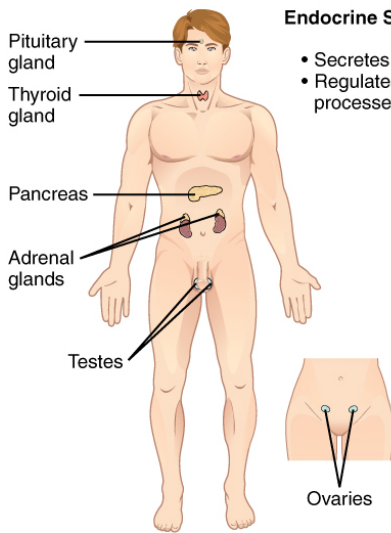
Muscular System

- Enables movement (with skeletal system)
- Helps maintain body temperature



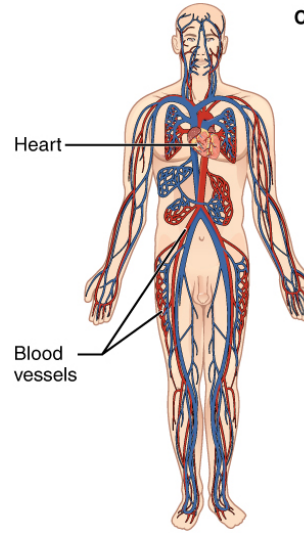
Nervous System

- Detects and processes sensory information
- Activates bodily responses



Endocrine System

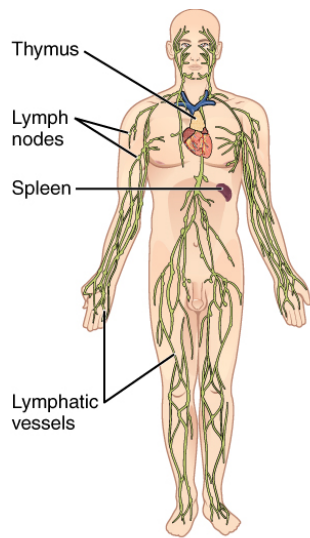
- Secretes hormones
- Regulates bodily processes



Cardiovascular System

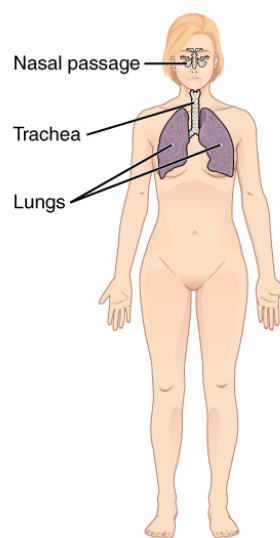
- Delivers oxygen and nutrients to tissues
- Equalizes temperature in the body

Figure 2.2. Organ Systems of the Human Body. Organs that work together are grouped into organ systems. From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/)



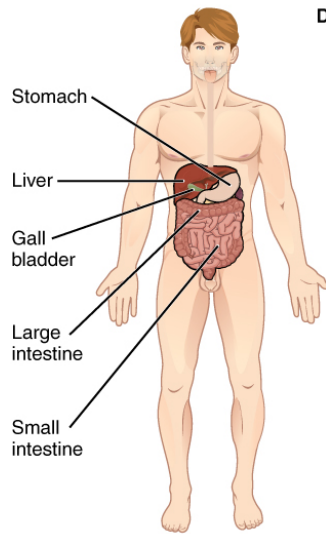
Lymphatic System

- Returns fluid to blood
- Defends against pathogens



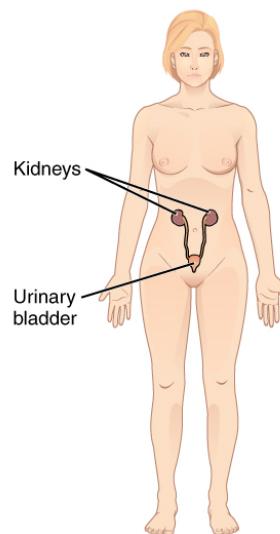
Respiratory System

- Removes carbon dioxide from the body
- Delivers oxygen to blood



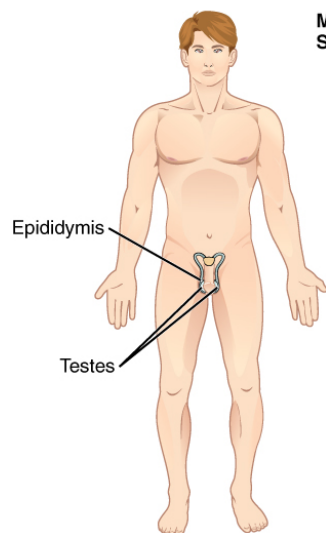
Digestive System

- Processes food for use by the body
- Removes wastes from undigested food



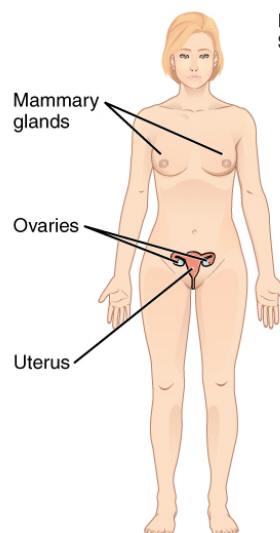
Urinary System

- Controls water balance in the body
- Removes wastes from blood and excretes them



Male Reproductive System

- Produces sex hormones and gametes
- Delivers gametes to female



Female Reproductive System

- Produces sex hormones and gametes
- Supports embryo/ fetus until birth
- Produces milk for infant

Figure 2.3. Organ Systems of the Human Body (continued). Organs that work together are grouped into organ systems. From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/)

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:



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://nicoletcollege.pressbooks.pub/lcmedicalterminology/?p=36#oembed-1>

Media 2.1. [Introduction to Anatomy & Physiology: Crash Course A&P #1](#) [Online video]. Copyright 2015 by CrashCourse.

Did you know?

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

Anatomical Position

Health care 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,” or **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.

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.

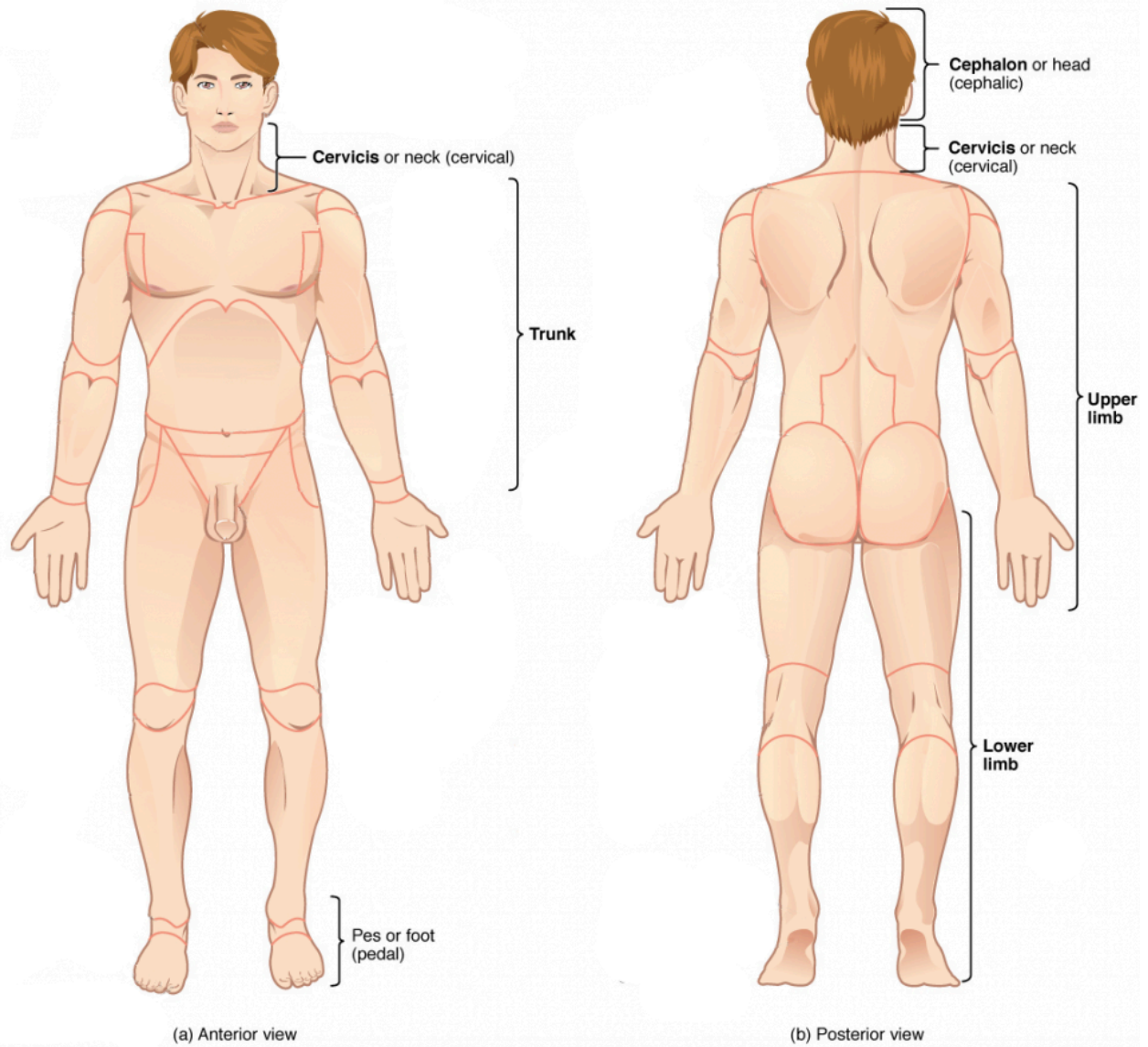


Figure 2.4. Regions of the Human Body. The human body is shown in anatomical position in an (a) anterior view and a (b) posterior view. The regions of the body are labeled in boldface. Remixed image from Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/)

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.

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. 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.

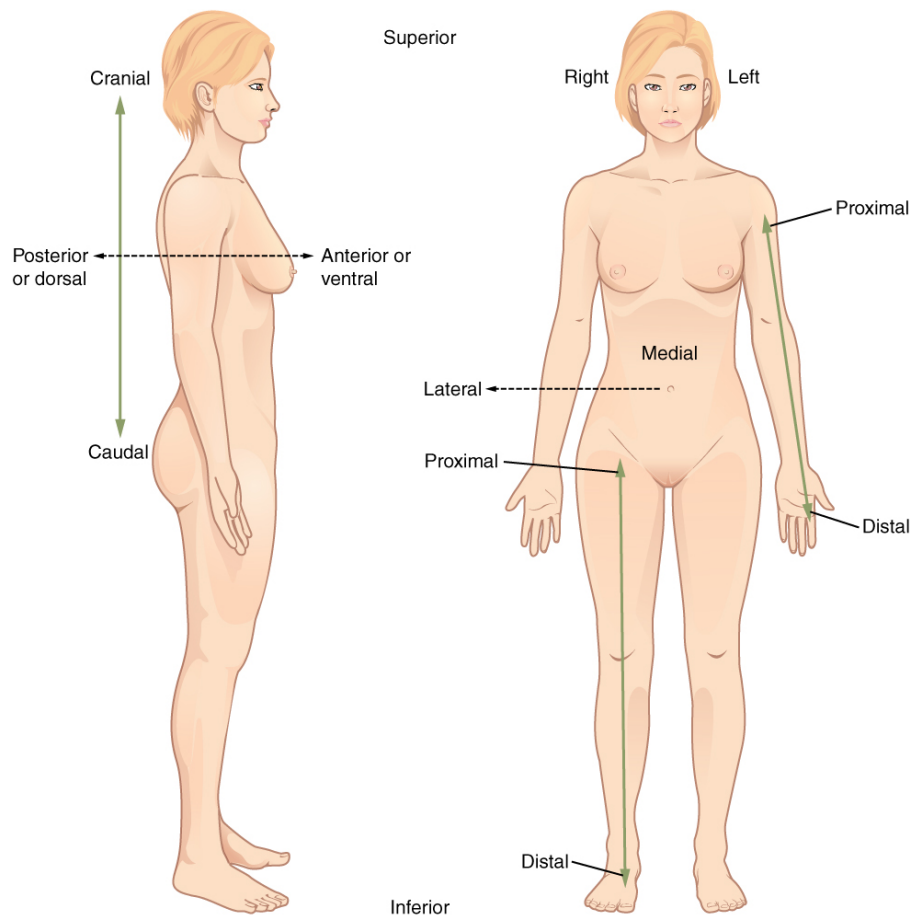


Figure 2.5. Directional Terms Applied to the Human Body. Paired directional terms are shown as applied to the human body. From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

Practice these 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 2.6). 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.

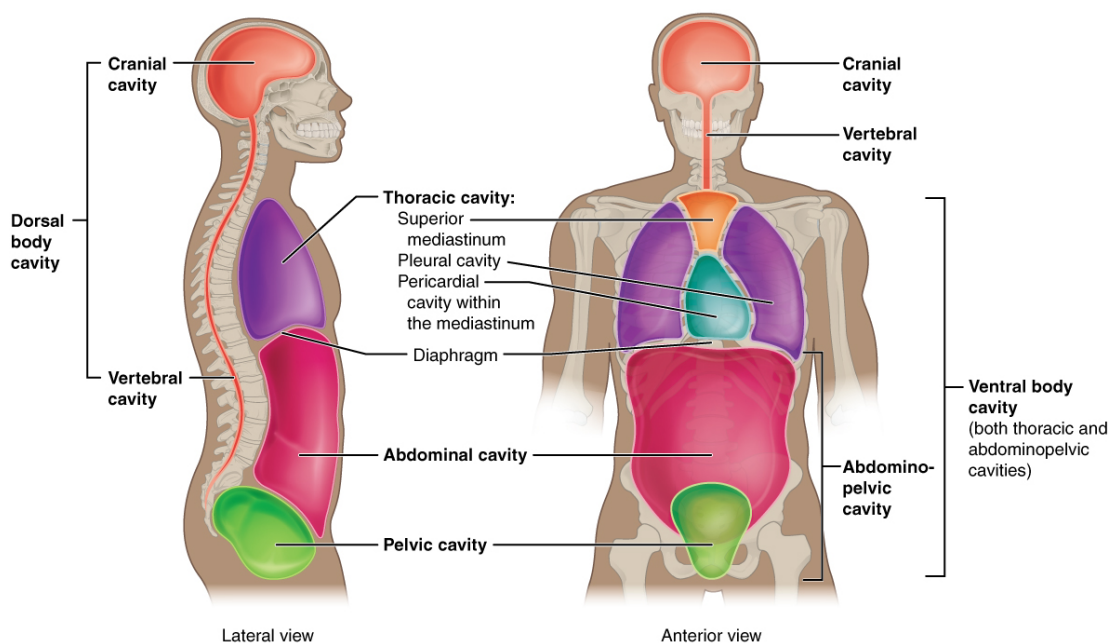


Figure 2.6. Dorsal and Ventral Body Cavities. The ventral cavity includes the thoracic and abdominopelvic cavities and their subdivisions. The dorsal cavity includes the cranial and spinal cavities. From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

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:

- In the posterior (dorsal) cavity, 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 is 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.



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Abdominal Regions and Quadrants

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

Practice locating the quadrants.



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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 2.7).

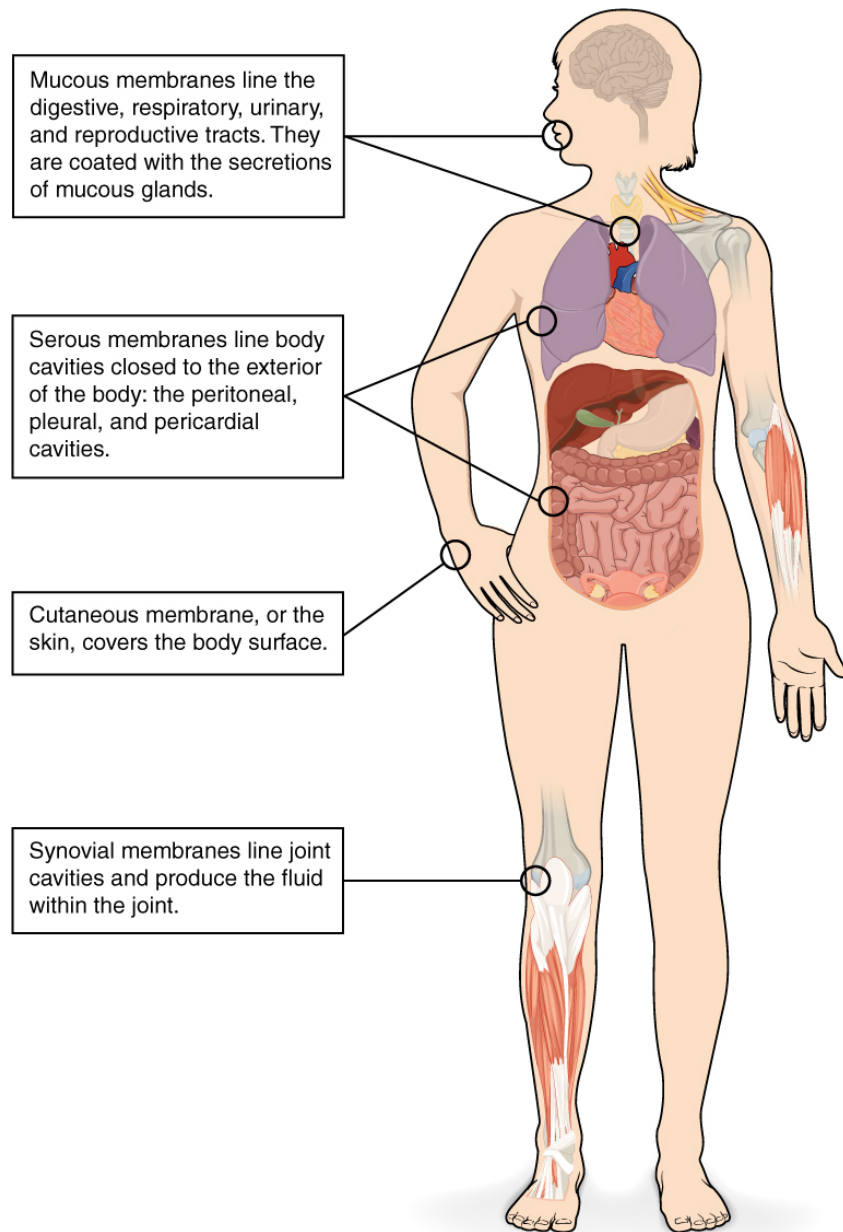


Figure 2.7. Tissue Membranes. The two broad categories of tissue membranes in the body are (1) connective tissue membranes, which include synovial membranes, and (2) epithelial membranes, which include mucous membranes, serous membranes, and the cutaneous membrane, in other words, the skin. From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

Did you know?

Synovial membranes line cavities which hold synovial fluid.

Synovial fluid lubricates the joints for movement.

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.

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 mucosa, 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”), help 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.
 - **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**.

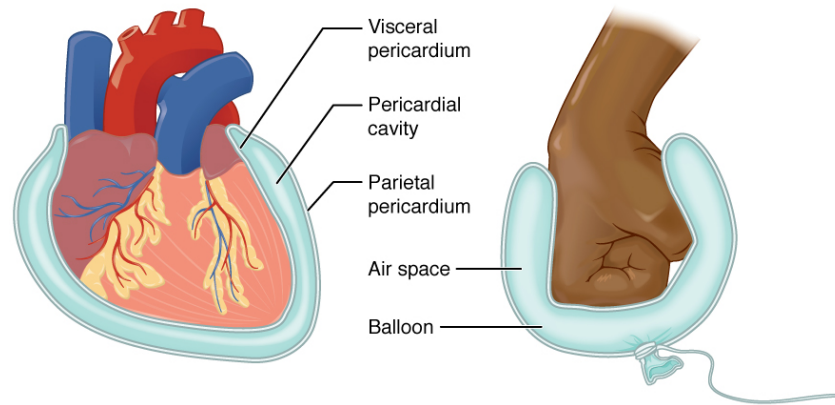


Figure 2.8. Serous Membrane. Serous membrane lines the pericardial cavity and reflects back to cover the heart—much the same way that an underinflated balloon would form two layers surrounding a fist. From Betts, et al., 2021. Licensed under [CC BY 4.0](#).

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.

Test Yourself



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References

[CrashCourse]. (2015, January 6). *Introduction to anatomy & physiology: Crash course A&P #1* [Video]. YouTube. <https://youtu.be/uBG12BujkPQ>

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3. Integumentary System

WTCS Learning Objectives

- Apply the rules of medical language to build, analyze, spell, pronounce, abbreviate, and define terms as they relate to the integumentary system
- Identify meanings of key word components of the integumentary system
- Categorize diagnostic, therapeutic, procedural or anatomic terms related to the integumentary system
- Use terms related to the integumentary system
- Use terms related to the diseases and disorders of 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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Introduction to the Integumentary System

Did You Know?

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

The integumentary system refers to the skin and its accessory structures. In the adult human body, the skin makes up about 16 percent of body weight and covers an area of 16-21 ft².

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.

Watch this video:

body.



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Media 3.1. [The science of skin – Emma Bryce](#) [Video]. Copyright 2018 by [Ted-Ed](#).

Practice integumentary system medical terms.



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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. The deeper layer of skin is well **vascularized**. It also has numerous sensory, and **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**

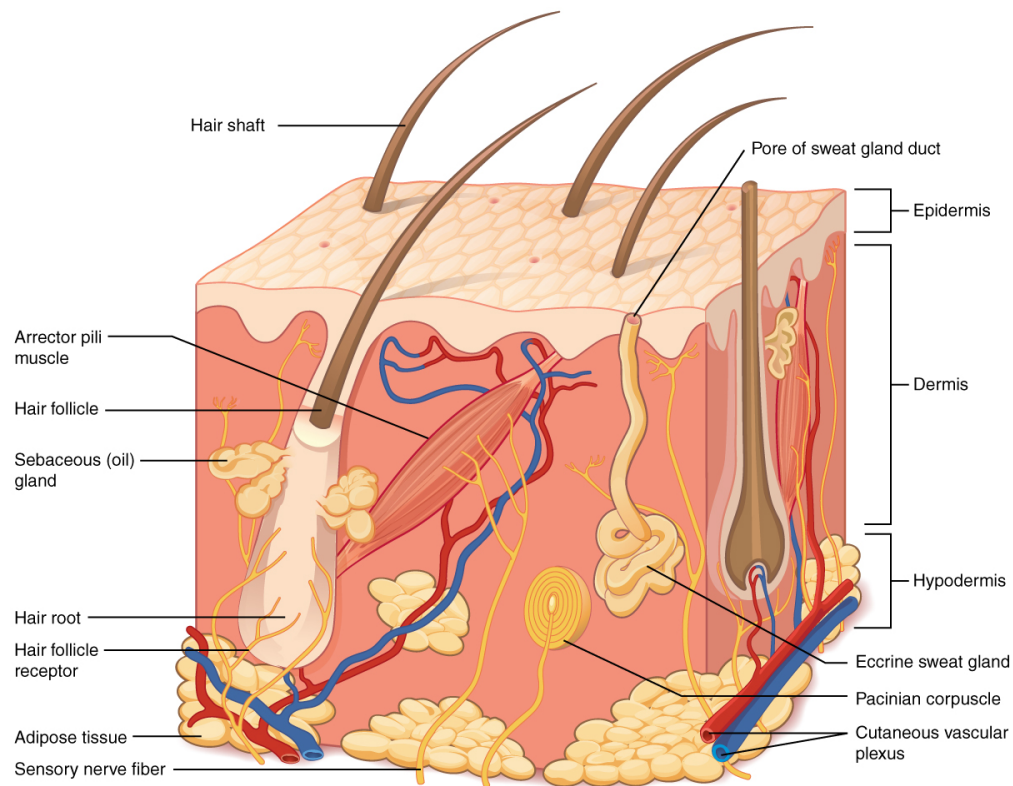


Figure 3.1 Layers of Skin. From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

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**.

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.

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 3.2).



Figure 3.2 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., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

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 3.2). Within the papillary layer are fibroblasts, a small number **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. This 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. This 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

The **hypodermis** 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 **[pb_glossary id="1697"]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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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.

Sensory Function

The skin acts as a sense organ because the epidermis, dermis, and the 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.

1. When the **body becomes warm** sweat glands, accessory structures to the skin, secrete water, salt, and other substances to cool the body.
 1. Even when the body does not appear to be noticeably sweating, approximately 500 mL of sweat are secreted a day.
2. 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.
 1. When the sweat evaporates from the skin surface, the body is cooled as body heat is dissipated.
 2. 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.
 3. This accounts for the skin redness that many people experience when exercising.
3. When **body temperatures drop**, the arterioles constrict to minimize heat loss, particularly in the ends of the digits

and tip of the nose.

1. This reduced circulation can result in the skin taking on a whitish hue.
2. Although the temperature of the skin drops as a result, passive heat loss is prevented, and internal organs and structures remain warm.
3. If the temperature of the skin drops too much (such as environmental temperatures below freezing), the conservation of body core heat can result **frostbite**.

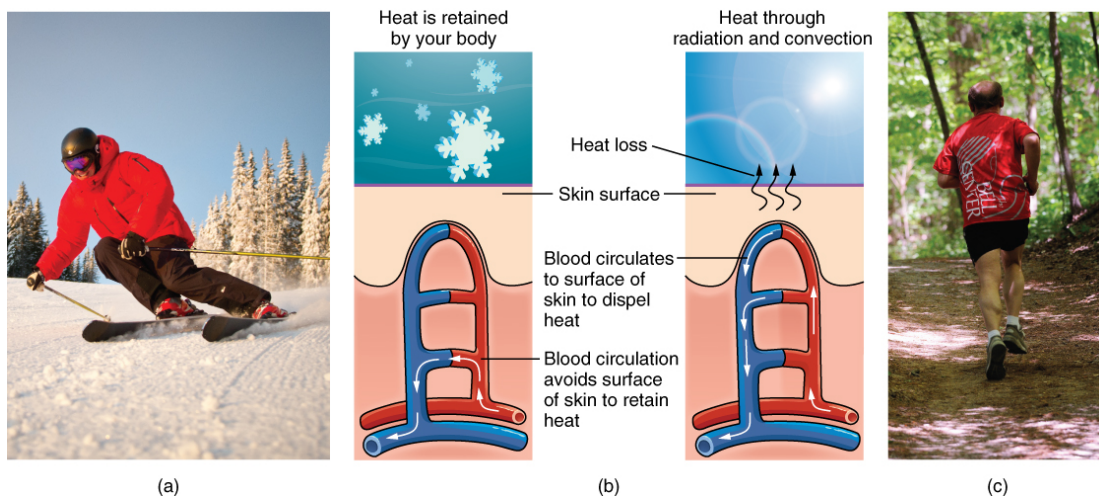


Figure 3.3 Thermoregulation. During strenuous physical activities, such as skiing (a) or running (c), the dermal blood vessels dilate and sweat secretion increases (b). These mechanisms prevent the body from overheating. In contrast, the dermal blood vessels constrict to minimize heat loss in response to low temperatures (b). (credit a: "Trysil" /flickr; credit c: Ralph Daily). From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

Concept Check

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

- When body temperature is too warm.
- When 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 D₃ 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 normal absorption of calcium and phosphorous, 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 3.2. [The Integumentary System, Part 2 – Skin Deeper: Crash Course A&P #7](#) [Online video]. Copyright 2015 by [CrashCourse](#). Media 3.2. [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 3.4).

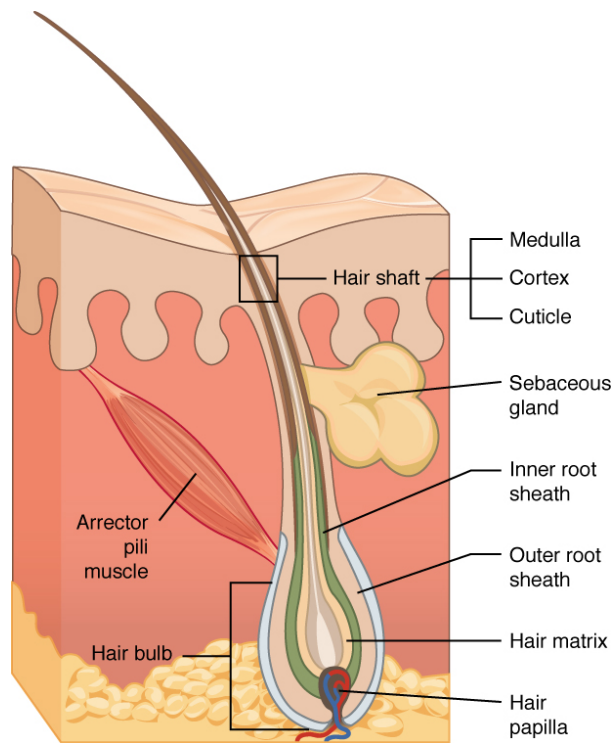


Figure 3.4 Hair. Hair follicles originate in the epidermis and have many different parts. From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

Hair Function

Did You Know?

When frightened, the

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 goose bumps and even more obvious in animals, such as when a frightened cat raises its fur. Of course, this is much more obvious in organisms with a heavier coat than most humans, such as dogs and cats.

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 3.5). 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.

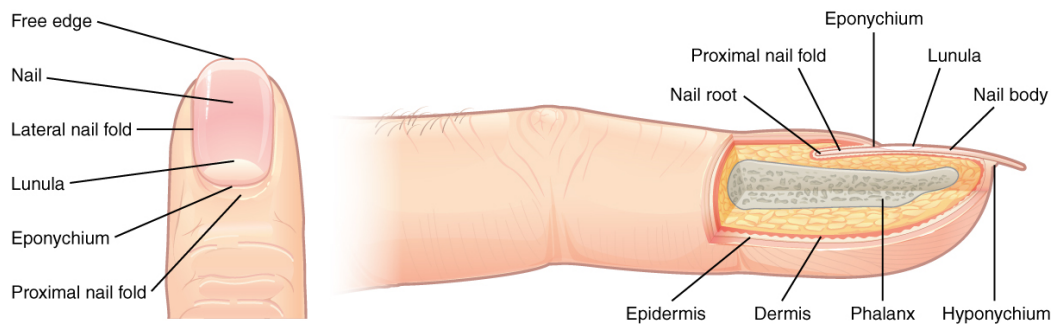


Figure 3.5 Nails. The nail is an accessory structure of the integumentary system. From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

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 excreted 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 type of gland that produces a 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 3.6). 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 dermicidin, an antimicrobial peptide. **Eccrine glands** are a primary component of thermoregulation in humans and thus help to maintain **homeostasis**.

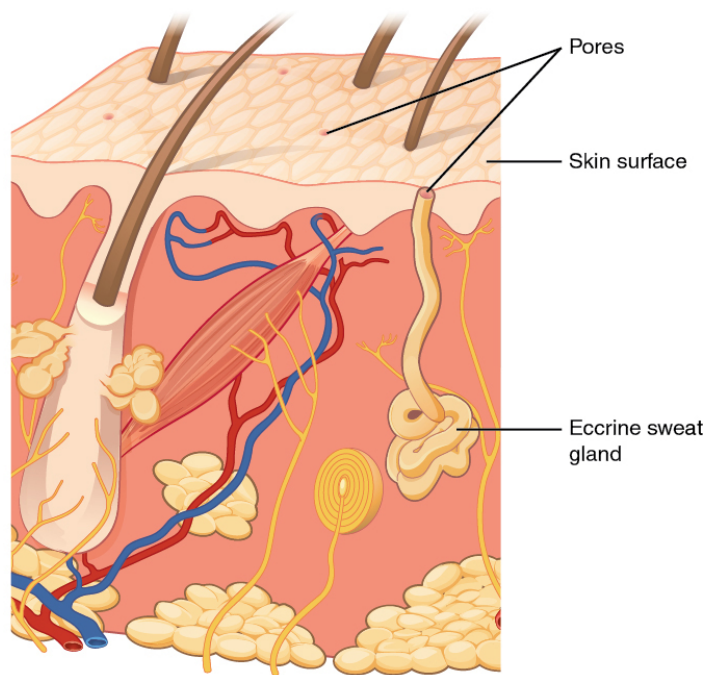


Figure 3.6 Eccrine Gland. Eccrine glands are coiled glands in the dermis that release sweat that is mostly water. From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

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.

Words not Easily Broken into Word Parts

This prevents sweating.



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Common Integumentary System Abbreviations

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



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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 3.7). 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 3.7 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., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

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 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 elderly to be intolerant to extreme heat.

Disease and Disorders

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.

One of the most talked about diseases is skin **cancer**. Most cancers are identified by the organ or tissue in which the cancer originates. One common form of cancer is skin cancer.

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.

Sun Damage

It requires about 10 days after initial sun exposure for melanin synthesis to peak, 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 3.8).

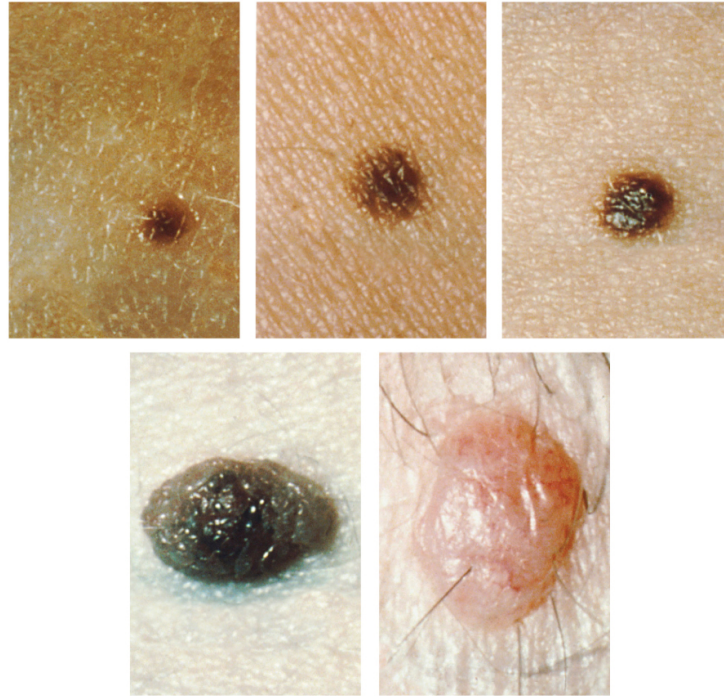


Figure 3.8 Moles. Moles range from benign accumulations of melanocytes to melanomas. These structures populate the landscape of our skin. (credit: the National Cancer Institute). From Betts, et al., 2021. Licensed under [CC BY 4.0](#).

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 areas 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, etc. 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 3.9). Like most cancers, basal cell



Figure 3.9 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., 2021. Licensed under [CC BY 4.0](#).

carcinomas respond best to treatment when caught early. Treatment options include surgery, freezing (cryosurgery), and topical ointments.

Squamous Cell Carcinoma (SCC)

Squamous cell carcinoma is a cancer that affects the keratinocytes of the stratum spinosum and presents as lesions commonly found on the scalp, ears, and hands (see Figure 3.10). 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 3.10 Squamous Cell Carcinoma Squamous cell carcinoma presents here as a lesion on a nose. (credit: the National Cancer Institute). From Betts, et al., 2021. Licensed under [CC BY 4.0](#).

Melanoma

A

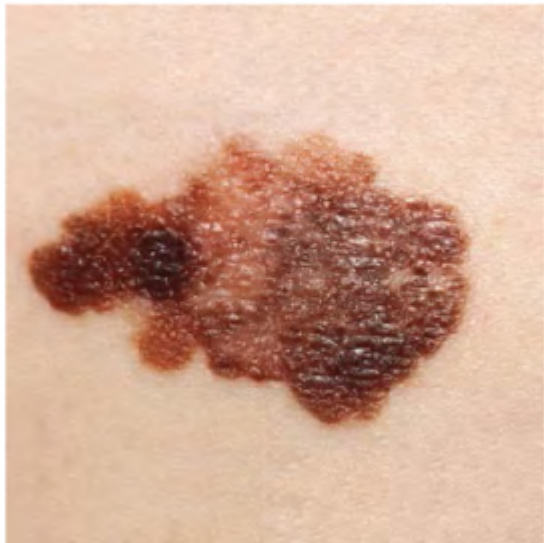


Figure 3.11 Melanoma. Melanomas typically present as large brown or black patches with uneven borders and a raised surface. (credit: the National Cancer Institute). From Betts, et al., 2021. Licensed under [CC BY 4.0](#).

melanoma is a 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 3.11). Treatment typically involves surgical excision and immunotherapy.

ABCDE for Early Diagnosis

Doctors often give their patients the following ABCDE mnemonic to help with the diagnosis of early-stage melanoma (see Fig 3.12). 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 a pencil eraser
- **E**volving – its shape has changed

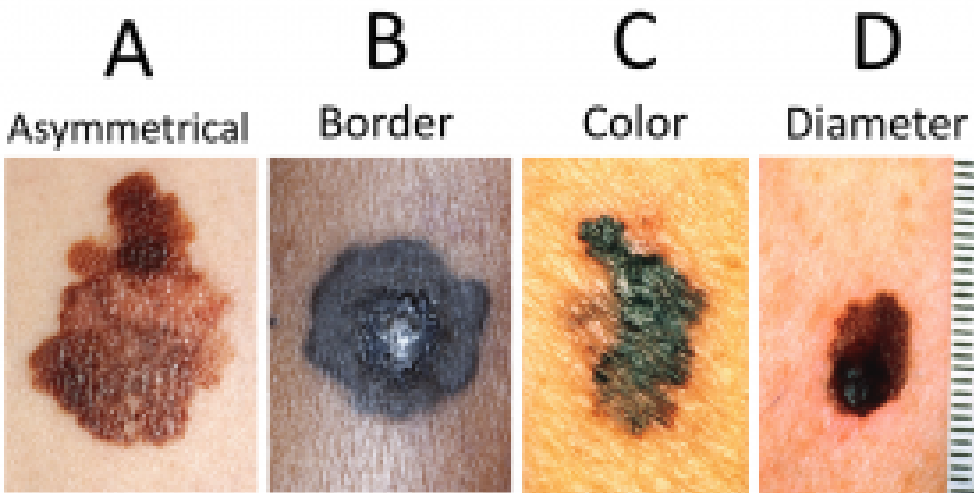


Fig 3.12 The ABC's of early diagnosis. Example of abnormal moles. (credit: the National Cancer Institute, moles C&D, n.d.). Mole A from Betts, et al., 2021. Licensed under CC BY 4.0.

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 (Betts, et al., 2021)

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 3.13). Neither albinism nor vitiligo directly affects the lifespan of an individual (Betts, et al., 2021)



Figure 3.13 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., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

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 **xanthoderma** or **jaundice**.
- 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).
- 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 do with the skin's pigmentation (Betts, et al., 2021)

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 (Betts, et al., 2021).

Eczema

Eczema is an allergic reaction that manifests as dry, itchy patches of skin that resemble rashes (see Figure 3.14). 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 (Betts, et al., 2021).



Figure 3.14 Eczema. Eczema is a common skin disorder that presents as a red, flaky rash. (credit: "Jambula"/Wikimedia Commons). From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

Acne

Acne is a skin

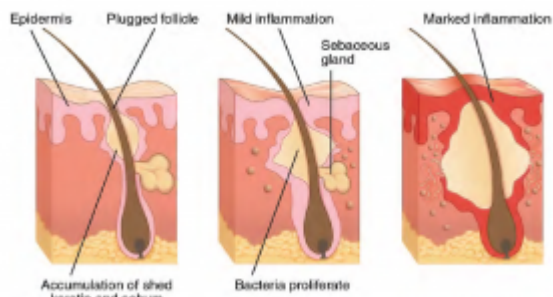


Figure 3.15. Acne. Acne is a result of over-productive sebaceous glands, which leads to formation of blackheads and inflammation of the skin. From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

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. An 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 3.15) (Betts, et al., 2021).

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 or 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, 2018a)

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 disease so a dermatologist is the best physician to diagnosis psoriasis. Treatments may include creams, ointments, ultraviolet light therapy and medication (Center for Disease Control and Prevention, 2018). 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**, as well as **scars** and **calluses**. They can be caused by sharp objects, heat, or excessive pressure or friction to the skin (Betts, et al., 2021).

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 with 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 (Betts, et al., 2021).

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 (Betts, et al., 2021).

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 3.16) (Betts, et al., 2021).

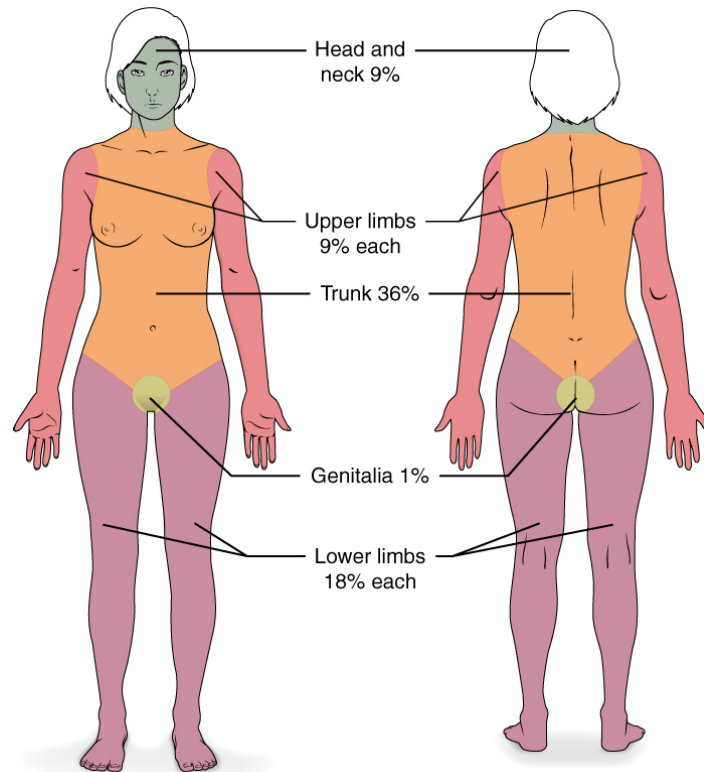


Figure 3.16 Calculating the Size of a Burn. The size of a burn will guide decisions made about the need for specialized treatment. Specific parts of the body are associated with a percentage of body area. From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

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 (Betts et al., 2021).

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 (Betts, et al., 2021).

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** (see Figure 3.17). In contrast, scars that result from acne and chickenpox have a sunken appearance and are called atrophic scars (Betts, et al., 2021).

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 (Betts, et al., 2021).



Figure 3.17 Post surgical keloid on abdomen. From [Htirgan](#). Licensed under [CC BY-SA 3.0](#).

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 (Betts, et al., 2021)

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 (Betts, et al., 2021). For detailed images of types of bedsores, see Minnesota Hospital Association's [Pressure Ulcer Staging Cards](#).

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 independent 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 (Betts, et al., 2021).

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 [‘What is a Dermatologist?’](#) page of the American Academy of Dermatology Association website.

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 (Mayo Clinic Staff, 2017). For more details about each step of the process visit the Skin Cancer Foundation’s site on [Mohs Surgery](#).

Test Yourself



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<https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>.

4. Respiratory System

WTCS Learning Objectives

- Apply the rules of medical language to build, analyze, spell, pronounce, abbreviate, and define terms as they relate to the respiratory system
- Identify meanings of key word components of the respiratory system
- Categorize diagnostic, therapeutic, procedural or anatomic terms related to the respiratory system
- Use terms related to the respiratory system
- Use terms related to the diseases and disorders of the respiratory system

Respiratory System Word Parts

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



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Introduction to the Respiratory System

How long you can hold your breath as you continue reading... How long can you do it? Chances are you are feeling uncomfortable already. A typical human cannot survive without breathing for more than three minutes, and even if you wanted to hold your breath longer, your **autonomic** nervous system would take control. Although oxygen is critical for cells, it is the accumulation of carbon dioxide that primarily drives your need to breathe.

The major structures of the respiratory system function primarily to provide oxygen to body tissues for cellular respiration, remove the waste product carbon dioxide, and help to maintain acid-base balance. Portions of the respiratory system are also used for non-vital functions, such as sensing odors, speech production, and for straining, such as coughing.

Did You Know?

If you hold your breath for longer than 3 minutes your autonomic nervous system will take control.

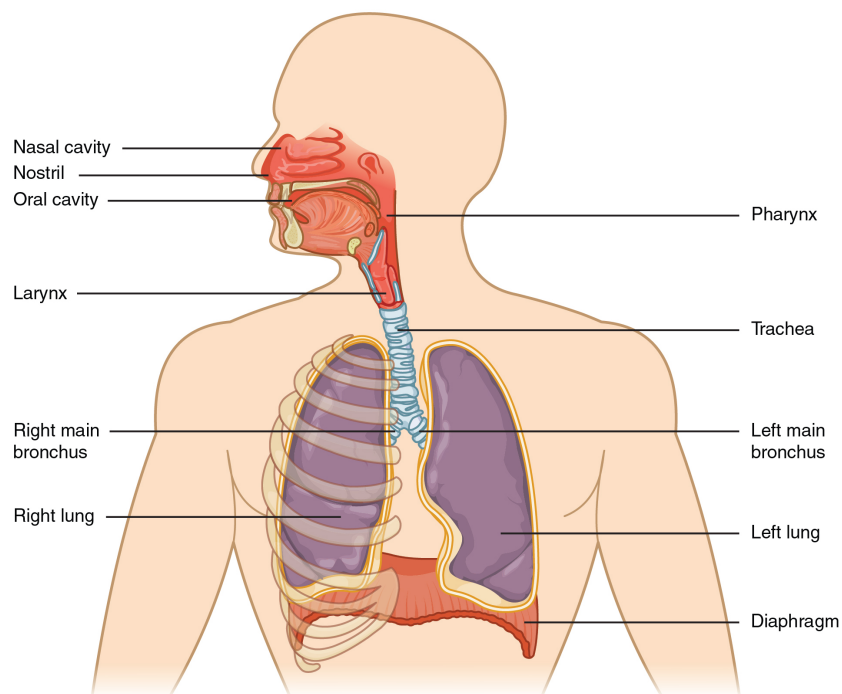


Figure 4.1 Major Respiratory Structures. The major respiratory structures span the nasal cavity to the diaphragm. From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

Watch this video:



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Media 4.1. [Respiratory System, Part 1: Crash Course A&P #31](#) [Online video]. Copyright 2015 by [CrashCourse](#).

Respiratory System Medical Terms



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Anatomy (Structures) of the Respiratory System

The Nose and its Adjacent Structures

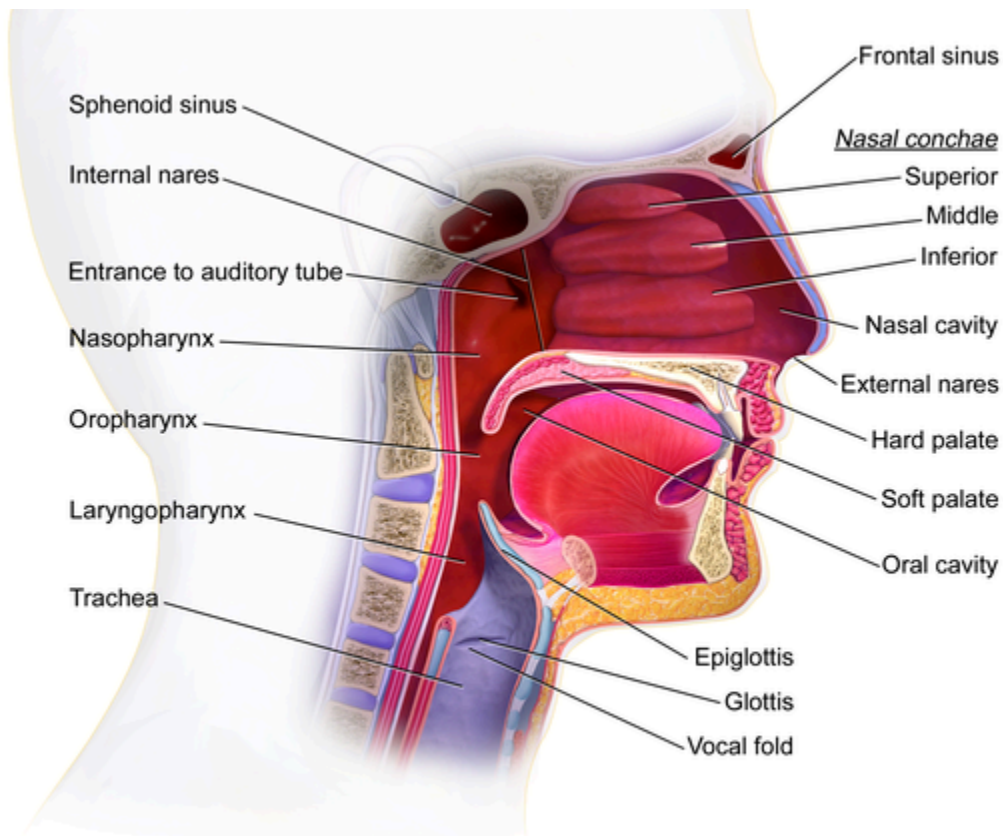
The major entrance and exit for the respiratory system is through the **nose**. When discussing the nose, it is helpful to divide it into two major sections:

- **external nose**
- **internal nose**

The **nares** open into the nasal cavity, which is separated into left and right sections by the nasal septum (Figure 4.2). The **nasal septum** is formed anteriorly by a portion of the **septal cartilage** and posteriorly by the perpendicular plate of the ethmoid bone and the thin vomer bones.

Each lateral wall of the nasal cavity has three bony projections the inferior conchae are separate bones and the superior and middle conchae are portions of the ethmoid bone. **Conchae** increase the surface area of the nasal cavity, disrupt the flow of air as it enters the nose, causing air to bounce along the epithelium, where it is cleaned and warmed. The conchae and meatuses trap water during exhalation preventing dehydration.

The floor of the nasal cavity is composed of the **hard palate** and the **soft palate**. Air exits the nasal cavities via the internal nares and moves into the pharynx.



The Upper Respiratory System

Figure 4.2 Upper Respiratory System. From Wikimedia 2019. Licensed under CC BY 3.0.

Paranasal sinuses serve to warm and humidify incoming air. They are lined with a mucosa which produces mucus. Paranasal sinuses are named for their associated bone:

- frontal sinus
- maxillary sinus
- sphenoidal sinus
- ethmoidal sinus

The nares and anterior portion of the nasal cavities are lined with mucous membranes, containing sebaceous glands and hair follicles that serve to prevent the passage of large debris, such as dirt, through the nasal cavity. An olfactory epithelium used to detect odors is found deeper in the nasal cavity.

Did You Know?

Cold air slows the movement of cilia that may result in the accumulation of mucus leading to **rhinorrhea** during cold weather.

The **cilia** of the respiratory epithelium help to remove mucus and debris with a constant beating motion, sweeping materials towards the throat to be swallowed. This moist epithelium functions to warm and humidify incoming air.

Pharynx

The **pharynx** is divided into three major regions: the **nasopharynx**, the **oropharynx**, and the **laryngopharynx** (see Figure 4.3).

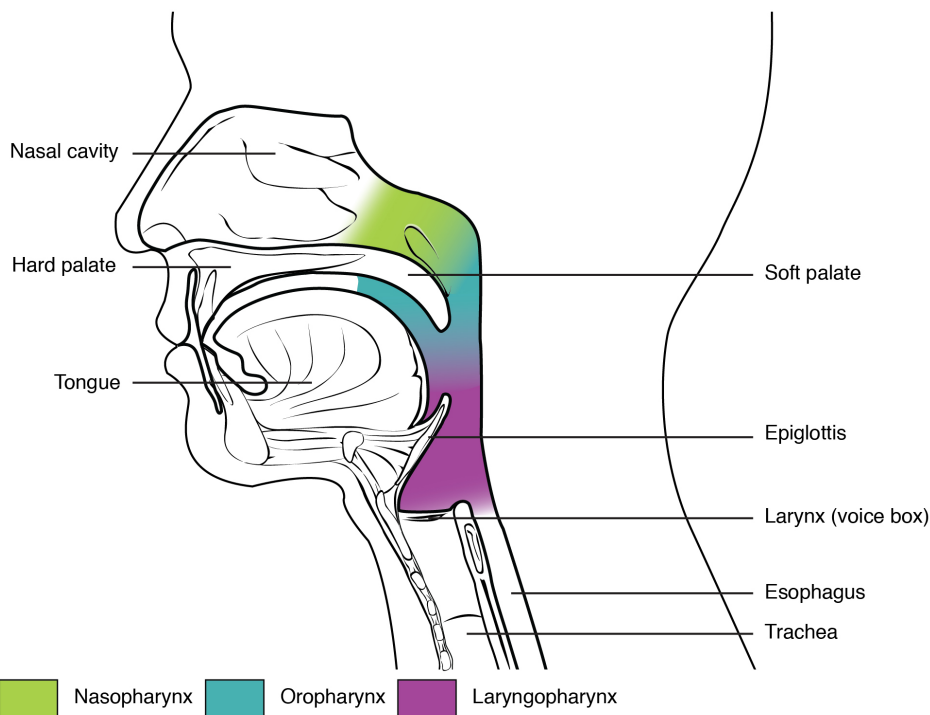


Figure 4.3 Divisions of the Pharynx. The pharynx is divided into three regions: the nasopharynx, the oropharynx, and the laryngopharynx. From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

At the top of the **nasopharynx** are the pharyngeal tonsils. The function of the **pharyngeal** tonsil is not well understood, but it contains a rich supply of **lymphocytes** and is covered with ciliated epithelium that traps and destroys invading pathogens that enter during inhalation. The pharyngeal tonsils are large in children, but tend to regress with age and may even disappear. The **uvula** and **soft palate** move like a pendulum during swallowing, swinging upward to close off the nasopharynx to prevent ingested materials from entering the nasal cavity. Auditory (Eustachian) tubes that connect to each middle ear cavity open into the nasopharynx. This connection is why colds often lead to ear infections.

The **oropharynx** is bordered superiorly by the **nasopharynx** and anteriorly by the oral cavity. The **oropharynx** contains two distinct sets of tonsils:

- The palatine tonsils.
 - A palatine tonsil is one of a pair of structures located laterally in the oropharynx
- The lingual tonsils.
 - The **lingual** tonsil is located at the base of the tongue.

Similar to the pharyngeal tonsil, the palatine and **lingual** tonsils are composed of lymphoid tissue, and trap and destroy pathogens entering the body through the oral or nasal cavities.

The **laryngopharynx** is **inferior** to the oropharynx and **posterior** to the larynx. It continues the route for ingested material and air until its **inferior** end, where the digestive and respiratory systems diverge. The stratified squamous epithelium of the oropharynx is continuous with the laryngopharynx. **Anteriorly**, the laryngopharynx opens into the larynx, whereas **posteriorly**, it enters the esophagus.

Larynx

The structure of the **larynx** is formed by several pieces of cartilage (see Figure 4.4). Three large cartilage pieces form the major structure of the **larynx**.

- Thyroid cartilage (anterior)
- Epiglottis (superior)
- Cricoid cartilage (inferior)

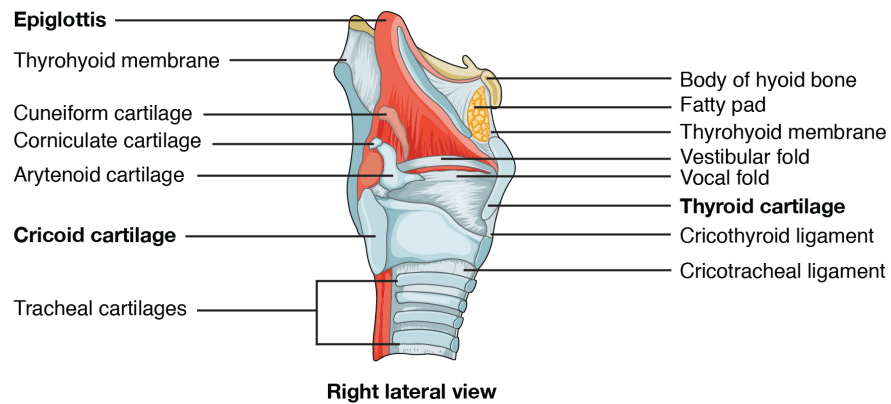
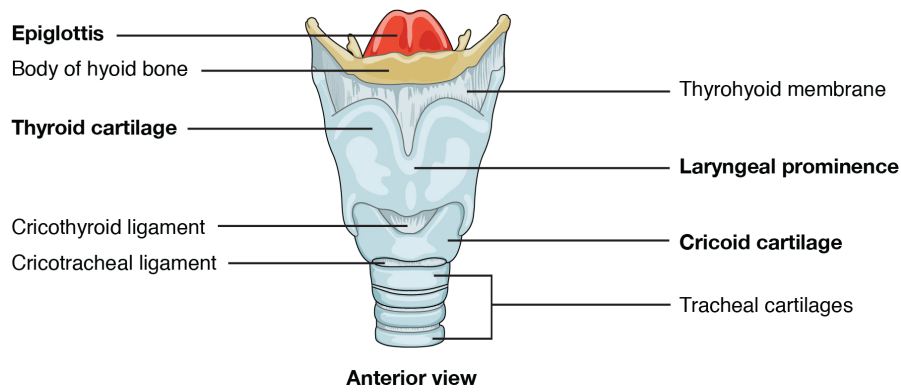


Figure 4.4 Larynx. The larynx extends from the laryngopharynx and the hyoid bone to the trachea. From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

When the **epiglottis** is in the “closed” position, the unattached end of the epiglottis rests on the **glottis**.

The act of swallowing causes the pharynx and larynx to lift upward, allowing the pharynx to expand and the epiglottis of the larynx to swing downward, closing the opening to the trachea. These movements produce a larger area for food to pass through, while preventing food and beverages from entering the trachea.

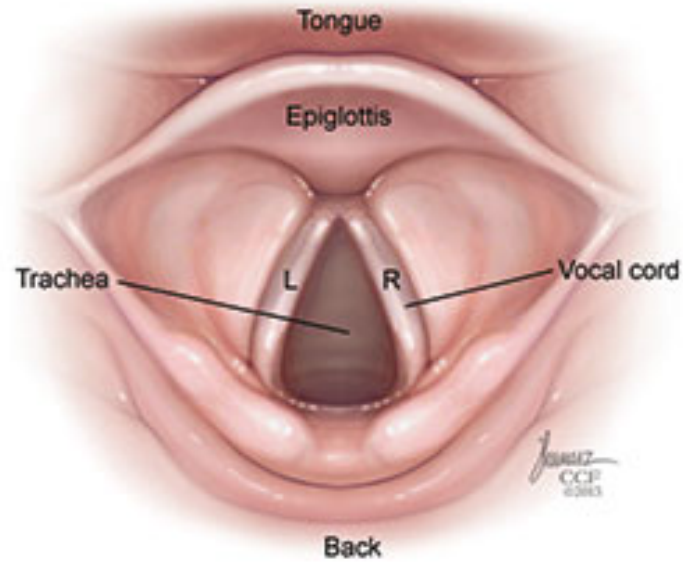


Figure 4.5 Healthy Vocal Cords. From ClevelandClinic.org

Similar to the nasal cavity and nasopharynx, this specialized epithelium produces mucus to trap debris and pathogens as they enter the trachea. The cilia beat the mucus upward towards the laryngopharynx, where it can be swallowed down the esophagus.

Trachea

The **trachea** is formed by 16 to 20 stacked, C-shaped pieces of hyaline cartilage that are connected by dense connective tissue (see Figure 4.6). The trachealis muscle and elastic connective tissue together form the **fibroelastic membrane**. The fibroelastic membrane allows the trachea to stretch and expand slightly during inhalation and exhalation, whereas the rings of cartilage provide structural support and prevent the trachea from collapsing. The trachealis muscle can be contracted to force air through the trachea during exhalation. The trachea is lined with pseudostratified ciliated columnar epithelium, which is continuous with the larynx. The esophagus borders the trachea **posteriorly**.

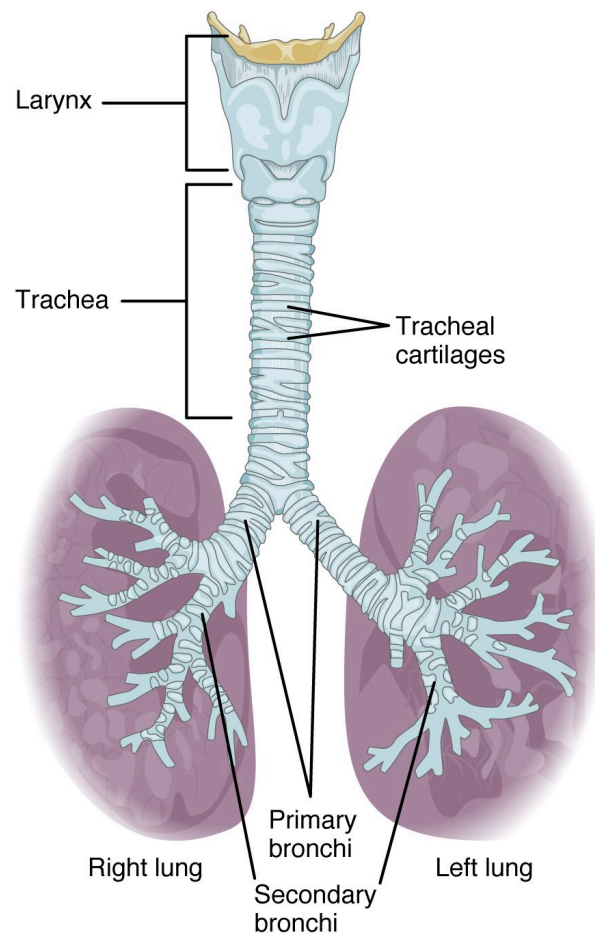


Figure 4.6 Trachea. The tracheal tube is formed by stacked, C-shaped pieces of hyaline cartilage. From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

Bronchial Tree

The trachea branches into the right and left primary bronchi at the **carina**. The carina is a raised structure that contains specialized nervous tissue that induces violent coughing if a foreign body, such as food, is present. Rings of cartilage, similar to those of the trachea, support the structure of the bronchi and prevent their collapse. The primary bronchi enter the lungs at the **hilum**. The bronchi continue to branch into bronchial a tree. A bronchial tree (or respiratory tree) is the collective term used for these multiple-branched bronchi. The main function of the bronchi, like other conducting zone structures, is to provide a passageway for air to move into and out of each lung. The mucous membrane traps debris and pathogens.

The bronchiole branches from the tertiary bronchi. Bronchioles, which are about 1 mm in diameter, further branch until they become the tiny terminal bronchioles, which lead to the structures of gas exchange. There are more than 1000 terminal bronchioles in each lung. The muscular walls of the bronchioles do not contain cartilage like those of the bronchi. This muscular wall can change the size of the tubing to increase or decrease airflow through the tube.

Respiratory Zone

In contrast to the **conducting zone**, the **respiratory zone** includes structures that are directly involved in gas exchange. The respiratory zone begins where the terminal bronchioles join a respiratory bronchiole, the smallest type of bronchiole (see Figure 4.7), which then leads to an alveolar duct, opening into a cluster of alveoli.

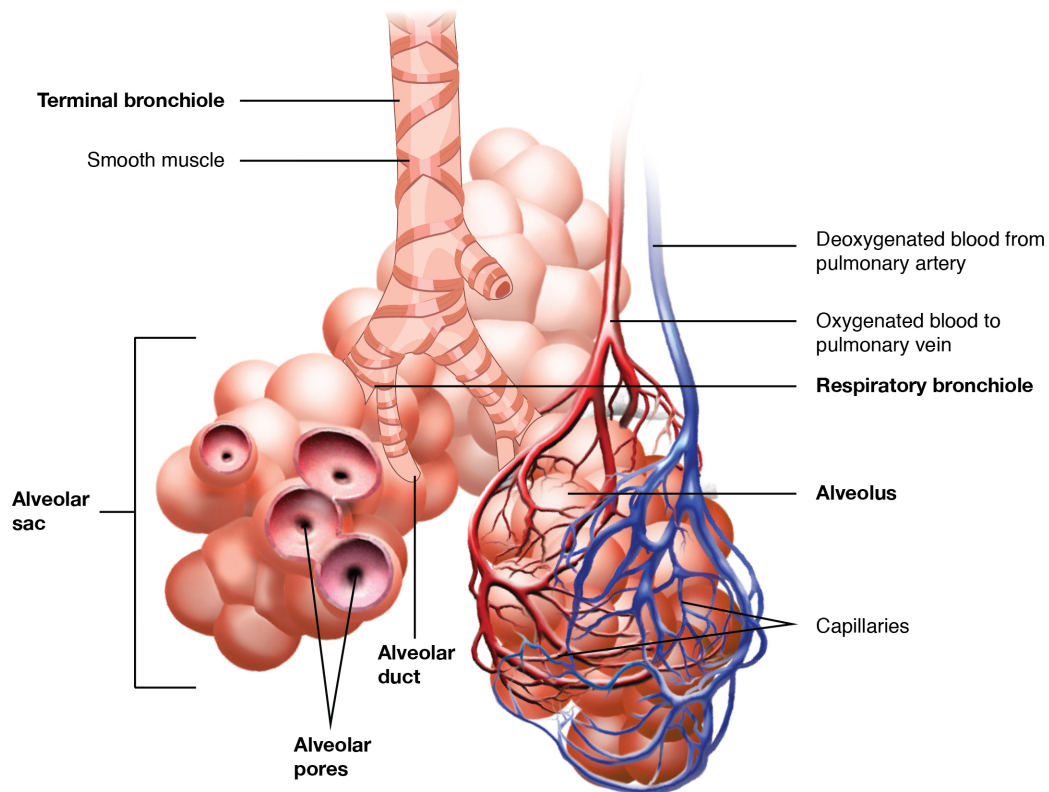


Figure 4.7 Respiratory Zone. Bronchioles lead to alveolar sacs in the respiratory zone, where gas exchange occurs. From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

Alveoli

An **alveolar duct** opens into a cluster of alveoli. An alveolus is one of the many small, grape-like sacs that are attached to the alveolar ducts. An alveolar sac is a cluster of many individual alveoli that are responsible for gas exchange. An alveolus is approximately 0.2 millimeters in diameter with elastic walls that allow the alveolus to stretch during air intake, which greatly increases the surface area available for gas exchange. Alveoli are connected to their neighbors by alveolar pores, which help maintain equal air pressure throughout the alveoli and lung (see Fig. 4.7).

Concept Check

- What are the components of the **bronchial** tree?
- What is the purpose of **cilia**?
- Where does **gas** exchange take place?

Gross Anatomy of the Lungs

The lungs are pyramid-shaped, paired organs that are connected to the trachea by the right and left bronchi; on the inferior surface, the lungs are bordered by the **diaphragm**. The lungs are enclosed by the pleurae, which are attached to the mediastinum. The right lung is shorter and wider than the left lung, and the left lung occupies a smaller volume than the right. The **cardiac notch** allows space for the heart (see Figure 4.8). The apex of the lung is the superior region, whereas the base is the opposite region near the diaphragm. The costal surface of the lung borders the ribs. The mediastinal surface faces the mid line.

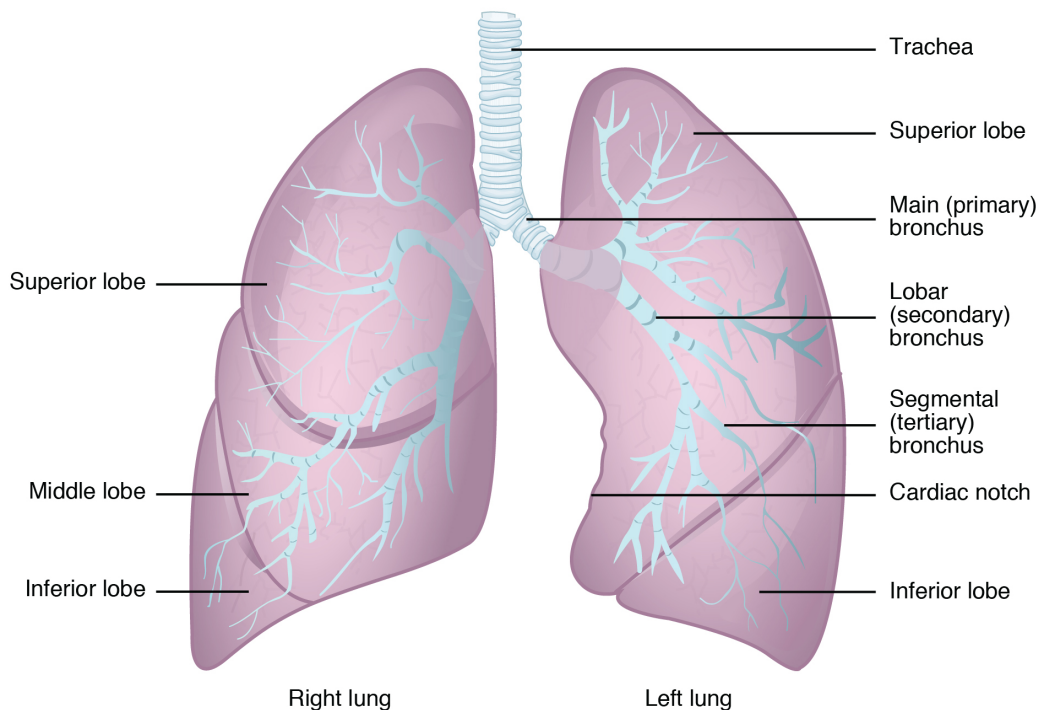


Figure 4.8 Gross Anatomy of the Lungs. From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

Each lung is composed of smaller units called lobes. Fissures separate these lobes from each other. The right lung consists of three lobes: the superior, middle, and inferior lobes. The left lung consists of two lobes: the superior and inferior lobes. A pulmonary lobule is a subdivision formed as the bronchi branch into bronchioles. Each lobule receives

its own large bronchiole that has multiple branches. An interlobular septum is a wall, composed of connective tissue, which separates lobules from one another.

Can you correctly label the respiratory system structures?



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Physiology (Function) of the Respiratory System

Blood Supply

The major function of the lungs is to perform gas exchange, which requires blood from the pulmonary circulation.

- This blood supply contains deoxygenated blood and travels to the lungs where **erythrocytes** pick up oxygen to be transported to tissues throughout the body.
- The **pulmonary artery** carries deoxygenated, arterial blood to the alveoli.
- The pulmonary artery branches multiple times as it follows the bronchi, and each branch becomes progressively smaller in diameter.
- One arteriole and an accompanying venule supply and drain one pulmonary lobule. As they near the alveoli, the pulmonary arteries become the pulmonary capillary network.
- The pulmonary capillary network consists of tiny vessels with very thin walls that lack smooth muscle fibers.
- The capillaries branch and follow the bronchioles and structure of the alveoli. It is at this point that the capillary wall meets the alveolar wall, creating the respiratory membrane.
- Once the blood is oxygenated, it drains from the alveoli by way of multiple pulmonary veins, which exit the lungs through the **hilum**.

Nervous Innervation

The blood supply of the lungs plays an important role in gas exchange and serves as a transport system for gases throughout the body. Innervation by the both the **parasympathetic** and **sympathetic** nervous systems provides an important level of control through dilation and constriction of the airway.

- The parasympathetic system causes bronchoconstriction.
- The sympathetic nervous system stimulates bronchodilation.

Reflexes such as coughing, and the ability of the lungs to regulate oxygen and carbon dioxide levels, also result from **autonomic** nervous system control.

Pleura of the Lungs

Each lung is enclosed within a cavity that is surrounded by the **pleura**. The pleura (plural = pleurae) is a serous membrane that surrounds the lung. The right and left pleurae, which enclose the right and left lungs, respectively, are separated by the mediastinum.

The pleurae consist of two layers:

1. The **visceral pleura** is the layer that is superficial to the lungs, and extends into and lines the lung fissures (see Figure 4.9).
2. The **parietal pleura** is the outer layer that connects to the thoracic wall, the mediastinum, and the diaphragm.

The visceral and parietal pleurae connect to each other at the **hilum**. The pleural cavity is the space between the visceral and parietal layers.

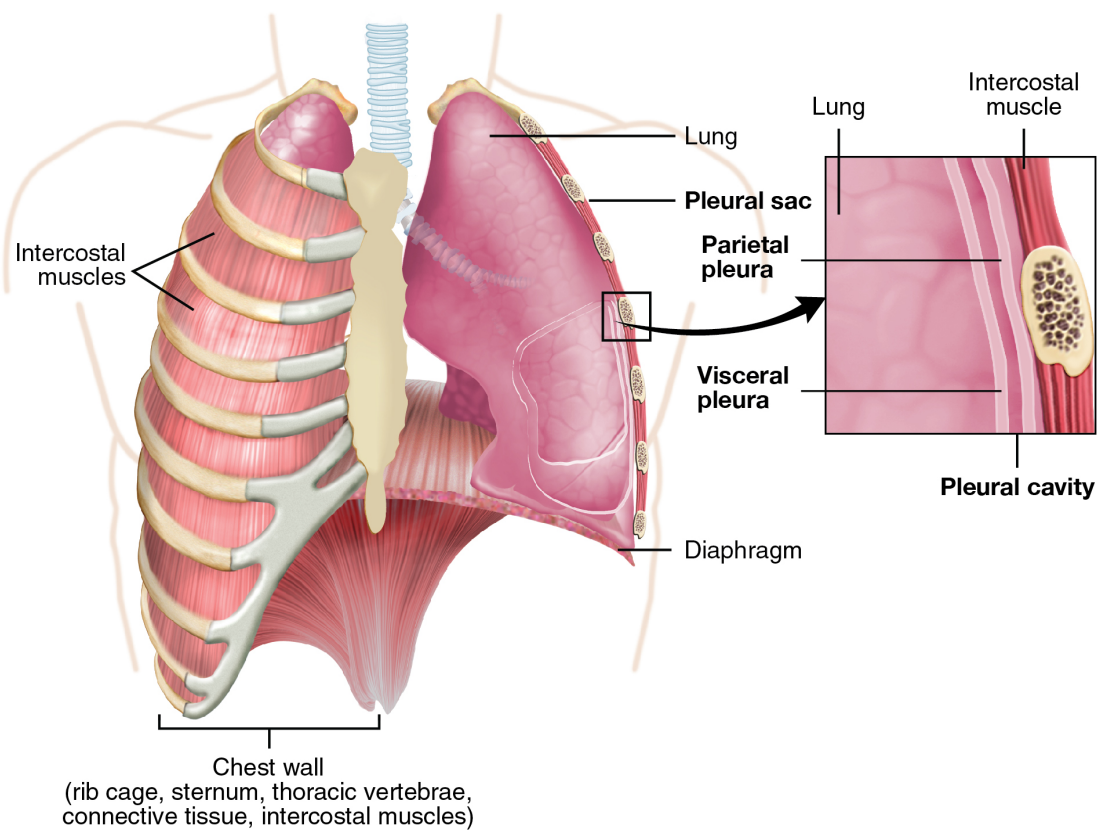


Figure 4.9 Parietal and Visceral Pleurae of the Lungs. From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

The pleurae perform two major functions:

1. **Produce pleural fluid** that lubricates surfaces, reduces friction to prevent trauma during breathing, and creates surface tension that helps maintain the position of the lungs against the thoracic wall. This adhesive characteristic of the pleural fluid causes the lungs to enlarge when the thoracic wall expands during ventilation, allowing the lungs to fill with air.
2. The pleurae also **create a division** between major organs that prevents interference due to the movement of the organs, while preventing the spread of infection.

Pulmonary Ventilation

The difference in pressures drives pulmonary ventilation because air flows down a pressure gradient, that is, air flows from an area of higher pressure to an area of lower pressure.

- Air flows into the lungs largely due to a difference in pressure; atmospheric pressure is greater than intra-alveolar pressure, and intra-alveolar pressure is greater than intrapleural pressure.
- Air flows out of the lungs during expiration based on the same principle; pressure within the lungs becomes greater than the atmospheric pressure.

Pulmonary ventilation comprises two major steps: **inspiration** and **expiration** (see video below). A respiratory cycle is one sequence of inspiration and expiration.

Two muscle groups are used during **normal inspiration** the diaphragm and the external intercostal muscles. Additional muscles can be used if a bigger breath is required.

- The diaphragm contracts, it moves inferiorly toward the abdominal cavity, creating a larger thoracic cavity and more space for the lungs.
- The external intercostal muscles contract and moves the ribs upward and outward, causing the rib cage to expand, which increases the volume of the thoracic cavity.

Due to the adhesive force of the pleural fluid, the expansion of the thoracic cavity forces the lungs to stretch and expand as well. This increase in volume leads to a decrease in intra-alveolar pressure, creating a pressure lower than atmospheric pressure. As a result, a pressure gradient is created that drives air into the lungs.



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Media 4.2. [3D Medical Mechanics of Breathing](#) [Online video]. Copyright 2014 by AIDA Educational Committee.

The process of **normal expiration** is passive, meaning that energy is not required to push air out of the lungs.

- The elasticity of the lung tissue causes the lung to recoil, as the diaphragm and intercostal muscles relax following inspiration.
- The thoracic cavity and lungs decrease in volume, causing an increase in interpulmonary pressure. The interpulmonary pressure rises above atmospheric pressure, creating a pressure gradient that causes air to leave the lungs.

There are different types, or modes, of breathing that require a slightly different process to allow inspiration and expiration:

- **Quiet breathing**, also known as **eupnea**, is a mode of breathing that occurs at rest and does not require the cognitive thought of the individual. During quiet breathing, the diaphragm and external intercostals must contract.
- **Diaphragmatic breathing**, also known as deep breathing, requires the diaphragm to contract. As the diaphragm relaxes, air passively leaves the lungs.
- **Costal breathing**, also known as a shallow breath, requires contraction of the intercostal muscles. As the intercostal muscles relax, air passively leaves the lungs.
- **Forced breathing**, also known as **hyperpnea**, is a mode of breathing that can occur during exercise or actions that require the active manipulation of breathing, such as singing.
 - During forced breathing, inspiration and expiration both occur due to muscle contractions. In addition to the contraction of the diaphragm and intercostal muscles, other accessory muscles must also contract.
 - During **forced inspiration**, muscles of the neck contract and lift the thoracic wall, increasing lung volume.
 - During **forced expiration**, accessory muscles of the abdomen contract, forcing abdominal organs upward against the diaphragm. This helps to push the diaphragm further into the thorax, pushing more air out. In addition, accessory muscles help to compress the rib cage, which also reduces the volume of the thoracic cavity.

Concept Check

- Breathing normally, place your hand on your stomach take in one full **respiratory** cycle.
 - What type of breathing are you doing?
- Keeping your hand on your stomach, take in one large breath and exhale.
 - What type of breathing are you doing?
- Complete 10 jumping jacks, once completed, place your hand on your stomach and take in one full respiratory cycle.
 - What type of breathing are you doing?

Respiratory Rate and Control of Ventilation

Breathing usually occurs without thought, although at times you can consciously control it, such as when you swim under water, sing a song, or blow bubbles. The respiratory rate is the total number of breaths that occur each minute. Respiratory rate can be an important indicator of disease, as the rate may increase or decrease during an illness or in a disease condition. The respiratory rate is controlled by the respiratory center located within the medulla oblongata in the brain, which responds primarily to changes in carbon dioxide, oxygen, and pH levels in the blood.

The normal respiratory rate of a child decreases from birth to adolescence:

- A child under 1 year of age has a normal respiratory rate between 30 and 60 breaths per minute.
- By the time a child is about 10 years old, the normal rate is closer to 18 to 30.
- By adolescence, the normal respiratory rate is similar to that of adults, 12 to 18 breaths per minute.

Did You Know?

Respiratory rate is the total number of breaths that occur each minute.

Watch this video:



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Media 4.3. [Overview of the Respiratory System](#) [Online video]. Copyright 2019 by [Alila Medical Media](#).

Medical Terms not Easily Broken into Word Parts



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Common Respiratory Abbreviations



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Diseases and Disorders

A variety of diseases can affect the respiratory system, such as asthma, emphysema, chronic obstruction pulmonary disorder (COPD), and lung cancer. All of these conditions affect the gas exchange process and result in labored breathing and other difficulties. (Betts, et al., 2021).

The Effects of Second-Hand Tobacco Smoke

The burning of a tobacco cigarette creates multiple chemical compounds that are released through **mainstream smoke** and through **sidestream smoke**. **Second-hand smoke**, which is a combination of sidestream smoke and the mainstream smoke that is exhaled by the smoker, has been demonstrated by numerous scientific studies to cause disease. At least **40 chemicals in sidestream smoke** have been identified that negatively impact human health, leading to the development of cancer or other conditions, such as immune system dysfunction, liver toxicity, cardiac **arrhythmias**, pulmonary **edema**, and neurological dysfunction.

Tobacco and second-hand smoke are considered to be **carcinogenic**. Exposure to second-hand smoke can cause lung cancer in individuals who are not tobacco users themselves.

- It is estimated that the risk of developing lung cancer is increased by up to **30 percent in nonsmokers** who live with an individual who smokes in the house, as compared to nonsmokers who are not regularly exposed to second-hand smoke.
- **Children who live with an individual who smokes** inside the home have a larger number of lower respiratory infections, which are associated with hospitalizations, and higher risk of sudden infant death syndrome (SIDS). Second-hand smoke in the home has also been linked to a greater number of ear infections in children, as well as worsening symptoms of asthma (Betts, et al., 2021).

Chronic Obstructive Pulmonary Disease (COPD)

COPD is a term used to represent a number of respiratory diseases including chronic bronchitis and emphysema. COPD is a **chronic** condition with most symptoms appearing in people in their middle 50s. Symptoms include shortness of breath, cough, and sputum production. Symptoms during flare ups or times of **exacerbation**, may include green or brown mucous, increase in the viscosity or amount of mucus, chest pain, fever, swollen ankles, headaches, dizziness, and blue lips or fingers. There is no cure for COPD. Shortness of breath may be controlled with **bronchodilators**. The best plan is to avoid triggers and getting sick. Clients with COPD are advised to avoid people who are sick, get the flu

shot and reduce their exposure to pollution and cigarette smoke. While there are several risk factors, most cases are associated with cigarette smoking (Centers for Disease Control and Prevention, 2021c). To learn more about COPD visit the [Centers for Disease Control and Prevention's webpage on COPD](#).

Asthma

Asthma is a common chronic condition that affects all age groups. In 2019 there were over 25 million Americans diagnosed with asthma and a disproportionate number of children and youth ([Centers for Disease Control and Prevention, 2021b](#)). Asthma is a chronic disease characterized by inflammation, **edema** of the airway, and bronchospasms which can inhibit air from entering the lungs. Bronchospasms can lead to an “asthma attack.” An attack may be triggered by environmental factors such as dust, pollen, pet hair, or dander, changes in the weather, mold, tobacco smoke, and respiratory infections, or by exercise and stress (Betts, et al., 2021).

Symptoms of an asthma attack involve coughing, shortness of breath, wheezing, and tightness of the chest. Symptoms of a severe asthma attack require immediate medical attention and may include **dyspnea** that results in **cyanotic** lips or face, confusion, drowsiness, a rapid pulse, sweating, and severe anxiety. The severity of the condition, frequency of attacks, and identified triggers influence the type of medication that an individual may require. Longer-term treatments are used for those with more severe asthma. Short-term, fast-acting drugs that are used to treat an asthma attack are typically administered via an inhaler. For young children or individuals who have difficulty using an inhaler, asthma medications can be administered via a nebulizer (Betts, et al., 2021).

Lung Cancer

Lung cancer is a leading cause of cancer death among both males and females in the United States ([Centers for Disease Control and Prevention, 2021a](#)). Symptoms often appear in the late stages with 50% being diagnosed at STAGE IV (American Cancer Society medical and editorial content team, 2021). Symptoms may include shortness of breath, wheezing, blood in the mucus, chronic chest infections, **dysphagia**, pleural effusion, and enlarged lymph nodes. There are two types of lung cancer, **small cell lung cancer (SCLC)** linked to cigarette smoking, grows quickly and metastasizes. **Non-small cell lung cancer (NSCLC)** is more common and grows slowly. Changes in lung cells may lead to **benign** tumours or **malignant** tumors. Cancers that start in other parts of the body may metastasize to the lungs. Risk factors include smoking, air pollution, family history exposure to second-hand smoke, exposure to radon gas, and exposure to carcinogens (American Cancer Society medical and editorial content team, 2019). Treatment will depend on the type of lung cancer and the stage at diagnosis. Treatments may include surgery, chemotherapy, targeted therapy, immunotherapy, and radiation therapy (American Cancer Society medical and editorial content team, 2019).

Sleep Apnea

Sleep apnea is a **chronic** disorder that occurs in children and adults. It is characterized by the **cessation** of breathing during sleep. These episodes may last for several seconds or several minutes, and may differ in the frequency with which they are experienced. Sleep apnea leads to poor sleep, symptoms include fatigue, evening napping, irritability, memory problems, morning headaches, and excessive snoring. A diagnosis of sleep apnea is usually done during a sleep study, where the patient is monitored in a sleep laboratory for several nights. Treatment of sleep apnea commonly includes the use of a device called a **continuous positive airway pressure (CPAP) machine** during sleep. The CPAP machine has

a mask that covers the nose, or the nose and mouth, and forces air into the airway at regular intervals. This pressurized air can help to gently force the airway to remain open, allowing more normal ventilation to occur (Betts, et al., 2021).

Medical Terms in Context



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Medical Specialties and Procedures Related to the Respiratory System

Pulmonologist

Respiratory medicine is concerned with the diagnosis and treatment of diseases related to the respiratory system. Respiratory medicine requires in-depth knowledge of internal medicine. A physician who specializes in the respiratory system is called a pulmonologist. For more information, visit the [American Lung Association's page on pulmonologists](#).

Respiratory Therapists (RTs)

Respiratory Therapists (RTs) are health care professionals that monitor, assess and treat people who are having problems breathing. RTs are licensed in the state in which they practice. In Wisconsin, licensure is renewed every two years ([American Association for Respiratory Care](#), 2021a). RTs are trained in ventilation and airway management, cardiopulmonary resuscitation, oxygen and aerosol therapy. They care for patients during cardiac stress-testing, pulmonary function testing, smoking cessation, high-risk births, rehabilitation, and surgery. They treat patients with asthma, bronchitis, COPD, emphysema, heart disease, and pneumonia (American Association for Respiratory Care,

2021b). For more information, visit the American Association for Respiratory Care's [What is a Respiratory Therapist?](#) web page.

Thoracic Surgeon

A thoracic surgeon refers to a surgeon who has specialized in either thoracic (chest) surgery or cardiothoracic (heart and chest) surgery and care or perform surgery for patients with serious conditions of the chest (American Board of Thoracic Surgery, n.d.). To learn more, visit the [American Board of Thoracic Surgery web page](#).

Spirometry Testing

Spirometry testing is used to find out how well lungs are working by measuring air volume.

- **Respiratory volume**, describes the amount of air in a given space within the lungs, or which can be moved by the lung, and is dependent on a variety of factors.
- **Tidal volume**, refers to the amount of air that enters the lungs during quiet breathing, whereas inspiratory reserve volume is the amount of air that enters the lungs when a person inhales past the tidal volume.
- **Expiratory reserve volume**, is the extra amount of air that can leave with forceful expiration, following tidal expiration.
- **Residual volume**, is the amount of air that is left in the lungs after expelling the expiratory reserve volume.
- **Respiratory capacity**, is the combination of two or more volumes.
- **Anatomical dead space**, refers to the air within the respiratory structures that never participates in gas exchange, because it does not reach functional alveoli.
- **Respiratory rate**, is the number of breaths taken per minute, which may change during certain diseases or conditions.

Both respiratory rate and depth are controlled by the respiratory centers of the brain, which are stimulated by factors such as chemical and pH changes in the blood. These changes are sensed by central chemoreceptors, which are located in the brain, and peripheral chemoreceptors, which are located in the aortic arch and carotid arteries. A rise in carbon dioxide or a decline in oxygen levels in the blood stimulates an increase in respiratory rate and depth (Betts, et al., 2021).

Watch this video:



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Media 4.4. [How to do a spirometry test and interpret the results](#) [Online video]. Copyright 2019 by [BMJ Learning](#).

Test Yourself



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5. Urinary System

WTCS Learning Objectives

- Apply the rules of medical language to build, analyze, spell, pronounce, abbreviate, and define terms as they relate to the urinary system
- Identify meanings of key word components of the urinary system
- Categorize diagnostic, therapeutic, procedural or anatomic terms related to the urinary system
- Use terms related to the urinary system
- Use terms related to the diseases and disorders of the urinary system

Urinary System Word Parts

Click on prefixes, combining forms, and suffixes to reveal a list of word parts to memorize for the urinary system. Then use the flashcards below to practice.



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Introduction to the Urinary System

The urinary system has roles you may be well aware of. Cleansing the blood and ridding the body of wastes probably come to mind. However, there are additional, equally important functions, played by the system. Take, for example, regulation of **pH**, a function shared with the lungs and the buffers in the blood. Additionally, the regulation of blood pressure is a role shared with the heart and blood vessels. What about regulating the concentration of **solutes** in the blood? Did you know that the kidney is important in determining the concentration of red blood cells? Eighty-five percent of the **erythropoietin (EPO)** produced to stimulate red blood cell production is produced in the kidneys. The kidneys also help control blood pressure by producing the enzyme **renin**. Additionally, the kidneys perform the final synthesis step of vitamin D production, converting calcidiol to calcitriol, the active form of vitamin D. If the kidneys fail, these functions are compromised or lost altogether, with devastating effects on **homeostasis**.

Watch this video:



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Media 5.1. [Urinary System, Part 1: Crash Course A&P #38](#) [Online video]. Copyright 2015 by [CrashCourse](#).

Urinary System Medical Terms



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Anatomy (Structures) of the Urinary System

Kidney(s)

The kidneys lie on either side of the spine in the retroperitoneal space between the parietal peritoneum and the posterior abdominal wall, well protected by muscle, fat, and ribs. They are roughly the size of your fist. The male kidney is typically a bit larger than the female kidney. The kidneys are well vascularized, receiving about twenty-five percent of the cardiac output at rest. Figure 5.1 displays the location of the kidneys.

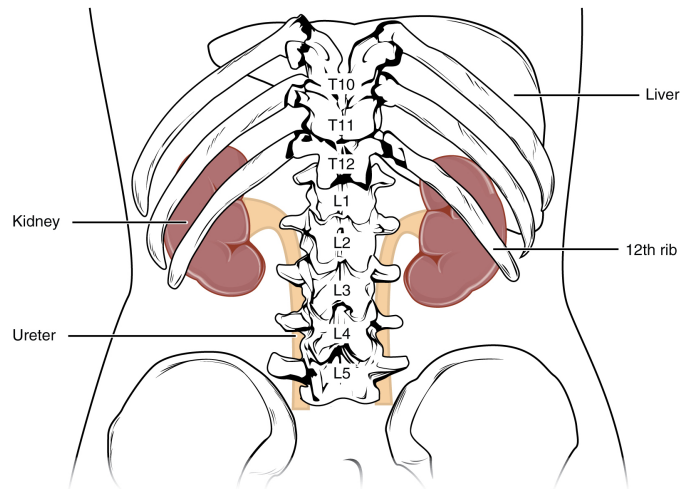


Figure 5.1 Kidneys. The kidneys are slightly protected by the ribs and are surrounded by fat for protection (not shown). From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

Kidneys' Internal Structure

Did You Know?

The right kidney is smaller than the left. It also sits slightly lower to make room for the liver located on the right side of your body.

A frontal section through the kidney reveals an outer region called the **renal cortex** and an inner region called the **medulla** (see Figure 5.2). The **renal columns** are connective tissue extensions that radiate downward from the cortex through the medulla to separate the most characteristic features of the medulla, the **renal pyramids** and **renal papillae**. The papillae are bundles of collecting ducts that transport urine made by nephrons to the **calyces** of the kidney for **excretion**. The renal columns also serve to divide the kidney into 6–8 lobes and provide a supportive framework for vessels that enter and exit the cortex. The pyramids and renal columns taken together constitute the kidney lobes.

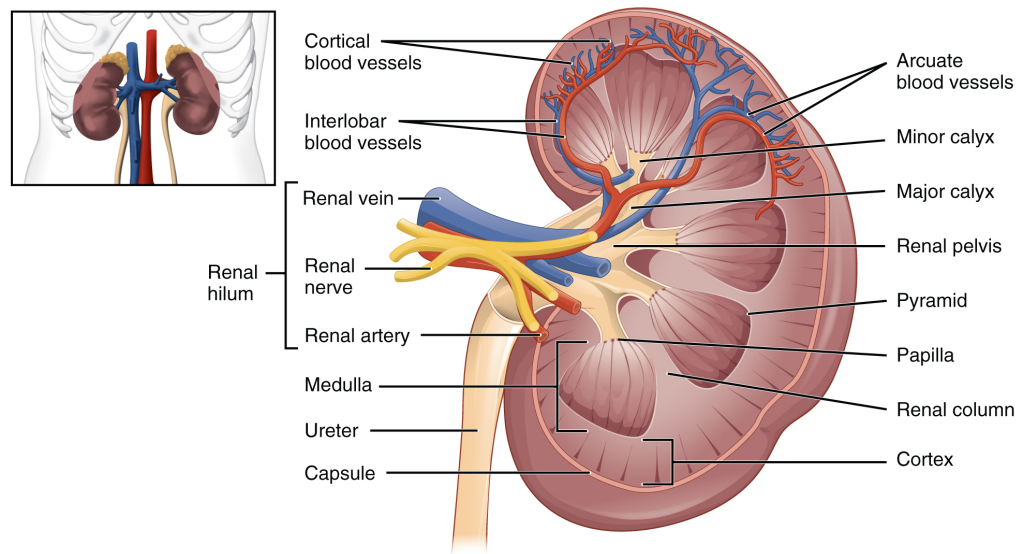


Figure 5.2 Left Kidney. From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

Renal Hilum

The **renal hilum** is the entry and exit site for structures servicing the kidneys: vessels, nerves, lymphatics, and ureters. The medial-facing hila are tucked into the sweeping convex outline of the cortex. Emerging from the hilum is the renal pelvis, which is formed from the major and minor **calyces** in the kidney. The smooth muscle in the renal pelvis funnels urine via **peristalsis** into the ureter. The renal arteries form directly from the descending aorta, whereas the renal veins return cleansed blood directly to the inferior vena cava. The artery, vein, and renal pelvis are arranged in an anterior-to-posterior order.

Nephrons and Vessels

The renal artery first divides into segmental arteries, followed by further branching to form interlobar arteries that pass through the renal columns to reach the cortex (see Figure 5.3). The **interlobar** arteries, in turn, branch into **arcuate** arteries, cortical **radiate** arteries, and then into afferent arterioles. The afferent arterioles service about 1.3 million nephrons in each kidney.

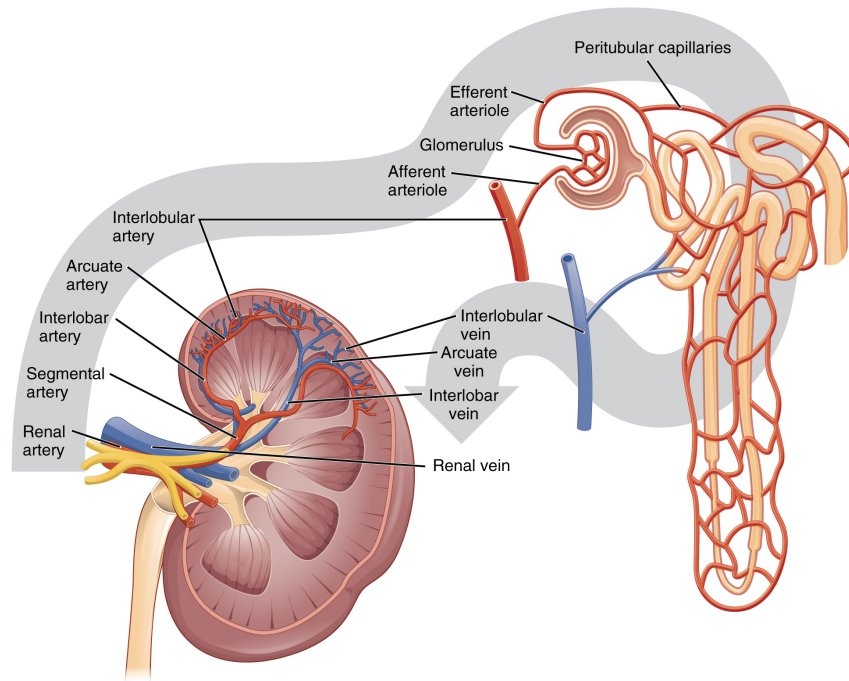


Figure 5.3 Blood Flow in the Kidney. From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

Nephrons are the “functional units” of the kidney; they cleanse the blood and balance the constituents of the circulation. The afferent arterioles form a tuft of high-pressure capillaries about 200 μm in diameter, the **glomerulus**. The rest of the nephron consists of a continuous sophisticated tubule whose proximal end surrounds the glomerulus in an intimate embrace—this is **Bowman’s capsule**. The glomerulus and Bowman’s capsule together form the **renal corpuscle**. As mentioned earlier, these glomerular capillaries filter the blood based on particle size. After passing through the renal corpuscle, the capillaries form a second arteriole, the **efferent arteriole** (see Figure 5.4). As the glomerular filtrate progresses through the nephron, these capillary networks recover most of the solutes and water, and return them to the circulation. Since a capillary bed (the glomerulus) drains into a vessel that in turn forms a second capillary bed, the definition of a portal system is met. This is the only portal system in which an arteriole is found between the first and second capillary beds. (Portal systems also link the hypothalamus to the anterior pituitary, and the blood vessels of the digestive viscera to the liver.)

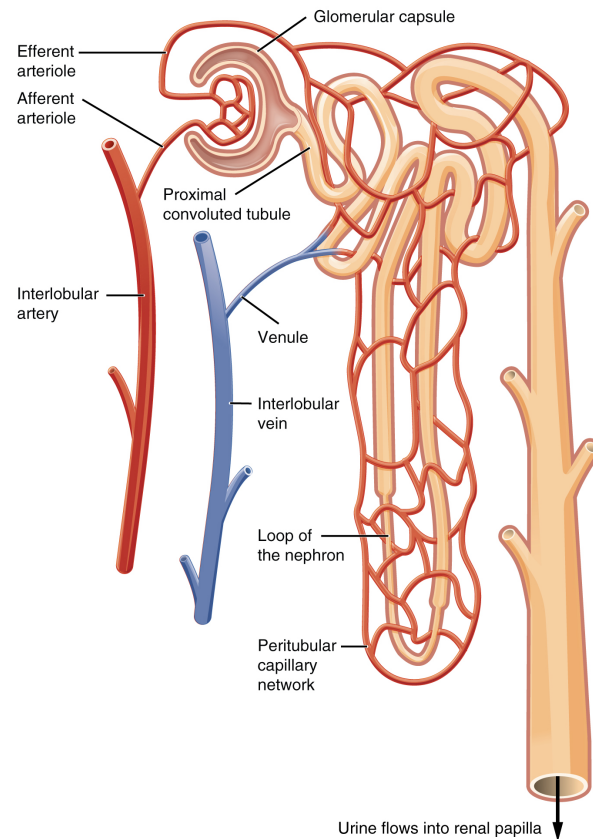


Figure 5.4. Blood Flow in the Nephron. The two capillary beds are clearly shown in this figure. The efferent arteriole is the connecting vessel between the glomerulus and the peritubular capillaries and vasa recta. From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

Ureter(s)

The kidneys and ureters are completely **retroperitoneal**, and the bladder has a **peritoneal** covering only over the dome. As urine is formed, it drains into the **calyces** of the kidney, which merge to form the funnel-shaped renal pelvis in the hilum of each kidney. The hilum narrows to become the **ureter** of each kidney. As urine passes through the ureter, it does not passively drain into the bladder but rather is propelled by waves of **peristalsis**. The ureters are approximately 30 cm long. The muscular layer of the ureter creates the peristaltic contractions to move the urine into the bladder without the aid of gravity.

Bladder

The urinary bladder collects urine from both ureters (see Figure 5.5). The bladder lies anterior to the uterus in females, posterior to the pubic bone and anterior to the rectum. During late pregnancy, its capacity is reduced due to compression by the enlarging uterus, resulting in increased frequency of urination. In males, the anatomy is similar, minus the uterus, and with the addition of the prostate inferior to the bladder. The bladder is partially retroperitoneal

(outside the peritoneal cavity) with its peritoneal-covered “dome” projecting into the abdomen when the bladder is distended with urine.

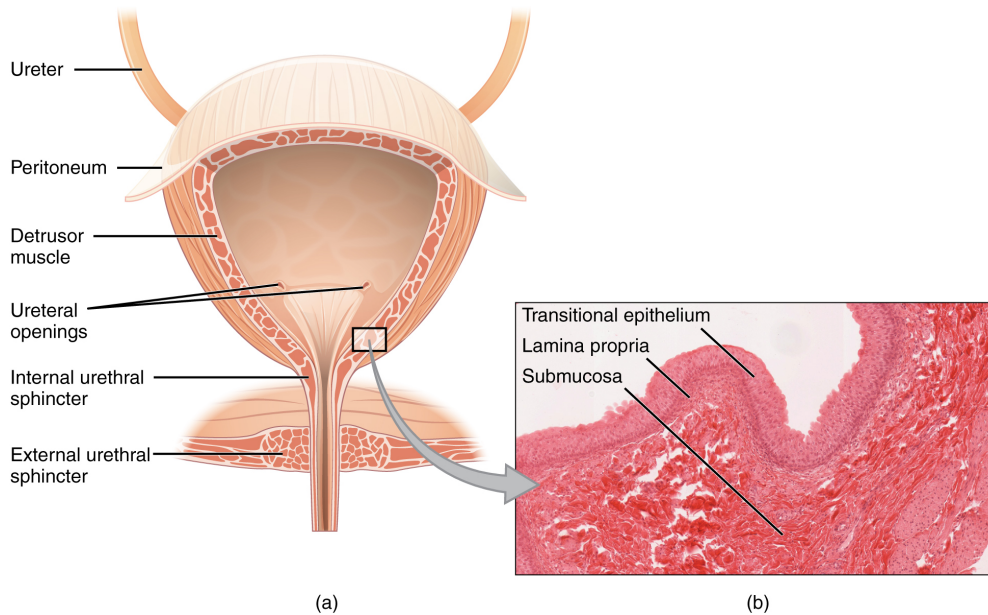


Figure 5.5 Bladder. (a) Anterior cross section of the bladder. (b) The detrusor muscle of the bladder (source: monkey tissue) LM × 448. (Micrograph provided by the Regents of the University of Michigan Medical School © 2012). From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

Urethra

The urethra transports urine from the bladder to the outside of the body for disposal. The urethra is the only urologic organ that shows any significant anatomic difference between males and females; all other urine transport structures are identical (see Figure 5.6).

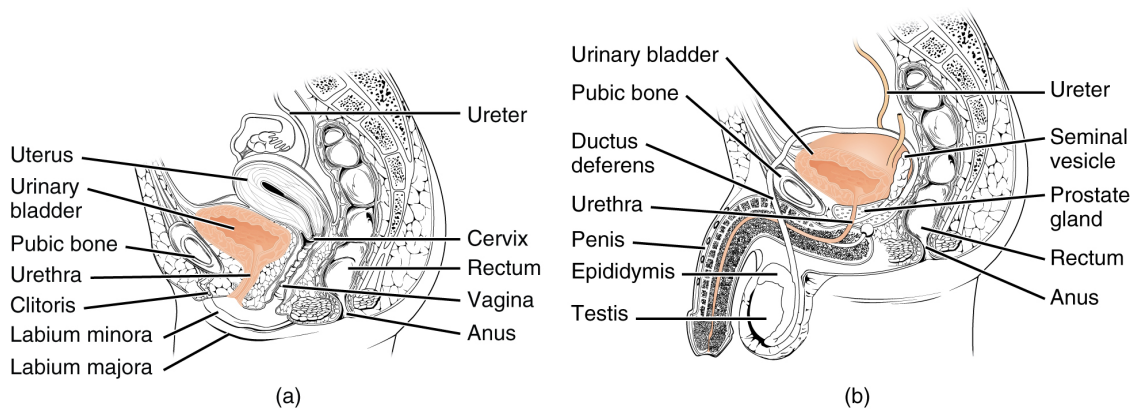


Figure 5.6. Female and Male Urethras. The urethra transports urine from the bladder to the outside of the body. This image shows (a) a female urethra and (b) a male urethra. From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

Voiding is regulated by an involuntary **autonomic** nervous system-controlled internal urinary sphincter, consisting of smooth muscle and voluntary skeletal muscle that forms the external urinary sphincter below it.

Micturition Reflex

Micturition is a less-often used, but proper term for **urination** or **voiding**. It results from an interplay of involuntary and voluntary actions by the internal and external urethral sphincters. When bladder volume reaches about 150 ml (5 ounces), an urge to void is sensed but is easily overridden. Voluntary control of urination relies on consciously preventing relaxation of the external urethral sphincter to maintain urinary continence. As the bladder fills, subsequent urges become harder to ignore. Ultimately, voluntary constraint fails with resulting incontinence, which will occur as bladder volume approaches 300 to 400 ml (10 to 13 oz).

- Normal micturition is a result of stretch **receptors** in the bladder wall that transmit nerve impulses to the sacral region of the spinal cord to generate a spinal reflex. The resulting parasympathetic neural outflow causes contraction of the **detrusor** muscle and relaxation of the involuntary internal urethral sphincter.
- At the same time, the spinal cord inhibits somatic motor neurons, resulting in the relaxation of the skeletal muscle of the external urethral **sphincter**.
- The micturition reflex is active in infants but with maturity, children learn to override the reflex by asserting external sphincter control, thereby delaying voiding (potty training). This reflex may be preserved even in the face of spinal cord injury that results in paraplegia or quadriplegia. However, relaxation of the external sphincter may not be possible in all cases, and therefore, periodic catheterization may be necessary for bladder emptying.

Did You Know?

A healthy adult bladder can store up to 455 ml (15 oz) of urine for between two to five hours.

Concept Check

- Describe **two** organs or **structures** essential to the urinary system.
- Identify the **structure** within the kidneys which filters blood.
- Name a commonly used term for the **micturition reflex**.

Anatomy Labeling Activity



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Physiology (Function) of the Urinary System

- Remove waste products and medicines from the body
- Balance the body's fluids
- Balance a variety of electrolytes
- Release hormones to control blood pressure
- Release a hormone to control red blood cell production
- Help with bone health by controlling calcium and phosphorus

Having reviewed the anatomy of the urinary system now is the time to focus on physiology. You will discover that different parts of the **nephron** utilize specific processes to produce urine: **filtration**, **reabsorption**, and **secretion**. You will learn how each of these processes works and where they occur along the nephron and collecting ducts. The physiologic goal is to modify the composition of the plasma and, in doing so, produce the waste product urine.

Nephrons: The Functional Unit

Nephrons take a simple filtrate of the blood and modify it into urine. Many changes take place in the different parts of the nephron before urine is created for disposal. The term “forming urine” will be used hereafter to describe the **filtrate** as it is modified into true urine. The principal task of the nephron population is to balance the **plasma** to homeostatic set points and excrete potential toxins in the urine. They do this by accomplishing three principle functions—filtration, reabsorption, and secretion. They also have additional secondary functions that exert control in three areas: blood pressure (via the production of renin), red blood cell production (via the hormone EPO), and calcium absorption (via the conversion of calcidiol into calcitriol, the active form of vitamin D).

Loop of Henle

The descending and ascending portions of the loop of Henle (sometimes referred to as the **nephron** loop) are, of course, just continuations of the same tubule. They run adjacent and parallel to each other after having made a hairpin turn at the deepest point of their descent. The descending loop of Henle consists of an initial short, thick portion and long, thin portion, whereas the ascending loop consists of an initial short, thin portion followed by a long, thick portion. The descending and ascending thin portions consist of simple squamous epithelium. Different portions of the loop have different **permeabilities** for solutes and water.

Collecting Ducts

The collecting ducts are continuous with the nephron but are not technically part of it. In fact, each duct collects filtrate from several nephrons for final modification. Collecting ducts merge as they descend deeper in the medulla to form about 30 terminal ducts, which empty at a papilla.

Glomerular Filtration Rate (GFR)

The volume of filtrate formed by both kidneys per minute is termed the **glomerular filtration rate** (GFR). The heart pumps about 5 L (169 fluid ounces) of blood per min under resting conditions. Approximately 20 percent or one liter enters the kidneys to be filtered. On average, this liter results in the production of about 125 mL/min filtrate produced in men (range of 90 to 140 mL/min) and 105 mL/min filtrate produced in women (range of 80 to 125 mL/min). This amount equates to a volume of about 180 L/day in men and 150 L/day in women. Ninety-nine percent of this filtrate is returned to the circulation by reabsorption so that only about 1–2 liters of urine are produced per day.

GFR is influenced by the hydrostatic pressure and colloid osmotic pressure on either side of the capillary membrane of the glomerulus. Recall that filtration occurs as pressure forces fluid and solutes through a **semipermeable** barrier with the solute movement constrained by particle size. **Hydrostatic** pressure is the pressure produced by a fluid against a surface. If you have fluid on both sides of a barrier, both fluids exert pressure in opposing directions. The net fluid movement will be in the direction of the lower pressure. **Osmosis** is the movement of solvent (water) across a membrane that is **impermeable** to a solute in the solution. This creates osmotic pressure which will exist until the solute concentration is the same on both sides of a semipermeable membrane. As long as the concentration differs, water will move. Glomerular filtration occurs when glomerular hydrostatic pressure exceeds the luminal **hydrostatic** pressure of Bowman's capsule. There is also an opposing force, the osmotic pressure, which is typically higher in the glomerular capillary.

A proper concentration of solutes in the blood is important in maintaining osmotic pressure both in the glomerulus and systemically. There are disorders in which too much protein passes through the filtration slits into the kidney filtrate. This excess protein in the filtrate leads to a deficiency of circulating **plasma** proteins. In turn, the presence of protein in the urine allows it to hold more water in the filtrate and results in an increase in urine volume. Because there is less circulating protein, principally albumin, the osmotic pressure of the blood falls. Less osmotic pressure pulling water into the capillaries tips the balance towards hydrostatic pressure, which tends to push it out of the capillaries. The net effect is that water is lost from the circulation to interstitial tissues and cells. This “plumps up” the tissues and cells, a condition termed systemic **edema**.

Reabsorption and Secretion

The renal corpuscle filters the blood to create a filtrate that differs from blood mainly in the absence of cells and large proteins. From this point to the ends of the collecting ducts, the filtrate or forming urine is undergoing modification through **secretion** and **reabsorption** before true urine is produced. Here, some substances are reabsorbed, whereas others are secreted. Note the use of the term “reabsorbed.” All of these substances were “absorbed” in the digestive tract—99 percent of the water and most of the solutes filtered by the nephron must be reabsorbed. Water and substances that are reabsorbed are returned to the circulation by the peritubular and vasa recta capillaries.

Urinalysis

Urinalysis (urine analysis) often provides clues to renal disease. Normally, only traces of protein are found in urine, and when higher amounts are found, damage to the glomeruli is the likely basis. Unusually large quantities of urine may point to diseases like diabetes mellitus or **hypothalamic** tumors that cause diabetes insipidus. The color of urine is determined mostly by the breakdown products of red blood cell destruction (see Figure 5.7). The “heme” of **hemoglobin** is converted by the liver into water-soluble forms that can be excreted into the **bile** and indirectly into the urine. This yellow pigment

is urochrome. Urine color may also be affected by certain foods like beets, berries, and fava beans. A kidney stone or a cancer of the urinary system may produce sufficient bleeding to manifest as pink or even bright red urine. Diseases of the liver or obstructions of bile drainage from the liver impart a dark “tea” or “cola” hue to the urine. **Dehydration** produces darker, concentrated urine that may also possess the slight odor of **ammonia**. Most of the ammonia produced from protein breakdown is converted into **urea** by the liver, so ammonia is rarely detected in fresh urine. The strong ammonia odor you may detect in bathrooms or alleys is due to the breakdown of urea into ammonia by bacteria in the environment. About one in five people detect a distinctive odor in their urine after consuming asparagus; other foods such as onions, garlic, and fish can impart their own aromas. These food-caused odors are harmless.

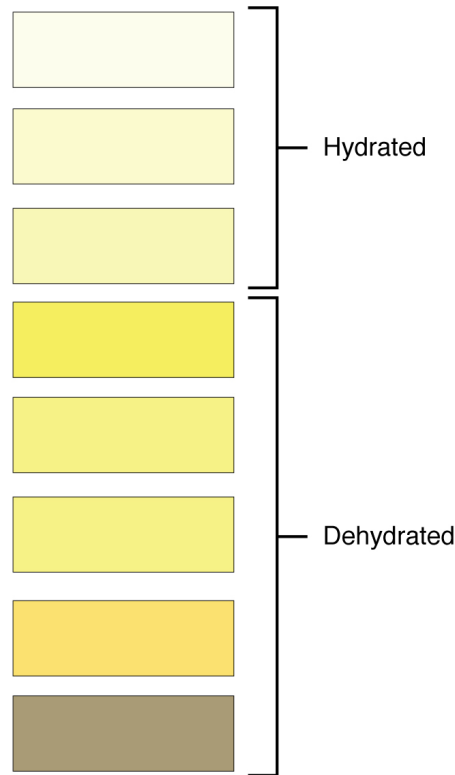


Figure 5.7 Urine Color. From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

Urine volume varies considerably. The normal range is one to two liters per day. The kidneys must produce a minimum urine volume of about 500 mL/day to rid the body of wastes. Output below this level may be caused by severe dehydration or renal disease and is termed **oliguria**. The virtual absence of urine production is termed **anuria**. Excessive urine production is **polyuria**, which may be due to diabetes mellitus or diabetes insipidus. In diabetes mellitus, blood glucose levels exceed the number of available sodium-glucose transporters in the kidney, and glucose appears in the urine. The osmotic nature of glucose attracts water, leading to its loss in the urine. In the case of diabetes insipidus, insufficient pituitary antidiuretic hormone (ADH) release or insufficient numbers of ADH receptors in the collecting ducts means that too few water channels are inserted into the cell membranes that line the collecting ducts of the kidney. Insufficient numbers of water channels (aquaporins) reduce water absorption, resulting in high volumes of very dilute urine.

Concept Check

- Contrast the following terms: **oliguria**, **anuria** and **polyuria**. What are the differences between these terms as they describe urinary output?
- Explain how urine **color** varies based on food consumed and/or **hydration** levels.

Endocrine Urinary Function

Several hormones have specific, important roles in regulating kidney function. They act to stimulate or inhibit blood flow. Some of these are endocrine, acting from a distance, whereas others are paracrine, acting locally.

Diuretics and Fluid Volume

A diuretic is a compound that increases urine volume. Three familiar drinks contain diuretic compounds: coffee, tea, and alcohol. The caffeine in coffee and tea works by promoting vasodilation in the nephron, which increases GFR. Alcohol increases GFR by inhibiting ADH release from the posterior pituitary, resulting in less water recovery by the collecting duct. In cases of high blood pressure, diuretics may be prescribed to reduce blood volume and, thereby, reduce blood pressure. The most frequently prescribed anti-hypertensive diuretic is **hydrochlorothiazide**.

Regulation of Nitrogen Wastes

Nitrogen wastes are produced by the breakdown of proteins during normal **metabolism**. Proteins are broken down into amino acids, which in turn are deaminated by having their nitrogen groups removed. **Deamination** converts the amino (NH₂) groups into ammonia (NH₃), ammonium ion (NH₄⁺), urea, or uric acid (Figure 5.8). Ammonia is extremely toxic, so most of it is very rapidly converted into urea in the liver. Human urinary wastes typically contain primarily urea with small amounts of ammonium and very little uric acid.

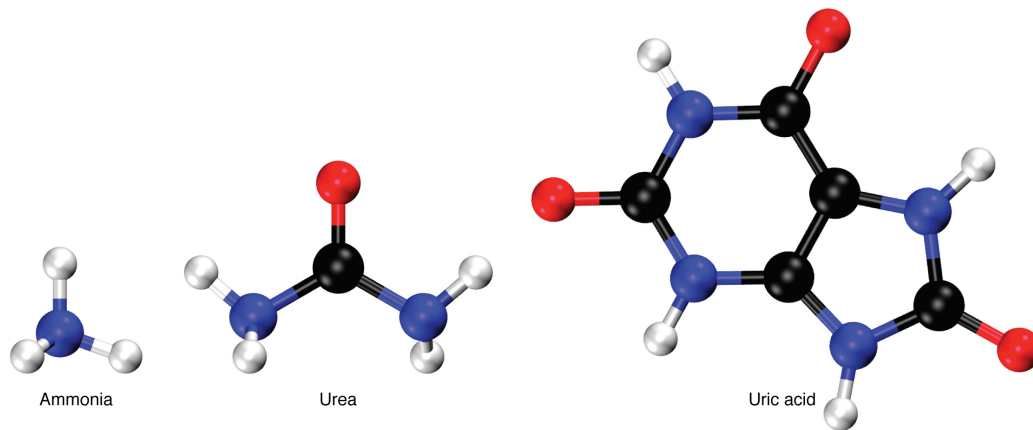


Figure 5.8 Nitrogen Wastes. From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

Watch this video:



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Media 5.2. [The Urinary System](#) [Online video]. Copyright 2017 by [Bozeman Science](#).

Urinary System Medical Terms not Easily Broken into Word Parts



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Urinary System Abbreviations

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



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Diseases and Disorders

Glomerulonephritis

Glomerulonephritis refers to acute or chronic nephritis that involves inflammation of the capillaries of the renal glomeruli. It has various causes, and is noted especially by blood or protein in the urine and by edema. If untreated, it could lead to kidney failure.

Hydronephrosis

Hydronephrosis is a condition whereby the kidneys begin to swell because of the retention of urine. Several conditions can cause hydronephrosis, such as a kidney stone or blood clot. Treatment will vary, depending on the cause (Cleveland Clinic, 2019). To learn more about hydronephrosis the [Cleveland Clinic's web page on hydronephrosis](#).

Polycystic Kidney Disease

Polycystic kidney disease (PKD) is a genetic disease where cysts grow inside the kidneys. The kidneys enlarge from the cystic collections and damage to the filtering structures of the kidneys can occur. As the disease progresses it may lead to chronic kidney disease (American Kidney Fund, 2020). To learn more, visit the [Kidney Fund's PKD web page](#).

Renal Cell Cancer

Renal cell cancer is a cancer occurring in the kidney tubes where urine is produced or collected. This one of the most common cancers found within the kidneys. Removal of the cancerous lesions is the typical approach from a treatment perspective (Centers for Disease Control, 2020). To learn more, visit the [CDC web page on Kidney Cancer](#).

Renal Failure

Renal failure occurs when kidneys suddenly or gradually become unable to filter waste products from blood. When kidneys stop filtering, high level of wastes may build. Two types exist acute kidney failure and chronic kidney failure (Mayo Clinic Staff, 2019a). To learn more about kidney failure visit [the Mayo Clinic's page on Chronic Kidney Failure](#).

Cystitis

Cystitis is inflammation of the urinary bladder, often caused by an infection. A chronic form of this condition is known as interstitial cystitis. Symptoms of cystitis include bladder pressure, voiding frequently, and pain (Mayo Clinic Staff, 2019b). To learn more about cystitis [visit the Mayo Clinic's page on Interstitial Cystitis](#).

Urinary Tract Infection

A urinary tract infection (UTI) is an infection caused by bacteria, or sometimes, fungi. The exact type of bacterial growth is determined by conducting urine for culture and sensitivity (C&S) testing. In rare cases a UTI may be caused by a virus (Lights & Boskey, 2019). For more information, visit [Healthline's web page on Urinary Tract Infections](#).

Urinary Incontinence

Urinary incontinence is a loss of bladder control. Those afflicted with the condition will experience urine leakage from the bladder. Weak bladder muscles are a risk factor for developing this condition (Kim & O'Connell, 2017). To learn more about this condition [visit Healthline's webpage Urologic Diseases](#).

Medical Terms in Context



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Medical Specialties and Procedures Related to the Urinary System

Urology is specialty that “excels in diagnosing and treating problems involving the male and female urinary tract and the male reproductive organs” (Mayo Clinic, 2021). Common clinical visits involve kidney stones, kidney failure and bladder dysfunction. To learn more about urology as a specialty visit the [Why Urology?](#) authored by the American Urological Association (2021).

Urologist

A urologist is a medical specialist involved in the diagnosis and treatment of urinary and male genitourinary system conditions, disorders, and diseases such as prostate disease, renal and bladder dysfunctions, and others (Watson, 2021).

Procedures and Testing

Urinalysis

A urinalysis is microscopic group of urine testing. This test detects and measures several substances in the urine such as products of normal and abnormal metabolism and bacteria (Lab Tests Online, 2020). To learn more about urinalysis visit [Lab Tests Online's Urinalysis web page](#).

Urine for C&S

Urine for culture and sensitivity. Urine produced by the kidneys is analyzed by way of a urine culture test which can detect and identify bacteria in the urine, which may be causing a urinary tract infection (UTI). If harmful bacteria is found a sensitivity report is generated. This report lists antibiotics sensitive in the treatment of the bacteria present (Lab Tests Online, 2020a). To learn more about Urine for C&S, visit [Lab Tests Online's Urine Culture web page](#).

24-Hour Urine Collection

This is a test whereby all urinary output is collected over a 24-hour period of time. The analysis of urinary output over this extended period of time provides a greater indication of normal or abnormal kidney function (Lab Tests Online, 2017). To learn more a, visit [Lab Tests Online's 24-hour Urine Sample article](#).

CT Scan of Kidney

Computed tomography is a diagnostic imaging procedure that uses a combination of x-rays and computer technology

to produce a variety of images. It provides detailed images of the kidney looking for disease, cancer, obstructions and other kidney conditions (Johns Hopkins Medicine, n.d.) . To learn more about a CT scan of the kidney visit [Johns Hopkins Medicine's page on Computed Tomography \(CT or CAT\) Scan of the Kidney](#).

Cystoscopy

A cystoscopy is a procedure allowing a physician to check for bladder or ureteral problems, such as bladder cancer. An endoscope, also known as a cystoscope, containing a camera at the end of it is used (Mayo Clinic, 2021). To learn more about cystoscopy visit the [Mayo Clinic Cystoscopy Overview](#).

Dialysis is a treatment that removes waste products from the blood when the kidneys are not fully functioning. This type of therapy is available at home or in a hospital or clinic and there are two main types: peritoneal dialysis and hemodialysis (National Kidney Foundation, 2020). To learn more about dialysis visit the [National Kidney Foundation webpage](#).

Intravenous Pyelogram

An intravenous pyelogram (IVP) is a specialized x-ray designed to produce views of the entire urinary tract. A dye is used to secure the enhanced imaging. The x-rays can also show how well the urinary tract is functioning and any identify any blockages (Mayo Clinic, 2020a). To learn more about IVP visit the [Mayo Clinic IVP webpage](#).

Kidney Scan

A kidney scan is an imaging test which views the kidneys. It is considered a nuclear imaging test as it uses radioactive tracers to pick up hot or cold spots within the kidney. These variation are are considered abnormal.

Kidney Transplant

When kidneys fail or when a person is in end stage chronic kidney disease, a surgical procedure is performed in the form of a kidney transplant. This procedure involves harvesting a donor kidney which is transplanted into the recipient in need of a functioning kidney to support vital function of the urinary system.

Test Yourself



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6. Male Reproductive System

WTCS Learning Objectives

- Apply the rules of medical language to build, analyze, spell, pronounce, abbreviate, and define terms as they relate to the male reproductive system
- Identify meanings of key word components of the male reproductive system
- Categorize diagnostic, therapeutic, procedural or anatomic terms related to the male reproductive system
- Use terms related to the male reproductive system
- Use terms related to the diseases and disorders of the male reproductive system

Male Reproductive System Word Parts

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



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Introduction to the Male Reproductive System

Gametes are the reproductive cells that combine to form a fetus. Organs called **gonads** produce the gametes, along with the hormones that regulate human reproduction. The male gametes are called sperm. **Spermatogenesis** occurs within the **seminiferous tubules** that make up most of the testis. The **scrotum** is a sac that holds the testes outside of the body cavity.

Watch this video:



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Media 6.1. [Reproductive System, Part 2 – Male Reproductive System: Crash Course A&P 41](#) [Online video].
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Male Reproductive Medical Terms



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Anatomy (Structures) of the Male Reproductive System

The structures of the male reproductive system include the **testes**, the epididymis, the penis, and the ducts and glands that produce and carry semen. Sperm exit the scrotum through the vas deferens. The spermatic cord is an enclosed sheath which includes the vas deferens, **arteries**, **veins** and **nerves**. The seminal vesicles and **prostate gland** add fluids to the **sperm** to create **semen**.

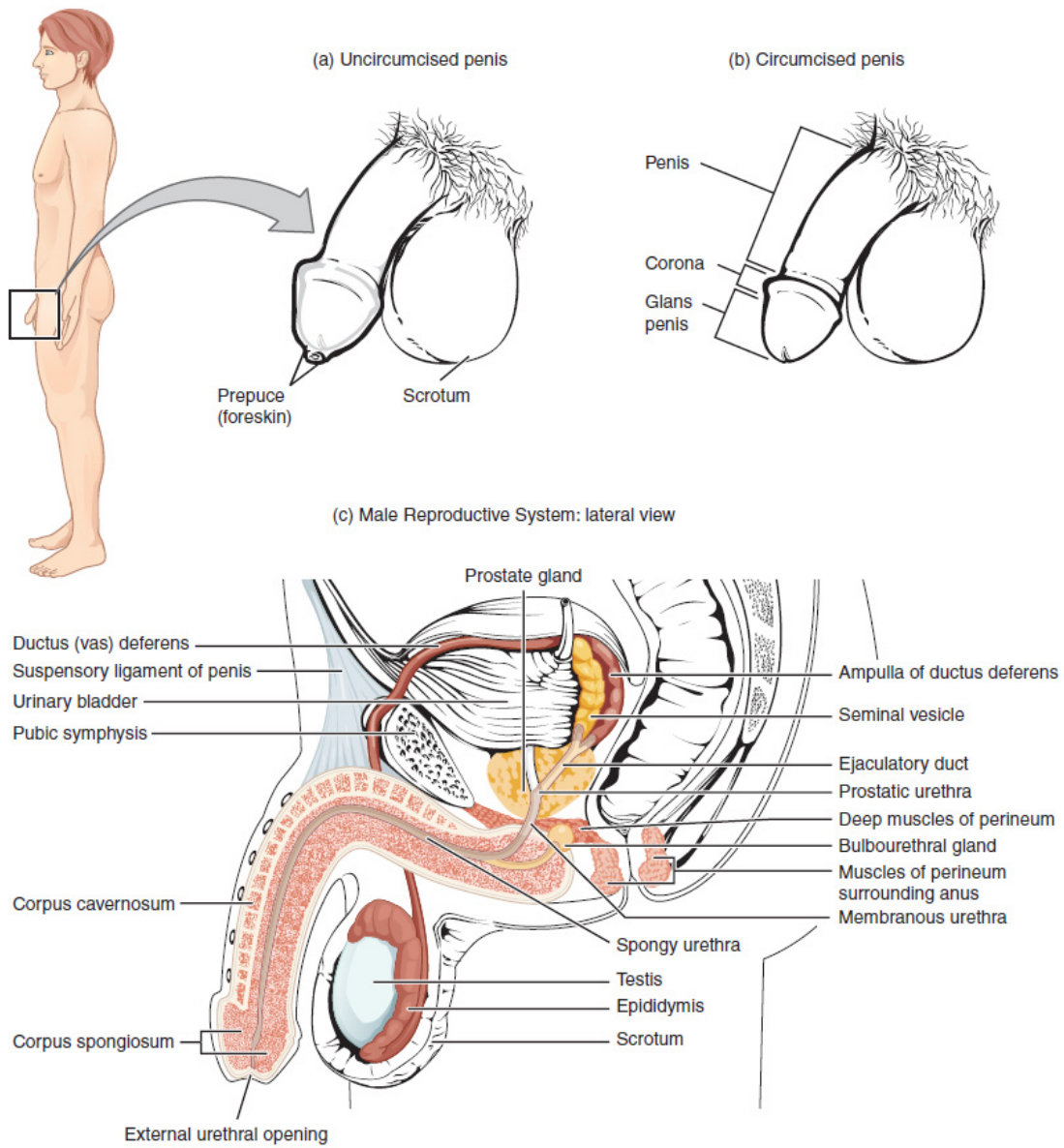


Figure 6.1. Male Reproductive System. From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

Physiology (Function) of the Male Reproductive System

Sperm

Sperm are smaller than most cells in the body; in fact, the volume of a sperm cell is 85,000 times less than that of the female gamete. Approximately 100 to 300 million sperm are produced each day, whereas women typically ovulate only one **oocyte** per month as is true for most cells in the body, the structure of sperm cells speaks to their function. Sperm have a distinctive head, mid-piece, and tail region.

Sperm Transport

To fertilize an egg, sperm must be moved from the seminiferous tubules in the testes, through the **epididymis**, and—later during ejaculation—along the length of the penis and out into the female reproductive tract. It takes an average of 12 days for sperm to move through the coils of the epididymis, with the shortest recorded transit time in humans being one day.

Epididymis

Sperm enter the head of the epididymis and are moved by the contraction of smooth muscles lining the **epididymal** tubes. As the sperm mature they acquire the ability to move under their own power. Once inside the female reproductive tract, they will use this ability to move independently toward the unfertilized egg. The more mature sperm are then stored in the tail of the epididymis until ejaculation occurs.

Ducts

During ejaculation, sperm exit the tail of the epididymis and are pushed by smooth muscle contraction to the **vas deferens** (also called the ductus deferens). The vas deferens is a thick, muscular tube that is bundled together inside the scrotum with connective tissue, blood vessels, and nerves into a structure called the **spermatic cord**. From each epididymis, each vas deferens extends through the inguinal canal in the abdominal wall and continues to a region called the ampulla. The sperm is mixed with fluid from the paired seminal vesicles and moves into its associated ejaculatory duct. The ejaculatory ducts transport the seminal fluid to the prostate gland.

Prostate Gland

The **prostate gland** secretes an alkaline, milky fluid to the passing seminal fluid (referred to as semen) to first coagulate and then decoagulate the semen following ejaculation. The temporary thickening of semen helps retain it within the female reproductive tract and once decoagulated the sperm can pass farther into the female reproductive tract.

Did You Know?

Sperm counts slowly decline after age 35, and some studies suggest that smoking can lower sperm counts irrespective of age.

Bulbourethral Glands

Bulbourethral glands release a thick, salty fluid that lubricates the end of the urethra and vagina, and helps to clean urine residues from the penile urethra.

Concept Check

- Write or draw out the components of the **pathway** that sperms takes from beginning until the end.
- Consider fertility challenges that may be experienced if a large number of defective sperm are produced.

Anatomy Labeling Activity



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Male Reproductive Terms not Easily Broken into Word Parts



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Common Male Reproductive System Abbreviations



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Diseases and Disorders

Erectile Disorder (ED)

Erectile dysfunction (ED) is a condition in which a male has difficulty either initiating or maintaining an erection. The combined prevalence of minimal, moderate, and complete ED is approximately 40% in men at age 40 and reaches nearly 70% by 70 years of age. In addition to aging, ED is associated with diabetes, vascular disease, psychiatric disorders, prostate disorders, the use of some drugs such as certain antidepressants, and problems with the testes resulting in low testosterone concentrations. These physical and emotional conditions can lead to disruptions in the vasodilation pathway and result in an inability to achieve an erection (Betts, et al., 2021).

Cancer

Prostate Cancer

According to the Centers for Disease Control and Prevention (CDC), prostate cancer is the second most common cancer occurring in men. However, some forms of prostate cancer grow very slowly and may not require treatment. Aggressive forms of prostate cancer, in contrast, involve **metastasis** to organs like the lungs and brain. There is no link between Benign Prostatic Hyperplasia and prostate cancer, but the symptoms are similar. Prostate cancer is detected by medical history, a blood test, and a digital rectal exam that allows physicians to palpate the prostate and check for unusual masses. If a mass is detected, the cancer diagnosis is confirmed by biopsy of the cells (Betts, et al., 2021).

Testicular Cancer

Testicular cancer begins in the **testicle** or testis. It is most often found in men age 15 to 35 years, although it can be diagnosed at any age (Mayo Clinic, 2020). Testicular cancer is rare and treatable when diagnosed early. Common symptoms are a painless lump in the testicle, swelling, a heavy feeling in the **scrotum** or abdomen, amongst others. Sometimes, testicular cancer is found during infertility testing. An **orchietomy** is the most common procedure for diagnosing and treating testicular cancer (Mayo Clinic,

Did You Know?

Family history is a

common risk factor
for testicular cancer.

2020). To learn more about testicular cancer, diagnosis and treatments please go to the [Mayo Clinic's page](#) on testicular cancer.

Sexually Transmitted Infections (STIs)

The terms for sexually transmitted infections (STI) and sexuality transmitted diseases (STD) are often used interchangeably. Sexuality transmitted disease (STD) implies the disease was acquired through sexual transmission. A disease is a disorder of structure or function in a human, which produces specific signs or symptoms. A disease must be managed, as with the case of human immunodeficiency virus (which can also be acquired through the transmission of other bodily fluids; thus not solely sexual transmission). The treatment may include **antiretrovirals** or **anti-virals** (Urology Care Foundation, 2019).

Chlamydia (CT)

Chlamydia is one of the most common sexually transmitted infections (STIs) caused by bacteria that infect the cervix, urethra and other reproductive organs. Chlamydia is easy to treat and can be cured. Many people with chlamydia do not have any symptoms and unknowingly pass the infection to their sexual partner(s). If symptoms develop, they usually appear two to six weeks after sexual contact with an infected person. Males may have penial discharge and itching around the urethra. The urethra is the opening in the penis. Males may also experience **dysuria**, **polyuria**, urethral pain and **urethritis** (Centers for Disease Control and Prevention, 2021a).

Chlamydia spreads through unprotected oral, anal or vaginal sex with an infected person. Chlamydia can be spread to the eyes via the hands with direct contact of infected fluids. Until a patient finishes their treatment, they continue to have the infection and can continue to pass it to others. Chlamydia is treated with antibiotic pills. If the patient has **epididymitis**, they may need to be hospitalized and be treated with intravenous (IV) antibiotics. All sexual partners within the past 60 days should be examined, treated, and informed that having no symptoms does not mean there is no infection (Centers for Disease Control and Prevention, 2021a).

Gonorrhea (Gonococcus) – (GC)

Gonorrhea is a sexually transmitted infection (STI) caused by bacteria that infects the cervix, urethra and other reproductive organs. Infections can also infect the throat and anus. Gonorrhea can be treated and cured. Many people infected with gonorrhea have no symptoms and can unknowingly pass the infection on to their sexual partner(s). If symptoms develop, they may appear two to seven days after sexual contact with an infected person. Symptoms vary depending on which part of the body is infected. Males may have yellowish-white discharge from the penis. They may also have dysuria, polyuria, testicular pain and testitis. Gonorrhea infection from oral sex may lead to sore throat and swollen glands. Gonorrhea infection from anal sex may cause itchiness and discharge from the anus. Gonorrhea is spread through unprotected oral, vaginal or anal sex with an infected person. Until the patient finishes their treatment, they continue to have the infection and can pass it to others (Centers for Disease Control and Prevention, 2021b).

Gonorrhea is treated with oral **antibiotics** in combination with an **intramuscular** (IM) injection. It is important that one completes the treatment and abstain from unprotected sexual activity for at least seven days following treatment. If the patient develops epididymitis, the patient may need to go to a hospital and be treated with intravenous antibiotics. All sexual partners within the past 60 days should be examined, treated and informed that having no symptoms does not mean there is no infection (Centers for Disease Control and Prevention, 2021b).

Reportable Diseases

Both chlamydia and gonorrhea are reportable diseases and the provider should report cases to local and state public health agencies as well as to the Centers for Disease Control and Prevention. Requirements and procedures vary by county and state. For more information see Medline's [Reportable Diseases list](#).

Human Papillomavirus- HPV

HPV is another common sexually transmitted infection (STI). Both males and females can be infected with HPV. Around three quarters of sexually active individuals have been exposed to HPV during their lifetime. There are over 100 strains of HPV and some strains of HPV can cause visible genital warts. The warts are usually painless but may be itchy, uncomfortable and hard to treat. Some strains of HPV cause genital, anal, throat and cervical cancers. HPV spreads through sexual activity and skin-to-skin contact in the genital area with an infected person. Since some people are **asymptomatic** they don't know they have the virus and consequently pass the virus to their sexual partners. Treatments are available for genital warts but there is no cure for HPV (Centers for Disease Control and Prevention, 2021c). To learn more about HPV symptoms, treatments, and prognosis visit the [CDC HPV Fact Sheet](#).

HPV Vaccine

A vaccine is available for 9 HPV strains. This vaccine, often known by the brand name Gardasil® 9, assists the immune system in protecting the body against infections and diseases caused by HPV (National Cancer Institute, 2019). To learn more about HPV vaccines, please visit the [National Cancer Institute's HPV Vaccine Fact Sheet](#).

Herpes Simplex Virus (HSV)

Genital herpes is a sexually transmitted infection (STI) that is caused by a virus called herpes simplex virus (HSV). There are two types of herpes simplex viruses:

- Type 1- oral herpes or cold sores (HSV-1)
- Type 2- genital herpes (HSV-2).

These viruses are very similar and either type can cause genital herpes or cold sores. Symptoms might include dysuria, enlarged glands, **myalgia**, **arthralgia** and fever. Once a patient is infected with HSV, the virus remains in their body even after the symptoms are gone and can cause recurring outbreaks. When the virus becomes active again, the symptoms return but are usually less painful and heal faster. Recurring outbreaks vary from person-to-person, however they can be triggered by emotional or physical stress, exposure to sunlight, hormonal changes, poor nutrition, sexual intercourse, lack of sleep or a low immune system (Centers for Disease Control and Prevention, 2021d).

Herpes is spread through direct contact with the sores or blisters of an infected person. Contact (and transfer of the virus) can occur from genitals-to-genitals, mouth-to-genitals or mouth-to-mouth. Herpes can also be passed to the anal area. Herpes spreads easily during sexual contact while symptoms are present, or just before an outbreak of symptoms. An infected person may spread herpes even when they have no symptoms; this is called asymptomatic shedding. One can spread the herpes virus to other parts of their body after touching the sores; **autoinoculation**. The fingers, eyes

and other body areas can accidentally become infected in this way. Hand washing after touching sores and blisters is recommended to prevent spreading the virus (Centers for Disease Control and Prevention, 2021d).

There is no cure for herpes. Antiviral pills help to reduce symptoms and speed the healing of blisters or sores and are prescribed by a doctor. Treatment of symptoms may be managed with medication for pain, bath salts, cold compresses and urinating in water may help to relieve discomfort. Keep the infected area clean and dry, wear cotton underwear and loose clothing to reduce discomfort. All sexual partner(s) should be informed. The only way to reduce the risk of transmission of herpes is to avoid direct contact with the sores and to use condoms. Condoms will reduce but not eliminate risk as the virus can be present and shed from the skin in the genital area (Centers for Disease Control and Prevention, 2021d).

To learn more about the symptoms, complications, treatments and prognosis of HSV please see the [CDC Herpes Fact Sheet](#).

STI Medical Abbreviations



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Medical Terms in Context



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Medical Specialties and Procedures related to the Male Reproductive System

Vasectomy

[Watch the Animated Dissection of Anatomy for Medicine's \(A.D.A.M.\) video](#) to learn about a vasectomy. As described in this video, a vasectomy is a procedure in which a small section of the ductus (vas) deferens is removed from the scrotum. This cuts off the path taken by sperm through the ductus deferens. (as cited in Betts, et al., 2021).

No-Scalpel Vasectomy (NSV)

An alternative to a traditional vasectomy is the no-scalpel vasectomy (NSV). This is a minimally invasive procedure and an added benefit is that the recovery time is shorter. All vasectomies are completed by a urologist (Gentle Procedures Clinic, n.d.). To learn more about the NSV procedure, visit [No-Scalpel Vasectomy Procedure Info](#) by the Gentle Procedures Clinic in Toronto, Ontario.

Urology

Urology is a surgical sub specialty in which the surgeon has additional training in the treatments of diseases and disorders of the male and female urogenital systems (American Urological Association, 2021). To learn more about urology and the training involved to become a urologist visit the [American Urological Association, Why Urology?](#)

Test Yourself



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7. Female Reproductive System

WTCS Learning Objectives

- Apply the rules of medical language to build, analyze, spell, pronounce, abbreviate, and define terms as they relate to the female reproductive system
- Identify meanings of key word components of the female reproductive system
- Categorize diagnostic, therapeutic, procedural or anatomic terms related to the female reproductive system
- Use terms related to the female reproductive system
- Use terms related to the diseases and disorders of the female reproductive system

Female Reproductive System Word Parts



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Introduction to the Female Reproductive System

The female reproductive system produces **gametes** and reproductive hormones. In addition, the female reproductive system supports the developing fetus and delivers it to the outside world. The female reproductive system is located primarily inside the pelvic cavity. The female gonads are called **ovaries** and the gamete they produce is called an **oocyte**.

Watch this video:



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Media 7.1. [Reproductive System, Part 1 – Female Reproductive System: Crash Course A&P #40](#) [Online video]. Copyright 2015 by [CrashCourse](#).

Female Reproductive System Medical Terms



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Anatomy (Structures) of the Female Reproductive System

External Female Genitals

The external female reproductive structures are referred to collectively as the **vulva** and they include:

- The **mons pubis** is a pad of fat that is located at the anterior, over the pubic bone. After puberty, it becomes covered in pubic hair.
- The **labia majora** (labia = “lips”; majora = “larger”) are folds of hair-covered skin that begin just posterior to the mons pubis.
- The **labia minora** (labia = “lips”; minora = “smaller”) is thinner and more pigmented and extends medially to the labia majora.
 - Although they naturally vary in shape and size from woman to woman, the labia minora serve to protect the female urethra and the entrance to the female reproductive tract.
 - The superior, anterior portions of the labia minora come together to encircle the **clitoris** (or glans clitoris), an organ that originates from the same cells as the glans penis and has abundant nerves that make it important in sexual sensation and orgasm. The **hymen** is a thin membrane that sometimes partially covers the entrance to the **vagina**.

- The vaginal opening is located between the opening of the urethra and the anus. It is flanked by outlets to the **Bartholin's glands**.

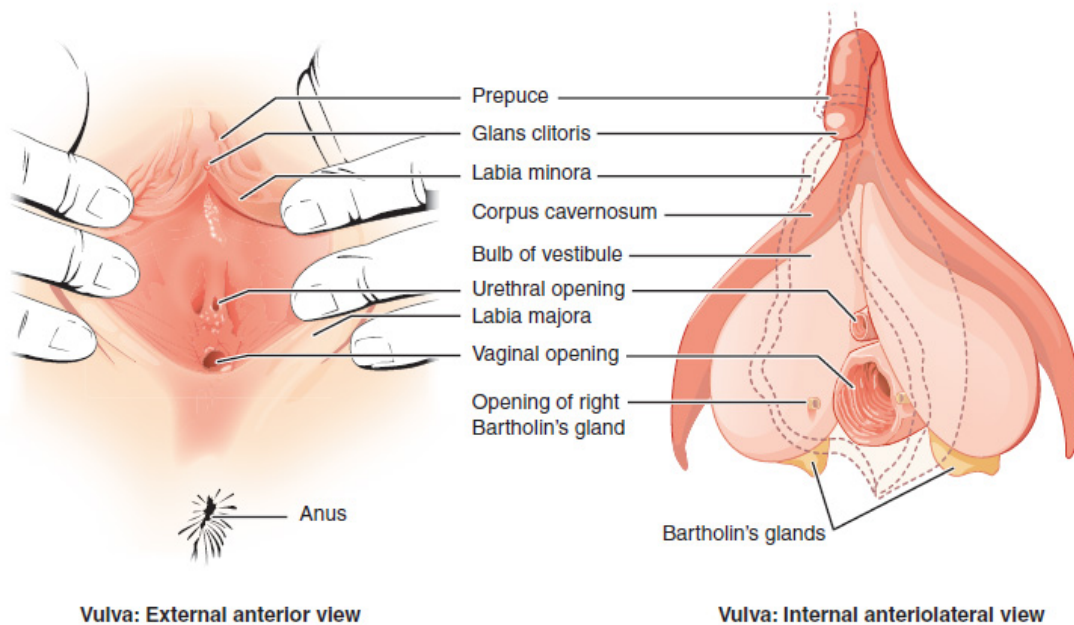


Figure 7.1. The Vulva. The external female genitalia are referred to collectively as the vulva. From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

Internal Female Reproductive Organs

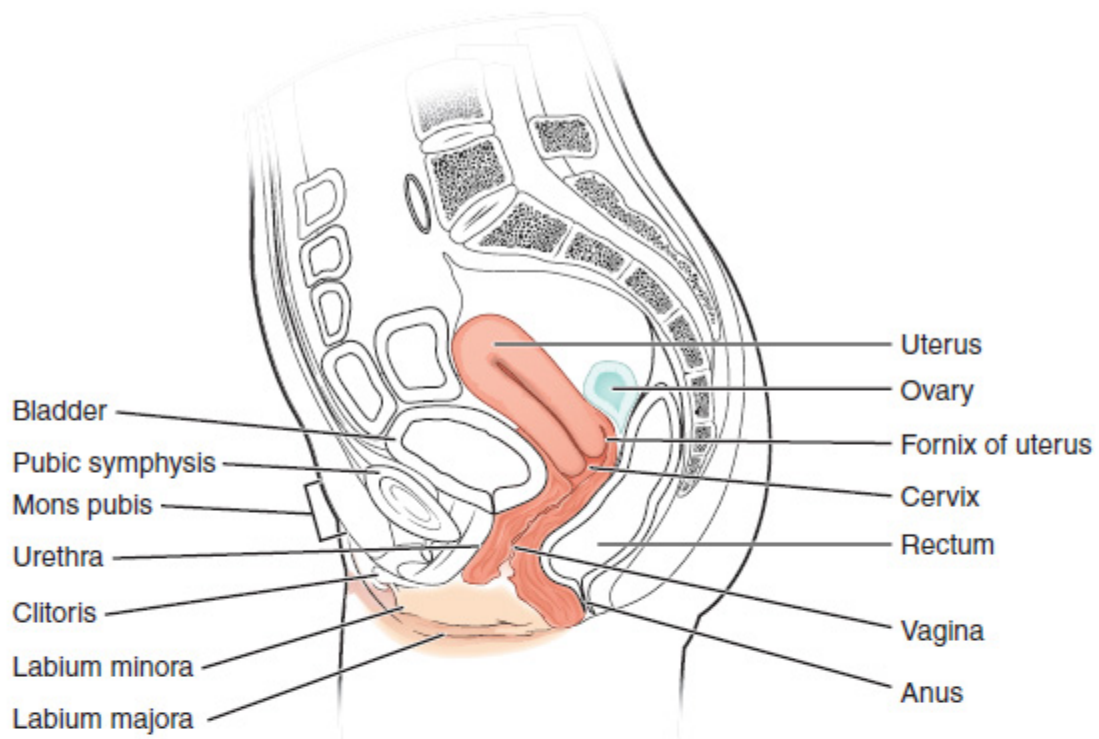
Vagina

The **vagina** is a muscular canal (approximately 10 cm long) that is the entrance to the reproductive tract. It also serves as the exit from the uterus during menses and childbirth. The cervix is the opening to the uterus.

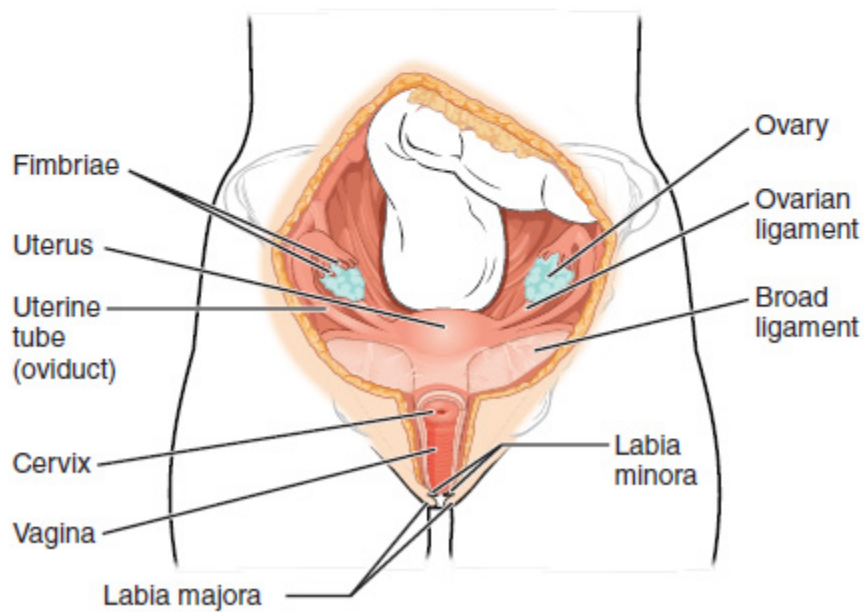
Together, the middle and inner layers allow the expansion of the vagina to accommodate intercourse and childbirth. The thin, perforated hymen can partially surround the opening to the vaginal orifice. The **Bartholin's glands** and the lesser vestibular glands (located near the clitoris) secrete mucus, which keeps the vestibular area moist.

The vagina has a normal population of microorganisms that help to **protect** against infection. There is both pathogenic bacteria, and yeast in the vagina. In a healthy woman, the most predominant type of vaginal bacteria is from the genus *Lactobacillus*, which secretes lactic acid. The lactic acid protects the vagina by maintaining an acidic pH (below 4.5).

Lactic acid, in combination with other vaginal secretions, makes the vagina a self-cleansing organ. However, **douching** can disrupt the normal balance of healthy microorganisms, and increase a woman's risk for infections and irritation. It is recommended that women do not douche and that they allow the vagina to maintain its normal healthy population of protective microbial flora.



(a) Human female reproductive system: lateral view



(b) Human female reproductive system: anterior view

Figure 7.2 Female Reproductive System. The major organs of the female reproductive system are located inside the pelvic cavity. From Betts, et al., 2021. Licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

Ovaries

The **ovaries** are the female gonads. There are two, one at each entrance to the fallopian tube. They are each about 2 to 3 cm in length, about the size of an almond. The ovaries are located within the pelvic cavity. The ovary itself is attached to the uterus via the ovarian ligament. This grouping of an oocyte and its supporting cells is called a **follicle**.

The Fallopian Tubes

The fallopian tubes are the conduit of the **oocyte** from the ovary to the uterus. Each of the two fallopian tubes is close to, but not directly connected to, the ovary. Instead fimbriae catch the oocyte like a baseball in a glove. The middle region of the tube, called the **ampulla**, is where fertilization often occurs.

The Uterus and Cervix

The **uterus** is the muscular organ that nourishes and supports the growing embryo. Its average size is approximately 5 cm wide by 7 cm long and it has three sections.

- The portion of the uterus superior to (pertaining to above) the opening of the uterine tubes is called the **fundus**.
- The middle section of the uterus is called the **body of uterus** (or corpus).
- The **cervix** is the narrow inferior portion of the uterus that projects into the vagina.
 - The cervix produces mucus secretions that become thin and stringy under the influence of high systemic plasma estrogen concentrations, and these secretions can facilitate sperm movement through the reproductive tract.

The wall of the uterus is made up of three layers:

- **Perimetrium:** the most superficial layer and serous membrane.
- **Myometrium:** a thick layer of smooth muscle responsible for uterine contractions.
- **Endometrium:** the innermost layer containing a connective tissue lining covered by epithelial tissue that lines the lumen. It provides the site of implantation for a fertilized egg, and sheds during menstruation if no egg is fertilized.

Concept Check

- Write or draw out the components of the pathway that an **oocyte** takes from beginning to end.

Physiology (Function) of the Female Reproductive System-Ovulation

Following ovulation, the Fallopian tube receives the oocyte. Oocytes lack flagella, and therefore cannot move on their own.

- High concentrations of estrogen that occur around the time of ovulation induce contractions of the smooth muscle along the length of the Fallopian tube.
- These contractions occur every 4 to 8 seconds, causing the oocyte to flow towards the uterus, through the coordinated beating of the cilia that line the outside and lumen of the length of the Fallopian tube which pulls the oocyte into the interior of the tube.
- Once inside, the muscular contractions and beating cilia move the oocyte slowly toward the uterus.
- When fertilization does occur, sperm typically meet the egg while it is still moving through the ampulla.

Watch this video:



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Watch this [video on ovulation from MedLine Plus](#) to observe ovulation and its initiation in response to the release of FSH and LH from the pituitary gland.

Media 7.2. Ovulation. From Betts, et al., 2021. Licensed under [CC BY 4.0](#).

The Menstrual Cycle

The three phases of the menstrual cycle are:

1. The **menses phase** of the menstrual cycle is the phase during which reproductive hormone levels are low, the woman menstruates, and the lining is shed. The menses phase lasts between 2 – 7 days with an average of 5 days.
2. The **proliferative phase** is when menstrual flow ceases and the endometrium begins to **proliferate** . During this phase reproductive hormones are working in **homeostasis** to trigger ovulation on approximately day 14 of a typical 28-day menstrual cycle. Ovulation marks the end of the proliferative phase.
3. The **secretory phase** the endometrial lining prepares for implantation of a fertilized egg. If no pregnancy occurs within approximately 10- 12 days the endometrium will grow thinner and shed starting the first day of the next cycle.

Anatomy Labeling Activity



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Female Reproductive System Terms not Easily Broken into Word Parts



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Female Reproductive System Medical Abbreviations



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Diseases and Disorders of the Female Reproductive System

Cancer

Breast Cancer

Breast cancer starts in the cells that line the ducts or the lobule of the breast. Some warning signs include a new lump in the breast or **axilla**, thickening or swelling, irritation or dimpling of the breast skin, redness or flaky skin, pain, discharge, all in the breast or nipple area, and change in breast size. Risk factors include family history, obesity, hormonal treatment and changes in breast cancer-related genes (BRCA1 or BRCA2) (Centers for Disease Control and Prevention, n.d.; Cancer Care Ontario, n.d.).

Treatment options include chemotherapy, radiation and surgical interventions such as **mastectomy**, biopsy, incision and drainage and **mammoplasty** (Cancer Treatment Centers of America, n.d.). To learn more about breast cancer, view the [Cancer Treatment Centers of America](#) webpage.

Cervical Cancer

Cervical cancer is typically slow-growing cancer and is highly curable when found and treated early. Advanced cervical cancer may cause abnormal bleeding or discharge from the vagina such as bleeding after sex. It is diagnosed during a Papanicolaou test (or Pap smear) which looks for precancers, cell changes, on the cervix. The Pap test can find cervical cancer early, when treatment is most effective. The Pap test only screens for cervical cancer (Centers for Disease Control and Prevention, 2019).

The HPV (Human papillomavirus) test looks for HPV strains which is the virus that can cause precancerous cell changes. Almost all cervical cancers are caused by HPV. HPV is a common virus that is passed from one person to another during sexual contact. In Canada, there is the HPV vaccine. The age of administration varies between states. To learn more about cervical cancer please visit the [Centers for Disease Control and Prevention's cervical cancer factsheet \(PDF file\)](#).

Endometriosis

Endometriosis is an abnormal condition of the **endometrium**. Endometriosis occurs when this tissue grows and implants outside the uterus. The female hormone estrogen causes these implants to grow, bleed, and break down. They are implanted outside the uterus have no way to leave the body. They become painful, inflamed, and swollen. The inflammation causes scar tissue around nearby organs which can interfere with their normal functioning and cause pain (Mayo Clinic, 2019).

Endometriosis generally appears between the ages of 15 and 50. Signs and symptoms may include **dysmenorrhea**, **lumbago**, **dyspareunia**, menstrual irregularity and infertility. One-third of women diagnosed with endometriosis have no symptoms at all. Diagnosis may include **laparoscopy** and endometrial biopsy. Treatment may include medication, surgical interventions such as **hysterectomy** and **oophorectomy**. The cause of endometriosis is unknown (Mayo Clinic, 2019). To learn more about endometriosis visit the [Mayo Clinic's Endometriosis profile](#).

PCOS

Polycystic Ovary Syndrome (PCOS) has no known etiology but researchers have linked it to excessive insulin production. Excessive insulin in the body can release extra male hormones in women. Since the ovaries produce high levels of **androgens** this causes the eggs to develop into cysts and instead of releasing during ovulation, the cysts build up and enlarge. The most common symptoms of PCOS include **oligomenorrhea**, **amenorrhea**, **polymenorrhea**, enlarged ovaries with multiple small painless cysts or follicles that form in the ovary, **acrochordons**, **acanthosis nigricans**, **hirsutism**, thinning hair, acne, weight gain, anxiety, depression, hyperglycemia, and infertility (Mayo Clinic, 2020).

Treatments like medications such as birth control pills or **antiandrogens** can help balance the hormones in your body and relieve some of the symptoms (Mayo Clinic, 2020). To learn more about Polycystic Ovary Syndrome visit the [Mayo Clinic's PCOS profile](#).

Sexually Transmitted Infections (STIs)

The terms for Sexually Transmitted Infections (STI) and Sexuality Transmitted Diseases (STD) are often used interchangeably. Sexuality Transmitted Diseases (STD) implies the disease was acquired through sexual transmission. A

disease is a disorder of structure or function in a human, which produces specific signs or symptoms. A disease must be managed, as with the case of Human Immunodeficiency Virus (which can also be acquired through the transmission of other bodily fluids; thus not solely sexual transmission). The treatment may include **antiretrovirals** or **anti-virals** (Urology Care Foundation, 2019).

Chlamydia (CT)

Chlamydia is one of the most common sexually transmitted infections (STIs) caused by bacteria that infect the cervix, urethra and other reproductive organs. Chlamydia is easy to treat and can be cured. Many people with chlamydia do not have any symptoms and unknowingly pass the infection to their sexual partner(s). If symptoms develop, they usually appear two to six weeks after sexual contact with an infected person. While females are most often asymptomatic they may experience **cervicitis**. Left untreated, chlamydia in females can lead to Pelvic Inflammatory Disease (PID) which can cause permanent damage to the reproductive organs and subsequent infertility (Centers for Disease Control and Prevention, 2021a).

Chlamydia spreads through unprotected oral, anal or vaginal sex with an infected person. Chlamydia can be spread to the eyes via the hands with direct contact of infected fluids. Until a patient finishes their treatment, they continue to have the infection and can continue to pass it to others. Chlamydia is treated with antibiotic pills. If the patient has **epididymitis**, they may need to be hospitalized and be treated with intravenous (IV) antibiotics. All sexual partners within the past 60 days should be examined, treated, and informed that having no symptoms does not mean there is no infection (Centers for Disease Control and Prevention, 2021a).

Gonorrhea (Gonococcus) – (GC)

Gonorrhea is a sexually transmitted infection (STI) caused by bacteria that infects the cervix, urethra and other reproductive organs. Infections can also infect the throat and anus. Gonorrhea can be treated and cured. Many people infected with Gonorrhea have no symptoms and can unknowingly pass the infection on to their sexual partner(s). If symptoms develop, they may appear two to seven days after sexual contact with an infected person. Symptoms vary depending on which part of the body is infected. Females may experience abnormal vaginal bleeding, discharge, or **dysuria**. Left untreated, Gonorrhea in females may lead to pelvic inflammatory disease and fertility complications such as ectopic pregnancy. Gonorrhea infection from oral sex may lead to sore throat and swollen glands. Gonorrhea infection from anal sex may cause itchiness and discharge from the anus. Gonorrhea is spread through unprotected oral, vaginal or anal sex with an infected person. Until the patient finishes their treatment, they continue to have the infection and can pass it to others (Centers for Disease Control and Prevention, 2021b).

Gonorrhea is treated with oral **antibiotics** in combination with an **intramuscular** (IM) injection. It is important that one completes the treatment and abstain from unprotected sexual activity for at least seven days following treatment. All sexual partners within the past 60 days should be examined, treated and informed that having no symptoms does not mean there is no infection (Centers for Disease Control and Prevention, 2021b).

Reportable Diseases

Both chlamydia and gonorrhea are reportable diseases and the provider should report cases to local and state public health agencies as well as to the Centers for Disease Control and Prevention. Requirements and procedures vary by county and state. For more information see Medline's [Reportable Diseases list](#).

Human Papillomavirus- HPV

HPV is a common sexually transmitted infection (STI). Both males and females can be infected with HPV. Almost three quarters of sexually active individuals have been exposed to HPV during their lifetime. There are over 100 strains of HPV and some strains of HPV can cause visible genital warts. The warts are usually painless but may be itchy, uncomfortable and hard to treat. Some strains of HPV cause genital, anal, throat and cervical cancers. HPV spreads through sexual activity and skin-to-skin contact in the genital area with an infected person. Since some people are **asymptomatic** they don't know they have the virus and consequently pass the virus to their sexual partners. Treatments are available for genital warts but there is no cure for HPV (Centers for Disease Control and Prevention, 2021c). To learn more about HPV symptoms, treatments, and prognosis visit the [CDC HPV Fact Sheet](#).

HPV Vaccine

A vaccine is available for 9 HPV strains. This vaccine, often known by the brand name Gardasil® 9, assists the immune system in protecting the body against infections and diseases caused by HPV (National Cancer Institute, 2019). To learn more about HPV vaccines, please visit the [National Cancer Institute's HPV Vaccine Fact Sheet](#).

Herpes Simplex Virus (HSV)

Genital herpes is a sexually transmitted infection (STI) that is caused by a virus called herpes simplex virus (HSV). There are two types of herpes simplex viruses:

- Type 1- oral herpes or cold sores (HSV-1)
- Type 2- genital herpes (HSV-2).

These viruses are very similar and either type can cause genital herpes or cold sores. Symptoms might include **dysuria**, enlarged glands, **myalgia**, **arthralgia** and fever. Once a patient is infected with HSV, the virus remains in their body even after the symptoms are gone and can cause recurring outbreaks. Between the outbreaks, the virus stays in their body. When the virus becomes active again, the symptoms return but are usually less painful and heal faster. Recurring outbreaks vary from person-to-person, however they can be triggered by emotional or physical stress, exposure to sunlight, hormonal changes, poor nutrition, sexual intercourse, lack of sleep or a low immune system (Centers for Disease Control and Prevention, 2021d).

Herpes is spread through direct contact with the sores or blisters of an infected person. Contact (and transfer of the virus) can occur from genitals-to-genitals, mouth-to-genitals or mouth-to-mouth. Herpes can also be passed to the anal area. Herpes spreads easily during sexual contact while symptoms are present, or just before an outbreak of symptoms. An infected person may spread herpes even when they have *no* symptoms; this is called **asymptomatic** shedding. One can spread the herpes virus to other parts of their body after touching the sores; **autoinoculation**. The fingers, eyes and other body areas can accidentally become infected in this way. Hand washing after touching sores and blisters is recommended to prevent spreading the virus (Centers for Disease Control and Prevention, 2021d).

There is no cure for herpes. Antiviral pills help to reduce symptoms and speed the healing of blisters or sores and are prescribed by a doctor. Treatment of symptoms may be managed with medication for pain, bath salts, cold compresses and urinating in water may help to relieve discomfort. Keep the infected area clean and dry, wear cotton underwear and loose clothing to reduce discomfort. All sexual partner(s) should be informed. The only way to reduce the risk of transmission of herpes is to avoid direct contact with the sores and to use condoms. Condoms will reduce but not

eliminate risk as the virus can be present and shed from the skin in the genital area (Centers for Disease Control and Prevention, 2021d).

To learn more about the symptoms, complications, treatments and prognosis of HSV please see the [CDC Herpes Fact Sheet](#).

Female Reproductive System Medical Abbreviations



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Medical Terms in Context



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Medical Specialties and Procedures related to the Female Reproductive System

Gynecology

A **gynecologist** is a specialist in the area of **gynecology** focusing on the diagnosis, treatment, management and prevention of diseases and disorders of the female reproductive system. Obstetrics is a specialty that provides care through pregnancy, labour, and **puerperium**. Further subspecialties in women's health include contraception,

reproductive **endocrinology**, infertility, adolescent gynecology, **endoscopy** and gynecological oncology (American Board of Medical Specialties, n.d.). To learn more about obstetrics or gynecology please visit the specialty and subspecialty page of the [American Board of Obstetrics and Gynecology](#).

Hysterectomy

A **hysterectomy** is done to stage or treat female reproductive cancers, treat precancerous conditions of the cervix and some non-cancerous conditions that have not responded to other forms of treatment. There are three types of hysterectomy:

- A **total hysterectomy** removes both the uterus and the cervix.
- A **subtotal hysterectomy** removes the uterus only.
- A **radical hysterectomy** removes uterus, cervix, part of the vagina, and ligaments.

Sometimes the ovaries and fallopian tubes are removed at the same time that a hysterectomy is done. A **bilateral** salpingo-oophorectomy (BSO) removes both ovaries and fallopian tubes. A **unilateral** salpingo-oophorectomy removes one ovary and one Fallopian tube (National Women's Health Network, 2015). To learn more about hysterectomy please follow visit the [National Women's Health Network's page on hysterectomies](#).

Test Yourself



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