Gout

According to the Arthritis Society, gout is an inflammatory arthritis caused when the immune system attacks the crystals that form when uric acid builds up in a joint. Gout has periods of **exacerbation** and remission and is commonly treated through lifestyle changes and medication. While any joint can be affected, it is common in the lower extremities and most often in the big toe (Choy & MacMullan, 2017). To learn more about the causes and treatments, please visit the Arthritis Society's web page about gout [New Tab].

Myasthenia Gravis

The National Institute of Neurological Disorders and Strokes describes **myasthenia gravis** as a "**chronic** autoimmune neuromuscular disorder that causes weakness in the skeletal muscle" (Office of Communications and Public Liaison, 2020). To learn more, visit the National Institute of Neurological Disorders and Stroke's page on Myasthenia Gravis [New Tab].

Fibromyalgia

Fibromyalgia is a challenging disease to diagnose, since symptoms manifest differently and are similar to other diseases. Symptoms may include chronic fatigue, gastrointestinal problems, headaches, and increased pain sensitivity. Historically, fibromyalgia was often misdiagnosed or dismissed as not real. According to The National Institute of Arthritis and Musculoskeletal and Skin Disease, there is agreement on the definition and treatment for fibromyalgia, but it is recommended to find a specialist who is familiar with fibromyalgia (National Institute of Arthritis and Musculoskeletal and Skin Diseases, 2021). To learn more about the diagnosis and treatment for fibromyalgia, please visit the National Institute of Arthritis and Musculoskeletal and Skin Diseases' fibromyalgia web page [New Tab].

Osteomyelitis

Osteomyelitis is a bone infection caused when staphylococcus bacteria travels through the blood stream from an infection in one part of the body to the bone. Staphylococcus bacteria is found on the skin and it can transfer to the bone through a wound and/or surgical contamination. The risk increases as people age or if their immune system is compromised (Mayo Clinic Staff, 2022). To learn more about the causes, symptoms and treatments for osteomyelitis, please visit the Mayo Clinic's osteomyelitis web page [New Tab].

Disorders of the Curvature of the Spine

Developmental anomalies, pathological changes, or obesity can enhance the normal vertebral column curves,

resulting in the development of abnormal or excessive curvatures (see Figure 13.10). Disorders associated with the curvature of the spine include:

- **Kyphosis:** Also referred to as humpback, is an excessive posterior curvature of the thoracic region. This can develop when osteoporosis causes weakening and erosion of the anterior portions of the upper thoracic vertebrae, resulting in their gradual collapse (see Figure 13.11).
- **Lordosis:** Also referred to as swayback, is an excessive anterior curvature of the lumbar region and is most commonly associated with obesity or late pregnancy. The accumulation of body weight in the abdominal region results in an anterior shift in the line of gravity that carries the weight of the body. This causes an anterior tilt of the pelvis and a pronounced enhancement of the lumbar curve.
- **Scoliosis:** An abnormal lateral curvature accompanied by twisting of the vertebral column. Scoliosis is the most common vertebral abnormality among girls. The cause is usually unknown, but it may result from weakness of the back muscles, defects such as differential growth rates in the right and left sides of the vertebral column, or differences in the length of the lower limbs. When present, scoliosis tends to get worse during adolescent growth spurts. Although most individuals do not require treatment, a back brace may be recommended for growing children. In extreme cases, surgery may be required (Betts et al., 2013).

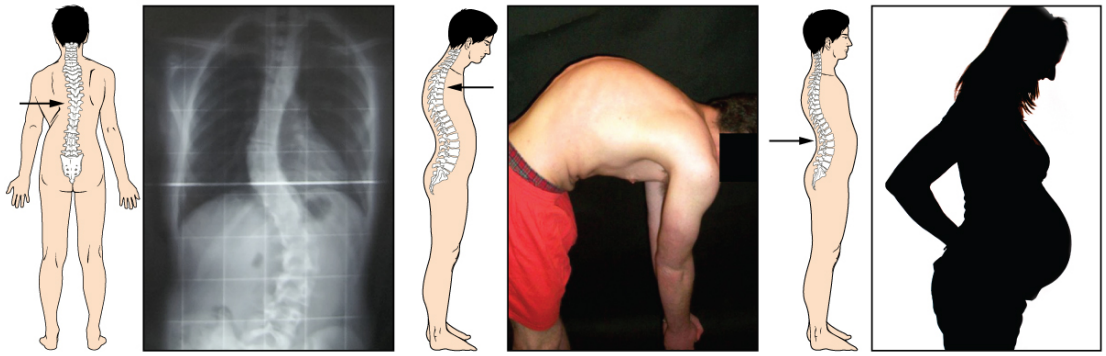

Figure 13.10 Abnormal Curvatures of the Vertebral Column. (a) Scoliosis is an abnormal lateral bending of the vertebral column. (b) An excessive curvature of the upper thoracic vertebral column is called kyphosis. (c) Lordosis is an excessive curvature in the lumbar region of the vertebral column. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 13.10 Image description.]

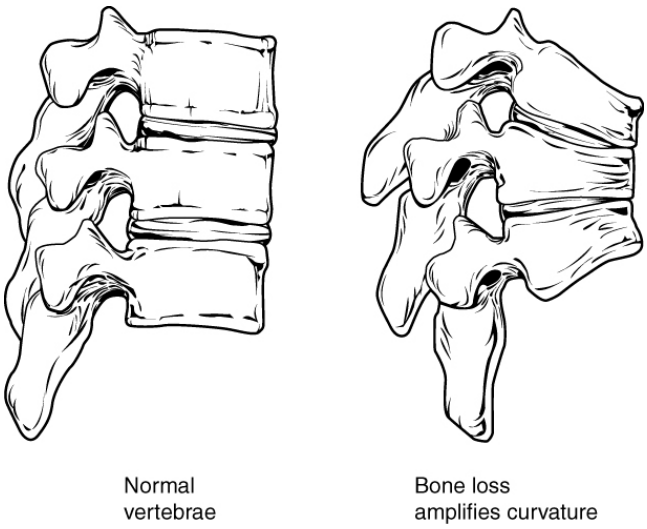

Figure 13.11. Osteoporosis. Osteoporosis is an age-related disorder that causes the gradual loss of bone density and strength. When the thoracic vertebrae are affected, there can be a gradual collapse of the vertebrae. This results in kyphosis, an excessive curvature of the thoracic region. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 13.11 Image description.]

Fractures

A **fracture** is a broken bone. It will heal whether or not a physician resets it in its anatomical position. If the bone is not reset correctly, the healing process will keep the bone in its deformed position. **Crepitation or crepitus** is the creaking or popping sound that is heard when fractured bones move against each other Fractures are classified by their complexity, location, and other features (see Figure 13.12). Some fractures may be described using more than one term because it may have features of more than one type (e.g., an open transverse fracture) (Betts et al., 2013; Cleveland Clinic, 2022).

Types of fractures include:

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

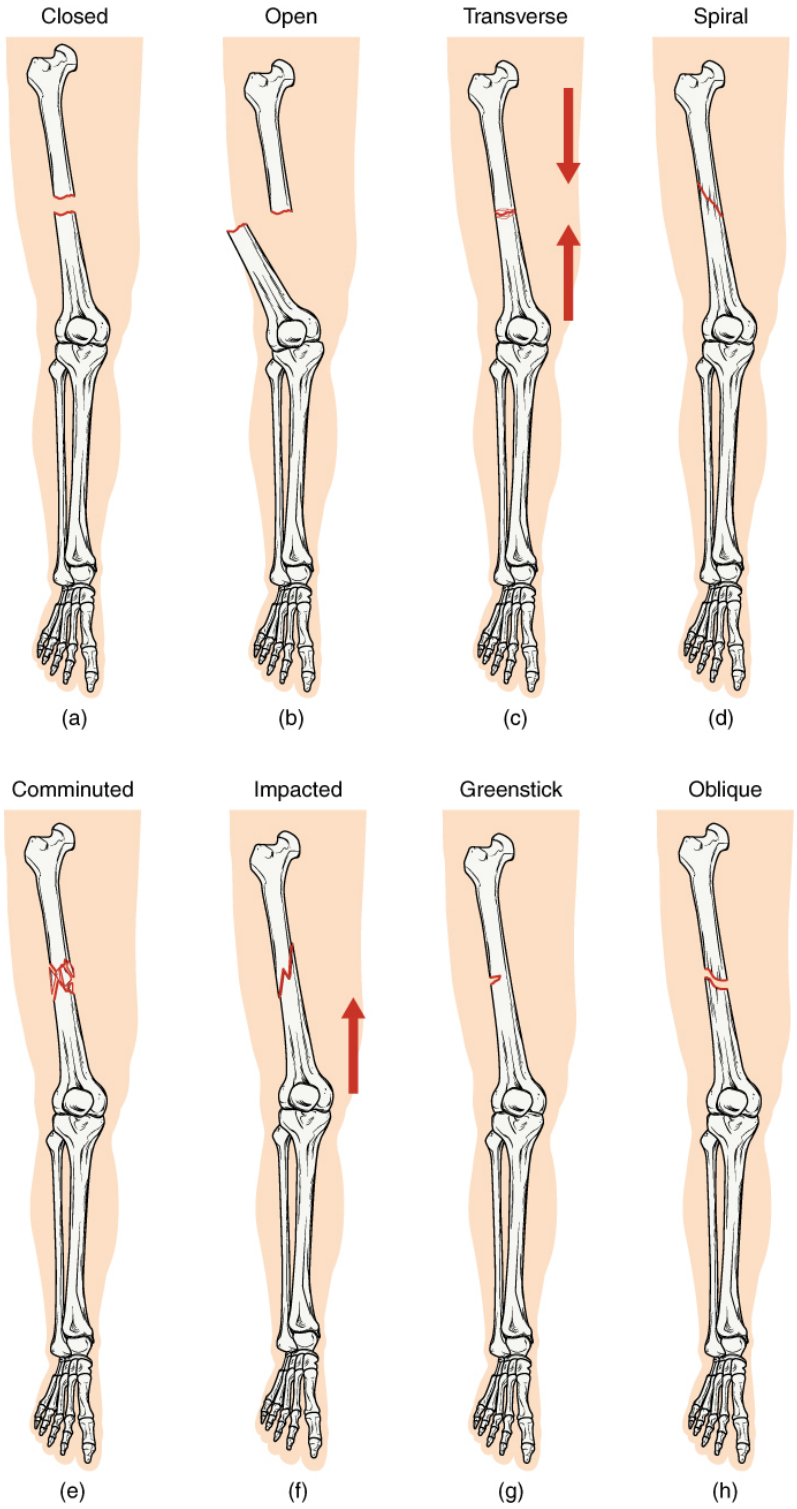

Figure 13.12. Types of Fractures. Compare healthy bone with different types of fractures: (a) closed fracture, (b) open fracture, (c) transverse fracture, (d) spiral fracture, (e) comminuted fracture, (f) impacted fracture, (g) greenstick fracture, and (h) oblique fracture. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 13.12 Image description.]

Bone Cancer

There are three types of primary bone cancers: osteosarcoma, Ewing Sarcoma, and chondrosarcoma. These are considered primary cancers because they originate in the bones. Osteosarcoma and Ewing Sarcoma are cancers found in children, teenagers, and young adults. Ewing Sarcoma is considered to be the more aggressive of the two cancers since it tends to **metastasize** quickly. Osteosarcoma is the most common type of bone cancer and it begins in the tissues of growing bones. Chondrosarcoma is a slow-growing bone cancer that affects adults and rarely metastasizes (Government of Canada, 2013). To learn more, visit the Public Health Agency of Canada's web page on bone cancer [New Tab].

Diagnostic Procedures

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

- **X-rays** are common diagnostic tests used to confirm or rule out fractures and broken bones. The radiation dose is low so it is considered a safe diagnostic test (Ontario Association of Radiologist, 2020).
- **Dual x-ray absorptionmetry (BMD)**, also called a bone mineral density test, is a test to determine osteoporosis by measuring the amount of bone mineral in a particular amount of bone (Radiology Info, 2022).
- **Arthroscopy** is a common procedure performed by orthopedic surgeons to view the inside of a joint to diagnose and/or repair joint problems. The patient is given a local anesthetic and the surgeon inserts an **arthroscope** through an incision in the skin. Depending on what the surgeon finds, a repair of the joint may take place during the procedure (Mayo Clinic Staff, 2022).

Medical Specialties Related to the Skeletal System

Orthopedic Surgeon

Orthopedic Surgeons are medical doctors who complete an additional 5-years of specialized training in the prevention, diagnosis, treatment and surgery of disorders and diseases related to the musculoskeletal systems (Canadian Medical Association, 2019). For more details, please visit the Canadian Medical Association's page on Orthopedic Surgery [PDF].

Rheumatologist

Rheumatologists are medical doctors who have additional training as internists with a sub-specialty in rheumatology. Many rheumatology disorders have an underlying autoimmune disorders. Consequently, rheumatologists are interested in autoimmune disorders and their impact on multiple body systems including the musculoskeletal systems (Canadian Medical Association, 2019). For more details, please follow the link to the Canadian Medical Association's page on Rheumatology [PDF].

Doctor of Chiropractic (DC)/Chiropractor

A Doctor of Chiropractic (DC) is regulated and licensed by each province in Canada. Chiropractors have seven years of university education, a supervised internship, and national examinations. Chiropractors are trained in the prevention, assessment and treatment of the spine, muscular system and nervous system. Chiropractors focus on spinal adjustments, nutrition, and preventing injury without the use of pharmaceuticals or surgical procedures (Cleveland Clinic, 2022). To learn more, visit the Cleveland Clinic's page on Chiropractic adjustment [New Tab].

Physiotherapist

A physiotherapist in Canada has a Master's degree in physiotherapy and has successfully completed a national Physiotherapy Competency Examination (PCE). Physiotherapists use an evidenced-based approach when assessing and designing treatment plans for their clients. Treatments may include exercises, massage, joint manipulation, and occupational retraining (Canadian Physiotherapy Association, n.d.). To learn more, please visit the Canadian Physiotherapy Association website [New Tab].

Image Descriptions

Figure 13.10 image description: This image shows the changes to the abnormal curves of the vertebral columns in different diseases. The left panel shows the change in the curve of the vertebral column in scoliosis, the middle panel shows the change in the curve of the vertebral column in kyphosis, and the right panel shows the change in the curve of the vertebral column in lordosis. [Return to Figure 13.10].

Figure 13.11 image description: This figure shows the changes to the spine in osteoporosis. The left panel shows the structure of normal vertebrae and the right panel shows the curved vertebrae in osteoporosis. [Return to Figure 13.11].

Figure 13.12 image description: In this illustration, each type of fracture is shown on the right femur from an anterior view. In the closed fracture, the femur is broken in the middle of the shaft with the upper and lower halves of the bone completely separated. However, the two halves of the bones are still aligned in that the broken edges are still facing each other. In an open fracture, the femur is broken in the middle of the shaft with the

upper and lower halves of the bone completely separated. Unlike the closed fracture, in the open fracture, the two bone halves are misaligned. The lower half is turned laterally and it has protruded through the skin of the thigh. The broken ends no longer line up with each other. In a transverse fracture, the bone has a crack entirely through its width, however, the broken ends are not separated. The crack is perpendicular to the long axis of the bone. Arrows indicate that this is usually caused by compression of the bone in a superior-inferior direction. A spiral fracture travels diagonally through the diameter of the bone. In a comminuted fracture, the bone has several connecting cracks at its middle. It is possible that the bone could splinter into several small pieces at the site of the comminuted fracture. In an impacted fracture, the crack zig zags throughout the width of the bone like a lightning bolt. An arrow indicates that these are usually caused by an impact that pushes the femur up into the body. A greenstick fracture is a small crack that does not extend through the entire width of the bone. The oblique fracture shown here is travelling diagonally through the shaft of the femur at about a thirty degree angle. [Return to Figure 13.12].

Attribution

Vocabulary & Check Your Knowledge

Skeletal System Vocabulary

Amphiarthrosis

Joints with some movement.

Ankylosis

Abnormal condition of stiffness.

Appendicular Skeleton

Consists of all the bones in the upper and lower limbs.

Arthralgia

Painful joint(s).

Arthritis

Inflammation of the joints.

Articulations

Also known as joints. It is where bones meet bones or bones meet bones.

Autoimmune Diseases/Disorders

Autoimmune diseases are disorders in which the immune system overreacts and begins to attack itself.

Axial Skeleton

Forms the vertical, central axis of the body and includes all bones of the head, neck, chest, and back.

Chronic

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

Diarthrosis

Freely moveable joints.

Edema

Swelling.

Hematopoiesis

The process in which the body produces blood.

Osteoarthritis

Inflammation of bones and joints.

Osteoporosis

Abnormal condition of bones that are porous.

Synarthrosis

Joints with no movements.

Skeletal System Glossary Reinforcement Activity

Skeletal System Glossary Reinforcement Activity (Text version)

1. Joints with some movement are called _____[Blank 1].
    a. Amphiarthrosis
    b. Diarthrosis
    c. Synarthrosis
2. The skeleton that consists of all the bones in the upper and lower limbs is called _____[Blank 2].
    a. Appendicular Skeleton
    b. Articulations
    c. Axial Skeleton
3. A condition that lasts a long time with periods of remission and exacerbation is called _____[Blank 3].
    a. Chronic
    b. Edema
    c. Hematopoiesis
4. Forward curvature of the lower lumbar spine is called _____[Blank 4].
    a. Scoliosis
    b. Lordosis
    c. Kyphosis
5. Comminuted fractures are _____[Blank 5].
    a. bones that are broken but do not protrude the skin
    b. bones that are broken and crushed into pieces

c. bones that are broken and pierce through the skin

Check your answers: [1]

Activity source: Skeletal System Glossary Reinforcement Activity by Kimberlee Carter, from *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY 4.0.

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Except where otherwise noted, this chapter is adapted from "Skeletal System" in *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY 4.0. / A derivative of Betts et al., which can be accessed for free from *Anatomy and Physiology (OpenStax)*. Adaptations: dividing Skeletal System chapter content into sub-chapters.

Notes

1. 1. a) Amphiarthrosis, 2. a) Appendicular Skeleton, 3. a) Chronic, 4. b) Lordosis, 5. b) bones that are broken and crushed into pieces.

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CHAPTER 14: MUSCULAR SYSTEM

Building a Medical Terminology Foundation 2e by Kimberlee Carter; Marie Rutherford; and Connie Stevens

Please visit the web version of *Building a Medical Terminology Foundation 2e* to access the complete book, interactive activities and ancillary resources.

14.1 - Introduction to the Muscular System

Learning Objectives

- Identify the anatomy of the muscular system and describe the main functions of the muscular system
- Analyze, translate, and define medical terms and common abbreviations of the muscular system
- Practice the spelling and pronunciation of muscular system terminology
- Identify the medical specialties associated with the muscular system and explore common diseases, disorders, diagnostic tests and procedures

Muscular System Word Parts

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

Prefix

- **a-** (absence of, without)
- **ab-** (away from)
- **ad-** (towards)
- **dys-** (painful, difficult, abnormal, laboured)
- **hyper-** (above, excessive)
- **inter-** (between)
- **intra-** (within, in)
- **poly-** (many, much)
- **sub-** (below, under)
- **supra-** (above)
- **sym-** (together, joined)

- **syn-** (together, joined)

Combining Form

- **kinesi/o** (movement, motion)
- **my/o** (muscle)
- **myos/o** (muscle)
- **radi/o** (nerve root)
- **sarc/o** (flesh, connective tissue)
- **ten/o** (tendon)
- **tendin/o** (tendon)
- **tend/o** (tendon)

Suffix

- **-al** (pertaining to)
- **-algia** (pain)
- **-ar** (pertaining to)
- **-asthenia** (weakness)
- **-centesis** (surgical puncture to aspirate fluid)
- **-desis** (surgical fixation, fusion)
- **-ectomy** (excision, surgical removal, cutting out)
- **-gram** (the record, radiographic image)
- **-graphy** (process of recording, radiographic imaging)
- **-ic** (pertaining to)
- **-itis** (inflammation)
- **-lysis** (loosening, separating, dissolution)
- **-oid** (resembling)
- **-oma** (tumour)
- **-penia** (abnormal reduction)
- **-physis** (growth)
- **-plasty** (surgical repair)
- **-rrhaphy** (suturing, repairing)
- **-sarcoma** (malignant tumour)
- **-schisis** (split, fissure)
- **-scopy** (process of viewing, visual examination)
- **-sis** (abnormal condition)
- **-tomy** (incision, cut into)
- **-trophy** (nourishment, development)

Introduction to the Muscular System

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

Watch [Muscles, Part 2 – Organismal Level: Crash Course Anatomy & Physiology #22 (11 min)]

Muscular System Medical Terms

Muscular System Medical Terms (Text Version)
Practice the following muscular system words by breaking into word parts and pronouncing.

1. **rhabdomyolysis (rhabd/o/my/o/lysis)**
    - dissolution of a striated muscle
2. **bradykinesia (brady/kines/ia)**
    - condition of slow movement
3. **myorrhaphy (my/o/rrhaphy)**
    - suturing of a muscle
4. **dystrophy (dys/trophy)**
    - abnormal development
5. **tendinitis (tendin/itis)**
    - inflammation of the tendon
6. **electromyogram (electr/o/my/o/gram)**
    - record of the electricity of the muscle
7. **hyperkinesia (hyper/kines/ia)**
    - condition of excessive movement
8. **myasthenia (my/asthenia)**

- weakness of muscles, muscle weakness

9. **hypertrophy (hyper/trophy)**
    - excessive development
10. **dyskinesia (dys/kines/ia)**
    - condition of difficult movement
11. **tenomyoplasty (ten/o/my/o/plasty)**
    - surgical repair of tendon and muscle
12. **myeloma (myel/oma)**
    - tumour in the spinal cord
13. **myalgia (my/algia)**
    - painful muscles
14. **polymyositis (poly/myos/itis)**
    - inflammation of many muscles
15. **tenorrhaphy (ten/o/rrhaphy)**
    - suturing of a tendon
16. **fibromyalgia (fibr/o/my/algia)**
    - pain in the fibers of muscles

Activity source: Muscular System Medical Terms by Kimberlee Carter, from *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY- 4.0. /Text version added.

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14.2 - Anatomy (Structures) of the Muscular System

Muscle is one of the four primary tissue types of the body, and it is made up of specialized cells called fibers. The body contains three types of muscle tissue: **skeletal muscle**, **cardiac muscle**, and **smooth muscle** (see Figure 14.1). All three muscle tissues have some properties in common; they all exhibit a quality called **excitability**, as their plasma membranes can change their electrical states (from polarized to depolarized) and send an electrical wave called an action potential along the entire length of the membrane. Fascia is fibrous connective tissue that encloses muscles.

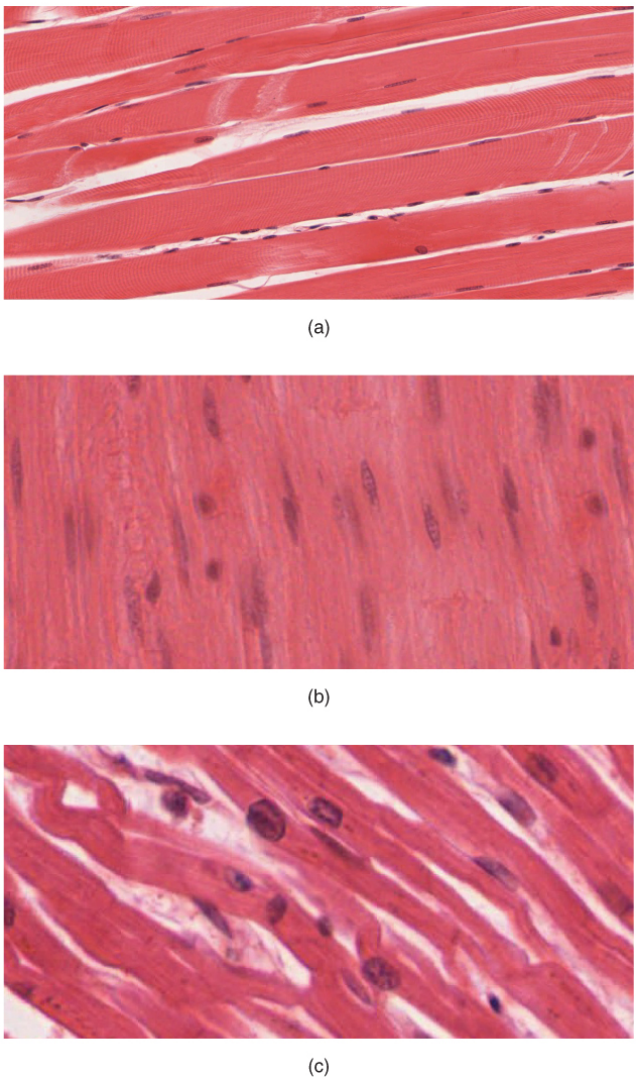


Figure 14.1 The Three Types of Muscle Tissue. The body contains three types of muscle tissue: (a) skeletal muscle, (b) smooth muscle, and (c) cardiac muscle. (Micrographs provided by the Regents of University of Michigan Medical School © 2012). From Betts et al., 2013. Licensed under CC BY 4.0.

Three Types of Muscle Tissues

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

Did You Know?

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

Skeletal Muscle

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

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

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

Smooth Muscle

Smooth muscle, so named because the cells do not have striations, is present in the walls of hollow organs like the urinary bladder, uterus, stomach, intestines, in the walls of passageways, such as the arteries and veins of the circulatory system, and the tracts of the respiratory, urinary, and reproductive systems. Smooth muscle is also

present in the eyes, where it functions to change the size of the iris and alter the shape of the lens, and in the skin, where it causes hair to stand erect in response to cold temperature or fear.

Cardiac Muscle

Cardiac muscle tissue is only found in the heart. Highly coordinated contractions of cardiac muscle pump blood into the vessels of the circulatory system. Similar to skeletal muscle, cardiac muscle is striated and organized into **sarcomeres**, possessing the same banding organization as skeletal muscle (see Figure 14.1). Cardiac muscle fibers cells also are extensively branched and are connected to one another at their ends by intercalated discs. An **intercalated disc** allows the cardiac muscle cells to contract in a wave-like pattern so that the heart can work as a pump.

Concept Check

- Compare and contrast the 3 types of muscles tissues.
- Where in the body do you find each of the muscle types?

Attribution

14.3 - Physiology (Function) of the Muscular System

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

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

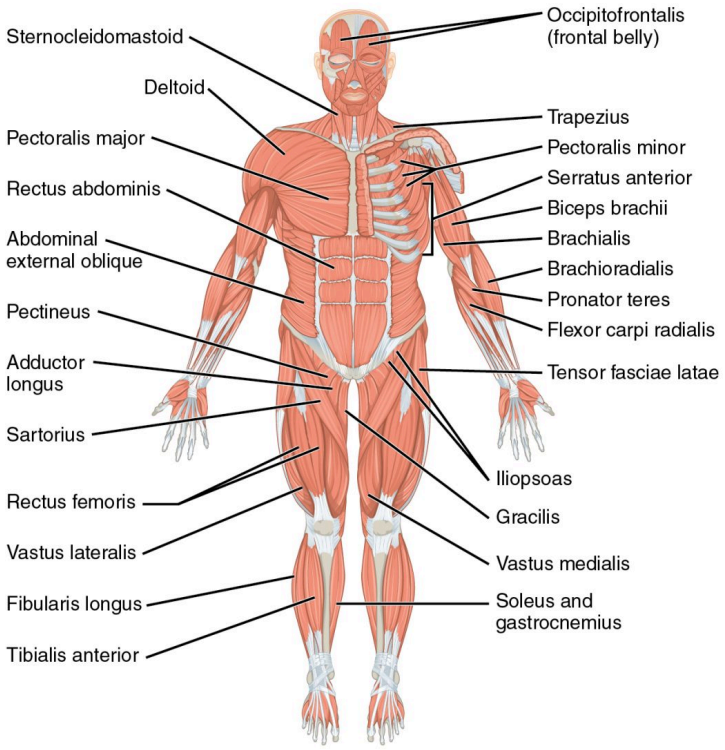
Naming of Muscles

Did You Know?

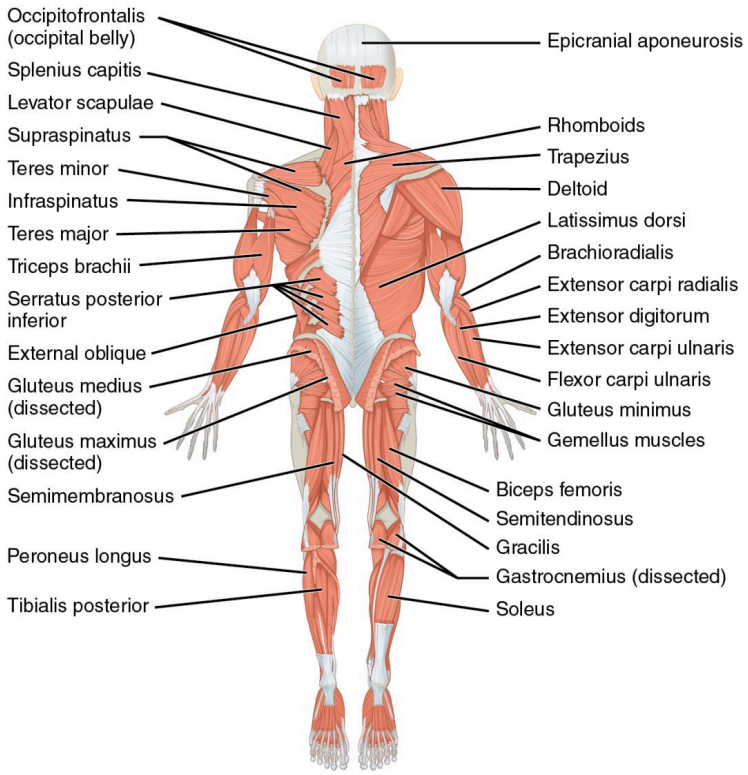
The tongue is made up of many muscles and muscles work in pairs.

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

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



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



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

Figure 14.2. Overview of the Muscular System. On the anterior and posterior views of the muscular system above, superficial muscles (those at the surface) are shown on the right side of the body while deep muscles (those underneath the superficial muscles) are shown on the left half of the body. For the legs, superficial muscles are shown in the anterior view while the posterior view shows both superficial and deep muscles. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 14.2 Image description.]

Table 14.1a-b. Understanding a Muscle Name from the Latin. Adapted from Betts et al., 2013. Licensed under CC BY 4.0.

Table 14.1a. Understanding a Muscle Name from the Latin. Example: abductor digiti minimi. Translation: A muscle that moves the little finger or toe away. Adapted from Betts et al., 2013. Licensed under CC BY 4.0.

Word	Latin Root 1	Latin Root 2	Meaning
abductor	ab = away from	duct = to move	a muscle that moves away from
digiti	digitus = digit	n/a	refers to a finger or toe
minimi	minimus = mini, tiny	n/a	little

Table 14.1b. Understanding a Muscle Name from the Latin. Example: adductor digiti minimi. Translation: A muscle that moves the little finger or toe toward. Adapted from Betts et al., 2013. Licensed under CC BY 4.0.

Word	Latin Root 1	Latin Root 2	Meaning
adductor	ad = to, toward	duct = to move	a muscle that moves towards
digiti	digitus = digit	n/a	refers to a finger or toe
minimi	minimus = mini, tiny	n/a	little

Muscular System Medical Abbreviations

Muscular System Abbreviations

- **DC** (Doctor of Chiropractic)
- **DO** (Doctor of Osteopathy)
- **EMG** (Electromyogram)
- **MD** (Muscular Dystrophy)
- **MG** (myasthenia gravis)
- **Ortho** (orthopedics)

Image Descriptions

Figure 14.2 image description: The top panel shows the anterior view of the human body with the major muscles labeled. Labels read (from top, head): occipitofrontalis (frontal belly), sternocleidomastoid, trapezius, deltoid, pectoralis minor, serratus anterior, pectoralis major, arm muscles: biceps brachii, brachialis, brachioradialis, pronator teres, flexor carpi radialis, abdomnial: rectus abdominis, abdominal external oblique, lower body: tensor fasciae latae, illiopsoas, pectineus, adductor longus, sartorius, gracilis, rectus femoris, vastus lateralis, vasus medialis, fibularis longus, tibialis anterior. The bottom panel shows the posterior view of the human body with the major muscles labeled. Labels read (from top, head, left side): epicranial aponeurosis, occipitofrontalis, splenius capitis, levator scapulae, rhombus, trapezius, supraspinatus, teras minor, infraspinatus, teres major, triceps brachii, seratus posterior inferior, external oblique, lower body: gluteus medius, gluteus maximus, semimebranosus, peroneus longus, tibialis posterior, (right side, from top) trapezius, deltpid, latissimus dorsi, arm: brachioradialis, extersor carpi radialis, extensor digitorum, extensor carpi ulnaris, flexor carpi ulnaris, lower body: gluteus minimus, gemellus muscles, biceps femoris, semitendinosus, gracilis, gastrocnemius, soleus. [Return to Figure 14.2].

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14.4 - Muscular Diseases, Disorders and Diagnostic Testing

Common Diseases and Disorders

Duchenne Muscular Dystrophy

Duchenne Muscular Dystrophy (DMD) is caused by the inability of the body to make dystrophin (a muscle protein). This causes the muscles to become weak as the person ages. This disease primarily affects boys, and signs and symptoms typically present before the age of five. Signs and symptoms may include frequent falls and trouble keeping up with peers. Since all muscles are affected, the person will eventually require a wheelchair and assistance with breathing (Muscular Dystrophy Canada, 2020). To learn more, please visit Muscular Dystrophy Canada's neuromuscular disorders web page [New Tab].

Cerebral Palsy

Cerebral Palsy (CP) is caused by an interruption to the normal development of a person's brain, leading to weakness in muscles. Depending on the area of the brain that is affected, signs and symptoms will vary in the type and severity between individuals. Balance and coordination are often challenging due to the inability to control muscles (Centers for Disease Control and Prevention, 2024; Ontario Federation for Cerebral Palsy, 2018). To learn more about Cerebral Palsy, please visit the Centers for Disease Control and Prevention [New Tab].

Carpal Tunnel Syndrome

Carpal tunnel syndrome may present with pain, numbness or weakness in the hand(s) caused by pressure on the median nerve. Some causes for this pressure are work-related, such as keyboarding with improper body mechanics, illnesses such as arthritis, and even pregnancy (Cleveland Clinic, 2024). To learn more, visit Cleveland Clinic's Carpal Tunnel web page [New Tab].

Paralysis

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

- **Paresis**: a partial paralysis wherein there is still some control of the muscles
- **Paraplegia**: paralysis that affects both legs and lower part of the body
- **Quadriplegia:** affects both arms, both legs and sometimes from the neck down
- **Hemiplegia:** affects one side of the body. For example, the arm and leg on the same side of the body (Cleveland Clinic, 2021)

To learn more about paralysis, please visit the Cleveland Clinic's Paralysis information web page [New Tab].

Sprain and Strain

A **sprain** is an injury to a joint whereby a ligament is stretched or torn.

A **strain** is an injury to a muscle whereby a tendon is stretched or torn.

Diagnostic Procedures

Electromyography (EMG) is a procedure that assesses the function of nerve cells that control muscles. Electrodes, either attached to the skin or inserted into the muscle, allow for the recording of electrical impulses. EMG can indicate functional problems with the peripheral nerves, muscles, or with the signals between the nerves and the muscles. This is just one test in a series of tests that assist in the diagnosis of neuromuscular disorders (Mayo Clinic Staff, 2019). To learn more, please visit the Mayo Clinic's Electromyography web page [New Tab].

Magnetic Resonance Imaging (MRI) is a test that uses radio frequency waves and a magnetic field to produce clear images that aid in the diagnosis of a wide range of conditions (London Health Sciences Centre, 2020). Leung (2017) notes that there has been increased clinical use of MRI for the treatment and monitoring of muscular disorders due to the high-quality MRI images that distinguish skeletal muscles from fat (para. 4).

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

Medical Terminology in Context

Musculoskeletal System – Referral Letter

Musculoskeletal System – Referral Letter (Text version)

Use the words below to fill in the referral letter:

- CTS
- tingling
- numbness
- osteoarthritis
- clumsiness
- metacarpal
- atrophy
- arthrodesis
- flexion
- tenorrhaphy
- median
- ligament

PATIENT NAME: Mrs. Anna JONES

AGE: 65

SEX: Female

DOB: June 29

REASON FOR REFERRAL: Evaluation and consideration for surgery for treating carpal tunnel syndrome.

Dear Dr. Porter

I am referring Mrs. Jones for evaluation and consideration for surgery for treating _____[Blank 1]. Mrs. Jones is 65 years old. She has moved to this area 2 years ago and I have been her primary care physician since then. Recently she has been complaining of _____[Blank 2], tingling, burning, and pain in her right hand, primarily in the thumb, index, and middle fingers. Occasionally the pain and _____[Blank 3] travel up the forearm toward her shoulder. The patient reports that the pain and unusual sensations have started gradually and worsened over the past couple of years.

The patient has worked as a data entry clerk at a pharmaceutical company for 35 years. Her work involved sitting at her desk and typing on a computer for an average of 7 hours on each workday. She is retired now. The patient reports that during the past few months she has also felt weakness and _____[Blank 4] in her hand, and this has made her everyday life difficult. She can tell that her grip is not as strong as before since she frequently drops things. Now she is finding the simple tasks such as buttoning her clothes, cutting vegetables, and brushing her teeth challenging. The x-ray of the right hand and wrist shows clear signs of _____[Blank 5] and osteoporosis of carpal and _____[Blank 6] bones. On visual examination there is no muscle . The wrist has limited _____[Blank 7] and extension range of motion.

It is important to note that the patient had been in a car accident in her teenage years and had suffered from a compact fracture of her left wrist bones. Multiple surgeries, including arthroplasty and _____[Blank 8], were done to restore the functionality of the left wrist and hand. Eventually, her orthopedic surgeon performed a subtotal _____[Blank 9] of the wrist to provide a stable and pain-free joint with a limited useful range of motion.

Based on the aforementioned observations and findings I have determined that Mrs. Jones is a fit

candidate for CTS surgery. A proper cut in the transverse carpal _____[Blank 10] would release the pressure off the _____[Blank 11] nerve and relieve the symptoms.

Thank you for seeing Mrs. Jones. Please do not hesitate to contact me directly with any questions or comments you may have concerning her care. Also, please keep me updated on her progress and kindly refer her back to my care once her condition resolves.

_____
Trevor Sharpe, MD, Family Medicine

> **Note:** Report samples (H5P and Pressbooks) are to encourage learners to identify correct medical terminology and do not represent the Association for Health Documentation Integrity (AHDI) formatting standards.

Check your answers: [1]

Medical Specialties Related to Muscular System

Orthopedic Surgeon

Orthopedic Surgeons are medical doctors who complete an additional 5-years of specialized training in the prevention, diagnosis, treatment and surgery of disorders and diseases related to the musculoskeletal systems (Canadian Medical Association, 2019). For more details, please visit the Canadian Medical Association's page on Orthopedic Surgery [PDF].

Neurologist

Neurologists are medical doctors who complete an additional 5 years of specialized training in the prevention, diagnosis, and treatment of disorders and conditions related to the brain, spinal cord, nerves and muscles (Canadian Medical Association, 2019). For more details, visit the Canadian Medical Association's page on Neurology profile [PDF].

Kinesiologist

Kinesiologists are regulated health-care professionals with a four-year degree in kinesiology or related discipline. In Ontario, a kinesiologist must be registered and in good standing with the College of Kinesiologists of Ontario. Kinesiologists work in a variety of settings that assist people with pain management, injury prevention, and health promotion through biomechanics (College of Kinesiologists of Ontario, n.d.). To learn more, visit the College of Kinesiologists of Ontario's website [New Tab].

Attribution

Notes

1. 1. CTS, 2.numbness, 3.tingling, 4.clumsiness, 5.osteoarthritis, 6.metacarpal, 7.atrophy, 8. tenorrhaphy, 9.arthrodesis, 10. ligament, 11.median

Vocabulary & Check Your Knowledge

Muscular System Vocabulary

Antagonistic

In opposition to each other.

Cardiac muscle

The heart muscle also known as the myocardium. Its appearance is similar to skeletal muscle. It pumps blood and gives the heartbeat.

Electromyography (EMG)

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

Fibromyalgia

Pain in the fibrous tissues of muscles.

Hemostasis

Biological process that results in stable equilibrium.

Hemiplegia

Paralysis that affects one side of the body.

Magnetic Resonance Imaging (MRI)

Radiofrequency waves and a strong magnetic field provide clear and detailed pictures of internal organs and tissues.

Myasthenia Gravis

Grave or serious muscle weakness.

Paraplegia

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

Paresis

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

Quadriplegia

Affects both arms, both legs and sometimes from the neck down.

Skeletal muscle

Also known as striated muscles. Skeletal muscles are responsible for voluntary muscle movement.

Smooth muscle

Also known as visceral muscles. Smooth muscle is mainly associated with the walls of internal organs. Smooth muscles are responsible for involuntary muscle movement.

Sprain

Injury to a joint whereby a ligament is stretched or torn.

Strain

Injury to a muscle whereby a tendon is stretched or torn.

Muscular System Glossary Reinforcement Activity

Muscular System Glossary Reinforcement Activity (Text version)

1. Muscle that is associated with the walls of internal organs and is responsible for involuntary muscle movement is called _____[Blank 1].
    a. Skeletal muscle
    b. Smooth muscle
    c. Cardiac muscle
2. Paralysis that effects one side of the body is called_____ [Blank 2].
    a. paraplegia
    b. paresis
    c. hemiplegia
3. An injury to a joint whereby a ligament is stretched or torn is called _____[Blank 3].
    a. a sprain
    b. a strain
    c. fibromyalgia
4. Myasthenia Gravis is _____[Blank 4].
    a. pain in the fibrous tissues of muscles.
    b. grave or serious muscle weakness.
    c. partial paralysis wherein there is still some control of the muscles.
5. Skeletal muscle is responsible for _____[Blank 5].

a. voluntary muscle movement.
b. pumping blood.
c. involuntary muscle movement.

Check your answers: [1]

Activity source: Muscular System Glossary Reinforcement Activity by Kimberlee Carter, from *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY-4.0. /Text version added.

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Notes

1. 1. Smooth muscle, 2. hemiplegia, 3. a sprain, 4. grave or serious muscle weakness, 5.voluntary muscle movement

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CHAPTER 15: SENSORY SYSTEMS

Building a Medical Terminology Foundation 2e by Kimberlee Carter; Marie Rutherford; and Connie Stevens

Please visit the web version of *Building a Medical Terminology Foundation 2e* to access the complete book, interactive activities and ancillary resources.

15.1 - Introduction to the Sensory Systems

Learning Objectives

- Identify the anatomy of the sensory systems and describe the main functions of the sensory systems
- Analyze, translate, and define medical terms and common abbreviations of the sensory systems
- Practice the spelling and pronunciation of sensory systems terminology
- Identify the medical specialties associated with the sensory systems and explore common diseases, disorders, diagnostic tests and procedures related to the sensory systems

Sensory Systems Word Parts

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

Prefix

- **bi-** (two)
- **bin-** (two)
- **a-** (absence of, without, no, not, negates meaning)
- **an-** (absence of, without, no, not negates meaning)
- **endo-** (within, in)

Combining Form

- **audi/o** (hearing)
- **aur/o** (ear)
- **aur/i** (ear)
- **blephar/o** (eyelid)

- **cochle/o** (cochlea)
- **conjunctiv/o** (conjunctiva)
- **cor/o** (pupil)
- **corne/o** (cornea)
- **core/o** (pupil)
- **cry/o** (cold)
- **dacry/o** (tear, tear duct)
- **dipl/o** (two, double)
- **ir/o** (iris)
- **irid/o** (iris)
- **is/o** (equal)
- **kerat/o** (cornea)
- **labyrith/o** (labyrinth, inner ear)
- **lacrim/o** (tear, tear duct)
- **mastoid/o** (mastoid bone)
- **myring/o** (tympanic membrane, eardrum)
- **ocul/o** (eye)
- **ophthalm/o** (eye)
- **opt/o** (vision)
- **ot/o** (ear)
- **phac/o** (lens)
- **phak/o** (lens)
- **phot/o** (light)
- **pupill/o** (pupil)
- **retin/o** (retina)
- **scler/o** (sclera)
- **staped/o** (stapes, middle ear)
- **ton/o** (tension, pressure)
- **tympan/o** (tympanic membrane, middle ear)
- **vestibul/o** (vestibule)

Suffix

- **-al** (pertaining to)
- **-algia** (pain)
- **-ar** (pertaining to)
- **-ary** (pertaining to)
- **-ectomy** (excision or surgical removal)
- **-eal** (pertaining to)
- **-gram** (record, radiographic image)
- **-graphy** (process of recording)
- **-ia** (condition of, diseased or abnormal state)
- **-ic** (pertaining to)

- **-itis** (inflammation)
- **-logist** (specialist or physician who studies and treats)
- **-logy** (study of)
- **-malacia** (softening)
- **-meter** (instrument used to measure)
- **-metry** (process of measuring)
- **-oma** (tumour, swelling)
- **-opia** (vision as it relates to condition)
- **-plegia** (paralysis)
- **-ptosis** (prolapse, drooping, sagging)
- **-stomy** (creation of artificial opening)
- **-pathy** (disease)
- **-pexy** (surgical fixation)
- **-phobia** (abnormal fear, aversion to specific things)
- **-plasty** (surgical repair)
- **-plegia** (paralysis)
- **-rrhea** (flow, discharge)
- **-sclerosis** (hardening)
- **-scope** (instrument used to view)
- **-scopy** (process of viewing)
- **-sis** (abnormal condition)
- **-tomy** (incision, cut into)

Introduction to the Sensory Systems

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

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

Gustation (Taste) and Olfaction (Smell)

Watch [Taste & Smell: Crash Course Anatomy & Physiology #16 (11 min) on YouTube]

Sensory Systems Medical Terms

Sensory Systems Medical Terms (Text Version)
Practice the following sensory system words by breaking into word parts and pronouncing.

1. **anisocoria (an-ī-sō-KŌR-ē-ă)**
    - condition of absence of equal pupil (size)
2. **aphakia (ă-FĀ-kē-ă)**
    - condition of no lens
3. **audiogram (OD-ē-ō-gram)**
    - graphic record (radiographic image) of hearing
4. **audiologist (od-ē-OL-ŏ-jĭst)**
    - specialist who studies and treats the hearing
5. **audiology (od-ē-OL-ŏ-jē)**
    - study of the hearing
6. **audiometer (od-ē-OM-ĕt-ĕr)**
    - instrument used to measure hearing
7. **audiometry (od-ē-OM-ĕ-trē)**
    - measuring hearing
8. **aural (OR-ăl)**
    - pertaining to the ear
9. **binocular (bĭn-ŎK-ū-lăr)**
    - pertaining to both eyes

10. **blepharitis (blĕf-ăr-Ī-tĭs)**
    - inflammation of the eyelid
11. **blepharoplasty (BLĔF-ă-rō-plăs-tē)**
    - surgical repair of the eyelid
12. **blepharoptosis (BLĔF-ă-rōp-TŌ-sĭs)**
    - condition of drooping of the eyelid
13. **cochlear (KOK-lē-ăr)**
    - pertaining to the cochlea
14. **cochlear implant (KOK-lē-ă IM-plant)**
    - pertaining to the cochlear implant
15. **conjunctivitis (kŏn-jŭnk-tĭ-VĪT-ĭs)**
    - inflammation of the conjunctiva
16. **corneal (KOR-nē-ă)**
    - pertaining to the cornea
17. **cryoretinopexy (krī-ō-RET-in-ō-pek-sē)**
    - surgical fixation of the retina using extreme cold
18. **dacrocystitis (dak-rē-ŏ-sis-TĪT-ĭs)**
    - inflammation of the tear (lacrimal) sac
19. **dacryocystorhinostomy (dak-rē-ŏ-sis-tŏ-rī-NOS-tŏ-mē)**
    - creation of an artificial opening between the lacrimal sac and the nose
20. **diplopia (dip-LŌ-pē-ă)**
    - condition of double vision
21. **electrocochleography (ē-lek-trō-kok-lē-OG-ră-fē)**
    - process of recording the electrical activity in the cochlea
22. **endophthalmitis (ĕn-dŏf-thăl-MĪ-tĭs)**
    - inflammation within the eye
23. **intraocular (in-tră-OK-yŭ-lăr)**

- pertaining to within the eye

24. **iridectomy (ir-ĭ-DEK-tŏ-mē)**
    - excision of (part of) the iris
25. **iridoplegia (ir-ĭ-dō-PLĒ-j(ē-)ă, īr)**
    - paralysis of the iris
26. **iridotomy (ĭr-ĭ-DŎT-ō-mē)**
    - incision into the iris
27. **iritis (ī-RĪT-ĭs)**
    - inflammation of the iris
28. **isocoria (ī-sō-KŌ-rē-ă)**
    - condition of equal pupils
29. **keratitis (ker-ă-TĪT-ĭs)**
    - inflammation of the cornea
30. **keratomalacia (kĕr-ă-tō-mă-LĀ-shē-ă)**
    - condition of softening of the cornea
31. **keratometer (kĕr-ă-TŎM-ĕ-ter)**
    - instrument used to measure (the curvature) of the eye
32. **keratoplasty (KER-ăt-ō-plas-tē)**
    - surgical repair of the cornea
33. **labyrinthectomy (lab-ĭ-rin-THEK-tŏ-mē)**
    - excision of the inner ear (labyrinth)
34. **labyrinthitis (lab-ĭ-rin-THĪT-ĭs)**
    - inflammation of the inner ear (labyrinth)
35. **lacrimal (LAK-rĭ-măl)**
    - pertaining to the tear duct
36. **leukocoria (loo-kō-KŎR-ē-ă)**
    - condition of white pupil

37. **mastoidectomy (măs-tŏy-d-ĔK-tō-mē)**
    - excision of the mastoid bone
38. **mastoiditis (mas-toyd-ĪT-ĭs)**
    - inflammation of the mastoid bone
39. **mastoidotomy (măs-toyd-ŎT-ō-mē)**
    - incision into the mastoid bone
40. **myringitis (mĭr-ĭn-JĪ-tĭs)**
    - inflammation of the tympanic membrane
41. **myringoplasty (mĭr-ĬN-gō-plăst-ē)**
    - surgical repair of the tympanic membrane
42. **myringotomy (mĭr-ĭn-GŎT-ō-mē)**
    - incision into the tympanic membrane
43. **nasolacrimal (nā-zō-LAK-rĭ-măl)**
    - pertaining to the nose and the tear duct
44. **nasopharyngeal (nā-zō-FAR-in-gēl)**
    - pertaining to the nose and pharynx (throat)
45. **oculomycosis (ŏk-ū-lō-mī-KŌ-sĭs)**
    - abnormal condition of the eye caused by a fungus
46. **ophthalmalgia (ŏf-thăl-MĂL-jē-ă)**
    - condition of pain in the eye
47. **ophthalmic (of-THAL-mik)**
    - pertaining to the eye
48. **ophthalmologist (ŏf-thăl-MŎL-ō-jĭst)**
    - specialist of the eye
49. **ophthalmology (Ophth) (ŏf-thăl-MŎL-ō-jē)**
    - study of the eye
50. **ophthalmopathy (ŏf-thăl-MŎP-ă-thē)**

- disease of the eye

51. **ophthalmoplegia (of-thal-mō-PLĒ-j(ē-)ă)**
    - paralysis of the eye
52. **ophthalmoscope (of-THAL-mŏ-skōp)**
    - instrument used to view the eye
53. **ophthalmoscopy (of-thal-MOS-kŏ-pē)**
    - process of viewing the eye
54. **optic (OP-tik)**
    - pertaining to vision
55. **optometry (op-TOM-ĕ-trē)**
    - measuring vision
56. **otalgia (ō-TĂL-jē-ă)**
    - condition of pain in the ear
57. **otologist (ō-TŎL-ō-jĭst)**
    - specialist who studies and treats disorders and diseases of the ear
58. **otology (ō-TŎL-ō-jē)**
    - study of the ear
59. **otomastoiditis (ō-tō-mas-toyd-ĪT-ĭs)**
    - inflammation of the ear and mastoid bone
60. **otomycosis (ō-tō-mī-KŌ-sĭs)**
    - abnormal condition of fungus in the ear
61. **otopyorrhea (ō-tō-pī-ō-RĒ-ă)**
    - discharge of pus from the ear
62. **otorhinolaryngologist (ō-tō-RĪ-nō-lăr-ĭn-GŎL-ō-jĭst)**
    - specialist or physician who studies and treats diseases and disorders of the ears,
63. **otorrhea (ō-tō-RĒ-ă)**
    - discharge from the ear

64. **otosclerosis (ō-tō-sklē-RŌ-sĭs)**
    - condition of hardening of the ear
65. **otoscope(Ō-tō-skōp)**
    - instrument used to view the ear
66. **otoscopy (ō-TŎS-kō-pē)**
    - process of viewing the ear
67. **phacomalacia (făk-ō-mă-LĀ-shē-ă)**
    - condition of softening of the lens
68. **photophobia (fō-tō-FŌ-bē-ă)**
    - condition of sensitivity to light
69. **pseudophakia (SOOD-ō-FĀ-kē-a)**
    - condition of fake lens
70. **pupillary (PŪ-pĭ-lĕr-ē)**
    - pertaining to pupil
71. **pupillometer (pū-pĭl-ŎM-ĕ-tĕr)**
    - instrument used to measure the pupil
72. **pupilloscope (pū-pĭl-ŎS-kōp)**
    - instrument used to view the pupil
73. **retinal (RĔT-ĭ-năl)**
    - pertaining to the retina
74. **retinoblastoma (ret-ĭn-ō-blas-TŌ-mă)**
    - tumour arising from a developing retinal cell
75. **retinopathy (ret-ĭn-OP-ă-thē)**
    - disease of the retina
76. **retinoscopy (ret-ĭn-OS-kŏ-pē)**
    - process of viewing the retina
77. **sclerokeratitis (sklĕr-ō-kĕr-ă-TĪ-tĭs)**

- inflammation of the sclera and cornea

78. **scleromalacia (sklĕ-rō-mā-LĀ-sē-ă)**
    - softening of the sclera
79. **sclerotomy (sklĕ-ROT-ŏ-mē)**
    - incision into the sclera
80. **stapedectomy (stā-pĕ-DEK-tŏ-mē)**
    - excision of the stapes
81. **tonometer (tō-NOM-ĕt-ĕr)**
    - instrument used to measure pressure (within the eye)
82. **tonometry (tō-NOM-ĕ-trē)**
    - process of measuring pressure
83. **tympanometer (tĭm-pă-NŎM-ĕ-tĕr)**
    - instrument used to measure the middle ear
84. **tympanometry (tĭm-pă-NŎM-ĕ-trē)**
    - measurement of the tympanic membrane
85. **tympanoplasty (tĭm-păn-ō-PLĂS-tē)**
    - membranesurgical repair of the tympanic
86. **vestibular (ves-TIB-yŭ-lăr)**
    - pertaining to the vestibule
87. **vestibulocochlear (ves-tĭ-būl-ō-KŌ-klē-ar)**
    - vestibul/o/cochle/ar
    - pertaining to the vestibule and cochlea
88. **xerophthalmia (zer-of-THAL-mē-ă)**
    - xer/ophthalm/ia
    - * Rebel, does not follow the rules*
    - condition of dry eye

Gustation (Taste)

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

1. **circumvallate**
2. **foliate**
3. **filiform**
4. **fungiform**

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

Only a few recognized **submodalities** exist within the sense of taste, or gustation. Until recently, only four tastes were recognized: **sweet**, **salty**, **sour**, and **bitter**. Research at the turn of the 20th century led to the recognition of the fifth taste, **umami**, during the mid-1980s. Recent research has suggested that there may also be a sixth taste for **fats** or lipids.

Olfaction (Smell)

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

Did You Know?

The human body can detect over 10,000 odours.

Concept Check

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

Attribution

15.2 - Anatomy & Physiology of the Sensory System

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

Watch [Hearing & Balance: Crash Course Anatomy & Physiology #17 (11 min) on YouTube]

Audition (Hearing)

Hearing, or **audition**, is the **transduction** of sound waves into a neural signal that is made possible by the structures of the ear (see Figure 15.1).

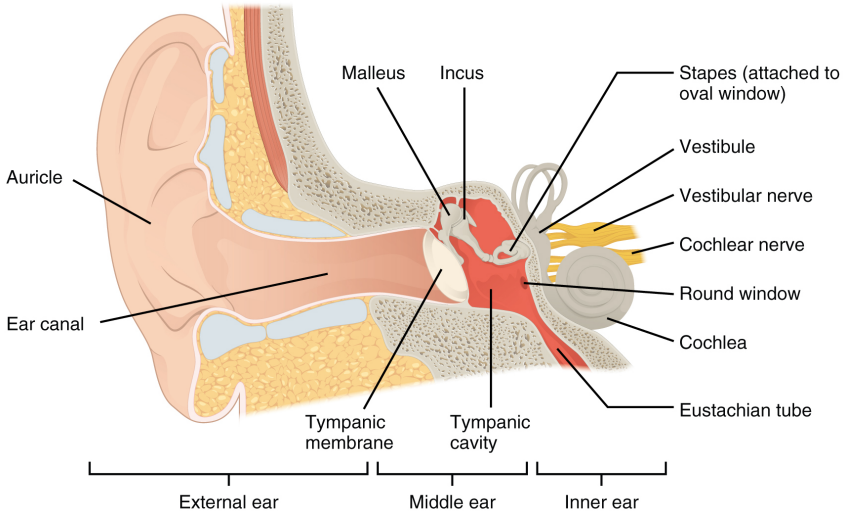


Figure 15.1 Structures of the Ear. The external ear contains the auricle, ear canal, and tympanic membrane. The middle ear contains the ossicles and is connected to the pharynx by the Eustachian tube. The inner ear contains the cochlea and vestibule, which are responsible for audition and equilibrium, respectively. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 15.1 Image description.]

- The **external ear** consists of the auricle, sometimes referred to as the pinna, ear canal, and tympanic membrane.
  The C-shaped curves of the auricle direct sound waves toward the **auditory canal**. The canal enters the skull through the external auditory meatus of the **temporal bone**. At the end of the auditory canal is the **tympanic membrane**, which vibrates after it is struck by sound waves.

- The **middle ear** consists of the ossicles, oval window, and tympanic membrane.
  The three **ossicles** are the malleus, incus, and stapes, which are Latin names that roughly translate to hammer, anvil, and stirrup. The malleus is attached to the tympanic membrane and articulates with the incus. The incus, in turn, articulates with the stapes. The stapes is then attached to the inner ear, where the sound waves will be transduced into a neural signal. Vibrations of the ossicles travel through the **oval window**, moving fluid in a wave-like motion. The frequency of the fluid waves match the frequencies of the sound waves. The middle ear is connected to the pharynx through the Eustachian tube, which helps equilibrate air pressure across the **tympanic membrane**. The tube is normally closed but will pop open when the muscles of the pharynx contract during swallowing or yawning.

- The **inner ear** is often described as a **bony labyrinth**, as it is composed of a series of canals embedded within the temporal bone.
  It consists of the **cochlea which is responsible for hearing** and the **vestibule that is responsible for balance.** The neural signals from these two regions are relayed to the brain stem through separate fiber bundles. However, these two distinct bundles travel together from the inner ear to the brain stem as the **vestibulocochlear** nerve. Sound is transduced into neural signals within the cochlear region of the inner ear, which contains the sensory neurons of the spiral ganglia. These ganglia are located within the spiral-shaped cochlea of the inner ear. The cochlea is attached to the stapes through the oval window.

The image below is a cross-sectional view of the cochlea that shows the scala vestibuli and scala tympani run along both sides of the cochlear duct (see Figure 15.2). The cochlear duct contains several organs of Corti, which tranduce the wave motion of the two scala into neural signals. The organs of Corti lie on top of the basilar membrane, which is the side of the cochlear duct located between the organs of Corti and the scala tympani. As the fluid waves move through the scala vestibuli and scala tympani, the basilar membrane moves at a specific spot, depending on the frequency of the waves. Higher frequency waves move the region of the basilar membrane that is close to the base of the cochlea. Lower frequency waves move the region of the basilar membrane that is near the tip of the cochlea.

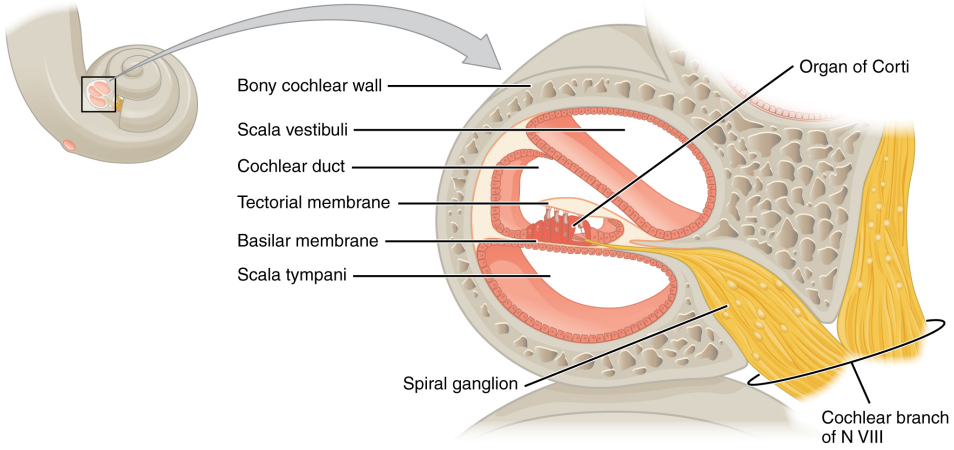


Figure 15.2 Cross Section of the Cochlea. The three major spaces within the cochlea are highlighted. The scala tympani and scala vestibuli lie on either side of the cochlear duct. The organ of Corti, containing the mechanoreceptor hair cells, is adjacent to the scala tympani, where it sits atop the basilar membrane. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 15.2 Image description.]

The cochlea encodes auditory stimuli for frequencies between 20 and 20,000 Hz, which is the range of sound that human ears can detect. The unit of Hertz measures the frequency of sound waves in terms of cycles produced per second. Frequencies as low as 20 Hz are detected by hair cells at the apex, or tip, of the cochlea. Frequencies in the higher ranges of 20 KHz are encoded by hair cells at the base of the cochlea, close to the round and oval windows. Most auditory stimuli contain a mixture of sounds at a variety of frequencies and intensities (represented by the amplitude of the sound wave). The hair cells along the length of the cochlear duct, which are each sensitive to a particular frequency, allow the cochlea to separate auditory stimuli by frequency, just as a prism separates visible light into its component colours.

Did You Know?

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

Equilibrium (Balance)

Along with audition, the **inner ear** is responsible for **encoding** information about **equilibrium**. The cells that sense head position, head movement, and body motion are located within the vestibule of the inner ear. Head position is sensed by otolith organs, whereas head movement is sensed by the semicircular canals (see Figure 15.3). The neural signals generated in the vestibular ganglion are transmitted through the vestibulocochlear nerve to the brain stem and cerebellum.

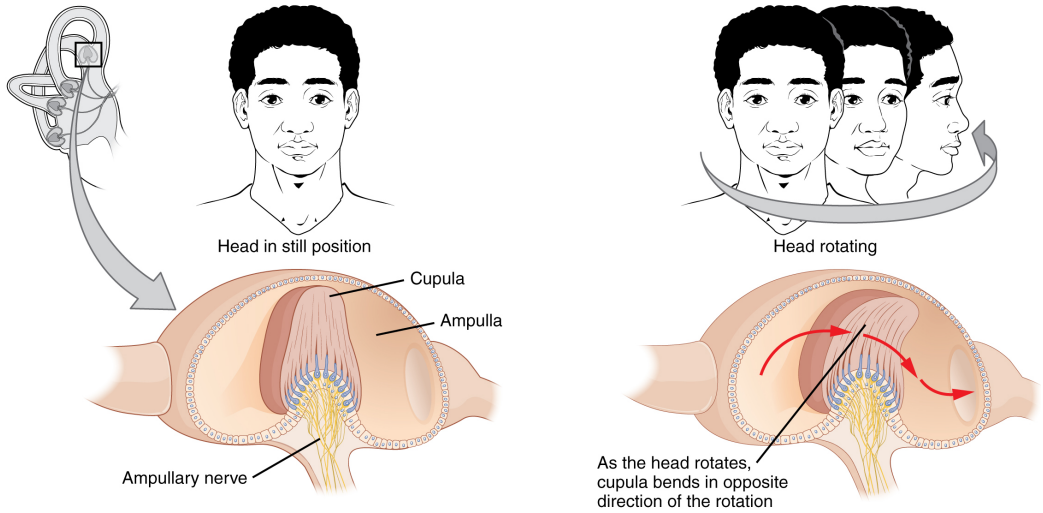


Figure 15.3 Rotational Coding by Semicircular Canals. Rotational movement of the head is encoded by the hair cells in the base of the semicircular canals. As one of the canals moves in an arc with the head, the internal fluid moves in the opposite direction, causing the cupula and stereocilia to bend. The movement of two canals within a plane results in information about the direction in which the head is moving, and activation of all six canals can give a very precise indication of head movement in three dimensions. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 15.3 Image description.]

Somatosensation (Touch)

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

Did You Know?

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

The two types of somatosensory signals that are transduced by free nerve endings are pain and temperature. Temperature receptors are stimulated when local temperatures differ from body temperature. Some

thermoreceptors are sensitive to just cold and others to just heat. **Nociception** is the sensation of potentially damaging stimuli. Mechanical, chemical, or thermal stimuli beyond a set threshold will elicit painful sensations. Stressed or damaged tissues release chemicals that activate receptor proteins in the nociceptors.

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

Concept Check

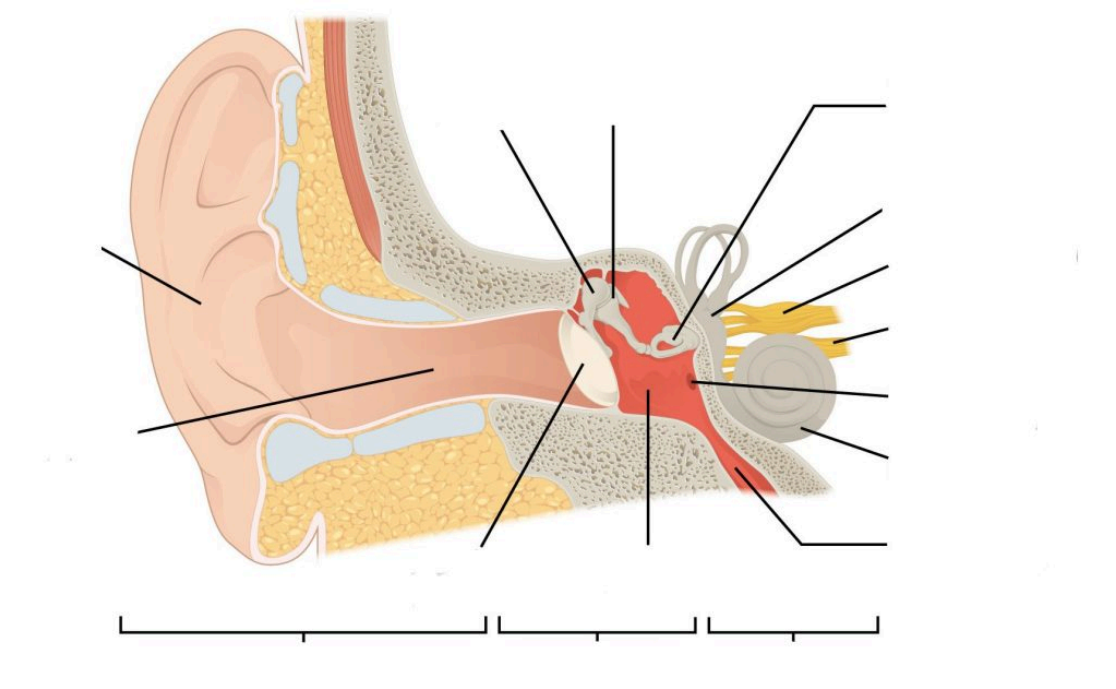
- What structure exists within the ear to assist with maintaining **equilibrium**?
- What are the medical terms used to describe the sense of taste and touch?

Sensory System Ear Anatomy

Sensory System Ear Anatomy labeling activity (Text Version)

Label the diagram with correct words listed below:

1. Parieto-occipital sulcus
2. Ear canal
3. Stapes (attached to oval window)
4. Tympanic cavity
5. Vestibule
6. Cochlear nerve
7. Eustachian tube
8. Middle ear
9. Tympanic membrane
10. Malleus
11. Incus
12. Inner ear
13. Round window
14. External ear
15. Cochlea
16. Vestibular nerve



Check your answers [1]

Activity source: Sensory System Ear Anatomy by Gisele Tuzon, from *Building a Medical Terminology Foundation*, illustration from *Anatomy and Physiology (OpenStax)*, licensed under CC BY 4.0./ Text version added.

Vision (Sight)

Watch Vision: Crash Course Anatomy & Physiology #18 (10 min) on YouTube

Vision is the special sense of sight that is based on the transduction of light stimuli received through the eyes. The eyes are located within either orbit in the skull. The bony orbits surround the eyeballs, protecting them and anchoring the soft tissues of the eye (see Figure 15.4). The eyelids, with lashes at their leading edges, help to protect the eye from abrasions by blocking particles that may land on the surface of the eye.

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

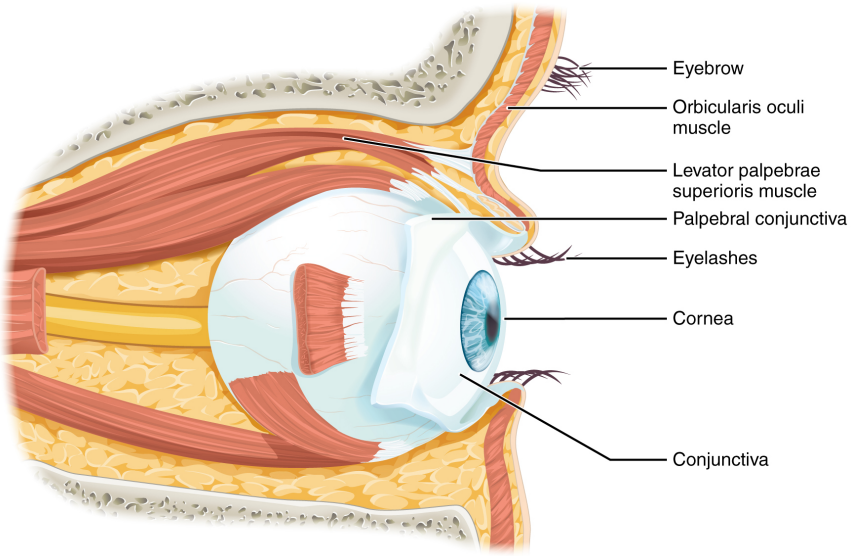


Figure 15.4 The Eye in the Orbit. The eye is located within the orbit and surrounded by soft tissues that protect and support its function. The orbit is surrounded by cranial bones of the skull. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 15.4 Image description.]

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

1. superior rectus
2. medial rectus
3. inferior rectus
4. lateral rectus

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

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

1. The **outermost layer** is the fibrous tunic, which includes the white sclera and clear cornea. The sclera accounts for five-sixths of the surface of the eye, most of which is not visible, though humans are unique compared with many other species in having so much of the "white of the eye" visible (see Figure 15.5). The transparent cornea covers the anterior tip of the eye and allows light to enter the eye.
2. The **middle layer** of the eye is the vascular tunic, which is mostly composed of the choroid, ciliary body, and iris. The choroid is a layer of highly vascularized connective tissue that provides a blood supply to the eyeball. The choroid is posterior to the ciliary body, a muscular structure that is attached to the lens by zonule fibers. These two structures bend the lens, allowing it to focus light on the back of the eye. Overlaying the ciliary body, and visible in the anterior eye, is the iris—the coloured part of the eye. The iris is a smooth muscle that opens or closes the pupil, which is the hole at the center of the eye that allows light to enter. The iris constricts the pupil in response to bright light and dilates the pupil in response to

dim light.

3. The **innermost layer** of the eye is the neural tunic, or retina, which contains the nervous tissue responsible for photoreception.

The eye is also divided into **two cavities**:

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

The **retina** is composed of several layers and contains specialized cells for the initial processing of visual stimuli. The photoreceptors (rods and cones) change their membrane potential when stimulated by light energy. The change in membrane potential alters the amount of neurotransmitter that the photoreceptor cells release onto bipolar cells in the outer synaptic layer. It is the bipolar cell in the retina that connects a photoreceptor to a retinal ganglion cell (RGC) in the inner synaptic layer. There, amacrine cells additionally contribute to retinal processing before an action potential is produced by the RGC. The axons of RGCs, which lie at the innermost layer of the retina, collect at the optic disc and leave the eye at the optic nerve (see Figure 15.5). Because these axons pass through the retina, there are no photoreceptors at the very back of the eye, where the optic nerve begins. This creates a "blind spot" in the retina, and a corresponding blind spot in our visual field.

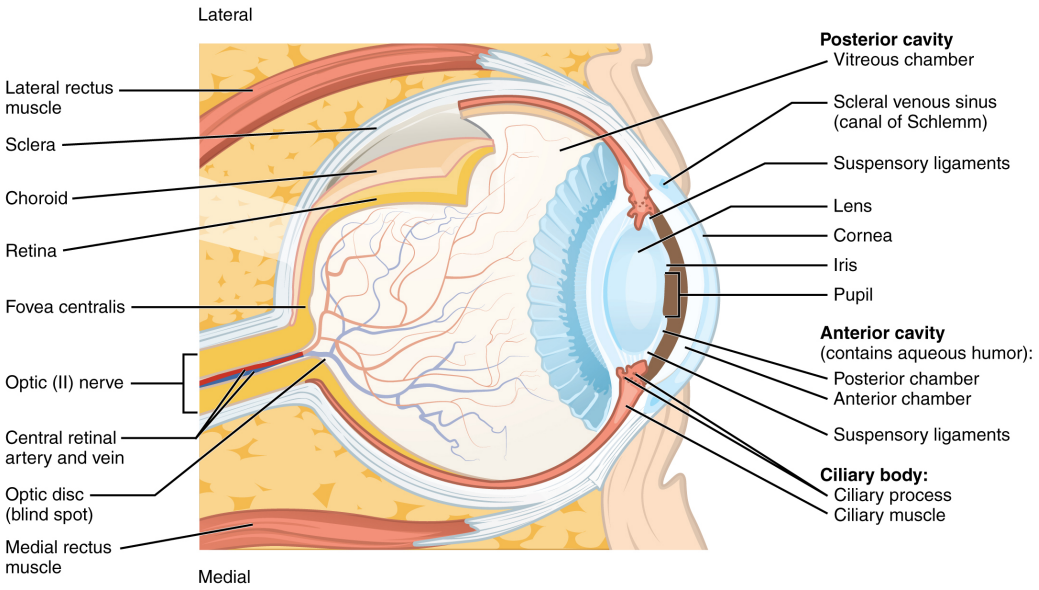


Figure 15.5. Structure of the Eye. The sphere of the eye can be divided into anterior and posterior chambers. The wall of the eye is composed of three layers: the fibrous tunic, vascular tunic, and neural tunic. Within the neural tunic is the retina, with three layers of cells and two synaptic layers in between. The center of the retina has a small indentation known as the fovea. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 15.5 Image description.]

Photoreceptors in the retina (rods and cones) are located behind the axons, RGCs, bipolar cells, and retinal blood vessels. A significant amount of light is absorbed by these structures before the light reaches the photoreceptor cells. At the exact center of the retina is a small area known as the fovea. At the fovea, the retina lacks the supporting cells and blood vessels, and only contains photoreceptors. Therefore, **visual acuity**, is greatest at the fovea. This is because the fovea is where the least amount of incoming light is absorbed by other retinal structures (see Figure 15.5). As one moves in either direction from this central point of the retina, visual acuity drops significantly.

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

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

There are **three types of cone opsins**, that are sensitive to different wavelengths of light and provide us with **colour vision**. By comparing the activity of the three different cones, the brain can extract colour information from visual stimuli (see Figure 15.6). For example, a bright blue light that has a wavelength of approximately 450 nm would activate the **"red"** cones minimally, the **"green"** cones marginally, and the **"blue"** cones predominantly. The relative activation of the three different cones is calculated by the brain, which perceives the colour as blue. However, cones cannot react to low-intensity light, and rods do not sense the colour of light. Therefore, our low-light vision is, in essence, in **grayscale**. In other words, in a dark room, everything appears as a shade of gray. If you think that you can see colours in the dark, it is most likely because your brain knows what colour something is and is relying on that memory.

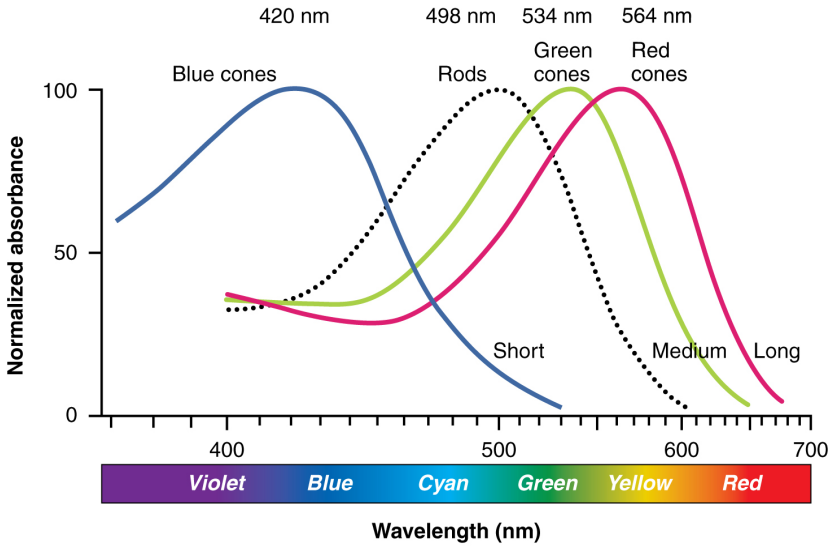


Figure 15.6 Comparison of Colour Sensitivity of Photopigments. Comparing the peak sensitivity and absorbance spectra of the four photopigments suggests that they are most sensitive to particular wavelengths. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 15.6 Image description.]

Sensory Systems Medical Terms, Abbreviations and Anatomy

Sensory System Medical Terms

Sensory System Medical Terms (Text Version)
Practice the following sensory system words by breaking into word parts and pronouncing.

1. **anisocoria (an-ī-sō-KŌR-ē-ă)**
    - condition of absence of equal pupil (size)
2. **aphakia (ă-FĀ-kē-ă)**
    - condition of no lens
3. **audiogram (OD-ē-ō-gram)**
    - graphic record (radiographic image) of hearing
4. **audiologist (od-ē-OL-ŏ-jĭst)**

- specialist who studies and treats the hearing

5. **audiology (od-ē-OL-ŏ-jē)**
    - study of the hearing
6. **audiometer (od-ē-OM-ĕt-ĕr)**
    - instrument used to measure hearing
7. **audiometry (od-ē-OM-ĕ-trē)**
    - measuring hearing
8. **aural (OR-ăl)**
    - pertaining to the ear
9. **binocular (bĭn-ŎK-ū-lăr)**
    - pertaining to both eyes
10. **blepharitis (blĕf-ăr-Ī-tĭs)**
    - inflammation of the eyelid
11. **blepharoplasty (BLĔF-ă-rō-plăs-tē)**
    - surgical repair of the eyelid
12. **blepharoptosis (BLĔF-ă-rōp-TŌ-sĭs)**
    - condition of drooping of the eyelid
13. **cochlear (KOK-lē-ăr)**
    - pertaining to the cochlea
14. **cochlear implant (KOK-lē-ă IM-plant)**
    - pertaining to the cochlear implant
15. **conjunctivitis (kŏn-jŭnk-tĭ-VĪT-ĭs)**
    - inflammation of the conjunctiva
16. **corneal (KOR-nē-ă)**
    - pertaining to the cornea
17. **cryoretinopexy (krī-ō-RET-in-ō-pek-sē)**
    - surgical fixation of the retina using extreme cold

18. **dacrocystitis (dak-rē-ŏ-sis-TĪT-ĭs)**
    - inflammation of the tear (lacrimal) sac
19. **dacryocystorhinostomy (dak-rē-ŏ-sis-tŏ-rī-NOS-tŏ-mē)**
    - creation of an artificial opening between the lacrimal sac and the nose
20. **diplopia (dip-LŌ-pē-ă)**
    - condition of double vision
21. **electrocochleography (ē-lek-trō-kok-lē-OG-ră-fē)**
    - process of recording the electrical activity in the cochlea
22. **endophthalmitis (ĕn-dŏf-thăl-MĪ-tĭs)**
    - inflammation within the eye
23. **intraocular (in-tră-OK-yŭ-lăr)**
    - pertaining to within the eye
24. **iridectomy (ir-ĭ-DEK-tŏ-mē)**
    - excision of (part of) the iris
25. **iridoplegia (ir-ĭ-dō-PLĒ-j(ē-)ă, īr)**
    - condition of paralysis of the iris
26. **iridotomy (ĭr-ĭ-DŎT-ō-mē)**
    - incision into the iris
27. **iritis (ī-RĪT-ĭs)**
    - inflammation of the iris
28. **isocoria (ī-sō-KŌ-rē-ă)**
    - condition of equal pupils
29. **keratitis (ker-ă-TĪT-ĭs)**
    - inflammation of the cornea
30. **keratomalacia (kĕr-ă-tō-mă-LĀ-shē-ă)**
    - softening of the cornea
31. **keratometer (kĕr-ă-TŎM-ĕ-ter)**

- instrument used to measure (the curvature) of the eye

32. **keratoplasty (KER-ăt-ō-plas-tē)**
    - surgical repair of the cornea
33. **labyrinthectomy (lab-ĭ-rin-THEK-tŏ-mē)**
    - excision of the inner ear (labyrinth)
34. **labyrinthitis (lab-ĭ-rin-THĪT-ĭs)**
    - inflammation of the inner ear (labyrinth)
35. **lacrimal (LAK-rĭ-măl)**
    - pertaining to the tear duct
36. **leukocoria (loo-kō-KŎR-ē-ă)**
    - condition of a white pupil
37. **mastoidectomy (măs-tŏy-d-ĔK-tō-mē)**
    - excision of the mastoid bone
38. **mastoiditis (mas-toyd-ĪT-ĭs)**
    - inflammation of the mastoid bone
39. **mastoidotomy (măs-toyd-ŎT-ō-mē)**
    - incision into the mastoid bone
40. **myringitis (mĭr-ĭn-JĪ-tĭs)**
    - inflammation of the tympanic membrane
41. **myringoplasty (mĭr-ĬN-gō-plăst-ē)**
    - surgical repair of the tympanic membrane
42. **myringotomy (mĭr-ĭn-GŎT-ō-mē)**
    - incision into the tympanic membrane
43. **nasolacrimal (nā-zō-LAK-rĭ-măl)**
    - pertaining to the nose and the tear duct
44. **nasopharyngeal (nā-zō-FAR-in-gēl)**
    - pertaining to the nose and pharynx (throat)

45. **oculomycosis (ŏk-ū-lō-mī-KŌ-sĭs)**
    - abnormal condition of the eye caused by a fungus
46. **ophthalmalgia (ŏf-thăl-MĂL-jē-ă)**
    - condition of pain in the eye
47. **ophthalmic (of-THAL-mik)**
    - pertaining to the eye
48. **ophthalmologist (ŏf-thăl-MŎL-ō-jĭst)**
    - specialist of the eye
49. **ophthalmology (Ophth) (ŏf-thăl-MŎL-ō-jē)**
    - study of the eye
50. **ophthalmopathy (ŏf-thăl-MŎP-ă-thē)**
    - disease of the eye
51. **ophthalmoplegia (of-thal-mō-PLĒ-j(ē-)ă)**
    - condition of paralysis of the eye
52. **ophthalmoscope (of-THAL-mŏ-skōp)**
    - instrument used to view the eye
53. **ophthalmoscopy (of-thal-MOS-kŏ-pē)**
    - process of viewing the eye
54. **optic (OP-tik)**
    - pertaining to vision
55. **optometry (op-TOM-ĕ-trē)**
    - measuring vision
56. **otalgia (ō-TĂL-jē-ă)**
    - condition of pain in the ear
57. **otologist (ō-TŎL-ō-jĭst)**
    - specialist who studies and treats disorders and diseases of the ear
58. **otology (ō-TŎL-ō-jē)**

- study of the ear

59. **otomastoiditis (ō-tō-mas-toyd-ĪT-ĭs)**
    - inflammation of the ear and mastoid bone
60. **otomycosis (ō-tō-mī-KŌ-sĭs)**
    - abnormal condition of fungus in the ear
61. **otopyorrhea (ō-tō-pī-ō-RĒ-ă)**
    - discharge of pus from the ear
62. **otorhinolaryngologist (ō-tō-RĪ-nō-lăr-ĭn-GŎL-ō-jĭst)**
    - specialist or physician who studies and treats disease and disorder of the ears,
63. **otorrhea (ō-tō-RĒ-ă)**
    - discharge from the ear
64. **otosclerosis (ō-tō-sklē-RŌ-sĭs)**
    - condition of hardening of the ear
65. **otoscope(Ō-tō-skōp)**
    - instrument used to view the ear
66. **otoscopy (ō-TŎS-kō-pē)**
    - process of viewing the ear
67. **phacomalacia (făk-ō-mă-LĀ-shē-ă)**
    - condition of softening of the lens
68. **photophobia (fō-tō-FŌ-bē-ă)**
    - condition of sensitivity to light
69. **pseudophakia (SOOD-ō-FĀ-kē-a)**
    - condition of fake lens
70. **pupillary (PŪ-pĭ-lĕr-ē)**
    - pertaining to pupil
71. **pupillometer (pū-pĭl-ŎM-ĕ-tĕr)**
    - instrument used to measure the pupil

72. **pupilloscope (pū-pĭl-ŎS-kōp)**
    - instrument used to view the pupil
73. **retinal (RĔT-ĭ-năl)**
    - pertaining to the retina
74. **retinoblastoma (ret-ĭn-ō-blas-TŌ-mă)**
    - tumour arising from a developing retinal cell
75. **retinopathy (ret-ĭn-OP-ă-thē)**
    - disease of the retina
76. **retinoscopy (ret-ĭn-OS-kŏ-pē)**
    - process of viewing the retina
77. **sclerokeratitis (sklĕr-ō-kĕr-ă-TĪ-tĭs)**
    - inflammation of the sclera and cornea
78. **scleromalacia (sklĕ-rō-mā-LĀ-sē-ă)**
    - condition of softening of the sclera
79. **sclerotomy (sklĕ-ROT-ŏ-mē)**
    - incision into the sclera
80. **stapedectomy (stā-pĕ-DEK-tŏ-mē)**
    - excision of the stapes
81. **tonometer (tō-NOM-ĕt-ĕr)**
    - instrument used to measure pressure (within the eye)
82. **tonometry (tō-NOM-ĕ-trē)**
    - process of measuring pressure
83. **tympanometer (tĭm-pă-NŎM-ĕ-tĕr)**
    - instrument used to measure the middle ear
84. **tympanometry (tĭm-pă-NŎM-ĕ-trē)**
    - measurement of the tympanic membrane
85. **tympanoplasty (tĭm-păn-ō-PLĂS-tē)**

- membranesurgical repair of the tympanic

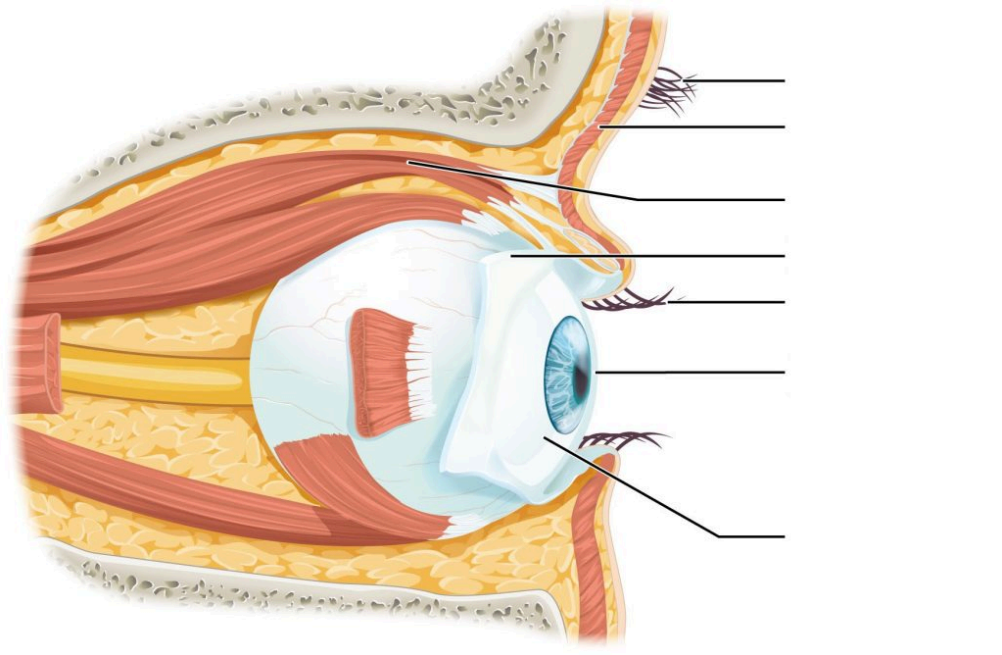
86. **vestibular (ves-TIB-yŭ-lăr)**
    - pertaining to the vestibule
87. **vestibulocochlear (ves-tĭ-būl-ō-KŌ-klē-ar)**
    - vestibul/o/cochle/ar
    - pertaining to the vestibule and cochlea
88. **xerophthalmia (zer-of-THAL-mē-ă)**
    - xer/ophthalm/ia
    - condition of dry eye

Anatomy Labeling Activity

Sensory System Eye Anatomy (Text Version)

Label the diagram with correct words listed below:

1. Eyebrow
2. Conjunctiva
3. Levator palpebrae superioris muscle
4. Palpebral conjunctiva
5. Cornea
6. Eyelashes
7. Orbicularis oculi muscle



Check your answers [2]

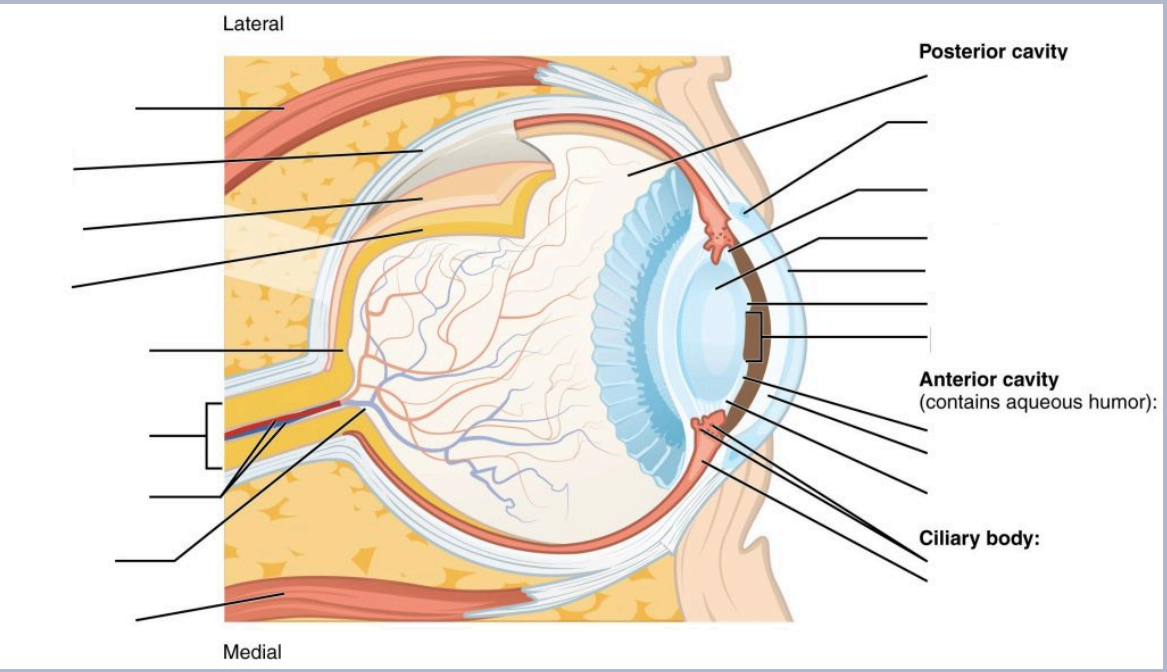
Activity source: Sensory System Eye Anatomy by Gisele Tuzon, from *Building a Medical Terminology Foundation*, illustration from *Anatomy and Physiology (OpenStax)*, licensed under CC BY 4.0./ Text version added.

Sensory System Eye Anatomy

Sensory System Eye Anatomy (Text Version)

Label the diagram with correct words listed below:

1. Fovea centralis
2. Suspensory ligaments
3. Ciliary muscle
4. Retina
5. Posterior chamber
6. Iris
7. Vitreous chamber
8. Anterior chamber
9. Choroid
10. Ciliary process
11. Optic disc (blind spot)
12. Lens
13. Central retinal artery and vein
14. Suspensory ligaments
15. Lateral rectus muscle
16. Optic (II) nerve
17. Sclera
18. Medial rectus muscle
19. Scleral venous sinus (canal of Schlemm)
20. Cornea
21. Pupil



Sensory System Eye Anatomy Diagram (Text Version)

This diagram shows a lateral and medial view of the eyeball. The major parts are labelled. Labels read from top, clockwise: showing the posterior cavity including the following structures: _____[Blank 1], _____[Blank 2] (canal of Schlemm), _____[Blank 3], _____[Blank 4], _____[Blank 5], _____[Blank 6], and ____[Blank 7]. Next is the anterior cavity (contains aqueous humor), _____[Blank 8], _____[Blank 9], and _____[Blank 10]. The Ciliary body _____[Blank 11] and _____[Blank 12], _____[Blank 13], _____[Blank 14] (blind spot of the eye), _____[Blank 15], _____[Blank 16], _____[Blank 17], _____[Blank 18], _____[Blank 19], and _____[Blank 20].

Check your answers [3]

Activity source: Sensory System Eye Anatomy by Gisele Tuzon, from *Building a Medical Terminology Foundation*, illustration from *Anatomy and Physiology (OpenStax)*, licensed under CC BY 4.0./ Text version added.

Sensory System Terms Not Easily Broken into Word Parts

Sensory System not easily broken into word parts (Text Version)

1. **astigmatism (Ast)**
    - blurry vision due to irregular curvature of the cornea or lens
2. **Optician**
    - specialist who fills prescriptions for lenses but cannot prescribe
3. **anosmia**
    - condition of being without smell/inability to smell
4. **stye**
    - infection of an oil gland of the eyelid (hordeolum)
5. **amblyopia**
    - reduced vision in one eye
    - associated with strabismus (lazy eye)
6. **Optometrist**
    - specialist who diagnoses, treats, and manages diseases and disorders of the eye
    - Doctor of Optometry
7. **visual acuity (VA)**
    - sharpness or clearness of vision
8. **cataract**
    - abnormal progressive disease of lens characterized by lack of transparency or cloudiness

Common Abbreviations for the Sensory System

Sensory System Abbreviations

- **ARMD (age-related macular degeneration)**
- **Ast** (astigmatism)
- **Em** (emmetropia)
- **IOL** (intraocular lens)
- **IOP** (intraocular pressure)
- **LASIK** (laser-assisted in situ keratomileusis)
- **Ophth** (ophthalmology)
- **PHACO** (phacoemulsification)
- **PRK** (photorefractive keratectomy)
- **VA** (visual acuity)
- **AOM** (acute otitis media)
- **ENT** (ears, nose, throat)
- **EENT** (eyes, ears, nose, and throat)
- **HOH** (hard of hearing)
- **OM** (otitis media)

Image Descriptions

Figure 15.1 image description: This image shows the structure of the ear with the major parts labeled. The ear is divided into 3 parts from left to right: external ear, middle ear, and inner ear. Labels for each part read: external ear (auricle, ear canal), middle ear (tympanic membrane, malleus, incus, tympanic cavity), inner ear (stapes, vestibule, vestibular nerve, cochlear nerve, cochlea, round window, eustachian tube). [Return to Figure 15.1].

Figure 15.2 image description: This diagram shows the structure of the cochlea in the inner ear. Labels read (from top, counterclockwise): bony cochlear wall, scala vestibuli, cochlear duct, tectorial membrane, basilar membrane, scala tympani, spiral ganglion, cochlear branch of N VIII, organ of Corti. [Return to Figure 15.2].

Figure 15.3 image description: The left panel of this image shows a person's head in a still position. Underneath this, the ampullary nerve is shown. Labels read: cupula, ampulla, ampullary nerve). The right panel shows a person rotating his head, and the below that, the direction of movement of the cupula is shown. Label reads: as the head rotates, cupula bends in opposite direction of the rotation. [Return to Figure 15.3].

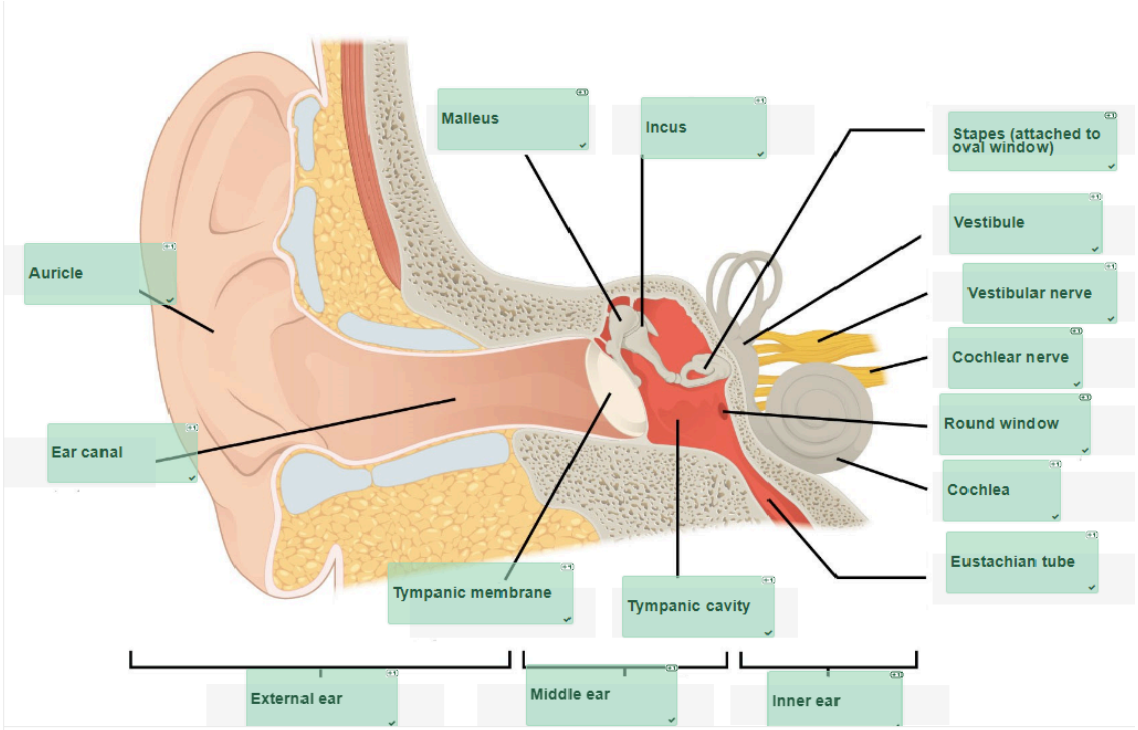
Figure 15.4 image description: This diagram shows the lateral view of the eye. The major parts are labeled. Labels read (from top): eyebrow, orbicularis oculi muscle, levator palpebrae superioris muscle, palpebral conjunctiva, eyelashes, cornea, conjunctiva. [Return to Figure 15.4].

Figure 15.5 image description: This diagram shows a lateral and medial view of the eyeball. The major parts are labelled. Labels read (from top, clockwise): posterior cavity (vitreous chamber, scleral venous sinus (canal of Schlemm), suspensory ligaments, lens, cornea, iris, pupil); anterior cavity (contains aqueous humor, posterior chamber, anterior chamber, suspensory ligaments); Ciliary body (ciliary process and muscle), medial rectus muscle, optic disc (blind spot), central retinal artery and vein, foveal centralis, retina, choroid, sclera, lateral rectus muscle. [Return to Figure 15.5].

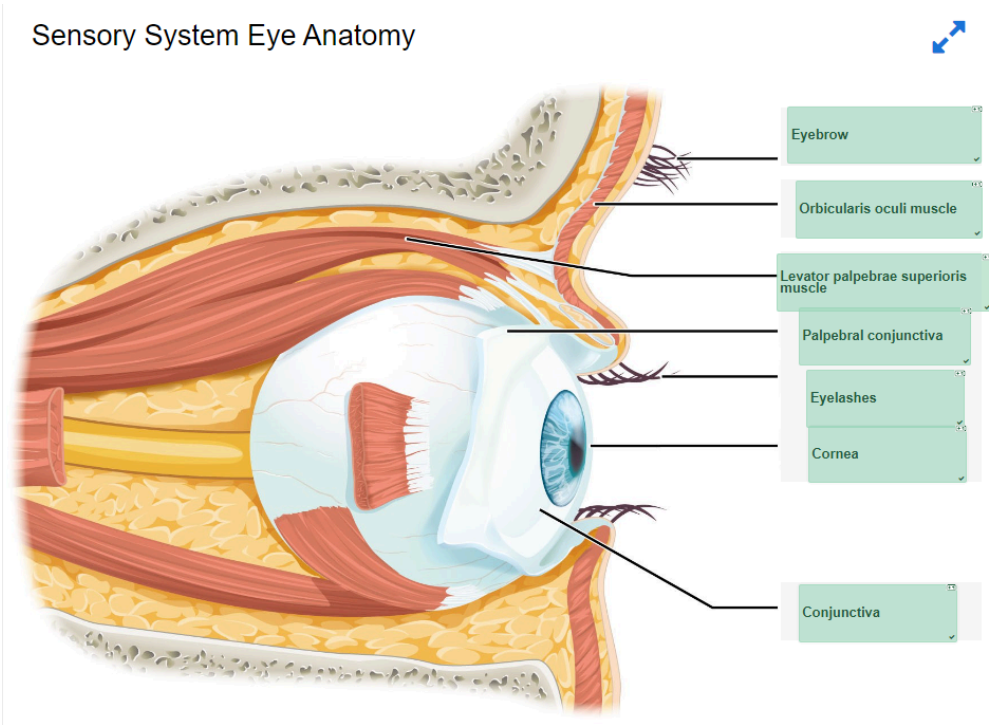
Figure 15.6 image description: This graph shows the normalized absorbance versus wavelength for different cell types in the eye. The Y-axis is normalized absorbance, and the X axis is wavelength (nm) with the colours violet, blue, cyan, green, yellow, and red across the bottom. The lines in the graph indicate blue cones which peak at 420 nm; rods which peak at 498 nm; green cones, which peak at 534 nm, and red cones which peak at 564 nm. Blue cones line is labelled as short, green cones as medium, and red cones as long. [Return to Figure 15.6].

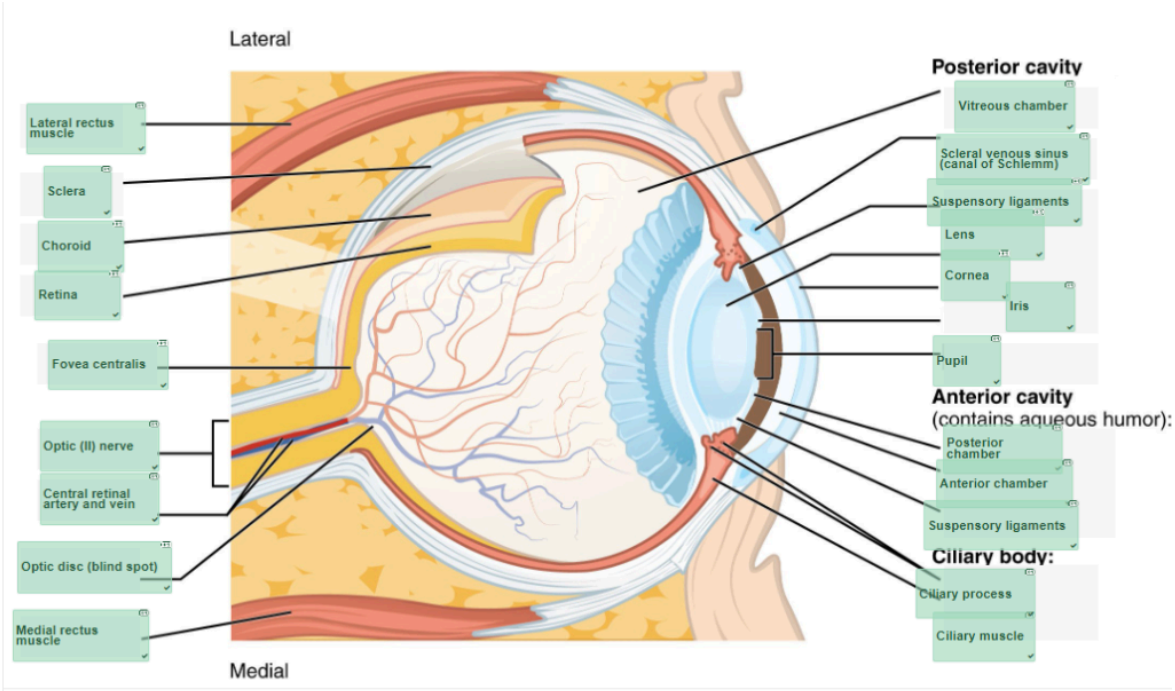
Attribution

Notes

1. 

Check your answers: Sensory System Ear Anatomy labeling activity (Text Version)text

2. 

3. 

Check your answers: Sensory System Eye Anatomy Diagram (Text Version) This diagram shows a lateral and medial view of the eyeball. The major parts are labelled. Labels read from top, clockwise: showing the posterior cavity including the following structures: **vitreous chamber**, **scleral venous sinus** (canal of Schlemm), **suspensory ligaments**, **lens**, **cornea**, **iris,** and **pupil**. Next is the anterior cavity (contains aqueous humor), **posterior chamber**, **anterior chamber**, and **suspensory ligaments**. The Ciliary body **ciliary process and ciliary muscle**, **medial rectus muscle**, **optic disc** (blind spot of the eye), **central retinal artery and vein**, **foveal centralis**, **optic nerve**, **retina**, **choroid**, **sclera**, and **lateral rectus muscle**.

15.3 - Sensory Diseases, Disorders and Diagnostic Testing

Olfactory Diseases and Disorders

Anosmia

Blunt force trauma to the face, such as that common in many car accidents, can lead to the loss of the olfactory nerve, and subsequently, loss of the sense of smell. This condition is known as **anosmia**. When the frontal lobe of the brain moves relative to the ethmoid bone, the olfactory tract axons may be sheared apart. Professional fighters often experience anosmia because of repeated trauma to the face and head. In addition, certain pharmaceuticals, such as antibiotics, can cause anosmia by killing all the olfactory neurons at once. If no axons are in place within the olfactory nerve, then the axons from newly formed olfactory neurons have no guide to lead them to their connections within the olfactory bulb. There are temporary causes of anosmia, as well, such as those caused by inflammatory responses related to respiratory infections or allergies. Loss of the sense of smell can result in food tasting bland. A person with an impaired sense of smell may require additional spice and seasoning levels for food to be tasted. Anosmia may also be related to some presentations of mild depression because the loss of enjoyment of food may lead to a general sense of despair. The ability of olfactory neurons to replace themselves decreases with age, leading to age-related anosmia. This explains why some elderly people salt their food more than younger people. However, this increased sodium intake can increase blood volume and blood pressure, increasing the risk of cardiovascular diseases in the elderly (Betts, et al., 2013).

Ears, Nose, and Throat Diseases and Disorders

Otitis Media

Otitis Media is known as inflammation of the middle ear canal that involves the eardrum. It is commonly seen in younger children due to bacterial and viral infections. Symptoms include possible fever, cough and cold symptoms, hearing loss, irritability and **otalgia**. Treatment involves symptomatic control as well as antibiotic (Amoxicillin) use if necessary (Government of Canada, 2016). To learn more about **otitis media**, review this website by the Government of Canada [PDF].

Otitis Externa

Otitis Externa is inflammation of the external ear canal and is known as swimmer's ear because it is associated with its exposure to water. Its clinical presentation and management are the same as otitis media (Piercefield

et al., 2011). To learn more about **otitis externa**, review this website from the Centers for Disease Control and Prevention [New Tab].

Conductive Hearing Loss

Hearing loss occurs when something disrupts sound through the mid and outer ear, such as physical damage to the ear drum (perforation). Hearing loss can be managed with pharmacotherapy, surgery, or a combination of the two (Centers for Disease Control and Prevention, 2023).

Sensorineural Hearing Loss

This hearing loss results from damage to the neural structures. Tumors as well as exposure to loud noises (acute/chronic) can lead to this type of hearing loss (Centers for Disease Control and Prevention, 2023). To learn more about sensorineural hearing loss, review the Centers for Disease Control and Prevention's web page about sensorineural hearing loss [New Tab].

Tinnitus

Tinnitus is a condition of ringing in the ears. It is due to inflammation of the middle ear. It is the first indicator of nerve damage, particularly in sensorineural hearing loss (National Library of Medicine, 2022). For more information, review this page on the role of inflammation in tinnitus [New Tab] from the National Library of Medicine.

Otosclerosis

This is hardening of the ear due to new bone formation of the inner ear ossicles. The etiology is idiopathic or may be hereditary. Clinical features are consistent with that of conductive hearing loss. Further management is required by an ENT surgeon (Veterans Affairs Canada, 2019). To learn more, visit the Veterans Affairs Canada web page on Otosclerosis [New Tab].

Rhinitis

Rhinitis is inflammation of the nasal cavity mucosal lining, which can lead to congestion and rhinorrhea (runny nose). The causes may be due to allergic reactions as well as viruses. Treatment regimens include symptomatic management, saline sprays, and oral antihistamines (Naclerio, Bachert, & Baraniuk, 2010). To learn more about rhinitis and other nasal conditions, please view Naclerio, Bachert, & Baraniuk's article *Pathophysiology of Nasal Congestion* [New Tab].

Dacryostenosis

Also known as nasolacrimal obstruction, this is an obstruction of the nasolacrimal duct. It prevents tears from draining from the eyes into the ducts and thus individuals have excessive tearing. The etiology is congenital and is the result of the duct not forming properly. This condition is managed via observation, as it resolves overtime (usually after 1 year) (Merck Manual, 2024). To learn more, visit the Merck Manual's web page about dacryostenosis [New Tab].

Eye Diseases and Disorders

Blindness

The term "blindness" may cover a broad spectrum of visual disabilities such as the inability to see because of injury, disease, or a congenital condition. The parameters for legal blindness are a visual field of 20 degrees or narrower and/or visual acuity is 20/200 or less in both eyes, even after correction. Many of the conditions described below can lead to visual disability, low vision, and legal blindness (Canadian National Institute for the Blind, n.d). To learn more about blindness, visit this website by the Canadian National Institute for the Blind [New Tab].

Cataract

A cataract is a clouding of the normally clear lens of your eye. For people who have cataracts, it may feel like they are looking through cloudy lenses or windows. The lens of the eye loses its flexibility due to the aging process, leading, in some cases, to senile cataracts. Infants are sometime born with congenital cataracts. Treatment usually involves surgery to remove the clouding of the lens (Mayo Clinic Staff, 2023). To learn more, visit the Mayo Clinic's web page about cataracts [New Tab].

Conjunctivitis

This is a condition involving inflammation of the conjunctiva. Its common causes are due to allergens, chemicals, foreign objects, as well as bacterial and viral pathogens. The cause of conjunctivitis determines if it is transmissible from one individual to another. Pink eye caused by the adenovirus, for example, is highly contagious compared to pollen, which is not. Management involves treating the underlying cause of conjunctivitis (Centers for Disease Control and Prevention, 2019). To learn more about conjunctivitis, please visit the Centers for Disease Control and Prevention's web page about conjunctivitis [New Tab].

Diabetic Retinopathy

This is a disease of the retina caused by diabetes mellitus. The retinal veins dilate, leading to swelling as fluid leaks from blood vessels into the retina. It is estimated that 20% of newly diagnosed diabetics suffer from diabetic retinopathy (American Optometric Association, 2020). To learn more, visit the American Optometric Association 's website on diabetic retinopathy [New Tab].

Glaucoma

This disease is part of a group of eye diseases which lead to progressive degeneration of the optic nerve. This, in turn, can lead to loss of nerve tissue that results in gradual irreversible vision loss and potential blindness if not detected and treated early. The most common form of glaucoma is primary open-angle glaucoma. This form is associated with elevated pressure caused by a backup of fluid in the eye (Canadian Association of Optometrists, n.d.). To learn more, visit the Canadian Association of Optometrists' web page about glaucoma [New Tab].

Macular Degeneration/Age-related Macular Degeneration (AMD)

Progressive damage of a portion of the retina is known as the macula. Severe central vision is lost while peripheral vision is retained. This is the leading cause of blindness in people over the age of 55 years (Canadian Association of Optometrists, 2024). To learn more, visit the Canadian Association of Optometrists' web page on AMD [New Tab].

Nystagmus

This is a condition whereby involuntary repetitive eye movements make it impossible to fixate on a single object. The condition is often referred to as dancing eyes (Dubow, 2020). To learn more about nystagmus, view this website from All About Vision [New Tab].

Retinal Detachment

According to the Eye Physicians & Surgeons of Ontario, this condition occurs when the retina gets pulled away or separated from its normal position. Flashing lights, floaters, and what appears to be a grey curtain are all symptoms of a retinal tear, which can lead to a retinal detachment. An ophthalmologist is a retinal specialist who can repair the retinal detachment. If left untreated, a retinal detachment could lead to blindness (Canadian Ophthlamological Society, 2007). To learn more, visit the Canadian Ophthalmological Society's brochure on Retinal Tear and Detachment [PDF].

Strabismus

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

- **Estropia:** the convergence of one or both eyes medially
- **Extropia:** the deviation of one eye laterally
- **Hypertropia:** the deviation of one eye superiorly
- **Hypotropia:** the deviation of one eye inferiorly

If not managed, the brain may reject input from one eye, resulting in vision loss of the respective eye (amblyopia). **Amblyopia** is a condition also known as lazy eye, which is caused when there is an imbalance of stimuli from the brain to the eyes (one eye receives more than the other). It usually occurs in childhood and requires early intervention to rectify this condition (Canadian Association of Optometrists, 2023). To learn more about strabismus, go to The Canadian Association of Optometrists' page on the subject [New Tab].

Sensory Systems Terms in Use

Sensory System – Consultation Report Activity

Sensory System – Consultation Report (Text Version)
Use the words below to fill in the consultation report:

- eye
- halos
- acuity
- iris
- dilate
- ophthalmoscope
- cataracts
- subcapsular
- surgery
- intraocular

PATIENT NAME: Betty FOX

AGE: 72

SEX: Female

DOB: October 2

DATE OF CONSULTATION: August 5

CONSULTING PHYSICIAN: Brian Gates, MD, Ophthalmology

REASON FOR CONSULTATION: Cataracts

HISTORY: I saw Mrs. Fox, a 72-year-old, for her regular _____[Blank 1] examination. She has been wearing reading glasses for several years now but has noticed that she has been having trouble reading and has been seeing _____[Blank 2] around lights while driving at night.

PHYSICAL EXAMINATION: A visual _____[Blank 3] test was performed. I used a slit lamp to view the cornea, _____[Blank 4], lens, and the space between the iris and cornea. I detected tiny abnormalities. I administered drops to _____[Blank 5] the pupils to examine the retina. Using an _____[Blank 6], I was able to examine the lenses for signs of _____[Blank 7]. I was able to determine that Mrs. Fox has posterior _____[Blank 8] cataracts in both eyes.

PLAN: I explained to Mrs. Fox that she required cataract _____[Blank 9]. I explained that her clouded lens would be replaced with an _____[Blank 10] lens – a clear artificial lens. She was in agreeance to having the surgery. I told her we would perform the surgery on her right eye first, then in about eight weeks we would do the left eye. Arrangements for her surgery will be made for next month.

_____
Brian Gates, MD, Ophthalmology

Note: Report samples (H5P and Pressbooks) are to encourage learners to identify correct medical terminology and do not represent the Association for Health Documentation Integrity (AHDI) formatting standards.

Check your answers [1]

Sensory System – Consultation Report

Sensory System – Consultation Report Activity (Text Version)
Use the words below to fill in the consultation report:

- OS
- watering
- antihistamines
- ophthalmalgia
- erythematous
- thyroid
- abnormalities
- masses
- anaesthetic
- puncta
- nasolacrimal
- dacryocystitis
- dacryocystorhinostomy
- medication

PATIENT NAME: Rose MACKENZIE
AGE: 57
SEX: Female
DOB: November 25
DATE OF CONSULTATION: April 16
CONSULTING PHYSICIAN: Ashley Cook MD, Ophthalmology

REASON FOR CONSULTATION: Epiphora in left eye.

HISTORY: Patient is a 57-year-old female who reports epiphora in _____[Blank 1]. Prior to the encounter, she attempted to cure the condition with various _____[Blank 2]. She states that this has been an ongoing issue for the past 2 years, but the _____[Blank 3] has affected her ability to safely drive over the past 8 months. She denied any persistent _____[Blank 4], although noted that the surface of the eye was occasionally irritated and _____[Blank 5] due to rubbing away the tears. She has had no prior eye surgery and no relevant family or personal history of dermatitis or _____[Blank 6] pathologies.

PHYSICAL EXAMINATION: Patient is alert and oriented x 3, and in no acute distress. Examination of the eye surface revealed no _____[Blank 7] other than the erythema and tearing. The skin surrounding the eye appeared normal, with no _____[Blank 8] or swelling.

An irrigation test was then conducted. The eye was treated with _____[Blank 9] eye drops prior to the test. A syringe filled with saline was inserted into the left _____[Blank 10] using a hollow wire. The syringe was then pressed to assess the pressure of the left _____[Blank 11] duct. The fluid did not pass through the nose, indicating inflammation of the duct. No further diagnostic testing was required.

ASSESSMENT: Chronic _____[Blank 12] of the left nasolacrimal duct.

PLAN: Return for _____[Blank 13] in 3 months. Patient was instructed to remove tears using tissue instead of her hand to avoid the risk of infection. No _____[Blank 14] is required in the meantime.

_____
Ashley Cook MD, Ophthalmology

Note: Report samples (H5P and Pressbooks) are to encourage learners to identify correct medical terminology and do not represent the Association for Health Documentation Integrity (AHDI) formatting standards.

Check your answers [2]

Medical Specialties and Procedures Related to the Sensory Systems

Several medical specialties support the sensory systems. An **optometrist** is an eye specialist that examines and evaluates for ocular pathology and an optometrist prescribes corrective lenses. An **ophthalmologist** evaluates and manages eye pathology as well as performs surgery. An **otorhinolaryngologist** (ENT) is a physician that

specializes in the ears, nose and throat treatment and conditions. An **audiologist** evaluates and manages individuals with hearing loss.

Attribution

Notes

1. 1.eye, 2.halos, 3.acuity, 4.iris, 5.dilate, 6.ophthalmoscope, 7.cataracts, 8.subcapsular, 9.surgery, 10.intraocular
2. 1.OS, 2.antihistamines, 3.watering, 4.ophthalmalgia, 5.erythematous, 6.thyroid, 7.abnormalities, 8.masses, 9.anaesthetic, 10.puncta, 11.nasolacrimal, 12.dacryocystitis, 13.dacryocystorhinostomy, 14.medication

Vocabulary & Check Your Knowledge

Sensory System Vocabulary

Acoustic Neuroma

A benign tumour in the internal auditory canal.

Blepharitis

Inflammation of eyelids.

Epistaxis

Nosebleed.

Glossopharyngeal

Pertaining to tongue and throat.

Hyperopia

Farsightedness. Near objects look blurred but distant objects are more clearly visible.

Kinesthesia

Body movement.

Mechanoreceptors

A sensory neuron that responds to mechanical pressure.

Myopia

Nearsightedness. Near objects are clear and seen but far objects are not.

Nociceptors

Sensory neurons that respond to pain.

Ophthalmia Neonatorum

Conjunctivitis in newborns (severe).

Pharyngitis

Inflammation of the pharynx.

Pharyngotonsillitis

Inflammation of the pharynx and tonsils.

Proprioception

Body movement.

Rhinitis

Inflammation of the nasal cavity, which can lead to rhinorrhea.

Rhinorrhea

Runny nose.

Sinusitis

Inflammation of the sinuses.

Stye

Acute infection of the eyelash's hair follicle.

Thermoreceptors

Specialized neurons that respond to changes in temperature.

Tonsillitis

Inflammation of the tonsils.

Tympanic Membrane

Eardrum.

Visceral

Pertaining to internal organs.

Visual Acuity

Sharpness of vision.

Sensory Systems Glossary Reinforcement activity

Sensory Systems Glossary Reinforcement activity (Text Version)

1. Specialized neurons that respond to changes in temperature are called _____[Blank 1].

a. thermoreceptors
b. mechanoreceptors
c. nociceptors

2. Body movement is called _____[Blank 2].

a. kinesthesia
b. visceral
c. proprioception

3. Sharpness of vision is called _____[Blank 3].

a. visual acuity
b. proprioception
c. kinesthesia

4. Sensory neurons that respond to pain are called _____[Blank 4].

a. thermoreceptors
b. nociceptors
c. glossopharyngeal

5. The eardrum is also called _____[Blank 4].

a. glossopharyngeal
b. mechanoreceptors
c. tympanic membrane

Check your answers [1]

Activity source: Sensory Systems Glossary Reinforcement activity by Kimberlee Carter, from *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY- 4.0. /Text version added.

Attribution

Notes

1. 1. thermoreceptors, 2. kinesthesia, 3. Sharpness of vision is called..., 4. Sensory neurons that respond to pain are called..., 5. The ear-drum is also called...

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Allen, R.C. (2024, February). *Dacryostenosis*. Merck Manual: Consumer Version. https://www.merckmanuals.com/en-ca/home/eye-disorders/eyelid-and-tearing-disorders/dacryostenosis

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CHAPTER 16: NERVOUS SYSTEM

Building a Medical Terminology Foundation 2e by Kimberlee Carter; Marie Rutherford; and Connie Stevens

Please visit the web version of *Building a Medical Terminology Foundation 2e* to access the complete book, interactive activities and ancillary resources.

16.1 - Introduction to the Nervous System

Learning Objectives

- Identify the anatomy of the nervous system and describe the main functions of the nervous system
- Analyse, translate, and define medical terms and common abbreviations of the nervous system and use correct abbreviations
- Practice the spelling and pronunciation of nervous system terminology
- Identify the medical specialties associated with the nervous system and explore common diseases, disorders, and procedures related to the nervous system

Nervous System Word Parts

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

Prefix

- **poly-** (many, much)
- **a-** (absence of, without, no, not)
- **an-** (absence of, without, no, not)
- **pan-** (all, total)
- **post-** (after)
- **para-** (beside, beyond, around, abnormal)
- **pre-** (before)
- **sub-** (below, under)
- **dys-** (painful, abnormal, difficult, laboured)
- **intra-** (within

- **hemi-** (half)
- **hyper-** (above, excessive)
- **inter-** (between)

Combining Form

- **cephal/o** (head)
- **cerebell/o** (cerebellum)
- **cerebr/o** (cerebrum)
- **dur/o** (dura mater, hard)
- **encephal/o** (brain)
- **esthesi/o** (sensation, sensitivity, feeling)
- **gangli/o** (ganglion)
- **ganglion/o** (ganglion)
- **gli/o** (glia, gluey substance)
- **mening/o** (meninges)
- **meningi/o** (meninges)
- **ment/o** (mind)
- **mon/o** (one, single)
- **myel/o** (spinal cord)
- **neur/o** (nerve)
- **phas/o** (speech)
- **poli/o** (gray matter)
- **psych/o** (mind)
- **quadr/i** (four)
- **radic/o** (nerve root)
- **radicul/o** (nerve root)
- **rhiz/o** (nerve root)

Suffix

- **-al** (pertaining to)
- **-algia** (pain)
- **-cele** (hernia, protrusion)
- **-cyte** (cell)
- **-ectomy** (excision, surgical removal, cutting out)
- **-genic** (producing, originating, causing)
- **-gram** (the record, radiographic image)
- **-graph** (instrument used to record)
- **-graphy** (process of recording, radiographic imaging)
- **-ia** (condition of, diseased state or abnormal state)
- **-ic** (pertaining to)
- **-iatrist** (specialist, physician)

- **-atry** (specialty, treatment)
- **-ictal** (seizure, attack)
- **-itis** (inflammation)
- **-logist** (specialist, physician)
- **-logy** (study of)
- **-lysis** (loosening, dissolution, separating)
- **-malacia** (softening)
- **-oid** (resembling)
- **-oma** (tumour)
- **-osis** (abnormal condition)
- **-paresis** (slight paralysis)
- **-pathy** (disease)
- **-plasty** (surgical repair)
- **-plegia** (paralysis)
- **-sclerosis** (hardening)
- **-rrhaphy** (suturing, repairing)
- **-tomy** (incision, cut into)

Introduction to the Nervous System

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

Watch The Nervous System, Part 1: Crash Course Anatomy & Physiology #8 (11 min) on YouTube

Nervous System Medical Terms

Nervous System Medical Terms (Text Version)
Practice the following **nervous system** words by breaking into word parts and pronouncing.

1. **quadriplegia**
    - quadr/i/plegia
    - paralysis of four (limbs)
2. **neurectomy**
    - neur/ectomy
    - excision of nerves
3. **poliomyelitis**
    - poli/o/myel/itis
    - inflammation of gray matter of the spinal cord
4. **intracerebral**
    - intra/cerebr/al
    - pertaining to within the cerebrum
5. **encephalosclerosis**
    - encephal/o/sclerosis
    - hardening of the brain
6. **interictal**
    - inter/ictal
    - occurs between seizures or attacks
7. **rhizotomy**
    - rhiz/o/tomy
    - incision into a nerve root
8. **hyperesthesia**
    - hyper/esthesi/a
    - excessive sensitivity to stimuli
9. **mental**

- ment/al
- pertaining to the brain

10. **neuralgia**
    - neur/algia
    - pain of the nerves
11. **radiculopathy**
    - radicul/o/pathy
    - disease of the nerve roots
12. **panplegia**
    - pan/plegia
    - total paralysis
13. **monoparesis**
    - mon/o/paresis
    - slight paralysis of one (limb)
14. **duritis**
    - dur/itis
    - inflammation of the dura mater
15. **anesthesia**
    - an/esthesi/a
    - without (loss of) feeling or sensation
16. **cerebellitis**
    - cerebell/itis
    - inflammation of the cerebellum
17. **encephalomalacia**
    - encephal/o/malacia
    - softening of the brain
18. **cerebral thrombosis**
    - cerebr/al thromb/osis
    - Abnormal condition of blood clot pertaining to the cerebrum (blood clot in a blood vessel in the brain)
19. **craniocerebral**

- crani/o/cerebr/al
- pertaining to the cranium and cerebrum

20. **glioma**
    - gli/oma
    - tumour composed of the glial tissue
21. **psychiatrist**
    - psych/iatrist
    - physician who studies and treats disorders of the mind
22. **cephalgia**
    - ceph/algia
    - *rebel does not follow the rules*
    - Pain in the head (headache)
23. **neuroma**
    - neur/oma
    - tumour made up of nerve (cells)
24. **psychogenic**
    - psych/o/genic
    - originating in the mind
25. **polyneuropathy**
    - poly/neur/o/pathy
    - disease of many nerves
26. **psychosis**
    - psych/osis
    - abnormal condition of the mind
27. **mononeuropathy**
    - mon/o/neur/o/pathy
    - disease affecting a single nerve
28. **electroencephalograph**
    - electr/o/encephal/o/graph
    - instrument used to record electrical activity of the brain
29. **radicotomy**

- radic/o/tomy
- incision into a nerve root

30. **aphasia**
    - a/phas/ia
    - condition of without speaking
31. **poliomyelitis**
    - poli/o/myel/itis
    - inflammation of the gray matter of the spinal cord
32. **gangliitis**
    - gangli/itis
    - inflammation of the ganglion
33. **hemiplegia**
    - hemi/plegia
    - paralysis of half (right or left) side of the body
34. **subdural hematoma**
    - sub/dur/al hemat/oma
    - tumour filled with blood pertaining to below the dura mater
35. **dysphasia**
    - dys/phas/ia
    - condition of difficulty speaking
36. **encephalitis**
    - encephal/itis
    - inflammation of the brain
37. **subdural**
    - sub/dur/al
    - pertaining to below the dura mater
38. **neurology**
    - neur/o/logy
    - study of nerves
39. **CT myelography**
    - CT myel/o/graphy

- process of recording the spinal cord with computed tomography

40. **glioblastoma**
    - gli/o/blast/oma
    - tumour composed of developing glial tissue
41. **neuroid**
    - neur/oid
    - resembling a nerve
42. **neuroarthropathy**
    - neur/o/arthr/o/pathy
    - disease of the nerves and joints
43. **meningitis**
    - mening/itis
    - inflammation of the meninges
44. **hemiparesis**
    - hemi/paresis
    - slight paralysis of half (right or left) side of the body
45. **neurorrhaphy**
    - neur/o/rrhaphy
    - suturing of a nerve
46. **psychology**
    - psych/o/logy
    - study of the mind
47. **neurologist**
    - neur/o/logist
    - specialist who studies and treats the nervous system
48. **neuroplasty**
    - neur/o/plasty
    - surgical repair of a nerve
49. **psychopathy**
    - psych/o/pathy
    - disease of the mind

50. **preictal**
    - pre/ictal
    - occurs before a seizure or attack
51. **radiculitis**
    - radicul/itis
    - inflammation of the nerve roots
52. **electroencephalography**
    - electr/o/encephal/o/graphy
    - process of recording the electrical activity of the brain
53. **cerebral angiography**
    - cerebr/al angi/o/graphy
    - process of recording (blood) vessel pertaining to the cerebrum
54. **psychiatry**
    - psych/iatry
    - specialty of the mind
55. **psychosomatic**
    - psych/o/somat/ic
    - pertaining to the mind and body
56. **neurotomy**
    - neur/o/tomy
    - incision into a nerve
57. **cerebral**
    - cerebr/al
    - pertaining to the brain
58. **neuropathy**
    - neur/o/pathy
    - disease of (peripheral) nerves
59. **myelomalacia**
    - myel/o/malacia
    - softening of the spinal cord
60. **encephalomyeloradiculitis**

- encephal/o/myel/itis
- inflammation of brain, spinal cord and nerve roots

61. **monoplegia**

    - mon/o/plegia
    - paralysis of one (limb)

62. **meningomyelocele**

    - mening/o/myel/o/cele
    - protrusion of the meninges and spinal cord

63. **paresthesia**

    - par/esthesi/a
    - * rebel does not follow the rules*
    - abnormal sensation in the extremeties

64. **psychologist**

    - psych/o/logist
    - specialist of the mind

65. **postictal**

    - post/ictal
    - occurs after a seizure or attack

66. **meningioma**

    - meningi/oma
    - tumour of the meninges

67. **neurolysis**

    - neur/o/lysis
    - dissolution of nerve (for pain mangement)

68. **electroencephalogram**

    - electr/o/encephal/o/gram
    - the record of electrical activity of the brain

69. **gliocyte**

    - gli/o/cyte
    - glial cell

70. **polyneuritis**

- poly/neur/itis
- inflammation of many nerves

71. **neuritis**
    - neur/itis
    - inflammation of the nerves
72. **ganglionectomy**
    - ganglion/ectomy
    - excision of a ganglion
73. **meningocele**
    - mening/o/cele
    - protrusion of the meninges
74. **rhizomeningomyelitis**
    - rhiz/o/mening/o/myel/itis
    - inflammation of the nerve root, meninges and spinal cord

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16.2 - Anatomy (Structures) of the Nervous System

The Central and Peripheral Nervous Systems

The nervous system can be divided into two major regions: the central and peripheral nervous systems. The **central nervous system (CNS)** is the brain and spinal cord, and the **peripheral nervous system (PNS)** is everything else (see Figure 16.1). The brain is contained within the cranial cavity of the skull, and the spinal cord is contained within the vertebral cavity of the vertebral column. It is a bit of an oversimplification to say that the CNS is what is inside these two cavities and the peripheral nervous system is outside of them, but that is one way to start to think about it. In actuality, there are some elements of the peripheral nervous system that are within the cranial or vertebral cavities. The peripheral nervous system is so named because it is on the periphery—meaning beyond the brain and spinal cord. Depending on different aspects of the nervous system, the dividing line between central and peripheral is not necessarily universal.

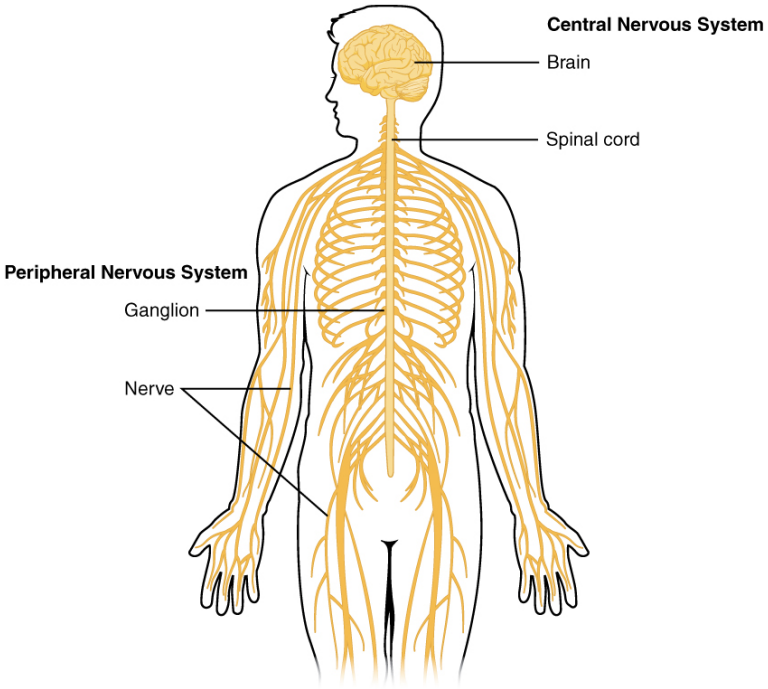


Figure 16.1 Central and Peripheral Nervous System. *The structures of the PNS are referred to as ganglia and nerves, which can be seen as distinct structures. The equivalent structures in the CNS are not obvious from this overall perspective and are best examined in prepared tissue under the microscope. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 16.1 Image description.]*

Nervous tissue, present in both the CNS and PNS, contains two basic types of cells: neurons and glial cells. **Neurons** are the primary type of cell that most anyone associates with the nervous system. They are responsible

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

Did You Know 1?

The brain has over 100 billion neurons.

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

Looking at nervous tissue, there are regions that predominantly contain cell bodies and regions that are largely composed of just axons. These two regions within nervous system structures are often referred to as **gray matter** (the regions with many cell bodies and dendrites) or **white matter** (the regions with many axons). Figure 16.2 demonstrates the appearance of these regions in the brain and spinal cord. The colours ascribed to these regions are what would be seen in "fresh," or unstained, nervous tissue. Gray matter is not necessarily gray. It can be pinkish because of blood content, or even slightly tan, depending on how long the tissue has been preserved. White matter is white because axons are insulated by a lipid-rich substance called myelin. Lipids can appear as white ("fatty") material, much like the fat on a raw piece of chicken or beef. Actually, gray matter may have that colour ascribed to it because next to the white matter, it is just darker—hence, gray.

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

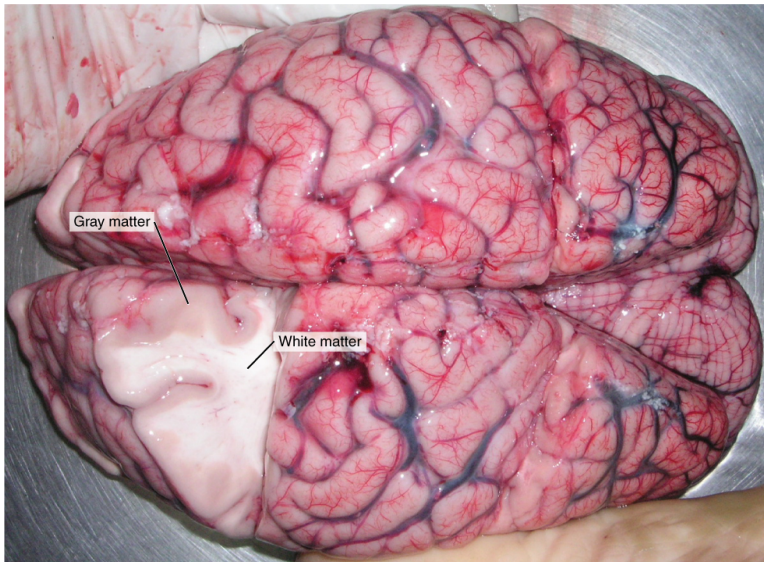


Figure 16.2 Gray Matter and White Matter. A brain removed during an autopsy, with a partial section removed, shows white matter surrounded by gray matter. Gray matter makes up the outer cortex of the brain. (credit: modification of work by "Suseno"/Wikimedia Commons). From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 16.2 Image description.]

The Adult Brain

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

The Cerebrum

The iconic gray mantle of the human brain, which appears to make up most of the mass of the brain, is the **cerebrum** (see Figure 16.3). The wrinkled portion is the cerebral cortex, and the rest of the structure is beneath that outer covering. There is a large separation between the two sides of the cerebrum called the **longitudinal** fissure. It separates the cerebrum into two distinct halves, a right and left **cerebral hemisphere**. Deep within the cerebrum, the white matter of the corpus callosum provides the major pathway for communication between the two hemispheres of the cerebral cortex.

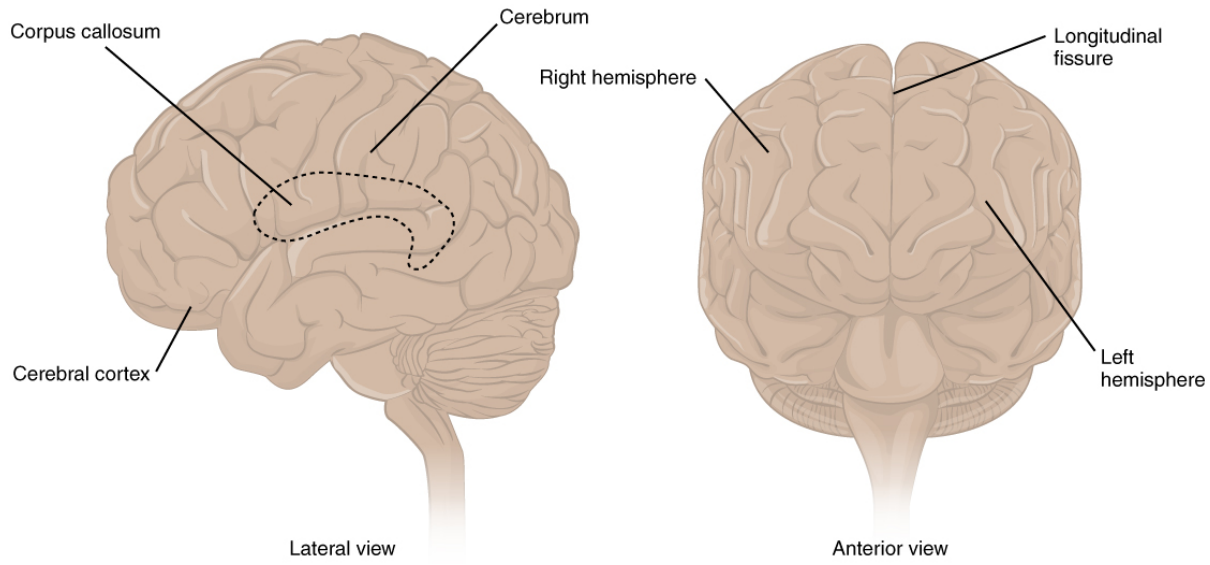


Figure 16.3 The Cerebrum. The cerebrum is a large component of the CNS in humans, and the most obvious aspect of it is the folded surface called the cerebral cortex. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 16.3 Image description.]

Did You Know 2?

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

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

Cerebral Cortex

The cerebrum is covered by a continuous layer of gray matter that wraps around either side of the forebrain—the

cerebral cortex. This thin, extensive region of wrinkled gray matter is responsible for the higher functions of the nervous system. A gyrus (plural = gyri) is the ridge of one of those wrinkles, and a sulcus (plural = sulci) is the groove between two gyri. The pattern of these folds of tissue indicates specific regions of the cerebral cortex.

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

The folding of the cortex maximizes the amount of gray matter in the cranial cavity. During embryonic development, as the **telencephalon** expands within the skull, the brain goes through a regular course of growth that results in everyone's brain having a similar pattern of folds. The surface of the brain can be mapped on the basis of the locations of large gyri and sulci. Using these landmarks, the cortex can be separated into four major regions, or lobes (see Figure 16.4). The lateral sulcus that separates the temporal lobe from the other regions is one such landmark. Superior to the lateral sulcus are the **parietal lobe** and **frontal lobe**, which are separated from each other by the **central sulcus**. The posterior region of the cortex is the **occipital lobe**, which has no obvious anatomical border between it and the parietal or temporal lobes on the lateral surface of the brain. From the medial surface, an obvious landmark separating the parietal and occipital lobes is called the parieto-occipital sulcus. The fact that there is no obvious anatomical border between these lobes is consistent with the functions of these regions being interrelated.

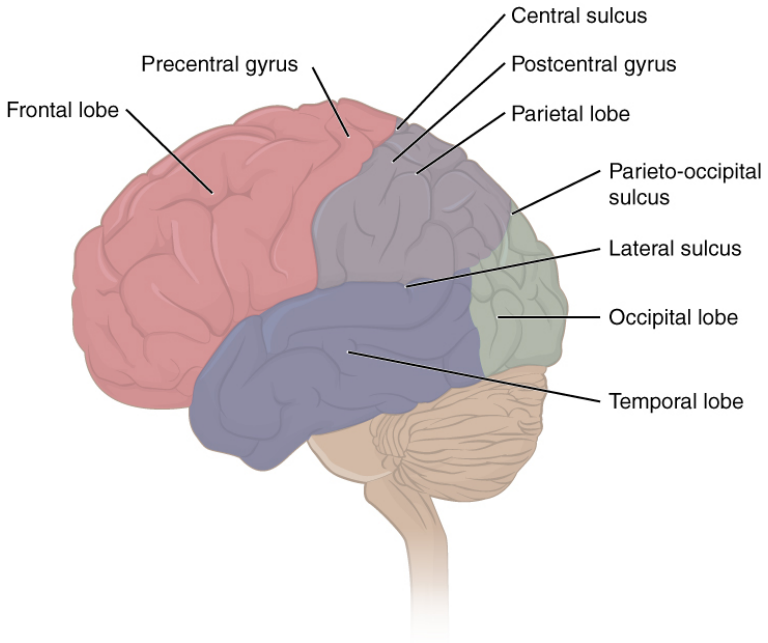


Figure 16.4 Lobes of the Cerebral Cortex. The cerebral cortex is divided into four lobes. Extensive folding increases the surface area available for cerebral functions. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 16.4 Image description.]

Concept Check 1

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

The Diencephalon

The diencephalon is deep beneath the cerebrum and constitutes the walls of the third ventricle. The diencephalon can be described as any region of the brain with "thalamus" in its name. The two major regions of the diencephalon are the thalamus itself and the hypothalamus (see Figure 16.5). There are other structures, such as the epithalamus, which contains the pineal gland, or the subthalamus, which includes the subthalamic nucleus that is part of the basal nuclei.

Thalamus

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

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

Hypothalamus

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

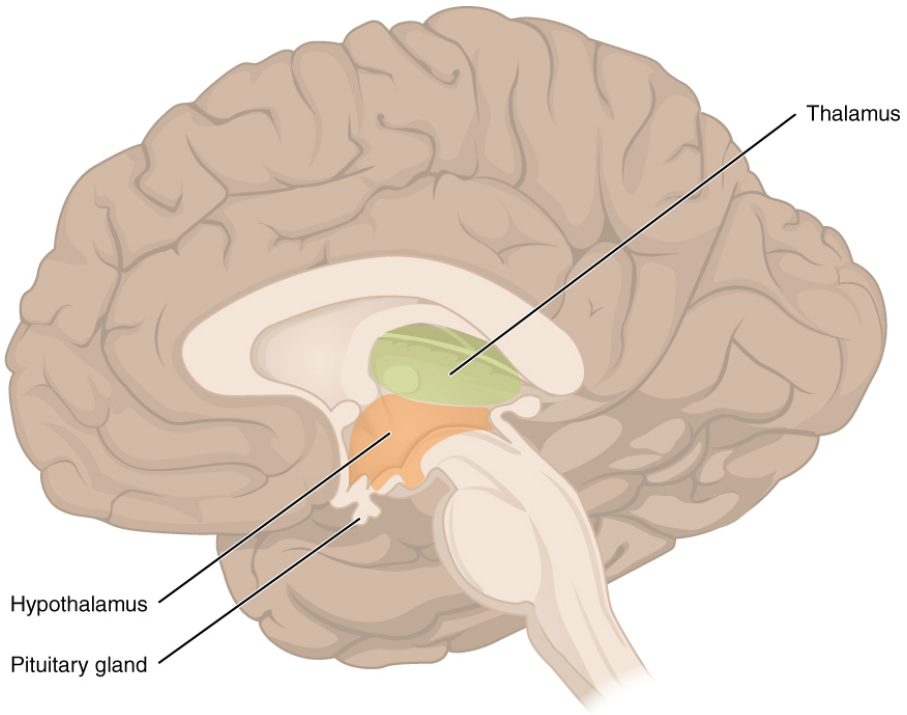


Figure 16.5 The Diencephalon. The diencephalon is composed primarily of the thalamus and hypothalamus, which together define the walls of the third ventricle. The thalami are two elongated, ovoid structures on either side of the midline that make contact in the middle. The hypothalamus is inferior and anterior to the thalamus, culminating in a sharp angle to which the pituitary gland is attached. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 16.5 Image description.]

Brain Stem

The midbrain and hindbrain (composed of the **pons** and the **medulla**) are collectively referred to as the brain stem (see Figure 16.6). The structure emerges from the ventral surface of the forebrain as a tapering cone that connects the brain to the spinal cord. Attached to the brain stem, but considered a separate region of the adult brain, is the cerebellum. The midbrain coordinates sensory representations of the visual, auditory, and somatosensory perceptual spaces. The pons is the main connection with the cerebellum. The pons and the medulla regulate several crucial functions, including the cardiovascular and respiratory systems and rates.

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

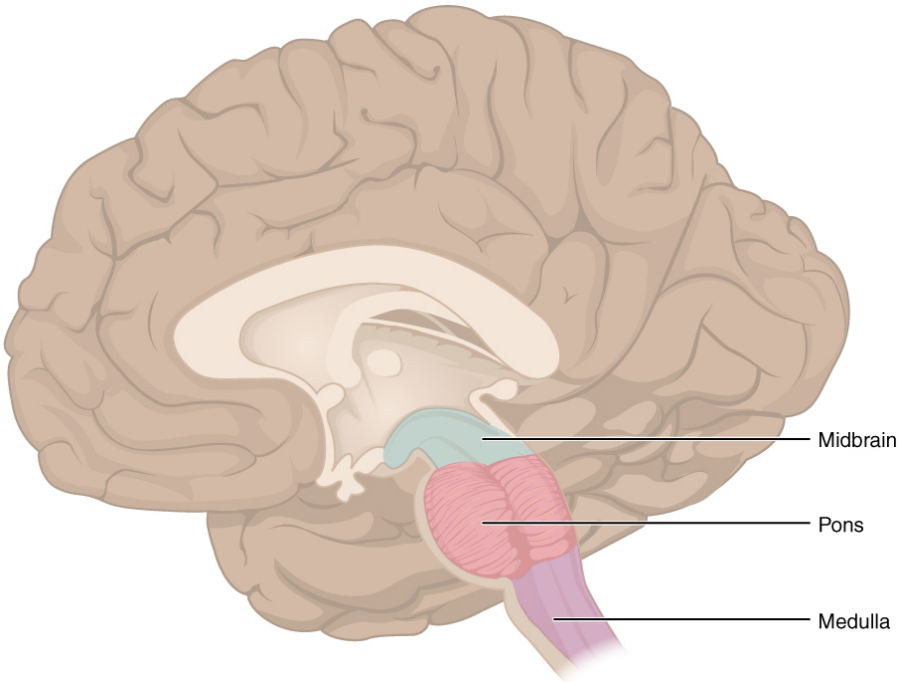


Figure 16.6 The Brain Stem. The brain stem comprises three regions: the midbrain, the pons, and the medulla. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 16.6 Image description.]

Midbrain

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

Pons

The word **pons** comes from the Latin word for bridge. It is visible on the anterior surface of the brain stem as the thick bundle of white matter attached to the cerebellum. The pons is the main connection between the cerebellum and the brain stem. The bridge-like white matter is only the anterior surface of the pons; the gray matter beneath that is a continuation of the tegmentum from the midbrain. Gray matter in the tegmentum region of the pons contains neurons receiving descending input from the forebrain that is sent to the cerebellum.

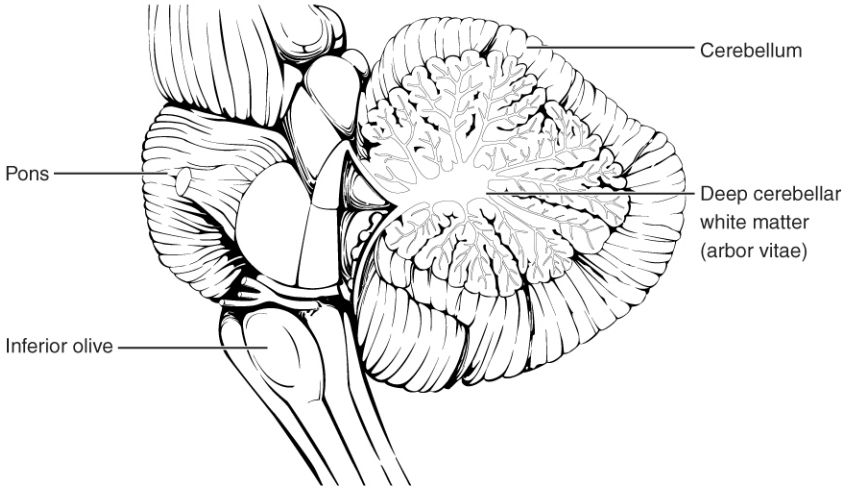
Medulla

The medulla is the region known as the **myelencephalon** in the embryonic brain. The initial portion of the name, "myel," refers to the significant white matter found in this region—especially on its exterior, which is continuous

with the white matter of the spinal cord. The tegmentum of the midbrain and pons continues into the medulla because this gray matter is responsible for processing cranial nerve information. A diffuse region of gray matter throughout the brain stem, known as the reticular formation, is related to sleep and wakefulness, such as general brain activity and attention.

The Cerebellum

The cerebellum, as the name suggests, is the "little brain." It is covered in **gyri** and sulci like the cerebrum, and looks like a miniature version of that part of the brain (see Figure 16.7). The cerebellum is largely responsible for comparing information from the cerebrum with sensory feedback from the periphery through the spinal cord. It accounts for approximately 10 percent of the mass of the brain.



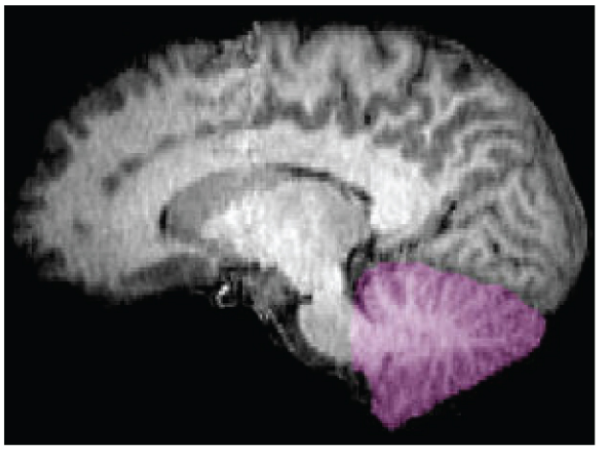


Figure 16.7 The Cerebellum. The cerebellum is situated on the posterior surface of the brain stem. Descending input from the cerebellum enters through the large white matter structure of the pons. Ascending input from the periphery and spinal cord enters through the fibers of the inferior olive. Output goes to the midbrain, which sends a descending signal to the spinal cord. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 16.7 Image description.]

Concept Check 2

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

The Spinal Cord

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

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

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

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

Did You Know 3?

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

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

Neurons

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

Parts of a Neuron

As you learned in the first section, the main part of a neuron is the **cell body**, which is also known as the soma (soma = "body"). The cell body contains the nucleus and most of the major organelles. But what makes neurons special is that they have many extensions of their cell membranes, which are generally referred to as processes. Neurons are usually described as having one, and only one, axon—a fiber that emerges from the cell body and projects to target cells. That single axon can branch repeatedly to communicate with many **target** cells. It is the axon that **propagates** the nerve impulse, which is communicated to one or more cells. The other processes of the neuron are dendrites, which receive information from other neurons at specialized areas of contact called synapses. The dendrites are usually highly branched processes, providing locations for other neurons to communicate with the cell body. Information flows through a neuron from the dendrites, across the cell body, and down the axon. This gives the neuron a polarity—meaning that information flows in this one direction. Figure 16.8 shows the relationship of these parts to one another.

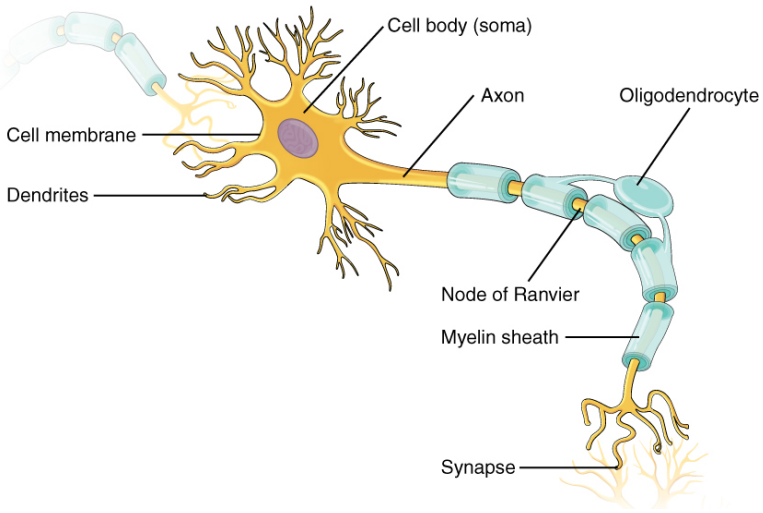


Figure 16.8 Parts of a Neuron. The major parts of the neuron are labeled on a multipolar neuron from the CNS. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 16.8 Image description.]

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

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

Types of Neurons

There are many neurons in the nervous system—a number in the trillions. And there are many different types of neurons. They can be classified by many different criteria. The first way to classify them is by the number of processes attached to the cell body. Using the standard model of neurons, one of these processes is the axon, and the rest are dendrites. Because information flows through the neuron from dendrites or cell bodies toward the axon, these names are based on the neuron's polarity (see Figure 16.9).

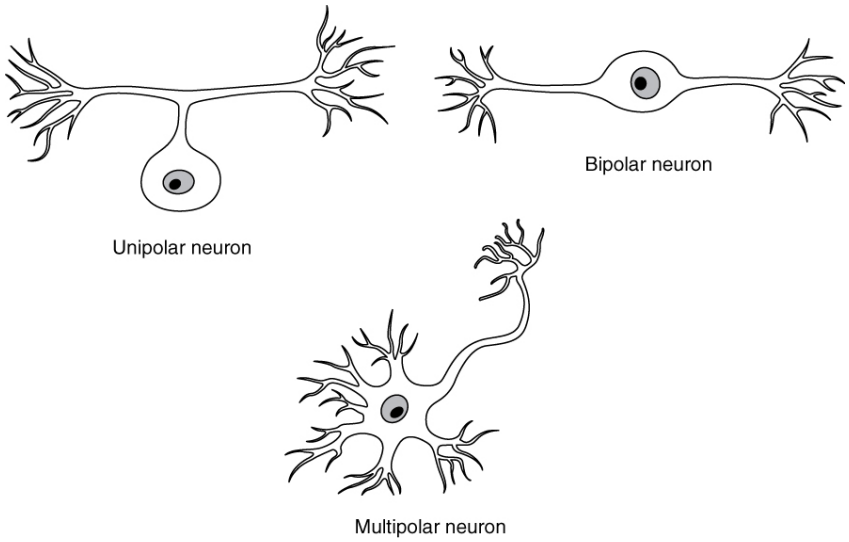


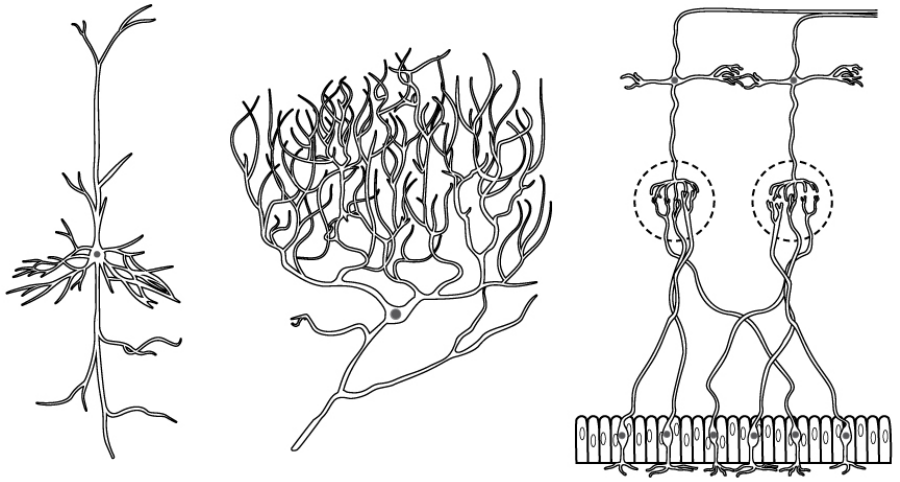
Figure 16.9 Neuron Classification by Shape. Unipolar cells have one process that includes both the axon and dendrite. Bipolar cells have two processes, the axon and a dendrite. Multipolar cells have more than two processes, the axon and two or more dendrites. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 16.9 Image description.]

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

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

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

Neurons can also be classified on the basis of where they are found, who found them, what they do, or even what chemicals they use to communicate with each other. Some neurons referred to in this section on the nervous system are named on the basis of those sorts of classifications (see Figure 16.10). For example, a multipolar neuron that has a very important role to play in a part of the brain called the cerebellum is known as a Purkinje (commonly pronounced per-KIN-gee) cell. It is named after the anatomist who discovered it (Jan Evangilista Purkinje, 1787–1869).



(a) Pyramidal cell of the cerebral cortex

(b) Purkinje cell of the cerebellar cortex

(c) Olfactory cells in the olfactory epithelium and olfactory bulbs

Figure 16.10 Other Neuron Classifications. Three examples of neurons that are classified on the basis of other criteria. (a) The pyramidal cell is a multipolar cell with a cell body that is shaped something like a pyramid. (b) The Purkinje cell in the cerebellum was named after the scientist who originally described it. (c) Olfactory neurons are named for the functional group with which they belong. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 16.10 Image description.]

Glial Cells

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

There are six types of glial cells. Four of them are found in the CNS and two are found in the PNS. Table 16.1 outlines some common characteristics and functions.

Table 16.1: Glial Cell Types by Location and Basic Function. From Betts et al., 2013. Licensed under CC BY 4.0.

CNS Glia	PNS Glia	Basic Function
Astrocyte	Satellite cell	Support
Oligodendrocyte	Schwann cell	Insulation, myelination
Microglia	–	Immune surveillance and phagocytosis
Ependymal cell	–	Creating CSF

Glial Cells of the CNS

One cell providing support to neurons of the CNS is the astrocyte, so named because it appears to be star-shaped under the microscope (astro- = "star"). **Astrocytes** have many processes extending from their main cell body (not axons or dendrites like neurons, just cell extensions). Those processes extend to interact with neurons, blood vessels, or the connective tissue covering the CNS that is called the pia mater (see Figure 16.11). Generally, they are supporting cells for the neurons in the central nervous system. Some ways in which they support neurons in the central nervous system are by maintaining the concentration of chemicals in the extracellular space, removing excess signaling molecules, reacting to tissue damage, and contributing to the **blood-brain barrier** (BBB). The blood-brain barrier is a physiological barrier that keeps many substances that circulate in the rest of the body from getting into the central nervous system, restricting what can cross from circulating blood into the CNS. Nutrient molecules, such as glucose or amino acids, can pass through the BBB, but other molecules cannot. This actually causes problems with drug delivery to the CNS. Pharmaceutical companies are challenged to design drugs that can cross the BBB as well as have an effect on the nervous system.

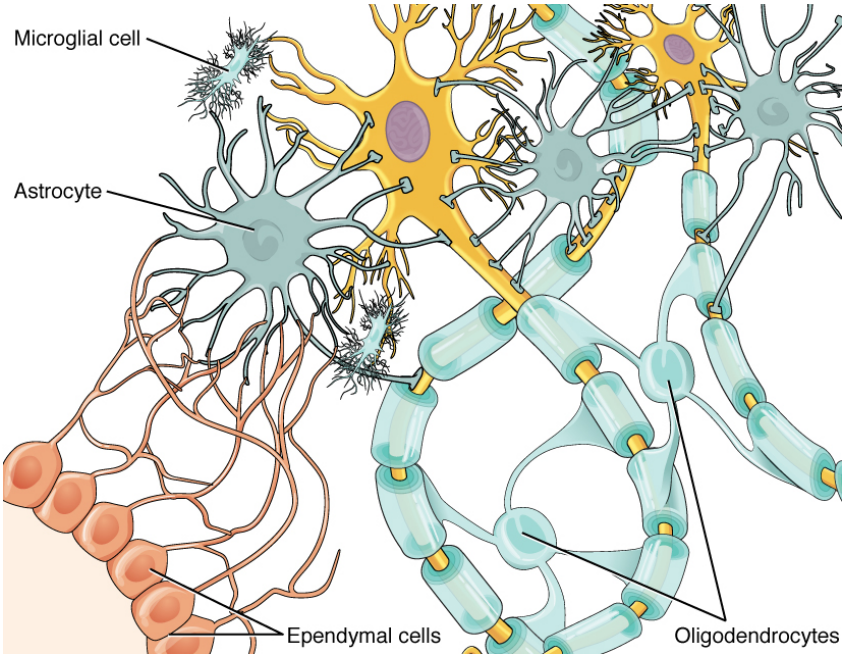


Figure 16.11 Glial Cells of the CNS. The CNS has astrocytes, oligodendrocytes, microglia, and ependymal cells that support the neurons of the CNS in several ways. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 16.11 Image description.]

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

pharmaceuticals to be developed that can affect the nervous system. Aside from finding efficacious substances, the means of delivery is also crucial.

Oligodendrocyte, sometimes called just "oligo," which is the glial cell type that insulates axons in the CNS. The name means "cell of a few branches" (oligo- = "few"; dendro- = "branches"; -cyte = "cell"). There are a few processes that extend from the cell body. Each one reaches out and surrounds an axon to insulate it in myelin.

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

The **ependymal** cell is a glial cell that filters blood to make cerebrospinal fluid (CSF), the fluid that circulates through the CNS. Because of the privileged blood supply inherent in the BBB, the extracellular space in nervous tissue does not easily exchange components with the blood. Ependymal cells line each ventricle, one of four central cavities that are remnants of the hollow center of the neural tube formed during the embryonic development of the brain. They also have cilia on their apical surface to help move the CSF through the ventricular space. The relationship of these glial cells to the structure of the CNS is seen in Figure 16.11.

Glial Cells of the PNS

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

The second type of glial cell is the **Schwann** cell, which insulate axons with myelin in the periphery. Schwann cells are different than oligodendrocytes, in that a Schwann cell wraps around a portion of only one axon segment and no others. Oligodendrocytes have processes that reach out to multiple axon segments, whereas the entire Schwann cell surrounds just one axon segment. The nucleus and cytoplasm of the Schwann cell are on the edge of the myelin sheath. The relationship of these two types of glial cells to ganglia and nerves in the PNS is seen in Figure 16.12.

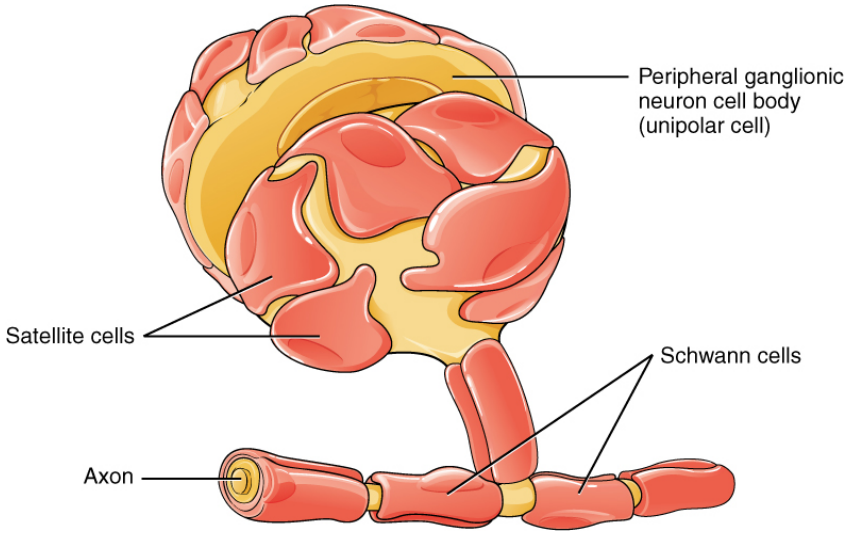


Figure 16.12 Glial Cells of the PNS. The PNS has satellite cells and Schwann cells. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 16.12 Image description.]

Myelin

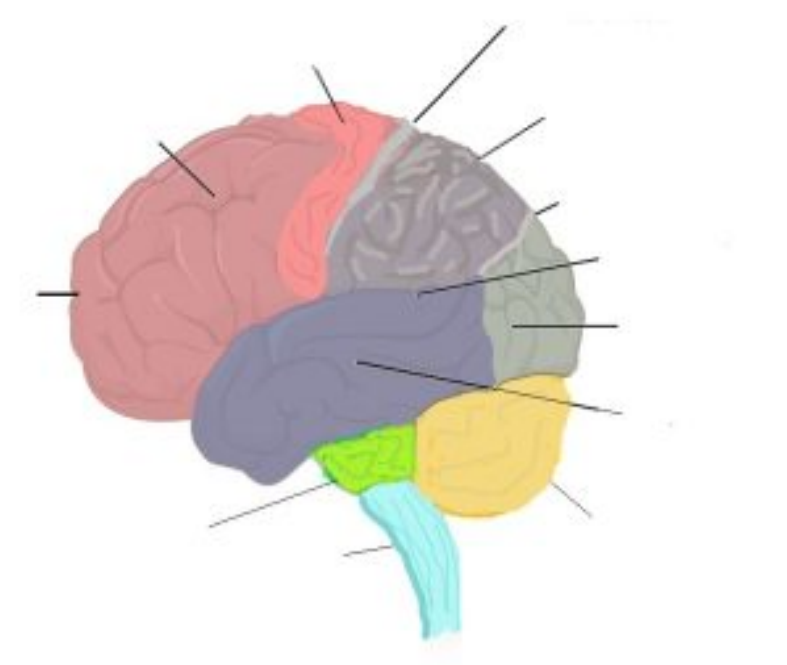
The appearance of the myelin sheath can be thought of as similar to the pastry wrapped around a hot dog for "pigs in a blanket" or a similar food. The glial cell is wrapped around the axon several times with little to no cytoplasm between the glial cell layers. For **oligodendrocytes**, the rest of the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

Check Your Knowledge of the Nervous System Brain Anatomy

Nervous System Brain Anatomy Labeling Activity

Nervous System Brain Anatomy Labeling Activity (Text Version)
Label the diagram with correct words listed below:

1. Central sulcus, longitudinal fissure
2. Pons
3. Precentral gyrus
4. Frontal Lobe
5. Occipital lobe
6. Cerebrum
7. Cerebellum
8. Lateral Sulcus
9. Brainstem
10. Parietal lobe
11. Temporal lobe
12. parieto-occipital sulcus



Nervous System Brain Anatomy Labeling Activity Diagram (Text Version)

This diagram shows the lateral view of the brain and the major lobes which are labeled. From the front of the brain (left): _____[Blank 1} is responsible for thought processes, followed by a raised surface area known as _____[Blank 2], a deep groove known as the _____[Blank 3], and another raised area knowns as _____[Blank 4]. The _____[Blank 5] is responsible for processes senses such as the sense of touch, followed by the _____[Blank 6] which is another deep groove on the surface of the brain. The _____[Blank 7] processes visual fields and the _____[Blank 8], which is responsible for memory capacity. The ____ [Blank 9] is responsible for balance, followed by the _____[Blank 10], which is often referred to as the medulla oblongata, and finally is the ____,[Blank 11] which is known as the bridge connecting the cerebrum to the cerebellum. The _____ [Blank 12] is a deep groove on the surface of the cerebrum.

Check your answers [1]

Activity source: Nervous System Brain Anatomy labeling activity by Sheila Bellefeuille from *Building a Medical Terminology Foundation*, illustration from *Anatomy and Physiology (OpenStax)*, licensed under CC BY 4.0./ Text version added.

Image Descriptions

Figure 16.1 image description: This diagram shows a silhouette of a human highlighting the nervous system. The central nervous system is composed of the brain and spinal cord. The brain is a large mass of ridged and striated tissue within the head. The spinal cord extends down from the brain and travels through the torso, ending in the pelvis. Pairs of enlarged nervous tissue, labeled ganglia, flank the spinal cord as it travels through the rib area. The ganglia are part of the peripheral nervous system, along with the many thread-like nerves that radiate from the spinal cord and ganglia through the arms, abdomen and legs. [Return to Figure 16.1].

Figure 16.2 image description: This photo shows an enlarged view of the dorsal side of a human brain. The right side of the occipital lobe has been shaved to reveal the white and gray matter beneath the surface blood vessels. The white matter branches though the shaved section like the limbs of a tree. The gray matter branches and curves on outside of the white matter, creating a buffer between the outer edges of the occipital lobe and the internal white matter. [Return to Figure 16.2].

Figure 16.3 image description: This figure shows the lateral view on the left panel and anterior view on the right panel of the brain. The major parts including the cerebrum are labeled. Lateral view labels (clockwise from top) read: cerebrum, cerebral cortex, corpus callosum (located on the interior of the brain). Anterior view labels indicate the right and left hemispheres, and the longitudinal fissure between them. [Return to Figure 16.3].

Figure 16.4 image description: This figure shows the lateral view of the brain and the major lobes are labeled. From the front of the brain (left) labels read: frontal lobe, precentral gyrus, central sulcus, postcentral gyrus, parietal lobe, lateral sulcus, occipital lobe, temporal lobe. [Return to Figure 16.4].

Figure 16.5 image description: This figure shows the location of the thalamus, hypothalamus and pituitary gland in the brain. Each part is labelled respectively. The thalamus is located in the midsection of the brain. The hypothalamus is located below the thalamus, and the pituitary gland below that. [Return to Figure 16.5].

Figure 16.6 image description: This figure shows the location of the midbrain, pons and the medulla in the brain that make up the brain stem. The midbrain is located at the top, the pons is located beneath that, and the medulla is the lowest most point of the brain stem. [Return to Figure 16.6].

Figure 16.7 image description: This figure shows the location of the cerebellum in the brain which is located on the posterior surface of the brain stem. Labels read (top, left): pons, inferior olive, (top, right) cerebellum, deep cerebellar white matter (arbor vitae). In the top panel, a lateral view labels the location of the cerebellum and the deep cerebellar white matter. In the bottom panel, a photograph of a brain, with the cerebellum in pink is shown. [Return to Figure 16.7].

Figure 16.8 image description: This illustration shows the anatomy of a neuron. The neuron has a very irregular cell body (soma) containing a purple nucleus. There are six projections protruding from the top, bottom and left side of the cell body. Each of the projections branches many times, forming small, tree-shaped structures protruding from the cell body. The right side of the cell body tapers into a long cord called the axon. The axon is insulated by segments of myelin sheath, which resemble a semitransparent toilet paper roll wound around the axon. The myelin sheath is not continuous, but is separated into equally spaced segments. The bare axon segments between the sheath segments are called nodes of Ranvier. An oligodendrocyte is reaching its two arm like projections onto two myelin sheath segments. The axon branches many times at its end, where it connects to the dendrites of another neuron. Each connection between an axon branch and a dendrite is called a synapse.

The cell membrane completely surrounds the cell body, dendrites, and its axon. The axon of another nerve is seen in the upper left of the diagram connecting with the dendrites of the central neuron. [Return to Figure 16.8].

Figure 16.9 image description: Three illustrations show some of the possible shapes that neurons can take. In the unipolar neuron, the dendrite enters from the left and merges with the axon into a common pathway, which is connected to the cell body. The axon leaves the cell body through the common pathway, the branches off to the right, in the opposite direction as the dendrite. Therefore, this neuron is T shaped. In the bipolar neuron, the dendrite enters into the left side of the cell body while the axon emerges from the opposite (right) side. In a multipolar neuron, multiple dendrites enter into the cell body. The only part of the cell body that does not have dendrites is the part that elongates into the axon. [Return to Figure 16.9].

Figure 16.10 image description: This diagram contains three black and white drawings of more specialized nerve cells. Part A shows a pyramidal cell of the cerebral cortex, which has two, long, nerve tracts attached to the top and bottom of the cell body. However, the cell body also has many shorter dendrites projecting out a short distance from the cell body. Part B shows a Purkinje cell of the cerebellar cortex. This cell has a single, long, nerve tract entering the bottom of the cell body. Two large nerve tracts leave the top of the cell body but immediately branch many times to form a large web of nerve fibers. Therefore, the purkinje cell somewhat resembles a shrub or coral in shape. Part C shows the olfactory cells in the olfactory epithelium and olfactory bulbs. It contains several cell groups linked together. At the bottom, there is a row of olfactory epithelial cells that are tightly packed, side-by-side, somewhat resembling the slats on a fence. There are six neurons embedded in this epithelium. Each neuron connects to the epithelium through branching nerve fibers projecting from the bottom of their cell bodies. A single nerve fiber projects from the top of each neuron and synapses with nerve fibers from the neurons above. These upper neurons are cross shaped, with one nerve fiber projecting from the bottom, top, right and left sides. The upper cells synapse with the epithelial nerve cells using the nerve tract projecting from the bottom of their cell body. The nerve tract projecting from the top continues the pathway, making a ninety degree turn to the right and continuing to the right border of the image. [Return to Figure 16.10].

Figure 16.11 image description: This diagram shows several types of nervous system cells associated with two multipolar neurons. Astrocytes are star shaped-cells with many dendrite like projections but no axon. They are connected with the multipolar neurons and other cells in the diagram through their dendrite like projections. Ependymal cells have a teardrop shaped cell body and a long tail that branches several times before connecting with astrocytes and the multipolar neuron. Microglial cells are small cells with rectangular bodies and many dendrite like projections stemming from their shorter sides. The projections are so extensive that they give the microglial cell a fuzzy appearance. The oligodendrocytes have circular cell bodies with four dendrite like projections. Each projection is connected to a segment of myelin sheath on the axons of the multipolar neurons. The oligodendrocytes are the same color as the myelin sheath segment and are adding layers to the sheath using their projections. [Return to Figure 16.11].

Figure 16.12 image description: This diagram shows a collection of PNS glial cells. The largest cell is a unipolar peripheral ganglionic neuron which has a common nerve tract projecting from the bottom of its cell body. The common nerve tract then splits into the axon, going off to the left, and the dendrite, going off to the right. The cell body of the neuron is covered with several satellite cells that are irregular, flattened, and take on the appearance of fried eggs. Schwann cells wrap around each myelin sheath segment on the axon, with their nucleus creating a small bump on each segment. [Return to Figure 16.12].

Attribution

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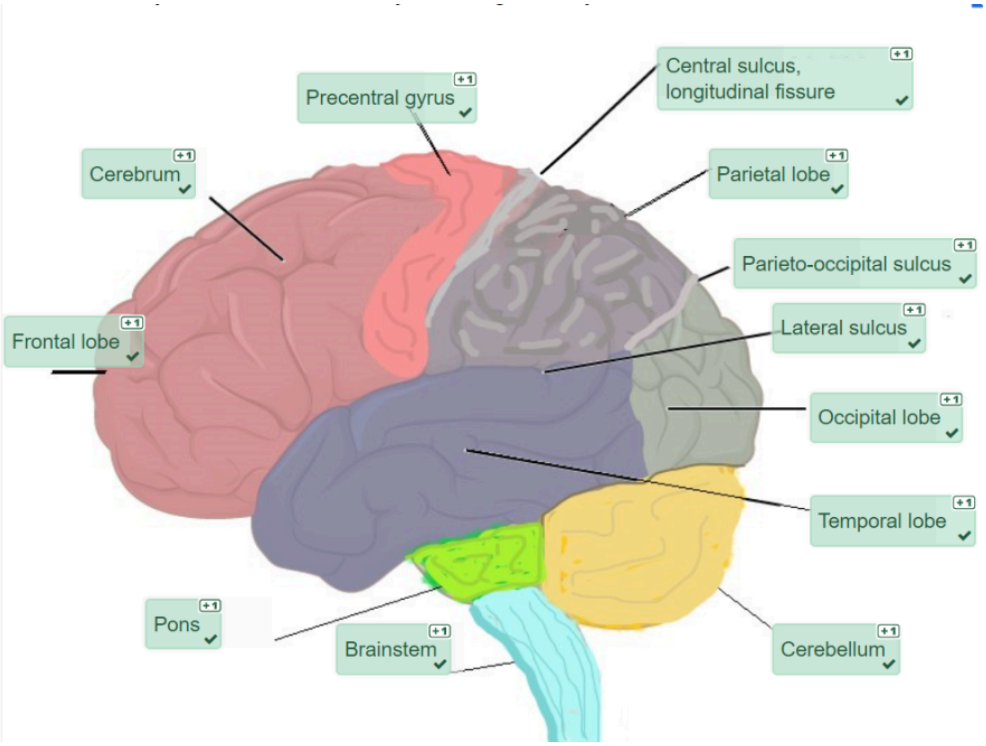
Notes

1. 

Check your answers: Nervous System Brain Anatomy labeling activity Diagram (Text Version) This diagram shows the lateral view of the brain and the major lobes which are labeled. From the front of the brain (left): **frontal lobe** is responsible for thought processes and is part of the **cerebrum**, followed by a raised surface area known as **precentral gyrus**, a deep groove known as the **central sulcus**, and another raised area knowns as **postcentral gyrus**. The **parietal lobe** is responsible for processes senses such as the sense of touch, followed by the **lateral sulcus** which is another deep groove on the surface of the brain. The **occipital lobe** processes visual fields and the **temporal lobe**, which is responsible for memory capacity. The **cerebellum** is responsible for balance, followed by the **brainstem** which is often referred to as the medulla oblongata, and finally is the **pons**, which is known as the bridge connecting the cerebrum to the cerebellum. The **parieto-occipital sulcus** is a deep groove on the surface of the cerebrum.

16.3 - Physiology (Function) of the Nervous System

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

Sensation

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

Response

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

Responses can be divided into those that are voluntary or conscious (contraction of skeletal muscle) and those that are involuntary (contraction of smooth muscles, regulation of cardiac muscle, activation of glands). Voluntary responses are governed by the somatic nervous system and involuntary responses are governed by the autonomic nervous system, which are discussed in the next section.

Integration

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

Controlling the Body

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

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

There is another division of the nervous system that describes functional responses. The **enteric nervous system (ENS)** is responsible for controlling the smooth muscle and glandular tissue in your digestive system. It is a large part of the PNS, and is not dependent on the CNS. It is sometimes valid, however, to consider the enteric system to be a part of the autonomic system because the neural structures that make up the enteric system are a component of the autonomic output that regulates digestion. There are some differences between the two, but for our purposes here there will be a good bit of overlap. See Figure 16.13 for examples of where these divisions of the nervous system can be found.

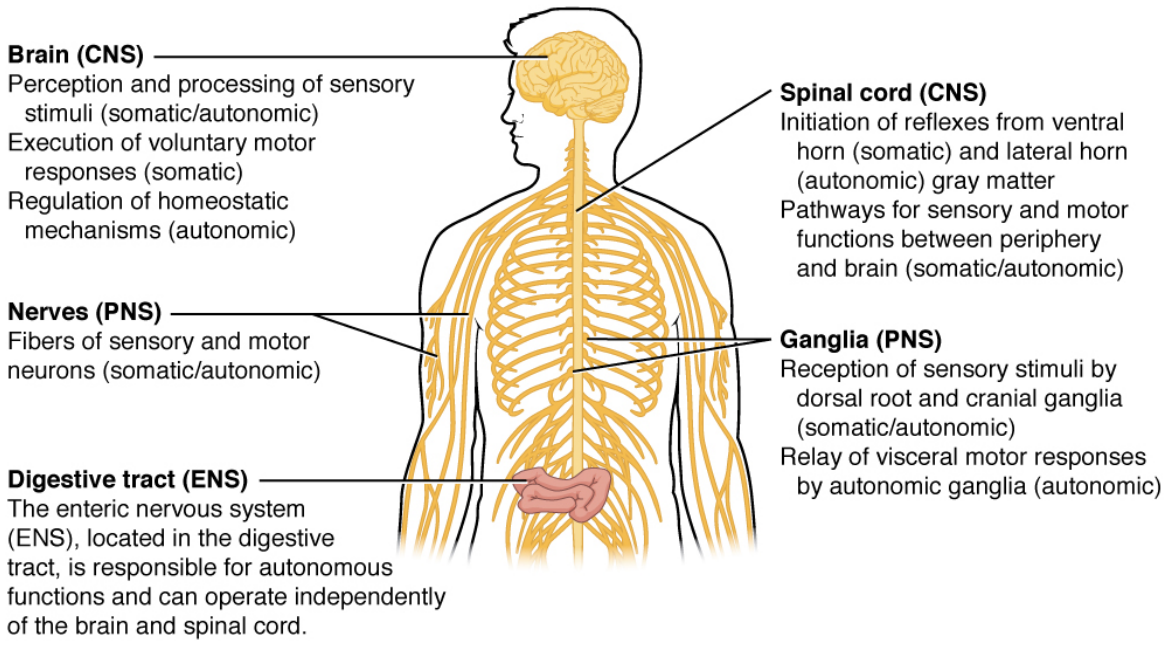


Figure 16.13 Somatic, Autonomic, and Enteric Structures of the Nervous System. Somatic structures include the spinal nerves, both motor and sensory fibers, as well as the sensory ganglia (posterior root ganglia and cranial nerve ganglia). Autonomic structures are found in the nerves also, but include the sympathetic and parasympathetic ganglia. The enteric nervous system includes the nervous tissue within the organs of the digestive tract. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 16.13 Image description.]

Functions of the Cerebral Cortex

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

Cognitive Abilities

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

Orientation and Memory

Orientation is the patient's awareness of his or her immediate circumstances. It is awareness of time, not in terms of the clock, but of the date and what is occurring around the patient. It is awareness of place, such that a patient should know where he or she is and why. It is also awareness of who the patient is—recognizing personal identity and being able to relate that to the examiner. The initial tests of orientation are based on the questions, "Do you know what the date is?" or "Do you know where you are?" or "What is your name?" Further understanding of a patient's awareness of orientation can come from questions that address remote memory, such as "Who is the President of the United States?", or asking what happened on a specific date.

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

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

Read the New York Times Magazine article Forgetting Everything [New Tab] to learn about a young man who texts his fiancée in a panic as he finds that he is having trouble remembering things. At the hospital, a neurologist administers the mental status exam, which is mostly normal except for the three-word recall test. The young man could not recall them even 30 seconds after hearing them and repeating them back to the doctor. An undiscovered mass in the mediastinum region was found to be Hodgkin's lymphoma, a type of cancer that affects the immune system and likely caused antibodies to attack the nervous system. The patient eventually regained his ability to remember, though the events in the hospital were always elusive. Considering that the effects on memory were temporary, but resulted in the loss of the specific events of the hospital stay, what regions of the brain were likely to have been affected by the antibodies and what type of memory does that represent?

Language and Speech

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

The neurological exam has two specific subtests that address language. One measures the ability of the patient to understand language by asking them to follow a set of instructions to perform an action, such as "touch your right finger to your left elbow and then to your right knee." Another subtest assesses the fluency and coherency

of language by having the patient generate descriptions of objects or scenes depicted in drawings, and by reciting sentences or explaining a written passage.

An important example of multimodal integrative areas is associated with language function (see Figure 16.14). Adjacent to the auditory association cortex, at the end of the lateral sulcus just anterior to the visual cortex, is **Wernicke's area**. In the lateral aspect of the frontal lobe, just anterior to the region of the motor cortex associated with the head and neck, is Broca's area. Both regions were originally described on the basis of losses of speech and language, which is called **aphasia**. The aphasia associated with Broca's area is known as an **expressive aphasia**, which means that speech production is compromised. This type of aphasia is often described as non-fluency because the ability to say some words leads to broken or halting speech. Grammar can also appear to be lost. The aphasia associated with Wernicke's area is known as a **receptive aphasia**, which is not a loss of speech production, but a loss of understanding of content. Patients, after recovering from acute forms of this aphasia, report not being able to understand what is said to them or what they are saying themselves, but they often cannot keep from talking.

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

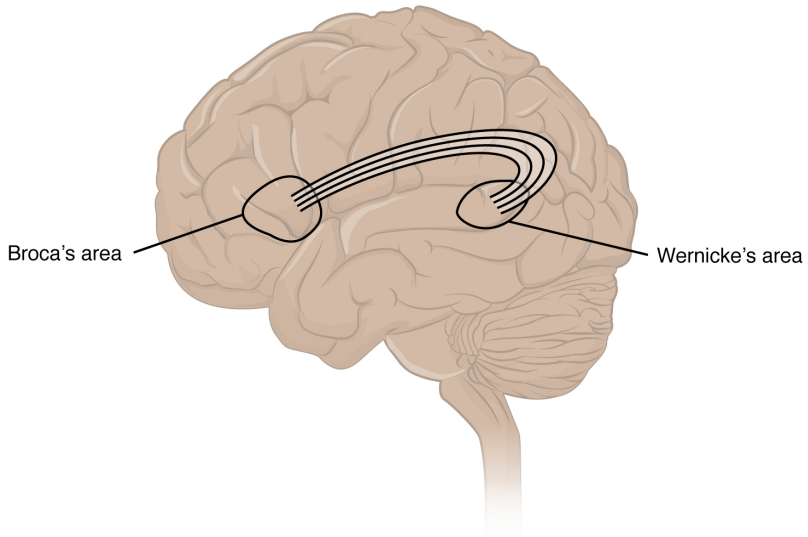


Figure 16.14 Broca's and Wernicke's Areas. Two important integration areas of the cerebral cortex associated with language function are Broca's and Wernicke's areas. The two areas are connected through the deep white matter running from the posterior temporal lobe to the frontal lobe. From Betts et al., 2013. Licensed under CC BY 4.0.

Sensorium

Those parts of the brain involved in the reception and interpretation of sensory stimuli are referred to collectively as the sensorium. The cerebral cortex has several regions that are necessary for sensory perception.

Several of the subtests can reveal activity associated with these sensory modalities, such as being able to hear a question or see a picture. Two subtests assess specific functions of these cortical areas.

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

Judgment and Abstract Reasoning

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

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

Everyday Connections

Left Brain, Right Brain

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

The reason for this is that the language functions of the cerebral cortex are localized to the left hemisphere in 95 percent of the population. Additionally, the left hemisphere is connected to the right side of the body through the corticospinal tract and the ascending tracts of the spinal cord. Motor commands from the precentral gyrus control the opposite side of the body, whereas sensory information processed by the postcentral gyrus is

received from the opposite side of the body. For a verbal command to initiate movement of the right arm and hand, the left side of the brain needs to be connected by the corpus callosum. Language is processed in the left side of the brain and directly influences the left brain and right arm motor functions, but is sent to influence the right brain and left arm motor functions through the corpus callosum. Likewise, the left-handed sensory perception of what is in the left pocket travels across the corpus callosum from the right brain, so no verbal report on those contents would be possible if the hand happened to be in the pocket.

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

Common Nervous System Abbreviations

Common Nervous System Abbreviations

- **AD** (Alzheimer's disease)
- **ADHD** (attention deficit hyperactivity disorder)
- **ALS** (amyotrophic lateral sclerosis)
- **CNS** (central nervous system)
- **CP** (cerebral palsy)
- **CSF** (cerebrospinal fluid)
- **CTE** (chronic traumatic encephalopathy)
- **CVA** (cerebrovascular accident)
- **EEG** (electroencephalogram)
- **EP studies** (evoked potential studies)
- **LP** (lumbar puncture)
- **MRI** (magnetic resonance imaging)
- **MS** (multiple sclerosis)
- **OCD** (obsessive-compulsive disorder)
- **PD** (Parkison's disease)
- **PET** (positron emission tomography)
- **PNS** (peripheral nervous system)
- **PTSD** (post-traumatic stress disorder)
- **SAH** (subarachnoid hemorrhage)
- **TIA** (transient ischemic attack)

Activity Source: Nervous System Abbreviations by Kim Carter, from *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY 4.0. /Text version added.

Image Descriptions

Figure 16.13 image description: A silhouette of a human with only the brain, spinal cord, PNS ganglia, nerves and a section of the digestive tract visible. The brain, which is part of the CNS, is the area of perception and processing of sensory stimuli (somatic/autonomic), the execution of voluntary motor responses (somatic), and the regulation of homeostatic mechanisms (autonomic). The spinal cord, which is part of the CNS, is the area where reflexes are initiated. The gray matter of the ventral horn initiates somatic reflexes while the gray matter of the lateral horn initiates autonomic reflexes. The spinal cord is also the somatic and autonomic pathway for sensory and motor functions between the PNS and the brain. The nerves, which are part of the PNS, are the fibers of sensory and motor neurons, which can be either somatic or autonomic. The ganglia, which are part of the PNS, are the areas for the reception of somatic and autonomic sensory stimuli. These are received by the dorsal root ganglia and cranial ganglia. The autonomic ganglia are also the relay for visceral motor responses. The digestive tract is part of the enteric nervous system, the ENS, which is located in the digestive tract and is responsible for autonomous function. The ENS can operate independent of the brain and spinal cord. [Return to Figure 16.13].

Attribution

16.4 - Nervous Systems Diseases, Disorders and Diagnostic Testing

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

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

Several diseases can result from the demyelination of axons. The causes of these diseases are not the same; some have genetic causes, some are caused by pathogens, and others are the result of autoimmune disorders. Though the causes are varied, the results are largely similar. The myelin insulation of axons is compromised, making electrical signaling slower (Betts et al., 2013).

Multiple sclerosis (MS) is one such disease. It is an example of an autoimmune disease. The antibodies produced by lymphocytes (a type of white blood cell) mark myelin as something that should not be in the body. This causes inflammation and the destruction of the myelin in the central nervous system. As the insulation around the axons is destroyed by the disease, scarring becomes obvious (Betts et al., 2013).

Guillain-Barre (pronounced gee-YAN bah-RAY) syndrome is an example of a demyelinating disease of the peripheral nervous system. It is also the result of an autoimmune reaction, but the inflammation is in peripheral nerves. Sensory symptoms or motor deficits are common, and autonomic failures can lead to changes in the heart rhythm or a drop in blood pressure, especially when standing, which causes dizziness (Betts et al., 2013).

Other Nerve Disorders

Infection, trauma, and congenital disorders can all lead to significant signs, as identified through the neurological exam. It is important to differentiate between an acute event, such as stroke, and a chronic or global condition, such as blunt force trauma. Responses seen in the neurological exam can help. A loss of language function observed in all its aspects is more likely a global event as opposed to a discrete loss of one function, such as not being able to say certain types of words. A concern, however, is that a specific function—such as controlling the muscles of speech—may mask other language functions. The various subtests within the mental status exam can address these finer points and help clarify the underlying cause of the neurological loss (Betts et al., 2013).

Stroke

Damage to the nervous system can be limited to individual structures or can be distributed across broad areas of the brain and spinal cord. Localized, limited injury to the nervous system is most often the result of circulatory problems. The loss of blood flow to part of the brain is known as a **stroke**, or a cerebrovascular accident (CVA). There are two main types of stroke, depending on how the blood supply is compromised: ischemic and hemorrhagic. An **ischemic stroke** is the loss of blood flow to an area because vessels are blocked or narrowed. This is often caused by an embolus, which may be a blood clot or fat deposit. Ischemia may also be the result of thickening of the blood vessel wall, or a drop in blood volume in the brain known as **hypovolemia**. A **hemorrhagic stroke** is bleeding into the brain because of a damaged blood vessel. Accumulated blood fills a region of the cranial vault and presses against the tissue in the brain (see Figure 16.15) (Betts et al., 2013).

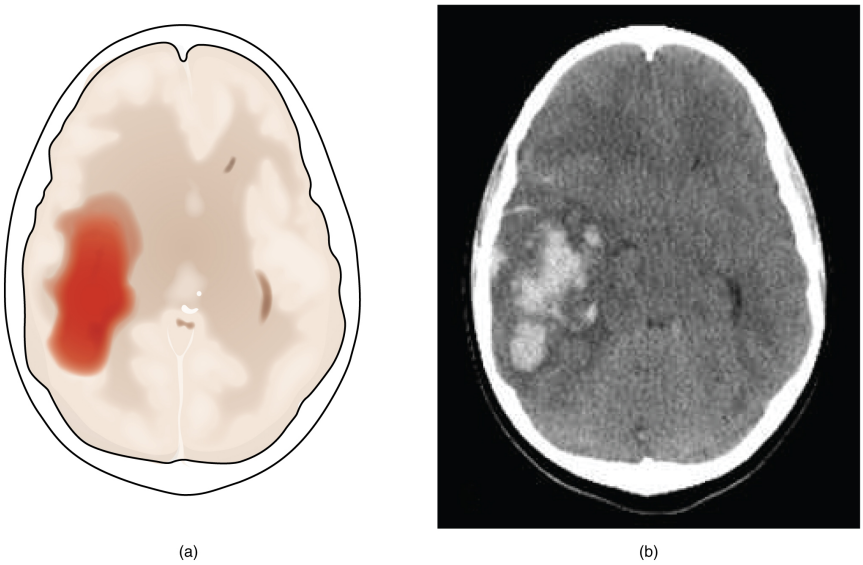


Figure 16.15 Hemorrhagic Stroke. (a) A hemorrhage into the tissue of the cerebrum results in a large accumulation of blood with an additional edema in the adjacent tissue. The hemorrhagic area causes the entire brain to be disfigured as suggested here by the lateral ventricles being squeezed into the opposite hemisphere. (b) A CT scan shows an intraparenchymal hemorrhage within the parietal lobe. (credit b: James Heilman). From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 16.15 Image description.]

Cerebral Palsy

Cerebral Palsy (CP) is caused by an interruption to the normal development of a person's brain leading to weakness with muscles. Depending on the area of the brain that is affected, signs and symptoms will vary in the type and severity between individuals. Balance and coordination are often challenging due the inability to control muscles (Centers for Disease Control and Prevention, 2024, Ontario Federation for Cerebral Palsy, 2018). To learn more about cerebral palsy, please visit the Centers for Disease Control and Prevention's web page on cerebral palsy [New Tab].

Traumatic Brain Injury (TBI)

According to the Minister of Health, approximately 20,000 people in Canada are hospitalized (each year) for traumatic brain injures. Brain injuries range from moderate to severe and include concussions. TBI can be caused by falls, automobile accidents, sports, assaults, and strokes. Investment has been made to educate people on how to prevent TBIs with a focus on concussions from sports (Taylor, 2019).

Neurological System Medical Terms in Use

Neurological System

Neurological System – History and Physical Examination (Text version)
Use the words below to fill in the history and physical examination form:

- festination
- depression
- fatigue
- postural
- rigidity
- cognition
- downgoing
- q.i.d

PATIENT NAME: Susan LOGAN

AGE: 62

SEX: Female

DOB: March 24

DATE OF ASSESSMENT: December 10

ADMITTING PHYSICIAN: Martin Lewis, MD, Neurology

DIAGNOSIS: Parkinson disease

HISTORY: This pleasant and co-operative 62-year-old woman has advanced parkinsonism which presents for more than 10 years. It is affecting her daily living to a great degree. She has minor difficulty with ADLs noted in difficulty dressing and meal preparation. She has had frequent falls occasionally related to freezing or to _____[Blank 1] but also occurring without any apparent cause. She has marked hesitancy on changing direction and unsteadiness after exertion and develops _____[Blank 2]. She has a minor problem with sialorrhea, eating, and swallowing. She can maintain basic personal hygiene without any difficulty. However, showering or bathing requires assistance. She has had some symptoms of anxiety and _____[Blank 3] along with her Parkinson disease.

PHYSICAL EXAMINATION: On neurologic exam, she did have mild-to-moderate impairment in _____[Blank 4] and short-time memory, although she is alert and oriented x3. She has pronounced tremor, worse in the left arm than the right. She has marked _____[Blank 5] in the upper left extremity; mild in the right. She has marked reduction of movement with long delays in initiating movement and frequent freezing. She has a moderately-flexed posture and cannot straighten

to command. She has _____[Blank 6] instability. Her speech is mildly dysarthric. She has paucity of spontaneous facial expression. She has an unsteady and erratic gait characterized by shuffling strides with festination in propulsion. She can arise from a chair with difficulty only after multiple attempts. Deep tendon reflexes (DTRs) are symmetrical, and toes are _____[Blank 7]. Cranial nerves are intact and unremarkable.

TREATMENT AND PLAN: She has been on Sinemet 25/100 t.i.d. for the last 7 years or so. She will be going on vacation soon, and I do not wish to start a second antiparkinsonian medication while she away from medical supervision. However, I have asked her to increase her Sinemet dose to _____[Blank 8]. We will see how she does with Sinemet and plan to add bromocriptine 1 mg per day when she returns.

FOLLOW UP: The patient has been scheduled for follow up in 3 weeks, upon her return from vacation. Her treatment regimen will be adjusted at that time.

_____
Martin Lewis, MD, Neurology

Note: Report samples (H5P and Pressbooks) are to encourage learners to identify correct medical terminology and do not represent the Association for Health Documentation Integrity (AHDI) formatting standards.

Check your answers: [1]

Neurological System – Consultation Report

Neurological System – Consultation Report (Text version)
Use the word below to fill in the consultation report:

- cognition
- dementia
- hypertension
- downgoing
- neurological
- symptomatic
- MRI
- stroke
- blurred

NEUROLOGICAL SYSTEM – CONSULTATION REPORT
PATIENT NAME: Robert BROWN
AGE: 74
SEX: Male

DOB: July 5
DATE OF CONSULTATION: April 15
CONSULTING PHYSICIAN: Martin Lewis, MD, Neurology

REASON FOR CONSULTATION: Assessment of cognitive changes and testing.

HISTORY: The patient presented a few days ago with a marked change in _____[Blank 1] identified by his family members and care staff. The reports describe two episodes of the patient presenting a somewhat confused state, instability with a "holding of the temples" and a report of blurring vision. The patient was also observed holding on to walls and furniture to walk around. This seems to have been two transient episodes and has not recurred since. Prior to that, he had maintained excellent cognitive abilities with full lingual ability, no signs of aphasia, _____[Blank 2] or loss of consciousness. The cognitive decline noticed was not of gradual onset but rather an acute change within hours to a day. The time span is unclear as the patient lives alone and there was a time lapse between a family visit and the arrival of a personal care assistant.

The patient is a good historian to questioning and does admit to some recent occasional headaches and _____[Blank 3] vision. These are new to him as he reports never having "had a headache" in his "whole life". He reports that the blurring is not constant but only seems to occur when he turns his head to right or left suddenly. There is a "tilting sensation" like he will fall but this clears when he brings his head back to center. He has no history of epilepsy or seizure disorders. No history of TM or ear trauma.

PHYSICAL EXAMINATION: HEENT: Head is normocephalic. EYES: PERRLA. EARS: Auditory exam reveals intact TMs bilaterally. No erythema. The nose and throat exam is unremarkable. NECK: JVD appears normal. VITAL SIGNS: Blood pressure is 132/86 with no previous history of _____[Blank 4]. Pulse is 83 and resp. 22 but the patient does admit to feeling anxious during the assessment. Temperature 37C.

NEURO: Orientation and language are normal. Extremity strength testing show some minimal weakness in the right upper. Reflexes are normal. Toes are _____[Blank 5] bilaterally. Has difficulty with heel-and toe-walk and is unable to tandem walk. The gait is alternately normal and minimally spastic.

IMPRESSION: What appears to be a transient or acute cognitive change with altered awareness, headache and cephalo-positional blurring of vision. There is some _____[Blank 6] change, although minimal and not clinically diagnostic, as evidenced by the slight changes in gait during testing but it does not remain consistently. This is puzzling.

PLAN: It is still not clear to me what these spells are. Some of the neurological possibilities to be considered are TIA, _____[Blank 7], brain and spinal cord tumors, inflammation, infection, vascular irregularities, and some neurodegenerative disorders. I have ordered a stat cerebral _____[Blank 8], electroencephalogram (EEG) and blood levels for CBC, chem panel. However, I feel we should also rule out the more common possibilities of pseudo-seizure, vertigo, and inner ear anomalies and am in the process of making these appropriate bookings.

I have booked a follow up with this patient in 10 days to review the results. He and his family have been advised to contact me immediately if he has another "spell" or to present to the ER where we can complete testing when the patient is _____[Blank 9].

Thank you for this most interesting referral. I will be in touch after I have reviewed the patient.

_____
Martin Lewis, MD, Neurology

Note: Report samples (H5P and Pressbooks) are to encourage learners to identify correct medical terminology and do not represent the Association for Health Documentation Integrity (AHDI) formatting standards.

Check your answers: [2]

Neurological System- Follow Up Report

Neurological System – Follow Up Report (Text version)
Use the words below to fill in the follow-up report:

- electroencephalogram
- balance
- pathology
- vertigo
- coordination
- white matter
- hemorrhagic
- wasting
- calcifications
- mass
- somnolence
- symptomatic

PATIENT NAME: Randy NORTON
AGE: 74
SEX: Male
DOB: October 14
DATE OF ASSESSMENT: January 18
ASSESSING PHYSICIAN: Martin Lewis, MD, Neurology

REASON FOR ASSESSMENT: Follow up assessment of cognitive changes and testing.

HISTORY: This 74-year-old patient was seen in consultation 10 days ago for assessment of cognitive changes. He underwent prescribed testing in the forms of cerebral MRI, _____[Blank 1] (EEG) and blood was drawn for CBC and chem panel. The patient was seen by our local ENT for inner ear and _____[Blank 2] testing. Test results showed normal hearing. No evidence of an inner ear _____[Blank 3] that might have contributed to the _____[Blank 4] or lack of balance and _____[Blank 5] reported as part of the presenting symptoms.

TEST RESULTS: Cerebral MRI reveals a few T2 hyperintensities in the _____[Blank 6] in the

left temporal lobe. The right hemisphere shows some diffuse _____[Blank 7] and some occipital wasting. There are multiple, small dark _____[Blank 8] areas and a few areas indicative of ischemia.

EEG: This showed some depressive effect indicative of an encephalopathy. The patient did not sleep during the exam but did show some signs of _____[Blank 9]. CBC and chem panels were normal.

IMPRESSIONS: This patient present with testing result that may be warning for Alzheimer wasting and also, some localized hemorrhagic events that have since stopped. This type of "leakage" is often not _____[Blank 10], and I do not feel that they are connected to his presenting complaints. I see no signs of tumor or _____[Blank 11] formation nor infectious process.

On repeat verbal assessment, the patient reports he has not experienced any more of the spells. We will follow him closely in regards to the _____[Blank 1]2 with a repeat MRI and perhaps a CT also in 3 months for results comparison to see whether the wasting has advanced or receded.

Thank you for asking me in on this most interesting case.

_____
Martin Lewis, MD, Neurology

Note: Report samples (H5P and Pressbooks) are to encourage learners to identify correct medical terminology and do not represent the Association for Health Documentation Integrity (AHDI) formatting standards.

Check your answers: [3]

Medical Specialties

Primary Specialist – Neurologist

Neurologists are medical doctors who complete an additional 5 years of specialized training in the prevention, diagnosis, and treatment of disorders and conditions related to the brain, spinal cord, nerves and muscles (Canadian Medical Association, 2019). For more details, please follow the link to the Canadian Medical Association's page on Neurology profile [PDF].

Procedures Related to the Nervous System

Lumbar Puncture

A neurologist may order this procedure to test cerebrospinal fluid (CSF). This procedure is recommended if they believe symptoms are caused by a problem in the nervous system that can be detected in the cerebrospinal fluid. The procedure involves inserting a needle into the spine after numbing it and taking a sample of cerebrospinal fluid (Canadian Cancer Society, n.d.).

Tensilon Test

This procedure can help a neurologist diagnose myasthenia gravis. In this test, the doctor injects with a medicine called Tensilon, then they observe how it affects muscle movements (Bergen, 2018). For more information, visit Healthline's Tensilon Test web page [New Tab].

Electromyography (EMG)

An EMG measures electrical activity between your brain or spinal cord to a peripheral nerve. This nerve is found in your arms and legs, and is responsible for muscle control during times of movement and rest. EMGs can help your neurologist diagnose spinal cord disease as well as general muscle or nerve dysfunction (Moores & Cirino, 2018).

Electroencephalogram (EEG)

With electrodes applied to your scalp, an EEG measures electrical activity in the brain. It's used to help diagnose conditions of the brain, including inflammation, tumors, and injuries, as well as seizures and psychiatric disorders.

Image Descriptions

Figure 16.15 image description: The left panel of this figure shows an image of the brain with a region in red. This red region indicates a hemorrhage associated with a stroke. The right panel shows a hemorrhage as it might appear on a CT scan. [Return to Figure 16.15].

Attribution

Except where otherwise noted, this chapter is adapted from "Nervous System" in *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY 4.0. / A derivative of Betts et al., which can be accessed for free from *Anatomy and Physiology (OpenStax)*. Adaptations: dividing Nervous System chapter content into sub-chapters.

Notes

1. 1.festination, 2.fatigue, 3.depression, 4.cognition, 5.rigidity, 6.postural, 7.downgoing, 8.q.i.d,
2. 1.cognition, 2.dementia, 3.blurred, 4.hypertension, 5.downgoing, 6.neurological, 7.stroke, 8.MRI, 9.symptomatic
3. 1.electroencephalogram, 2.balance, 3.pathology, 4.vertigo, 5.coordination, 6.white matter, 7.calcifications, 8.hemorrhagic, 9.somnolence, 10.symptomatic, 11.mass, 12.wasting

Vocabulary & Check Your Knowledge

Nervous System Vocabulary

Afferent nerves
Nerves that carry sensory signals (nerve impulses) toward the CNS from the periphery.

Aphasia
Loss of language function.

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

Astrocyte
Glial cell type of the CNS that provides support for neurons and maintains the blood-brain barrier.

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

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

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

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

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

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

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

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

Blood-brain Barrier (BBB)
Physiological barrier between the circulatory system and the central nervous system that establishes a privileged blood supply, restricting the flow of substances into the CNS.

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

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

Broca's Area
Region of the frontal lobe associated with the motor commands necessary for speech production and located only in the cerebral hemisphere responsible for language production, which is the left side in approximately 95 percent of the population

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

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

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

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

Central Sulcus

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

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

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

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

Cerebral Hemisphere

One half of the bilaterally symmetrical cerebrum.

Cerebrospinal Fluid (CSF)

Circulatory medium within the CNS that is produced by ependymal cells in the choroid plexus filtering the blood.

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

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

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

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

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

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

Dorsal (posterior) nerve root
Axons entering the posterior horn of the spinal cord.

Dura mater
Tough, fibrous, outer layer of the meninges that is attached to the inner surface of the cranium and vertebral column and surrounds the entire CNS.

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

Embolus
Obstruction in a blood vessel such as a blood clot, fatty mass, air bubble, or other foreign matter that interrupts the flow of blood to an organ or some part of the body.

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

Ependymal cell
Glial cell type in the CNS responsible for producing cerebrospinal fluid.

Epithalamus
Region of the diencephalon containing the pineal gland.

Fissures
A groove, natural division or elongated cleft, furrow or tear; naturally occurring in the brain, they are also known as sulcus/sulci.

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

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

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

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

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

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

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

Hydrocephalus
An abnormal buildup of cerebrospinal fluid (CSF) in the ventricles of the brain.

Hypothalamus
Major region of the diencephalon that is responsible for coordinating autonomic and endocrine control of homeostasis.

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

Integration

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

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

Lumbar puncture
Procedure used to withdraw CSF from the lower lumbar region of the vertebral column that avoids the risk of damaging CNS tissue because the spinal cord ends at the upper lumbar vertebrae.

Medulla oblongata
The continuation of the spinal cord within the skull, forming the lowest part of the brainstem, contains the control centers for heart and lung nerve function.

Meninges
Protective outer coverings of the CNS composed of connective tissue.

Microglia
Glial cell type in the CNS that serves as the resident component of the immune system.

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

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

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

Myelin
Lipid-rich insulating substance surrounding the axons of many neurons, allowing for faster transmission of electrical signals.

Myelin sheath
Lipid-rich layer of insulation that surrounds an axon, formed by oligodendrocytes in the CNS and Schwann cells in the PNS; facilitates the transmission of electrical signals.

Nerve
Cord-like bundle of axons located in the peripheral nervous system that transmits sensory input and response output to and from the central nervous system.

Neuron
Neural tissue cell that is primarily responsible for generating and propagating electrical signals into, within, and out of the nervous system.

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

Neurotransmitter
Chemical that is released from a nerve cell, transmits an impulse from a nerve cell to another nerve, muscle, organ, or other tissue.

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

Nucleus
In the nervous system, a localized collection of neuron cell bodies that are functionally related; a “center” of neural function.

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

Olfaction
Special sense responsible for smell, which has a unique, direct connection to the cerebrum.

Oligodendrocyte
Glial cell type in the CNS that provides the myelin insulation for axons in tracts.

Paresis
Partial loss of, or impaired, voluntary muscle control.

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

Peripheral nervous system (PNS)
Anatomical division of the nervous system that is largely outside the cranial and vertebral cavities, namely all parts except the brain and spinal cord.

Pia mater
Thin, innermost membrane of the meninges that directly covers the surface of the CNS.

Pons
Latin word meaning bridge, essential part of the brain located above the medulla, action in regulation and controls of vital functions primarily sleep, respiration, swallowing, bladder control, hearing, balance (equilibrium), taste, ocular movement, facial expression and sensation.

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

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

Satellite cell
Glial cell type in the PNS that provides support for neurons in the ganglia.

Schwann cell
Glial cell type in the PNS that provides the myelin insulation for axons in nerves.

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

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

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

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

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

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

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

Sulcus/sulci
Groove formed by convolutions in the surface of the cerebral cortex; see fissure.

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

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

Sympathetic nervous system (SNS)
Part of the nervous system that serves to accelerate heart rate, constrict blood vessels and raise blood pressure in response to stress.

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

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

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

Transient ischemic attack (TIA)
Temporary disruption of blood flow to the brain in which symptoms occur rapidly but last only a short time.

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

Ventricle
Central cavity within the brain where CSF is produced and circulates.

Wernicke's area
Region at the posterior end of the lateral sulcus in which speech comprehension is localized.

White matter

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

Nervous System Glossary Reinforcement Activity

Nervous System Glossary Reinforcement Activity (Text version)

1. The outer gray matter covering the forebrain, marked by wrinkles and folds known as gyri and sulci is called the _____[Blank 1].

    a. Multipolar
    b. Cerebral cortex
    c. Dendrite

2. The single process of the neuron that carries an electrical signal (action potential) away from the cell body toward a target cell is called the _____[Blank 2].

    a. Axon
    b. Cauda equina
    c. Cerebrum

3. The large opening in the occipital bone of the skull through which the spinal cord emerges and the vertebral arteries enter the cranium is called the _____[Blank 3].

    a. Foramen magnum
    b. Corpus callosum
    c. Dura mater

4. The disruption of blood flow to the brain because blood cannot flow through blood vessels as a result of a blockage or narrowing of the vessel is called _____[Blank 4].

    a. Ischemic stroke
    b. Embolus
    c. Initial segment

5. The major region of the diencephalon that is responsible for coordinating autonomic and endocrine control of homeostasis is called the _____[Blank 5].

    a. Hypothalamus
    b. Myelin
    c. Neuron

Check your answers: [1]

Activity source: Nervous System Glossary Reinforcement Activity by Gisele Tuzon, from *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY- 4.0. /Text version added.

Attribution

Notes

1. 1. a) Cerebral cortex, 2.a) Axon, 3. a) Foramen magnum, 4. a) Ischemic stroke, 5. a) Hypothalamus

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CHAPTER 17: ENDOCRINE SYSTEM

Building a Medical Terminology Foundation 2e by Kimberlee Carter; Marie Rutherford; and Connie Stevens

Please visit the web version of *Building a Medical Terminology Foundation 2e* to access the complete book, interactive activities and ancillary resources.

17.1 - Introduction to Endocrine System

Learning Objectives

- Identify the anatomy of the endocrine system and describe the main functions of the endocrine system
- Analyze, translate, and define medical terms and common abbreviations of the endocrine system
- Practice the spelling and pronunciation of endocrine system terminology
- Identify the medical specialties associated with the endocrine system and explore common diseases, disorders, diagnostic tests and procedures

Endocrine System Word Parts

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

Prefix

- **hypo**– (below, under, deficient)
- **hyper-** (above, excessive)
- **para-** (around, beside, beyond, abnormal)
- **syn-** (joined, together)
- **pan-** (all, total)

Combining Form

- **acr/o** (extremities, height)
- **aden/o** (gland)
- **adren/o** (adrenal glands)
- **adrenal/o** (adrenal glands)

- **calc/i** (calcium)
- **cortic/o** (cortex, outer layer of a body organ)
- **dips/o** (thirst)
- **glyc/o** (sugar)
- **endocrin/o** (endocrine)
- **kal/i** (potassium)
- **natr/o** (sodium)
- **parathyroid/o** (parathyroid gland)
- **pituitar/o** (pituitary gland)
- **thyr/o** (thyroid gland)
- **thyroid/o** (thyroid gland)

Suffix

- **-al** (pertaining to)
- **-drome** (run, running together)
- **-ectomy** (excision, cut out)
- **-emia** (in the blood)
- **-ia** (conditon of, abnormal state, diseased state)
- **-ism** (state of)
- **-itis** (inflammation)
- **-logist** (specialist or physician who studies and treats)
- **-logy** (study of)
- **-megaly** (enlarged, enlargement)
- **-oid** (resembling)
- **-oma** (tumour)
- **-pathy** (disease)
- **-plasia** (condition of, formation, development, growth)
- **-tomy** (incision, cut into)

Activity source: Endocrine System Word Parts by Kimberlee Carter, from *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY- 4.0. / Text version.

Introduction to the Endocrine System

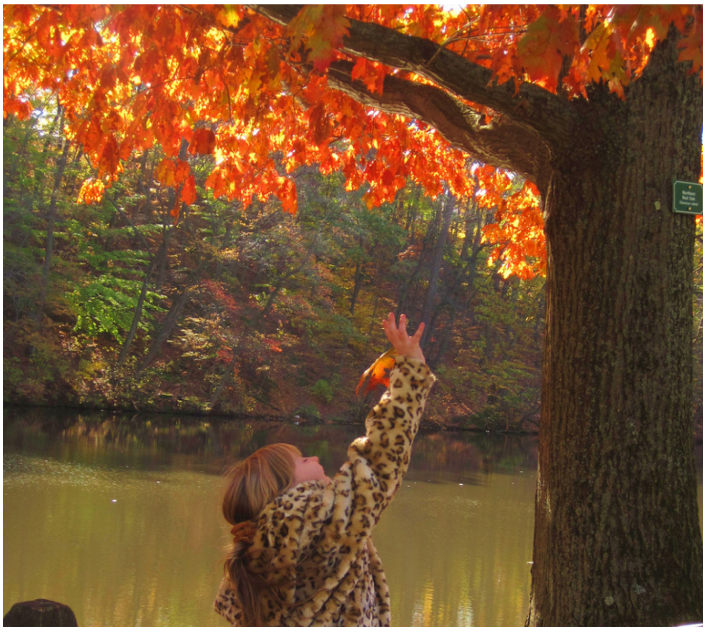

Figure 17.1 A Child Catches a Falling Leaf. Hormones of the endocrine system coordinate and control growth, metabolism, temperature regulation, the stress response, reproduction, and many other functions. (credit: Image by seenthroughmylense, CC BY 2.0).

You may never have thought of it this way, but when you send a text message to two friends to meet you at the dining hall at six, you're sending digital signals that (you hope) will affect their behaviour—even though they are some distance away. Similarly, certain cells send chemical signals to other cells in the body that influence their behaviour. This long-distance intercellular communication, coordination, and control is critical to maintain equilibrium (homeostasis). This intercellular activity is the fundamental function of the endocrine system.

Watch Endocrine System, Part 1 – Glands & Hormones: Crash Course Anatomy & Physiology #23 (11 min) on YouTube

Endocrine System Medical Terms

Endocrine System Medical Terms (Text Version)

Practice the following endocrine system words by breaking into word parts and pronouncing.

1. **endocrinopathy**
    - endocrin/o/pathy
    - disease of the endocrine system
2. **adrenalectomy**
    - adrenal/ectomy
    - excision of the adrenal glands
3. **parathyroidectomy**
    - parathyroid/ectomy
    - excision of the parathyroid glands
4. **adenitis**
    - aden/itis
    - inflammation of the gland
5. **parathyroidoma**
    - parathyroid/oma
    - tumour of the parathyroid glands
6. **thyroiditis**
    - thyroid/itis
    - inflammation of the thyroid gland
7. **thyroidotomy**
    - thyroid/o/tomy
    - incision into the thyroid gland
8. **hyperthyroidism**
    - hyper/thyroid/ism
    - state of excessive thyroid gland activity
9. **acromegaly**
    - acr/o/megaly
    - enlargement of the extremeties
10. **adrenomegaly**
    - adren/o/megaly
    - enlargement of one or both adrenal glands

11. **glycemia**
    - glyc/emia
    - sugar in the blood
12. **hypokalemia**
    - hypo/kal/emia
    - deficient potassium in the blood
13. **hypopituitarism**
    - hypo/pituitar/ism
    - state of deficient pituitary gland activity
14. **adenomegaly**
    - aden/o/megaly
    - enlarged gland
15. **hypocalcemia**
    - hypo/calc/emia
    - deficient calcium in the blood
16. **polydipsia**
    - poly/dips/ia
    - condition of excessive thirst
17. **hypoglycemia**
    - hypo/glyc/emia
    - deficient sugar in the blood
18. **hyperkalemia**
    - hyper/kal/emia
    - excessive potassium in the blood
19. **endocrinopathy**
    - endocrin/o/pathy
    - disease of the endocrine system
20. **hypercalcemia**
    - hyper/calc/emia
    - excessive calcium in the blood
21. **panhypopituitarism**

- pan/hypo/pituitar/ism *rebel does not follow the rules
- state of total deficient pituitary gland activity

22. **cortical**
    - cortic/al
    - pertaining to the cortex
23. **thyroidectomy**
    - thyroid/ectomy
    - excision of the thyroid gland
24. **syndrome**
    - syn/drome
    - run together (signs and symptoms occur together characterizing of a specific disorder)
25. **thyroparathyroidectomy**
    - thyr/o/parathyroid/ectomy
    - excision of the thyroid gland and parathyroid glands
26. **adrenalitis**
    - adrenal/itis
    - inflammation of adrenal glands
27. **thyroidectomy**
    - thyroid/ectomy
    - excision of the thyroid gland
28. **endocrinologist**
    - endocrin/o/logist
    - specialist who studies and treats diseases of the endocrine system
29. **adrenopathy**
    - adren/o/pathy
    - disease of the adrenal gland(s)
30. **corticoid**
    - cortic/oid
    - resembling the cortex
31. **euthyroid**
    - eu/thyr/oid

- resembling a normal thyroid gland

32. **endocrinology**
    - endocrin/o/logy
    - study of the endocrine system
33. **hyponatremia**
    - hypo/natr/emia
    - deficient sodium in the blood
34. **adenectomy**
    - aden/ectomy
    - excision of a gland
35. **euglycemia**
    - eu/glyc/emia
    - normal (level) of blood sugar in the blood
36. **adenosis**
    - aden/osis
    - abnormal condition of a gland
37. **adrenocorticohyperplasia**
    - adren/o/cortic/o/hyper/plasia
    - excessive development of the adrenal cortex

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Attribution

17.2 - Anatomy (Structures) of the Endocrine System

The Endocrine Gland

The endocrine system consists of cells, tissues, and organs that secrete hormones as a primary or secondary function. The **endocrine gland** is the major player in this system. The primary function of the endocrine gland is to secrete hormones directly into the surrounding fluid. The surrounding fluid (interstitial fluid) and the blood vessels then transport the hormones throughout the body. The endocrine system includes the pituitary, thyroid, parathyroid, adrenal, and pineal glands (see Figure 17.2). Some of these glands have both endocrine and non-endocrine functions. For example, the pancreas contains cells that function in digestion as well as cells that secrete the endocrine hormones like insulin and glucagon, which regulate blood glucose levels. The hypothalamus, thymus, heart, kidneys, stomach, small intestine, liver, skin, female ovaries, and male testes are other organs that contain cells with endocrine function. Moreover, fat (adipose) tissue has long been known to produce hormones, and recent research has revealed that even bone tissue has endocrine functions.

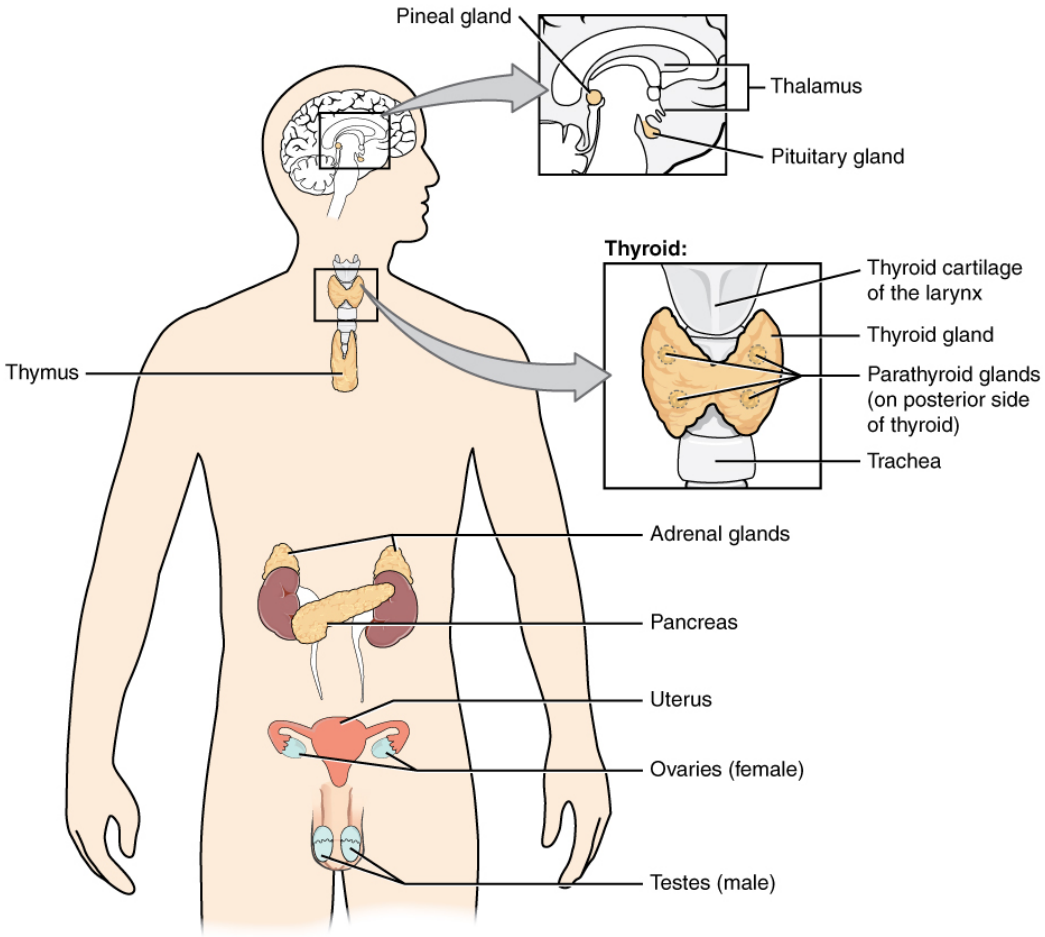


Figure 17.2 Endocrine System. Endocrine glands and cells are located throughout the body and play an important role in maintaining equilibrium (homeostasis). From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 17.2 Image description.]

The ductless endocrine glands are not to be confused with the body's **exocrine system**, whose glands release their secretions through ducts. Examples of exocrine glands include the sebaceous and sweat glands of the skin. As just noted, the pancreas also has an exocrine function: most of its cells secrete pancreatic juice through the pancreatic and accessory ducts to the lumen of the small intestine.

Did You Know?

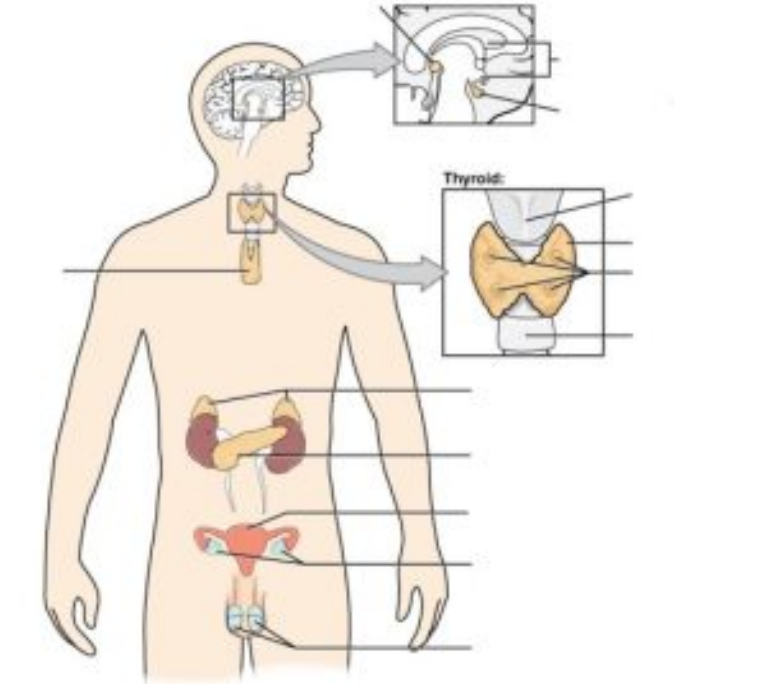
The pancreas acts as a endocrine and exocrine gland.

Endocrine System Anatomy labeling activity

Endocrine System Anatomy labeling activity (Text Version)

Label the diagram with words listed below:

1. Trachea
2. Testes (male)
3. Pancreas
4. Thyroid cartilage of the larynx
5. Pineal gland
6. Thyroid gland
7. Thalamus
8. Adrenal glands
9. Uterus
10. Ovaries (female)
11. Parathyroid glands (on posterior side of thyroid)
12. Thymus
13. Pituitary gland



Endocrine System Diagram (Text Version)

This diagram shows the endocrine glands and cells that are located throughout the body. The endocrine system organs shown from top to bottom include the pea size structure known as the _____[Blank 1] as well as the primary glandular structure of the endocrine system found enclosed within the _____[Blank 2] known as the _____[Blank 3]. The pituitary is located on the anterior side of the thalamus while the pineal gland is located on the posterior side of the thalamus. The _____[Blank 4] is a shield shaped cartilage that forms part of the laryngeal skeleton. This is a butterfly-shaped gland that wraps around the _____[Blank 5] within the neck. Four small, disc-shaped _____[Blank 6] are embedded into the posterior side of the thyroid. The _____[Blank 7] are located on top of the kidneys. The _____[Blank 8] is located at the center of the abdomen. In females, the _____[Blank 9] connects the two _____[Blank 10] a by two long, curved, tubes in the pelvic region. In males, the two _____[Blank 11] are in the scrotum below the penis. One the left side of

the diagram and located in the center of the chest is the _____[Blank 12], a glandular structure responsible for the secretion of a hormone called thymosin.

Check your answers [1]

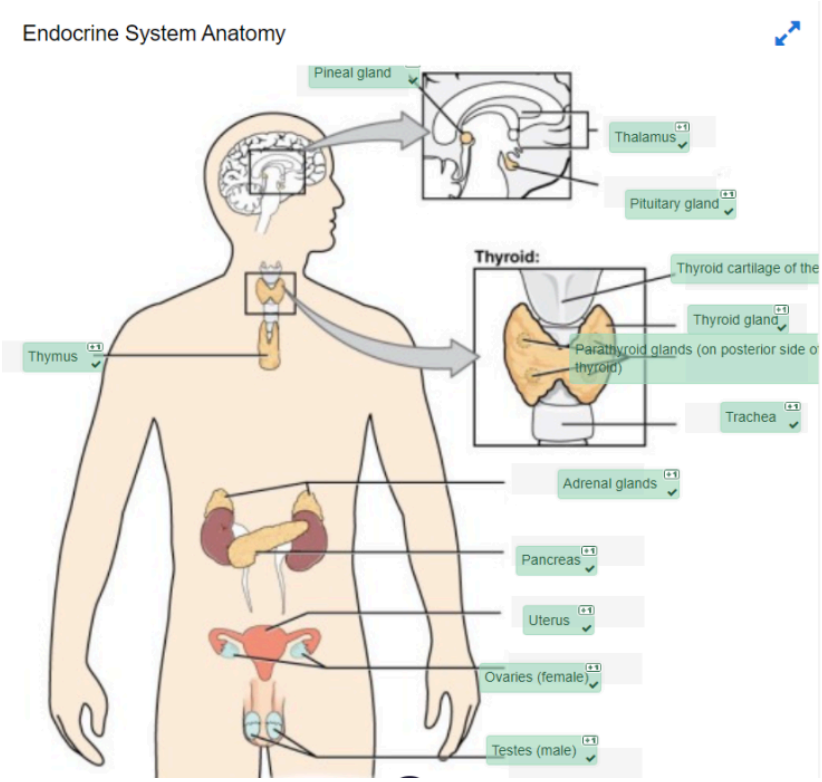
Activity source: Endocrine System Anatomy by Gisele Tuzon, from *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY- 4.0. /Text version added.

Image Descriptions

Figure 17.2 image description: This diagram shows the endocrine glands and cells that are located throughout the body. The endocrine system organs include the pineal gland and pituitary gland in the brain. The pituitary is located on the anterior side of the thalamus while the pineal gland is located on the posterior side of the thalamus. The thyroid gland is a butterfly-shaped gland that wraps around the trachea within the neck. Four small, disc-shaped parathyroid glands are embedded into the posterior side of the thyroid. The adrenal glands are located on top of the kidneys. The pancreas is located at the center of the abdomen. In females, the two ovaries are connected to the uterus by two long, curved, tubes in the pelvic region. In males, the two testes are located in the scrotum below the penis. [Return to Figure 17.2].

Attribution

Notes

1. 

Check your answers: Endocrine System Diagram (Text Version) This diagram shows the endocrine glands and cells that are located throughout the body. The endocrine system organs shown from top to bottom include the pea size structure known as the **pineal gland** as well as the primary glandular structure of the endocrine system found enclosed within the **thalamus** known as the **pituitary gland**. The pituitary is located on the anterior side of the thalamus while the pineal gland is located on the posterior side of the thalamus. The **thyroid cartilage of the larynx** is a shield shaped cartilage that forms part of the laryngeal skeleton. The **thyroid gland** is a butterfly-shaped gland that wraps around the **trachea** within the neck. Four small, disc-shaped **parathyroid glands** are embedded into the posterior side of the thyroid. The **adrenal glands** are located on top of the kidneys. The **pancreas** is located at the center of the abdomen. In females, the **uterus** connects the two **ovaries** a by two long, curved, tubes in the pelvic region. In males, the two **testes** are in the scrotum below the penis. One the left side of the diagram and located in the center of the chest is the **thymus**, a glandular structure responsible for the secretion of a hormone called thymosin.

17.3 - Physiology (Function) of the Endocrine System

Endocrine Signaling

The **endocrine system** uses one method of communication called chemical signaling. These chemical signals are sent by the endocrine organs. The endocrine organs secrete chemicals—called **hormones**—into the fluid outside of the tissue cells (extracellular fluid). Hormones are then transported primarily via the bloodstream throughout the body, where they bind to receptors on target cells, creating a particular response. For example, the hormones released when you are presented with a dangerous or a frightening situation, called the fight-or-flight response, occurs through the release of hormones from the adrenal gland—**epinephrine** and **norepinephrine**—within seconds. In contrast, it may take up to 48 hours for target cells to respond to certain reproductive hormones.

In addition, endocrine signaling is typically less specific than neural (nerve) signaling. The same hormone may also play a role in a variety of different physiological processes depending on the target cells involved. For example, the hormone oxytocin generates uterine contractions in women who are in labour. This hormone is also important in generating the milk release reflex during breastfeeding, and may be involved in the sexual response and in feelings of emotional attachment in both males and females.

Generally, the nervous system involves quick responses to rapid changes in the external environment, and the endocrine system is usually slower acting—taking care of the internal environment of the body, maintaining equilibrium (homeostasis), and in controlling reproduction (see Table 17.1). So how does the fight-or-flight response, that was mentioned earlier, happen so quickly if hormones are usually slower acting? It is because the two systems are connected. It is the fast action of the nervous system in response to the danger in the environment that stimulates the adrenal glands to secrete their hormones, epinephrine and norepinephrine. As a result, the nervous system can cause rapid endocrine responses to keep up with sudden changes in both the external and internal environments, when necessary.

Table 17.1: Endocrine and Nervous Systems. From Betts et al., 2013. Licensed under CC BY 4.0.

Characteristic	Endocrine System	Nervous System
Signaling mechanism(s)	Chemical	Chemical/electrical
Primary chemical signal	Hormones	Neurotransmitters
Distance traveled	Long or short	Always short
Response time	Fast or slow	Always fast
Environment targeted	Internal	Internal and external

Other Types of Chemical Signaling

There are four different types of chemical signaling occurring in multicellular organisms: endocrine signaling, **autocrine** signaling, **paracrine** signaling, and direct signaling.

In **endocrine signaling**, hormones secreted into the extracellular fluid spreads into the blood or lymphatic system, and can, therefore, travel great distances throughout the body.

In contrast, **autocrine signaling** occurs within the same cell. An **autocrine** (auto- = "self") is a chemical that triggers a response in the same cell that secreted the chemical. For example, Interleukin-1 (or IL-1), is a chemical signaling molecule that plays a role in inflammation. The cells that release IL-1 also have receptors on their surface that bind IL-1, resulting in autocrine signaling.

Paracrine signaling occurs amongst neighbouring cells. A **paracrine** (para- = "near") is a chemical that triggers a response in neighbouring cells. Although paracrines may enter the bloodstream, their concentration is generally too low to elicit a response from distant tissues. A familiar example for those with asthma is **histamine**, a paracrine that is released by immune cells. Histamine causes the smooth muscle cells of the lungs to constrict, narrowing the airways.

Direct signaling occurs between neighbouring cells across gap junctions. Gap junctions are channels that connect neighbouring cells, that allow small molecules to move between the neighbouring cells.

Concept Check 1

- Describe the communication methods used by the endocrine system.
- Compare and contrast endocrine and exocrine glands.
- True or false: neurotransmitters are a special class of paracrines? Explain your answer.

Did You Know 1?

Researchers say that one week of camping without electronics resets our biological body clock and synchronizes our melatonin hormones with sunrise and sunset (Shurkin, 2013).

Hormones

Although a given hormone may travel throughout the body in the bloodstream, it will affect the activity only of its target cells; that is, cells with receptors for that particular hormone. Once the hormone binds to the receptor, a chain of events is initiated that leads to the target cell's response. Hormones play a critical role in the regulation of physiological processes because of the target cell responses they regulate. These responses contribute to human reproduction, growth and development of body tissues, metabolism, fluid, and electrolyte balance, sleep, and many other body functions. The major hormones of the human body and their effects are identified in Table 17.2.

Table 17.2: Endocrine Glands and Their Major Hormones. From Betts et al., 2013. Licensed under CC BY 4.0.

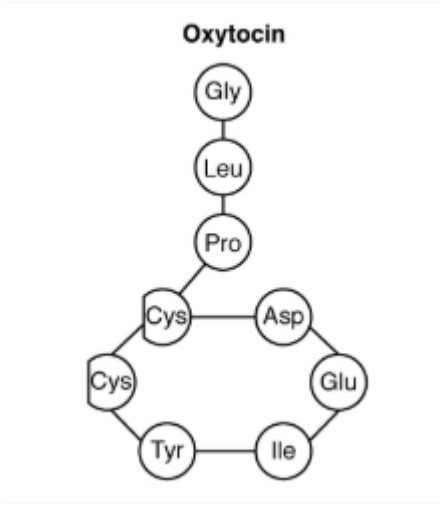
Endocrine Gland	Associated Hormones	Chemical Class	Effect
Pituitary (anterior)	Growth hormone (GH)	Protein	Promotes growth of body tissues
Pituitary (anterior)	Prolactin (PRL)	Peptide	Promotes milk production
Pituitary (anterior)	Thyroid-stimulating hormone (TSH)	Glycoprotein	Stimulates thyroid hormone release
Pituitary (anterior)	Adrenocorticotropic hormone (ACTH)	Peptide	Stimulates hormone release by adrenal cortex
Pituitary (anterior)	Follicle-stimulating hormone (FSH)	Glycoprotein	Stimulates gamete production
Pituitary (anterior)	Luteinizing hormone (LH)	Glycoprotein	Stimulates androgen production by gonads
Pituitary (posterior)	Antidiuretic hormone (ADH)	Peptide	Stimulates water reabsorption by kidneys
Pituitary (posterior)	Oxytocin	Peptide	Stimulates uterine contractions during childbirth
Thyroid	Thyroxine (T_4), triiodothyronine (T_3)	Amine	Stimulate basal metabolic rate
Thyroid	Calcitonin	Peptide	Reduces blood Ca^{2+} levels
Parathyroid	Parathyroid hormone (PTH)	Peptide	Increases blood Ca^{2+} levels
Adrenal (cortex)	Aldosterone	Steroid	Increases blood Na^{+} levels
Adrenal (cortex)	Cortisol, corticosterone, cortisone	Steroid	Increase blood glucose levels
Adrenal (medulla)	Epinephrine, norepinephrine	Amine	Stimulate fight-or-flight response
Pineal	Melatonin	Amine	Regulates sleep cycles
Pancreas	Insulin	Protein	Reduces blood glucose levels
Pancreas	Glucagon	Protein	Increases blood glucose levels
Testes	Testosterone	Steroid	Stimulates development of male secondary sex characteristics and sperm production

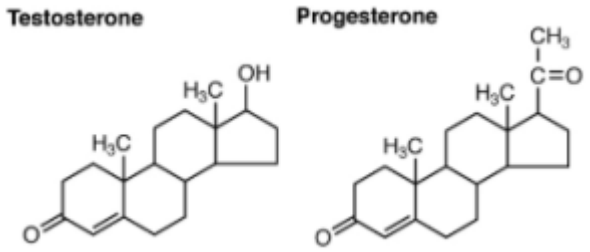
Endocrine Gland	Associated Hormones	Chemical Class	Effect
Ovaries	Estrogens and progesterone	Steroid	Stimulate development of female secondary sex characteristics and prepare the body for childbirth

Types of Hormones

The hormones of the human body can be divided into two major groups on the basis of their chemical structure. Hormones derived from amino acids include amines, peptides, and proteins. Those derived from lipids include steroids (see Table 17.3). These chemical groups affect a hormone's distribution, the type of receptors it binds to, and other aspects of its function.

Table 17.3 Amine, Peptide, Protein, and Steroid Hormone Structure. Adapted from Betts et al., 2013. Licensed under CC BY 4.0.

Hormone Class	Components	Examples
Amine Hormone	Amino acids with modified groups (e.g. norepinephrine's carboxyl group is replaced with a benezene ring)	 *Norepinephrine cellular structure.*
Peptide Hormone	Short chains of linked amino acids	 *Oxytocin cellular structure.*

Hormone Class	Components	Examples
Protein Hormone	Long chains of linked amino acides	 *Human growth hormone illustration.*
Steroid Hormones	Derived from 4ipid cholesterol	 *Testosterone and progesterone cellular structure.*

Amine Hormones

Hormones derived from the modification of amino acids are referred to as amine hormones. Amine hormones are synthesized from the amino acids tryptophan or tyrosine. An example of a hormone derived from tryptophan is melatonin, which is secreted by the pineal gland and helps regulate circadian rhythm.

Peptide and Protein Hormones

Whereas the amine hormones are derived from a single amino acid, peptide and protein hormones consist of multiple amino acids that link to form an amino acid chain. Examples of peptide hormones include antidiuretic hormone (ADH), a pituitary hormone important in fluid balance. Some examples of protein hormones include growth hormone, which is produced by the pituitary gland, and follicle-stimulating hormone (FSH). FSH helps stimulate the maturation of eggs in the ovaries and sperm in the testes.

Steroid Hormones

The primary hormones derived from lipids are steroids. Steroid hormones are derived from the lipid cholesterol. For example, the reproductive hormones testosterone and the estrogens—which are produced by the gonads (testes and ovaries)—are steroid hormones. The adrenal glands produce the steroid hormone aldosterone, which is involved in osmoregulation, and cortisol, which plays a role in metabolism.

Like cholesterol, steroid hormones are not soluble in water (they are hydrophobic). Because blood is water-based, lipid-derived hormones must travel to their target cell bound to a transport protein.

Pathways of Hormone Action

The message a hormone sends is received by a **hormone receptor**, a protein located either inside the cell or within the cell membrane. The receptor will process the message by initiating other signaling events or cellular mechanisms that result in the target cell's response. Hormone receptors recognize molecules with specific shapes and side groups, and respond only to those hormones that are recognized. The same type of receptor may be located on cells in different body tissues, and trigger somewhat different responses. Thus, the response triggered by a hormone depends not only on the hormone, but also on the target cell.

Once the target cell receives the hormone signal, it can respond in a variety of ways. The response may include the stimulation of protein **synthesis**, activation or deactivation of enzymes, alteration in the **permeability** of the cell membrane, altered rates of mitosis and cell growth, and stimulation of the secretion of products. Moreover, a single hormone may be capable of inducing different responses in a given cell.

Factors Affecting Target Cell Response

You will recall that target cells must have receptors specific to a given hormone if that hormone is to trigger a response, but several other factors influence the target cell response. For example, the presence of a significant

level of a hormone circulating in the bloodstream can cause its target cells to decrease their number of receptors for that hormone. This process is called **downregulation**, and it allows cells to become less reactive to the excessive hormone levels. When the level of a hormone is chronically reduced, target cells engage in **upregulation** to increase their number of receptors. This process allows cells to be more sensitive to the hormone that is present. Cells can also alter the sensitivity of the receptors themselves to various hormones.

Two or more hormones can interact to affect the response of cells in a variety of ways. The three most common types of interaction are as follows:

- The permissive effect, in which the presence of one hormone enables another hormone to act. For example, thyroid hormones have complex permissive relationships with certain reproductive hormones. A dietary deficiency of iodine, a component of thyroid hormones, can therefore affect reproductive system development and functioning.
- The synergistic effect, in which two hormones with similar effects produce an amplified response. In some cases, two hormones are required for an adequate response. For example, two different reproductive hormones—FSH from the pituitary gland and estrogens from the ovaries—are required for the maturation of female ova (egg cells).
- The antagonistic effect, in which two hormones have opposing effects. A familiar example is the effect of two pancreatic hormones, insulin and glucagon. Insulin increases the liver's storage of glucose as glycogen, decreasing blood glucose, whereas glucagon stimulates the breakdown of glycogen stores, increasing blood glucose.Regulation of Hormone Secretion

To prevent abnormal hormone levels and a potential disease state, hormone levels must be tightly controlled. The body maintains this control by balancing hormone production and degradation. Feedback loops govern the initiation and maintenance of most hormone secretion in response to various stimuli.

Role of Feedback Loops

The contribution of feedback loops to homeostasis will only be briefly reviewed here. Positive feedback loops are characterized by the release of additional hormone in response to an original hormone release. The release of oxytocin during childbirth is a positive feedback loop. The initial release of oxytocin begins to signal the uterine muscles to contract, which pushes the fetus toward the cervix, causing it to stretch. This, in turn, signals the pituitary gland to release more oxytocin, causing labor contractions to intensify. The release of oxytocin decreases after the birth of the child.

The more common method of hormone regulation is the negative feedback loop. Negative feedback is characterized by the inhibition of further secretion of a hormone in response to adequate levels of that hormone. This allows blood levels of the hormone to be regulated within a narrow range. An example of a negative feedback loop is the release of glucocorticoid hormones from the adrenal glands, as directed by the hypothalamus and pituitary gland. As glucocorticoid concentrations in the blood rise, the hypothalamus and pituitary gland reduce their signaling to the adrenal glands to prevent additional glucocorticoid secretion (see Figure 17.3).

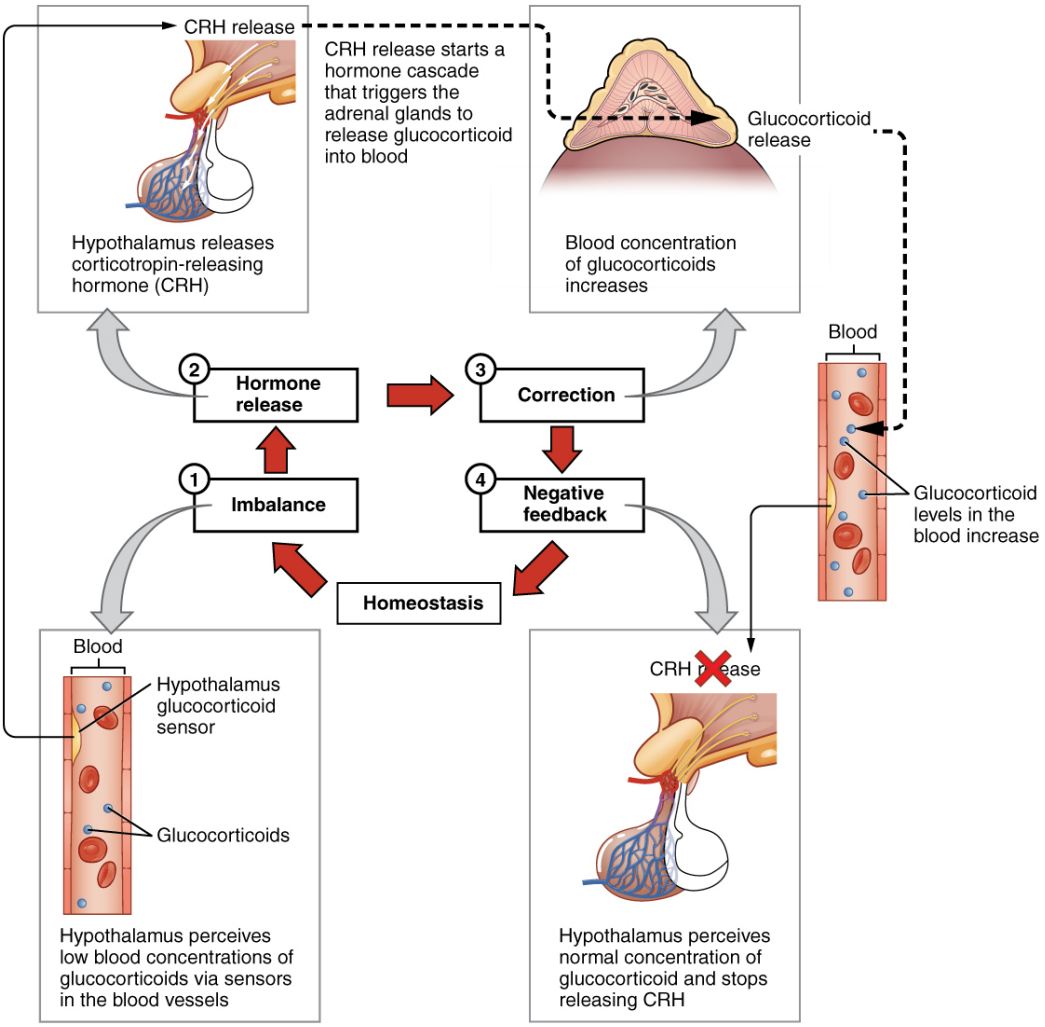


Figure 17.3 Negative Feedback Loop. The release of adrenal glucocorticoids is stimulated by the release of hormones from the hypothalamus and pituitary gland. This signaling is inhibited when glucocorticoid levels become elevated by causing negative signals to the pituitary gland and hypothalamus. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 17.3 Image description.]

Concept Check 2

- Describe how a hormone receptor functions and reacts to messages received.
- Contrast upregulation and downregulation. Are both of these processes necessary? Why or why

not?

Anterior Pituitary Gland

The anterior pituitary originates from the digestive tract in the embryo and migrates toward the brain during fetal development. There are three regions: the pars distalis is the most anterior, the pars intermedia is adjacent to the posterior pituitary, and the pars tuberalis is a slender "tube" that wraps the infundibulum.

Recall that the posterior pituitary does not synthesize hormones, but merely stores them. In contrast, the anterior pituitary does manufacture hormones. However, the secretion of hormones from the anterior pituitary is regulated by two classes of hormones. These hormones—secreted by the hypothalamus—are the releasing hormones that stimulate the secretion of hormones from the anterior pituitary and the inhibiting hormones that inhibit secretion.

Hypothalamic hormones are secreted by neurons, but enter the anterior pituitary through blood vessels. Within the infundibulum is a bridge of capillaries that connects the hypothalamus to the anterior pituitary. This network, called the **hypophyseal portal system**, allows hypothalamic hormones to be transported to the anterior pituitary without first entering the systemic circulation. The system originates from the superior hypophyseal artery, which branches off the carotid arteries and transports blood to the hypothalamus. The branches of the superior hypophyseal artery form the hypophyseal portal system (see Figure 17.4). Hypothalamic releasing and inhibiting hormones travel through a primary capillary plexus to the portal veins, which carry them into the anterior pituitary. Hormones produced by the anterior pituitary (in response to releasing hormones) enter a secondary capillary plexus, and from there drain into the circulation.

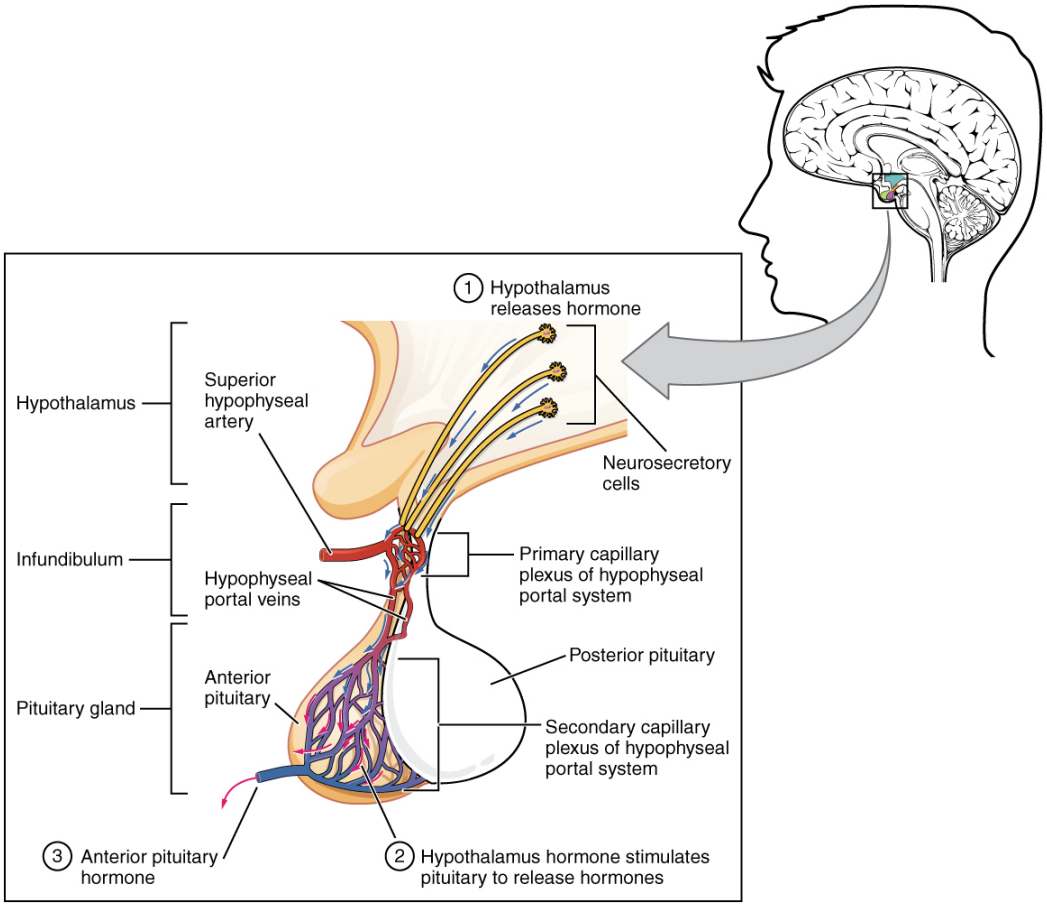


Figure 17.4 Anterior Pituitary. The anterior pituitary manufactures seven hormones. The hypothalamus produces separate hormones that stimulate or inhibit hormone production in the anterior pituitary. Hormones from the hypothalamus reach the anterior pituitary via the hypophyseal portal system. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 17.4 Image description.]

The anterior pituitary produces seven hormones. These are the growth hormone (GH), thyroid-stimulating hormone (TSH), adrenocorticotropic hormone (ACTH), follicle-stimulating hormone (FSH), luteinizing hormone (LH), beta endorphin, and prolactin. Of the hormones of the anterior pituitary, TSH, ACTH, FSH, and LH are collectively referred to as tropic hormones (trope- = "turning") because they turn on or off the function of other endocrine glands.

Growth Hormone

The endocrine system regulates the growth of the human body, protein synthesis, and cellular replication. A major hormone involved in this process is **growth hormone (GH)**, also called somatotropin—a protein hormone produced and secreted by the anterior pituitary gland. Its primary function is anabolic; it promotes protein synthesis and tissue building through direct and indirect mechanisms (see Figure 17.5). GH levels are controlled by the release of GHRH and GHIH (also known as somatostatin) from the hypothalamus.

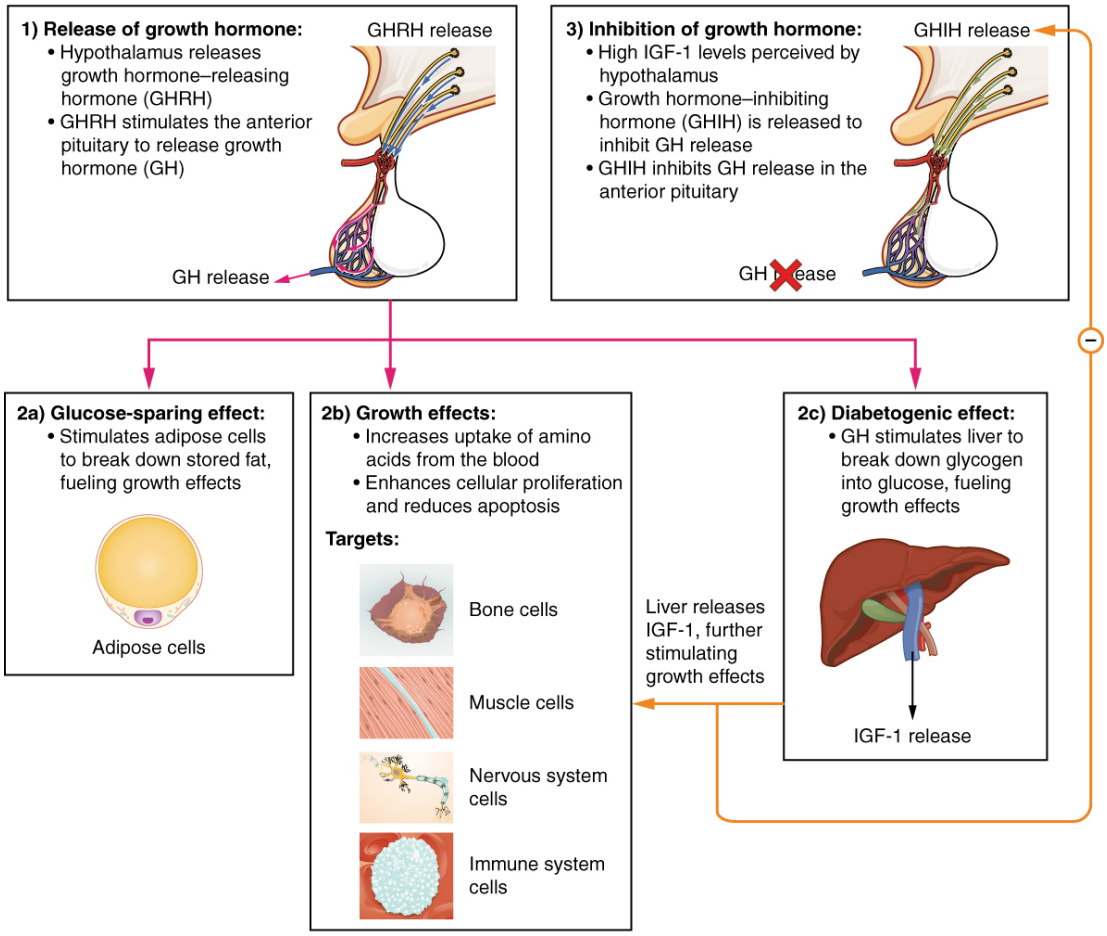


Figure 17.5 Hormonal Regulation of Growth. Growth hormone (GH) directly accelerates the rate of protein synthesis in skeletal muscle and bones. Insulin-like growth factor 1 (IGF-1) is activated by growth hormone and indirectly supports the formation of new proteins in muscle cells and bone. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 17.5 Image description.]

A glucose-sparing effect occurs when GH stimulates lipolysis, or the breakdown of adipose tissue, releasing fatty acids into the blood. As a result, many tissues switch from glucose to fatty acids as their main energy source, which means that less glucose is taken up from the bloodstream.

GH also initiates the diabetogenic effect in which GH stimulates the liver to break down glycogen to glucose, which is then deposited into the blood. The name "diabetogenic" is derived from the similarity in elevated blood glucose levels observed between individuals with untreated diabetes mellitus and individuals experiencing GH excess. Blood glucose levels rise as the result of a combination of glucose-sparing and diabetogenic effects.

GH indirectly mediates growth and protein synthesis by triggering the liver and other tissues to produce a group of proteins called **insulin-like growth factors (IGFs)**. These proteins enhance cellular **proliferation** and inhibit apoptosis, or programmed cell death. IGFs stimulate cells to increase their uptake of amino acids from the blood for protein synthesis. Skeletal muscle and cartilage cells are particularly sensitive to stimulation from IGFs.

Dysfunction of the endocrine system's control of growth can result in several disorders. For example, **gigantism** is a disorder in children that is caused by the secretion of abnormally large amounts of GH, resulting in excessive

growth. A similar condition in adults is **acromegaly**, a disorder that results in the growth of bones in the face, hands, and feet in response to excessive levels of GH in individuals who have stopped growing. Abnormally low levels of GH in children can cause growth impairment—a disorder called **pituitary dwarfism** (also known as growth hormone deficiency).

Posterior Pituitary Gland

The posterior pituitary is actually an extension of the neurons of the nuclei of the hypothalamus. The cell bodies of these regions rest in the hypothalamus, but their axons descend as the hypothalamic–hypophyseal tract within the infundibulum, and end in axon terminals that comprise the posterior pituitary (see Figure 17.6).

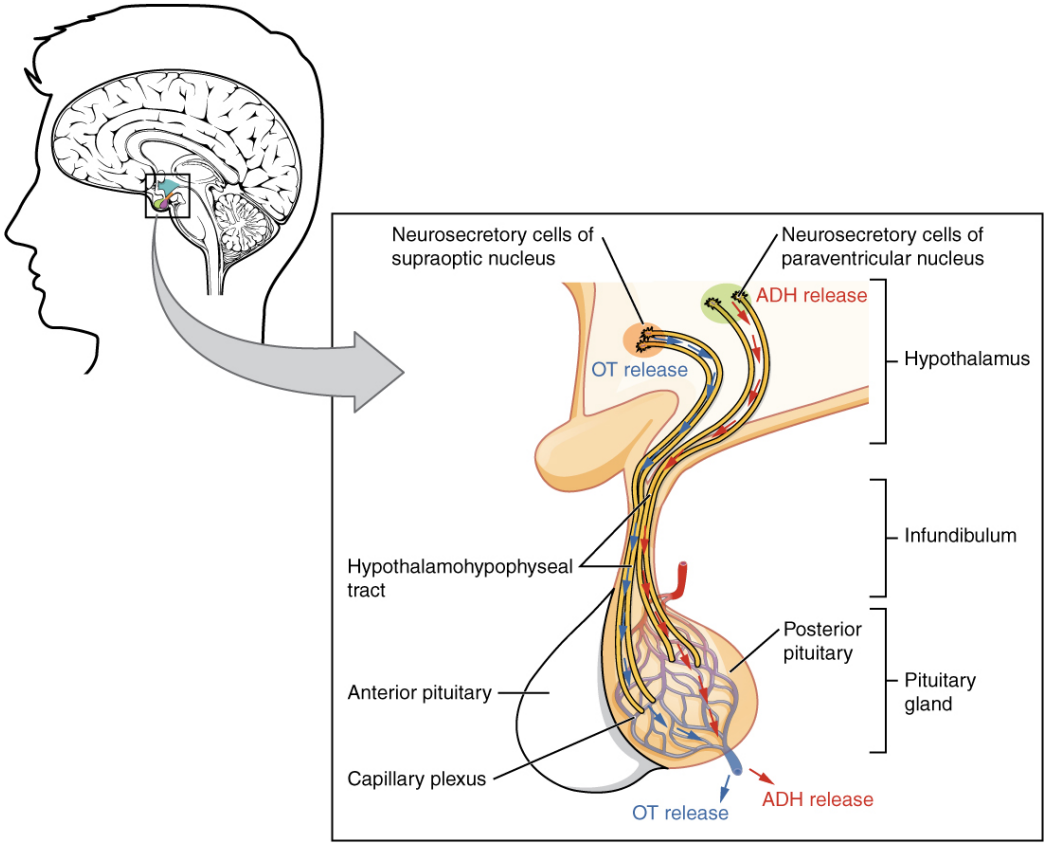


Figure 17.6 Posterior Pituitary. Neurosecretory cells in the hypothalamus release oxytocin (OT) or ADH into the posterior lobe of the pituitary gland. These hormones are stored or released into the blood via the capillary plexus. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 17.6 Image description.]

The posterior pituitary gland does not produce hormones, but rather stores and secretes hormones produced by the hypothalamus. The paraventricular nuclei produce the hormone oxytocin, whereas the supraoptic nuclei produce ADH. These hormones travel along the axons into storage sites in the axon terminals of the posterior pituitary. In response to signals from the same hypothalamic neurons, the hormones are released from the axon terminals into the bloodstream.

Did You Know 2?

Oxytocin is not only used during childbirth, but also breastfeeding.

Oxytocin

When fetal development is complete, the peptide-derived hormone **oxytocin** (tocia- = "childbirth") stimulates uterine contractions and dilation of the cervix. Throughout most of pregnancy, oxytocin hormone receptors are not expressed at high levels in the uterus. Toward the end of pregnancy, the synthesis of oxytocin receptors in the uterus increases, and the smooth muscle cells of the uterus become more sensitive to its effects. Oxytocin is continually released throughout childbirth through a positive feedback mechanism. As noted earlier, oxytocin prompts uterine contractions that push the fetal head toward the cervix. In response, cervical stretching stimulates additional oxytocin to be synthesized by the hypothalamus and released from the pituitary. This increases the intensity and effectiveness of uterine contractions and prompts additional dilation of the cervix. The feedback loop continues until birth.

Although the mother's high blood levels of oxytocin begin to decrease immediately following birth, oxytocin continues to play a role in maternal and newborn health. First, oxytocin is necessary for the milk ejection reflex (commonly referred to as "let-down") in breastfeeding women. As the newborn begins suckling, sensory receptors in the nipples transmit signals to the hypothalamus. In response, oxytocin is secreted and released into the bloodstream. Within seconds, cells in the mother's milk ducts contract, ejecting milk into the infant's mouth. Secondly, in both males and females, oxytocin is thought to contribute to parent–newborn bonding, known as attachment. Oxytocin is also thought to be involved in feelings of love and closeness, as well as in the sexual response.

Antidiuretic Hormone (ADH)

The solute concentration of the blood, or blood osmolarity, may change in response to the consumption of certain foods and fluids, as well as in response to disease, injury, medications, or other factors. Blood osmolarity is constantly monitored by **osmoreceptors**—specialized cells within the hypothalamus that are particularly sensitive to the concentration of sodium ions and other solutes.

In response to high blood osmolarity, which can occur during dehydration or following a very salty meal, the osmoreceptors signal the posterior pituitary to release **antidiuretic hormone (ADH)**. The target cells of ADH

are located in the tubular cells of the kidneys. Its effect is to increase epithelial permeability to water, allowing increased water reabsorption. The more water reabsorbed from the filtrate, the greater the amount of water that is returned to the blood and the less that is excreted in the urine. A greater concentration of water results in a reduced concentration of solutes. ADH is also known as vasopressin because, in very high concentrations, it causes constriction of blood vessels, which increases blood pressure by increasing peripheral resistance. The release of ADH is controlled by a negative feedback loop. As blood osmolarity decreases, the hypothalamic osmoreceptors sense the change and prompt a corresponding decrease in the secretion of ADH. As a result, less water is reabsorbed from the urine filtrate.

Interestingly, drugs can affect the secretion of ADH. For example, alcohol consumption inhibits the release of ADH, resulting in increased urine production that can eventually lead to dehydration and a hangover. A disease called diabetes insipidus is characterized by chronic underproduction of ADH that causes chronic dehydration. Because little ADH is produced and secreted, not enough water is reabsorbed by the kidneys. Although patients feel thirsty, and increase their fluid consumption, this doesn't effectively decrease the solute concentration in their blood because ADH levels are not high enough to trigger water reabsorption in the kidneys. Electrolyte imbalances can occur in severe cases of diabetes insipidus.

Thyroid-Stimulating Hormone

The activity of the thyroid gland is regulated by **thyroid-stimulating hormone (TSH)**, also called thyrotropin. TSH is released from the anterior pituitary in response to thyrotropin-releasing hormone (TRH) from the hypothalamus. As discussed shortly, it triggers the secretion of thyroid hormones by the thyroid gland. In a classic negative feedback loop, elevated levels of thyroid hormones in the bloodstream then trigger a drop in production of TRH and subsequently TSH.

Adrenocorticotropic Hormone

The **adrenocorticotropic hormone (ACTH)**, also called corticotropin, stimulates the adrenal cortex (the more superficial "bark" of the adrenal glands) to secrete corticosteroid hormones such as cortisol. ACTH come from a precursor molecule known as pro-opiomelanotropin (POMC) which produces several biologically active molecules when cleaved, including ACTH, melanocyte-stimulating hormone, and the brain opioid peptides known as endorphins. The release of ACTH is regulated by the corticotropin-releasing hormone (CRH) from the hypothalamus in response to normal physiologic rhythms. A variety of stressors can also influence its release, and the role of ACTH in the stress response is discussed later in this chapter.

Follicle-Stimulating Hormone and Luteinizing Hormone

The endocrine glands secrete a variety of hormones that control the development and regulation of the reproductive system (these glands include the anterior pituitary, the adrenal cortex, and the gonads—the testes in males and the ovaries in females). Much of the development of the reproductive system occurs during puberty and is marked by the development of sex-specific characteristics in both male and female adolescents. Puberty is initiated by gonadotropin-releasing hormone (GnRH), a hormone produced and secreted by the hypothalamus.

GnRH stimulates the anterior pituitary to secrete **gonadotropins**—hormones that regulate the function of the gonads. The levels of GnRH are regulated through a negative feedback loop; high levels of reproductive hormones inhibit the release of GnRH. Throughout life, gonadotropins regulate reproductive function and, in the case of women, the onset and cessation of reproductive capacity.

The gonadotropins include two glycoprotein hormones: **follicle-stimulating hormone (FSH)** stimulates the production and maturation of sex cells, or gametes, including ova in women and sperm in men. FSH also promotes follicular growth; these follicles then release estrogens in the female ovaries. **Luteinizing hormone (LH)** triggers ovulation in women, as well as the production of estrogens and progesterone by the ovaries. LH stimulates production of testosterone by the male testes.

Prolactin

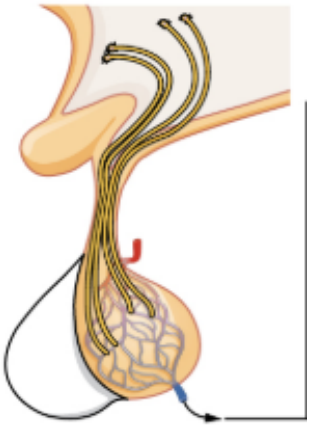
As its name implies, **prolactin (PRL)** promotes lactation (milk production) in women. During pregnancy, it contributes to development of the mammary glands, and after birth, it stimulates the mammary glands to produce breast milk. However, the effects of prolactin depend heavily upon the permissive effects of estrogens, progesterone, and other hormones. And as noted earlier, the let-down of milk occurs in response to stimulation from oxytocin.

In a non-pregnant woman, prolactin secretion is inhibited by prolactin-inhibiting hormone (PIH), which is actually the **neurotransmitter** dopamine, and is released from neurons in the hypothalamus. Only during pregnancy do prolactin levels rise in response to prolactin-releasing hormone (PRH) from the hypothalamus.

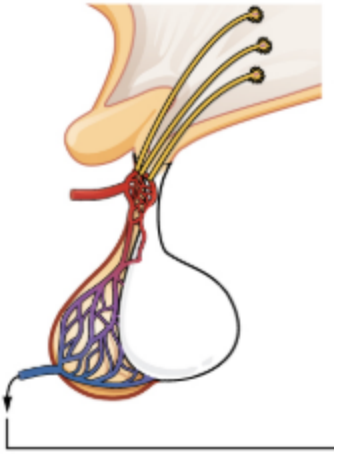
Intermediate Pituitary: Melanocyte-Stimulating Hormone

The cells in the zone between the pituitary lobes secrete a hormone known as melanocyte-stimulating hormone (MSH) that is formed by cleavage of the pro-opiomelanocortin (POMC) precursor protein. Local production of MSH in the skin is responsible for melanin production in response to UV light exposure. The role of MSH made by the pituitary is more complicated. For instance, people with lighter skin generally have the same amount of MSH as people with darker skin. Nevertheless, this hormone is capable of darkening of the skin by inducing melanin production in the skin's melanocytes. Women also show increased MSH production during pregnancy; in combination with estrogens, it can lead to darker skin pigmentation, especially the skin of the areolas and labia minora. Table 17.4 is a summary of the pituitary hormones and their principal effects.

Table 17.4a & b – Major Pituitary Hormones. Major pituitary hormones and their target organs. Adapted from Betts et al., 2013. Licensed under CC BY 4.0



The posterior pituitary gland



The Anterior Pituitary Gland

Table 17.4a – Posterior Pituitary Hormones

Releasing hormone (hypothalamus)	Pituitary Hormone	Target	Effects
ADH	Stores ADH	Kidneys, sweat glands, circulatory system	Water balance
–	OT	Female reproductive system	Triggers uterine contractions during childbirth

Table 17.4b – Anterior Pituitary Hormones

Releasing hormone (hypothalamus)	Pituitary Hormone	Target	Effects
GnRH	LH	Reproductive system	Stimulates production of sex hormones by gonads
GnRH	FSH	Reproductive system	stimulates production of sperm and eggs
TRH	TSH	Thyroid gland	Stimulates the release of thyroid hormone (TH), TH regulates metabolism
PRH (inhibited by PIH)	PRL	Mammary glands	Promotes milk production
GHRH (inhibited by GHIH)	GH	Liver, bone, muscles	Induces targets to produce insulin-like growth factors (IGF). IGFs stimulate body growth and higher metabolic rate.
CRH	ACTH	Adrenal glands	Induces targets to produce glucocorticoids, which regulate metabolism and stress response

Pineal Gland

A tiny endocrine gland whose functions are not entirely clear. The **pinealocyte** cells that make up the pineal gland are known to produce and secrete the amine hormone **melatonin**, which is derived from serotonin.

The secretion of melatonin varies according to the level of light received from the environment. When photons of light stimulate the retinas of the eyes, a nerve impulse is sent to a region of the hypothalamus which is important in regulating biological rhythms. When blood levels of melatonin fall, they promote wakefulness. In contrast, as light levels decline, such as during the evening, melatonin production increases, boosting blood levels and causing drowsiness.

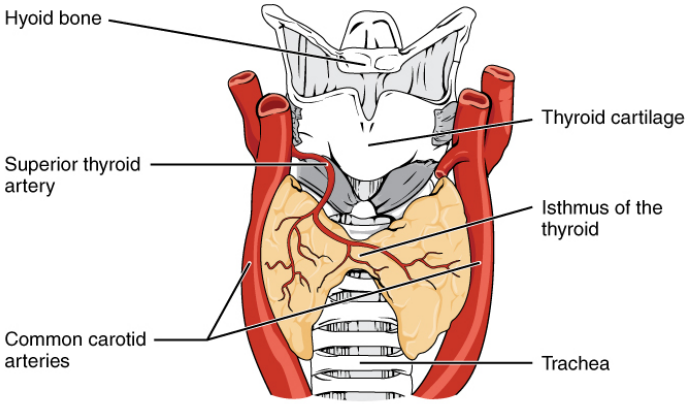
Watch 2-Minute Neuroscience: Melatonin (2 min) on YouTube

What should you avoid doing in the middle of your sleep cycle that would lower melatonin?

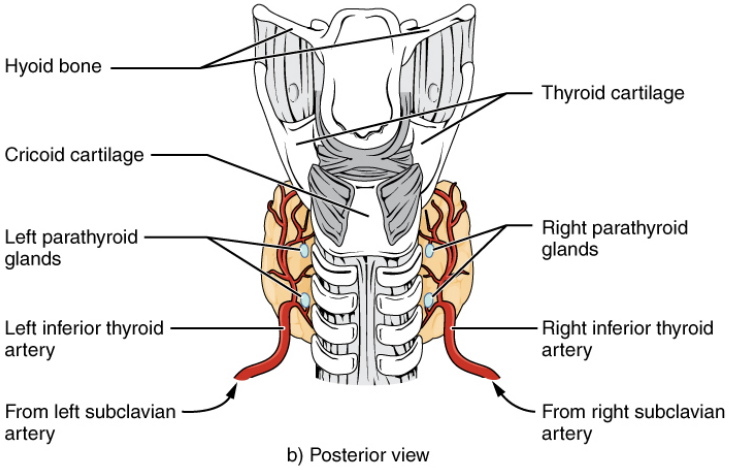
The secretion of melatonin may influence the body's circadian rhythms, the dark-light fluctuations that affect not only sleepiness and wakefulness, but also appetite and body temperature. Interestingly, children have higher melatonin levels than adults, which may prevent the release of gonadotropins from the anterior pituitary, thereby inhibiting the onset of puberty. Finally, an antioxidant role of melatonin is the subject of current research. Jet lag occurs when a person travels across several time zones and feels sleepy during the day or wakeful at night. Traveling across multiple time zones significantly disturbs the light-dark cycle regulated by melatonin. It can take up to several days for melatonin synthesis to adjust to the light-dark patterns in the new environment, resulting in jet lag. Some air travelers take melatonin supplements to induce sleep.

Thyroid Gland

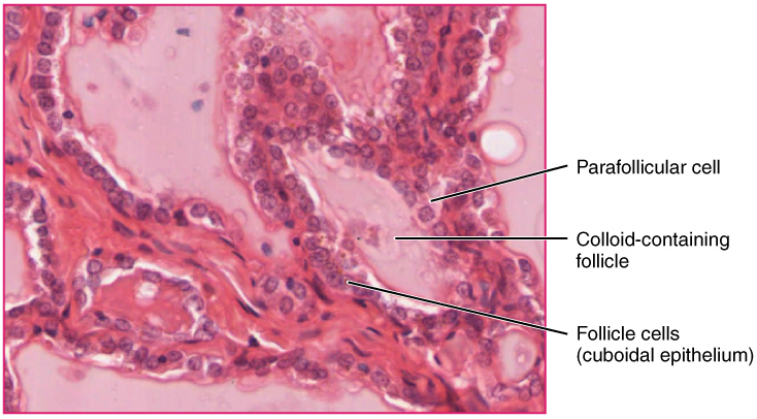
A butterfly-shaped organ, the **thyroid gland** is located anterior to the trachea, just inferior to the larynx (see Figure 17.7). The medial region, called the isthmus, is flanked by wing-shaped left and right lobes. Each of the thyroid lobes are embedded with parathyroid glands, primarily on their posterior surfaces. The tissue of the thyroid gland is composed mostly of thyroid follicles. The follicles are made up of a central cavity filled with a sticky fluid called **colloid**.



a) Anterior view



b) Posterior view



c) Thyroid follicle cells

Figure 17.7 Thyroid Gland. The thyroid gland is located in the neck where it wraps around the trachea. (a) Anterior view of the thyroid gland. (b) Posterior view of the thyroid gland. (c) The glandular tissue is composed primarily of thyroid follicles. The larger parafollicular cells often appear within the matrix of follicle cells. LM × 1332. (Micrograph provided by the Regents of University of Michigan Medical School © 2012). From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 17.7 Image description.]

Regulation of TH Synthesis

The release of T_3 and T_4 from the thyroid gland is regulated by thyroid-stimulating hormone (TSH). Low blood levels of T_3 and T_4 stimulate the release of thyrotropin-releasing hormone (TRH) from the hypothalamus, which triggers secretion of TSH from the anterior pituitary. In turn, TSH stimulates the thyroid gland to secrete T_3 and T_4. The levels of TRH, TSH, T_3, and T_4 are regulated by a negative feedback system in which increasing levels of T_3 and T_4 decrease the production and secretion of TSH. The thyroid hormones, T_3 and T_4, are often referred to as metabolic hormones because their levels influence the body's basal metabolic rate, the amount of energy used by the body at rest.

The thyroid gland also secretes a hormone called **calcitonin** that is produced by the parafollicular cells (also called C cells) that stud the tissue between distinct follicles. Calcitonin is released in response to a rise in blood calcium levels.

Parathyroid Gland

The **parathyroid glands** are tiny, round structures usually found embedded in the posterior surface of the thyroid gland. A thick connective tissue capsule separates the glands from the thyroid tissue. Most people have four parathyroid glands, but occasionally there are more in tissues of the neck or chest. The function of one type of parathyroid cells, the oxyphil cells, is not clear. The primary functional cells of the parathyroid glands are the chief cells. These epithelial cells produce and secrete the **parathyroid hormone (PTH)**, the major hormone involved in the regulation of blood calcium levels.

Adrenal Gland

The **adrenal glands** are wedges of glandular and neuroendocrine tissue adhering to the top of the kidneys by a fibrous capsule (see Figure 17.8). The adrenal glands have a rich blood supply and experience one of the highest rates of blood flow in the body. They are served by several arteries branching off the aorta, including the suprarenal and renal arteries. Blood flows to each adrenal gland at the adrenal cortex and then drains into the adrenal medulla. Adrenal hormones are released into the circulation via the left and right suprarenal veins.

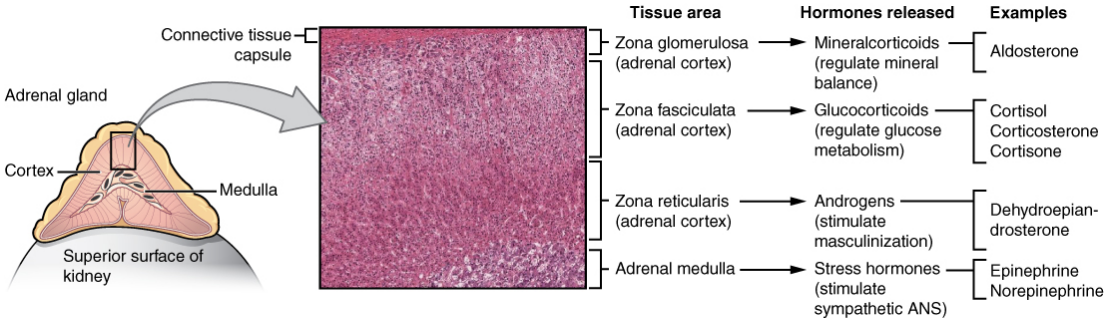


Figure 17.8 Adrenal Glands. Both adrenal glands sit atop the kidneys and are composed of an outer cortex and an inner medulla, all surrounded by a connective tissue capsule. The cortex can be subdivided into additional zones, all of which produce different types of hormones. LM × 204. (Micrograph provided by the Regents of University of Michigan Medical School © 2012). From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 17.8 Image description.]

The **adrenal cortex**, as a component of the hypothalamic-pituitary-adrenal (HPA) axis, secretes steroid hormones important for the regulation of the long-term stress response, blood pressure and blood volume, nutrient uptake and storage, fluid and electrolyte balance, and inflammation. The HPA axis involves the stimulation of hormone release of adrenocorticotropic hormone (ACTH) from the pituitary by the hypothalamus. ACTH then stimulates the adrenal cortex to produce the hormone cortisol. This pathway will be discussed in more detail below.

The **adrenal medulla** is neuroendocrine tissue composed of postganglionic sympathetic nervous system (SNS) neurons. It is really an extension of the autonomic nervous system, which regulates homeostasis in the body. The sympathomedullary (SAM) pathway involves the stimulation of the medulla by impulses from the hypothalamus via neurons from the thoracic spinal cord. The medulla is stimulated to secrete the amine hormones epinephrine and norepinephrine.

One of the major functions of the adrenal gland is to respond to stress. Stress can be either physical or psychological or both. Physical stresses include exposing the body to injury, walking outside in cold and wet conditions without a coat on, or malnutrition. Psychological stresses include the perception of a physical threat, a fight with a loved one, or just a bad day at school.

The body responds in different ways to short-term stress and long-term stress following a pattern known as the **general adaptation syndrome (GAS)**. Stage one of GAS is called the **alarm reaction**. This is short-term stress, the fight-or-flight response, mediated by the hormones epinephrine and norepinephrine from the adrenal medulla via the SAM pathway. Their function is to prepare the body for extreme physical exertion. Once this stress is relieved, the body quickly returns to normal. The section on the adrenal medulla covers this response in more detail.

If the stress is not soon relieved, the body adapts to the stress in the second stage called the **stage of resistance**. If a person is starving for example, the body may send signals to the gastrointestinal tract to maximize the absorption of nutrients from food.

If the stress continues for a longer term however, the body responds with symptoms quite different than the fight-or-flight response. During the **stage of exhaustion**, individuals may begin to suffer depression, the suppression of their immune response, severe fatigue, or even a fatal heart attack. These symptoms are mediated by the hormones of the adrenal cortex, especially cortisol, released as a result of signals from the HPA axis.

Adrenal hormones also have several non–stress-related functions, including the increase of blood sodium and glucose levels, which will be described in detail below.

Adrenal Cortex

The adrenal cortex consists of multiple layers of lipid-storing cells that occur in three structurally distinct regions. Each of these regions produces different hormones.

Watch **Endocrine System, Part 2 – Hormone Cascades: Crash Course Anatomy & Physiology #24 (10 min) on YouTube**

Concept Check 3

- Which hormone produced by the adrenal glands is responsible for the mobilization of energy stores?

Hormones of the Zona Glomerulosa

The most superficial region of the adrenal cortex is the zona glomerulosa, which produces a group of hormones collectively referred to as **mineralocorticoids** because of their effect on body minerals, especially sodium and potassium. These hormones are essential for fluid and electrolyte balance.

Aldosterone is the major mineralocorticoid. It is important in the regulation of the concentration of sodium and potassium ions in urine, sweat, and saliva. For example, it is released in response to elevated blood K^+, low blood Na^+, low blood pressure, or low blood volume. In response, aldosterone increases the excretion of K^+ and the retention of Na^+, which in turn increases blood volume and blood pressure. Its secretion is prompted when CRH from the hypothalamus triggers ACTH release from the anterior pituitary.

Aldosterone is also a key component of the renin-angiotensin-aldosterone system (RAAS) in which specialized cells of the kidneys secrete the enzyme renin in response to low blood volume or low blood pressure. Renin then catalyzes the conversion of the blood protein angiotensinogen, produced by the liver, to the hormone angiotensin I. Angiotensin I is converted in the lungs to angiotensin II by **angiotensin-converting enzyme** (ACE). Angiotensin II has three major functions:

1. Initiating vasoconstriction of the arterioles, decreasing blood flow
2. Stimulating kidney tubules to reabsorb NaCl and water, increasing blood volume
3. Signaling the adrenal cortex to secrete aldosterone, the effects of which further contribute to fluid retention, restoring blood pressure and blood volume

For individuals with hypertension, or high blood pressure, drugs are available that block the production of angiotensin II. These drugs, known as ACE inhibitors, block the ACE enzyme from converting angiotensin I to angiotensin II, thus mitigating the latter's ability to increase blood pressure.

Hormones of the Zona Fasciculata

The intermediate region of the adrenal cortex is the zona fasciculata, named as such because the cells form small fascicles (bundles) separated by tiny blood vessels. The cells of the zona fasciculata produce hormones called **glucocorticoids** because of their role in glucose metabolism. The most important of these is **cortisol**, some of which the liver converts to cortisone. A glucocorticoid produced in much smaller amounts is corticosterone. In response to long-term stressors, the hypothalamus secretes CRH, which in turn triggers the release of ACTH by the anterior pituitary. ACTH triggers the release of the glucocorticoids. Their overall effect is to inhibit tissue building while stimulating the breakdown of stored nutrients to maintain adequate fuel supplies. In conditions of long-term stress, for example, cortisol promotes the catabolism of glycogen to glucose, the catabolism of stored triglycerides into fatty acids and glycerol, and the catabolism of muscle proteins into amino acids. These raw materials can then be used to synthesize additional glucose and ketones for use as body fuels. The hippocampus, which is part of the temporal lobe of the cerebral cortices and important in memory formation, is highly sensitive to stress levels because of its many glucocorticoid receptors.

You are probably familiar with prescription and over-the-counter medications containing glucocorticoids, such as cortisone injections into inflamed joints, prednisone tablets and steroid-based inhalers used to manage severe asthma, and hydrocortisone creams applied to relieve itchy skin rashes. These drugs reflect another role of cortisol—the downregulation of the immune system, which inhibits the inflammatory response.

Hormones of the Zona Reticularis

The deepest region of the adrenal cortex is the zona reticularis, which produces small amounts of a class of steroid sex hormones called androgens. During puberty and most of adulthood, androgens are produced in the gonads. The androgens produced in the zona reticularis supplement the gonadal androgens. They are produced in response to ACTH from the anteri or pituitary and are converted in the tissues to testosterone or estrogens. In adult women, they may contribute to the sex drive, but their function in adult men is not well understood. In post-menopausal women, as the functions of the ovaries decline, the main source of estrogens becomes the androgens produced by the zona reticularis.

Adrenal Medulla

As noted earlier, the adrenal cortex releases glucocorticoids in response to long-term stress such as severe illness. In contrast, the adrenal medulla releases its hormones in response to acute, short-term stress mediated by the sympathetic nervous system (SNS).

The medullary tissue is composed of unique postganglionic SNS neurons called **chromaffin** cells, which are large and irregularly shaped, and produce the neurotransmitters **epinephrine** (also called adrenaline) and **norepinephrine** (or noradrenaline). Epinephrine is produced in greater quantities—approximately a 4 to 1 ratio with norepinephrine—and is the more powerful hormone. Because the chromaffin cells release epinephrine and norepinephrine into the systemic circulation, where they travel widely and exert effects on distant cells, they are considered hormones. Derived from the amino acid tyrosine, they are chemically classified as catecholamines.

The secretion of medullary epinephrine and norepinephrine is controlled by a neural pathway that originates

from the hypothalamus in response to danger or stress (the SAM pathway). Both epinephrine and norepinephrine signal the liver and skeletal muscle cells to convert glycogen into glucose, resulting in increased blood glucose levels. These hormones increase the heart rate, pulse, and blood pressure to prepare the body to fight the perceived threat or flee from it. In addition, the pathway dilates the airways, raising blood oxygen levels. It also prompts vasodilation, further increasing the oxygenation of important organs such as the lungs, brain, heart, and skeletal muscle. At the same time, it triggers vasoconstriction to blood vessels serving less essential organs such as the gastrointestinal tract, kidneys, and skin, and downregulates some components of the immune system. Other effects include a dry mouth, loss of appetite, pupil dilation, and a loss of peripheral vision.

The **pancreas** is a long, slender organ, most of which is located posterior to the bottom half of the stomach (see Figure 17.9). Although it is primarily an exocrine gland, secreting a variety of digestive enzymes, the pancreas has an endocrine function. Its **pancreatic islets**—clusters of cells formerly known as the islets of Langerhans—secrete the hormones glucagon, insulin, somatostatin, and pancreatic polypeptide (PP).

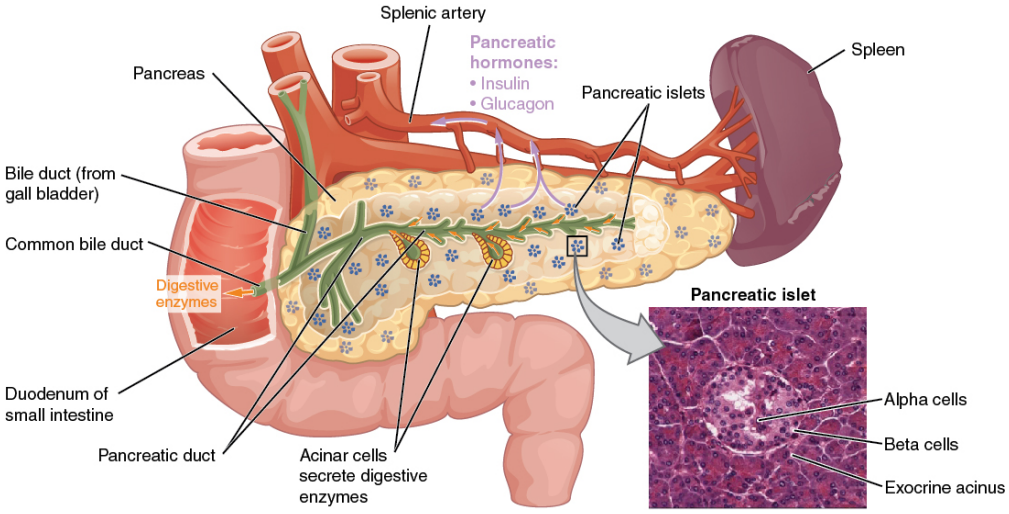


Figure 17.9 Pancreas. The pancreatic exocrine function involves the acinar cells secreting digestive enzymes that are transported into the small intestine by the pancreatic duct. Its endocrine function involves the secretion of insulin (produced by beta cells) and glucagon (produced by alpha cells) within the pancreatic islets. These two hormones regulate the rate of glucose metabolism in the body. The micrograph reveals pancreatic islets. LM × 760. (Micrograph provided by the Regents of University of Michigan Medical School © 2012). From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 17.9 Image description.]

Cells and Secretions of the Pancreatic Islets

The pancreatic islets each contain four varieties of cells:

- The **alpha cell** produces the hormone glucagon and makes up approximately 20 percent of each islet. Glucagon plays an important role in blood glucose regulation; low blood glucose levels stimulate its release.
- The **beta cell** produces the hormone insulin and makes up approximately 75 percent of each islet. Elevated blood glucose levels stimulate the release of insulin.
- The **delta cell** accounts for four percent of the islet cells and secretes the peptide hormone somatostatin. Recall that somatostatin is also released by the hypothalamus (as GHIH), and the stomach and intestines also secrete it. An inhibiting hormone, pancreatic somatostatin inhibits the release of both glucagon and

insulin.

- The **PP cell** accounts for about one percent of islet cells and secretes the pancreatic polypeptide hormone. It is thought to play a role in appetite, as well as in the regulation of pancreatic exocrine and endocrine secretions. Pancreatic polypeptide released following a meal may reduce further food consumption; however, it is also released in response to fasting.

Regulation of Blood Glucose Levels by Insulin and Glucagon

Glucose is required for cellular respiration and is the preferred fuel for all body cells. The body derives glucose from the breakdown of the carbohydrate-containing foods and drinks we consume. Glucose not immediately taken up by cells for fuel can be stored by the liver and muscles as glycogen, or converted to triglycerides and stored in the adipose tissue. Hormones regulate both the storage and the utilization of glucose as required. Receptors located in the pancreas sense blood glucose levels, and subsequently the pancreatic cells secrete glucagon or insulin to maintain normal levels.

Gonadal Glands

The male testes and female ovaries—which produce the sex cells (sperm and ova) and secrete the gonadal hormones. The roles of the gonadotropins released from the anterior pituitary (FSH and LH) were discussed earlier.

The primary hormone produced by the male testes is **testosterone**, a steroid hormone important in the development of the male reproductive system, the maturation of sperm cells, and the development of male secondary sex characteristics such as a deepened voice, body hair, and increased muscle mass. Interestingly, testosterone is also produced in the female ovaries, but at a much reduced level. In addition, the testes produce the peptide hormone **inhibin**, which inhibits the secretion of FSH from the anterior pituitary gland. FSH stimulates spermatogenesis.

The primary hormones produced by the ovaries are **estrogens**, which include estradiol, estriol, and estrone. Estrogens play an important role in a larger number of physiological processes, including the development of the female reproductive system, regulation of the menstrual cycle, the development of female secondary sex characteristics such as increased adipose tissue and the development of breast tissue, and the maintenance of pregnancy. Another significant ovarian hormone is **progesterone**, which contributes to regulation of the menstrual cycle and is important in preparing the body for pregnancy as well as maintaining pregnancy. In addition, the granulosa cells of the ovarian follicles produce inhibin, which—as in males—inhibits the secretion of FSH. During the initial stages of pregnancy, an organ called the placenta develops within the uterus. The placenta supplies oxygen and nutrients to the fetus, excretes waste products, and produces and secretes estrogens and progesterone. The placenta produces human chorionic gonadotropin (hCG) as well. The hCG hormone promotes progesterone synthesis and reduces the mother's immune function to protect the fetus from immune rejection. It also secretes human placental lactogen (hPL), which plays a role in preparing the breasts for lactation, and relaxin, which is thought to help soften and widen the pubic symphysis in preparation for childbirth.

Common Endocrine System Abbreviations

Endocrine System Common Abbreviations

- **ACTH** (adrenocorticotropic hormone)
- **ADH** (antidiuretic hormone)
- **DI** (diabetes insipidus)
- **DKA** (diabetic ketoacidosis)
- **DM** (diabetes mellitus)
- **FBS** (fasting blood sugar)
- **FNA** (fine needle aspiration)
- **FSH** (follicle-stimulating hormone)
- **GH** (growth hormone)
- **HbA1C** (glycosylated hemoglobin)
- **LH** (luteinizing hormone)
- **PRL** (prolactin)
- **RAIU** (radioactive iodine uptake)
- **TSH** (thyroid-stimulating hormone)
- **Thyroid Profile** (T4, T3, and TSH)
- **T4** (thyroxine level)
- **T3**, (triiodothyronine level)
- **TSH** (thyroid stimulating hormone)

Concept Check

- Do you recall the term which describes high level of glucose in the blood?
- Do you recall the neurotransmitter responsible for assisting the response to danger or stress?
- Suggest what may happen if the adrenal cortex failed to secrete its hormones.

Image Descriptions

Figure 17.3 image description: This diagram shows a negative feedback loop using the example of glucocorticoid regulation in the blood. Step 1 in the cycle is when an imbalance occurs. The hypothalamus perceives low blood concentrations of glucocorticoids in the blood. This is illustrated by there being only 5 glucocorticoids floating in a cross section of an artery. Step 2 in the cycle is hormone release, where the hypothalamus releases corticotropin-releasing hormone (CRH). Step 3 is labeled correction. Here, the CRH release starts a hormone cascade that triggers the adrenal gland to release glucocorticoid into the blood. This allows the blood concentration of glucocorticoid to increase, as illustrated by 8 glucocorticoid molecules now being present in the cross section of the artery. Step 4 is labeled negative feedback. Here, the hypothalamus perceives normal concentrations of glucocorticoids in the blood and stops releasing CRH. This brings blood glucocorticoid levels back to homeostasis. [Return to Figure 17.3].

Figure 17.4 image description: This illustration zooms in on the hypothalamus and the attached pituitary gland. The anterior pituitary is highlighted. Three neurosecretory cells are secreting hormones into a web-like network of arteries within the infundibulum. The artery net is labeled the primary capillary plexus of the hypophyseal portal system. The superior hypophyseal artery enters the primary capillary plexus from outside of the infundibulum. The hypophyseal portal vein runs down from the primary capillary plexus, through the infundibulum, and connects to the secondary capillary plexus of the hypophyseal portal system. The secondary capillary plexus is located within the anterior pituitary. The hormones released from the neurosecretory cells of the hypothalamus travel through the primary capillary plexus, down the hypophyseal portal vein, and into the secondary capillary plexus. There, the hypothalamus hormones stimulate the anterior pituitary to release its hormones. The anterior pituitary hormones leave the primary capillary plexus from a single vein at the bottom of the anterior lobe. [Return to Figure 17.4].

Figure 17.5 image description: This flow chart illustrates the hormone cascade that stimulates human growth. In step 1, the hypothalamus releases growth hormone-releasing hormone (GHRH). GHRH travels into the primary capillary plexus of the anterior pituitary, where it stimulates the anterior pituitary to release growth hormone (GH). The release of growth hormone causes three types of effects. In the glucose-sparing effect, GH stimulates adipose cells to break down stored fat, fueling the growth effects (discussed next). The target cells for the glucose-sparing effects are adipose cells. In the growth effects, GH increases the uptake of amino acids from the blood and enhances cellular proliferation while also reducing apoptosis. The target cells for the growth effects are bone cells, muscle cells, nervous system cells, and immune system cells. In the diabetogenic effect, GH stimulates the liver to break down glycogen into glucose, fueling the growth effects. The liver also releases IGF in response to GH. The IGF further stimulates the growth effects but also negatively feeds back to the hypothalamus. When high IGF one levels are perceived by the hypothalamus, it releases growth hormone inhibiting hormone (GHIH). GHIH inhibits GH release by the anterior pituitary. [Return to Figure 17.5].

Figure 17.6 image description: This illustration zooms in on the hypothalamus and the attached pituitary gland. The posterior pituitary is highlighted. Two nuclei in the hypothalamus contain neurosecretory cells that release different hormones. The neurosecretory cells of the paraventricular nucleus release oxytocin (OT) while the neurosecretory cells of the supraoptic nucleus release anti-diuretic hormone (ADH). The neurosecretory cells stretch down the infundibulum into the posterior pituitary. The tube-like extensions of the neurosecretory cells within the infundibulum are labeled the hypothalamophypophyseal tracts. These tracts connect with a web-like network of blood vessels in the posterior pituitary called the capillary plexus. From the capillary plexus, the posterior pituitary secretes the OT or ADH into a single vein that exits the pituitary. [Return to Figure 17.6].

Figure 17.7 image description: Part A of this figure is a diagram of the anterior view of the thyroid gland. The thyroid gland is a butterfly-shaped gland wrapping around the trachea. It narrows at its center, just under the thyroid cartilage of the larynx. This narrow area is called the isthmus of the thyroid. Two large arteries, the common carotid arteries, run parallel to the trachea on the outer border of the thyroid. A small artery enters the superior edge of the thyroid, near the isthmus, and branches throughout the two "wings" of the thyroid. Part B of this figure is a posterior view of the thyroid. The posterior view shows that the thyroid does not completely wrap around the posterior of the trachea. The posterior sides of the thyroid wings can be seen protruding from under the cricoid cartilage of the larynx. The posterior sides of the thyroid "wings" each contain two small, disc-shaped parathyroid glands embedded in the thyroid tissue. Within each wing, one disc is located superior to the other. These are labeled the left and right parathyroid glands. Just under the inferior parathyroid glands are two arteries that bring blood to the thyroid from the left and right subclavian arteries. Part C of this figure is a micrograph of thyroid tissue. The thyroid follicle cells are cuboidal epithelial cells. These cells form a ring around irregular-shaped cavities called follicles. The follicles contain light colored colloid. A larger parafollicular cell is embedded between two of the follicular cells near the edge of a follicle. [Return to Figure 17.7].

Figure 17.8 image description: This diagram shows the left adrenal gland located atop the left kidney. The gland is composed of an outer cortex and an inner medulla all surrounded by a connective tissue capsule. The cortex can be subdivided into additional zones, all of which produce different types of hormones. The outermost layer is the zona glomerulosa, which releases mineralcorticoids, such as aldosterone, that regulate mineral balance. Underneath this layer is the zona fasciculate, which releases glucocorticoids, such as cortisol, corticosterone and cortisone, that regulate glucose metabolism. Underneath this layer is the zona reticularis, which releases androgens, such as dehydroepiandrosterone, that stimulate masculinization. Below this layer is the adrenal medulla, which releases stress hormones, such as epinephrine and norepinephrine, that stimulate the symphathetic ANS. [Return to Figure 17.8].

Figure 17.9 image description: This diagram shows the anatomy of the pancreas. The left, larger side of the pancreas is seated within the curve of the duodenum of the small intestine. The smaller, rightmost tip of the pancreas is located near the spleen. The splenic artery is seen travelling to the spleen, however, it has several branches connecting to the pancreas. An interior view of the pancreas shows that the pancreatic duct is a large tube running through the center of the pancreas. It branches throughout its length in to several horseshoe-shaped pockets of acinar cells. These cells secrete digestive enzymes, which travel down the bile duct and into the small intestine. There are also small pancreatic islets scattered throughout the pancreas. The pancreatic islets secrete the pancreatic hormones insulin and glucagon into the splenic artery. An inset micrograph shows that the pancreatic islets are small discs of tissue consisting of a thin, outer ring called the exocrine acinus, a thicker, inner ring of beta cells and a central circle of alpha cells. [Return to Figure 17.9].

Attribution

17.4 - Endocrine System Diseases, Disorders and Diagnostic Testing

Acromegaly

A disorder in adults caused when abnormally high levels of GH trigger growth of bones in the face, hands, and feet.

Addison's disease

A rare disorder that causes low blood glucose levels and low blood sodium levels. The signs and symptoms of Addison's disease are vague and are typical of other disorders as well, making diagnosis difficult. They may include general weakness, abdominal pain, weight loss, nausea, vomiting, sweating, and cravings for salty food (Betts et al., 2013).

Cushing's disease

A disorder characterized by high blood glucose levels and the accumulation of lipid deposits on the face and neck. It is caused by hypersecretion of cortisol. The most common source of Cushing's disease is a pituitary tumor that secretes cortisol or ACTH in abnormally high amounts (Betts et al., 2013).

Gigantism

A disorder in children caused when abnormally high levels of GH prompt excessive growth in the body (Betts et al., 2013).

Hirsutism

Hirsutism is a symptom of an excessive production of **androgens** causing hair growth in women where they typically do not have hair growth. While some medications may cause the increased androgen production it can also be linked to endocrine disorders such as Polycystic Ovary Syndrome (PCOS), Cushing syndrome, and tumours in the ovaries or adrenal glands (Mayo Clinic Staff, 2021).

Hyperthyroidism

A condition marked by high levels of thyroid hormones that results in weight loss, profuse sweating, and increased heart rate (Betts et al., 2013).

Hypothyroidism

A condition marked by low levels of thyroid hormones that results in weight gain, cold sensitivity, and reduced mental activity (Betts et al., 2013).

Graves Disease

A condition marked by a disorder of the thyroid gland, resulting in hyperthyroidism (Betts et al., 2013).

Diabetes Inspidius

A condition caused by a lack of or hyposecretion of the antidiuretic hormone (ADH). The condition can also be caused by the failure of the kidneys to respond to ADH (Betts et al., 2013).

Diabetes (Mellitus)

A condition marked by a disorder of the pancreas, resulting in high levels of glucose in the blood (Betts et al., 2013).

Endocrine System Medical Terms in Context

Endocrine System – Consultation Report

Endocrine System – Consultation Report (Text version)

Use the words below to fill in the consultation report:

- menstrual
- palpitations
- conjunctival
- antibodies
- side effects
- medications
- discontinue
- elevated

PATIENT NAME: Jane SMITH
AGE: 26
SEX: Female
DATE OF CONSULTATION: January 15, 2020
CONSULTING PHYSICIAN: Mary Johnstone, MD, Internal Medicine
REASON FOR CONSULTATION: Hyperthyroidism; Graves disease.
PATIENT NAME: Jane SMITH
AGE: 26
SEX: Female
DATE OF CONSULTATION: January 15, 2020
CONSULTING PHYSICIAN: Mary Johnstone, MD, Internal Medicine
REASON FOR CONSULTATION: Hyperthyroidism; Graves disease.
HISTORY: Around 2 months ago she started noticing _____[Blank 1] and peripheral tremor. She was feeling more anxious and edgy. She had a 10-pound weight loss despite eating well. She was having some heat intolerance and diarrhea, and her _____[Blank 2] cycles were irregular. She also noticed her eyes were different. She went to see her family doctor who did lab work and was found to have a TSH suppressed with a free T4 around 40 and free T3 around 10. She then had a 24-hour thyroid uptake and scan that was abnormal with a 24-hour of 70 and a diffuse pan with a homogeneous pattern percentage in keeping with Graves disease. Her TSI was _____[Blank 3] at around 30.

PHYSICAL EXAMINATION: On physical exam her blood pressure was 140/60, heart rate was 120 with regular rhythm. She had mild proptosis with no infection of the _____[Blank 4] area. Normal eye movement. No pretibial myxedema. She had a diffuse goiter of around 60 g with no murmur and no nodularity. No abnormal lymphadenopathies. There was a positional tremor. Her weight was 90 pounds.

SOCIAL HISTORY: Jane has no significant past medical history. She is finishing her fourth year in biological studies. She is also working on a part-time basis. She is not aware of a family history of thyroid disease. She is currently on no medications. She is a smoker, around 15 cigarettes a day. She rarely drinks alcohol. She denies marijuana use.

SUMMARY: Jane presents with Graves disease. She has hyperthyroidism positive _____[Blank 5] and an increased thyroid uptake and a thyroid scan in keeping with her condition.
We talked about different repair options. We discussed Tapazole versus radioactive iodine. We discussed the pros and cons of each treatment option. She preferred to start on Tapazole. We talked about the potential _____[Blank 6] of these medications including the risk of rash, increasing liver enzymes, and the rare risk of agranulocytosis. I explained to her that if she has a mild or high fever, she should have her CBC checked through the ER, and if there is evidence of a granulocytosis, she cannot resume Tapazole. Usually Tapazole is well tolerated.

PLAN: I have started her on Tapazole 30 mg, and she will repeat lab work in a month and see me at that point. I explained to her that usually 8-18 months of treatment are necessary. Response varies from

patient to patient. Frequent levels are necessary to adjust the _____[Blank 7] according to response.

If she has side effects to Tapazole or there is no response, or she is experiencing regular flares, then she should _____[Blank 8] the use of the Tapazole. Other options such as radioactive viral can be considered. I would not favour radioactive iodine in her case as she is a smoker and that she has had a mild ophthalmopathy. Radioactive iodine can worsen ophthalmopathy, therefore it should be avoided in smokers.
We talked about the importance of discontinuing smoking as it can worsen the disease.

_____
Mary Johnstone, MD, Internal Medicine

> **Note:** Report samples (H5P and Pressbooks) are to encourage learners to identify correct medical terminology and do not represent the Association for Health Documentation Integrity (AHDI) formatting standards.

Check your answers: [1]

Endocrine System – Consultation Report

"Endocrine System – Consultation Report" (Text version)
Use the words below to fill in the consultation report:

- diabetes
- metabolic
- palpitations
- neuropathy
- congestive
- rhythm
- pulses
- diuretics
- sugars
- vascular disease
- edema

PATIENT NAME: Margaret JONES
SEX: Female
AGE: 56
DATE OF CONSULTATION: January 15, 2020
CONSULTING PHYSICIAN: Mary Johnstone, MD, Internal Medicine

REASON FOR CONSULTATION: Type 2 diabetes.

HISTORY: I saw Margaret as a follow up today in regards to poorly controlled type 2 _____[Blank

1]. She is reluctant to make any changes in her current medications. She is very afraid of side effects of all her medications. She has not been testing her blood sugar but is planning to start doing it again. Unfortunately, Mary did not do lab work prior to seeing me. I do not have an updated lab work for at least 2 years. It is very difficult to assess her _____[Blank 2] control without any information. She continues to be sedentary, but she tells me she has no chest pain or shortness of breath when doing the chores around the house or going up or down the stairs. She denies of orthopnea, ankle swelling, _____[Blank 3], presyncope or syncope.

PAST MEDICAL HISTORY

1. Type 2 diabetes diagnosed 2009. Advanced microvascular complications including non-proliferative retinopathy. Nephropathy with significant microalbuminuria. No _____[Blank 4]. Positive coronary artery disease and peripheral vascular disease. Poor control for several years.
2. Coronary artery disease. CABG 4 in 2019. LIMA to LAD SVG to OM and RCA. Grade 2 left ventricular function. Previous episodes of _____[Blank 5] heart failure preserved ejection fraction with regular admissions due to volume overload.
3. Hypertension.
4. Hypercholesterolemia.
5. Smoker.
6. Alcohol, 5-8 beers a week.
7. Obesity.
8. Peripheral vascular disease, femoral popliteal bypass in 2017.

MEDICATIONS
Aspirin 81 g q.d..
Bisoprolol 5 mg q.d.
Ramipril 20 mg q.d.
Rosuvastatin 20 mg q.d.
Invokana 300 mg q.d.
Tresiba 20 units q.d.
Metformin 1 b.i.d.
Ozempic 1 mg q.wk.

PHYSICAL EXAMINATION: On physical exam her weight was 100 kg. Blood pressure 160/70, heart rate 88/min. Sa and S2 were heard in 4 areas with regular _____[Blank 6]. There is a 2/6 systolic murmur best heard in aortic area with no radiation. Strong carotid pulses and radial _____[Blank 7]. JVP was 3 cm above sternal angle. Lungs were clear. There was bilateral leg _____[Blank 8] with venous changes in keeping with venous stasis dermatitis. Abdomen was soft, no evidence of ascites. No focal findings.

SUMMARY: Margaret has a history of poorly controlled type 2 diabetes and today is very difficult to assess her metabolic control as I do not have any information as she is not checking her blood _____[Blank 9] and has not had lab work for several years. She tells me she is compliant with her plan.
She also has a history of coronary artery disease and currently has no exertional symptoms. There is no

evidence of significant volume overload, but she has a history of recurrent admissions due to congestive heart failure preserved ejection fraction. She is currently not on _____[Blank 10] and I do not think that needs to be restarted. She should continue on the combination of ACE inhibitors, beta-blockers, antiplatelets, and high intensity setting therapy.

PLAN: I asked her to do lab work and come back to see me to reassess if her treatment plan is adequate. We talked about the importance of quitting smoking. Smoking is associated with increased risk of further coronary events and progression of her peripheral _____[Blank 11].

_____
Mary Johnstone, MD, Internal Medicine

Note: Report samples (H5P and Pressbooks) are to encourage learners to identify correct medical terminology and do not represent the Association for Health Documentation Integrity (AHDI) formatting standards.

Check your answers: [2]

Medical Specialties and Procedures Related to the Endocrine System

Endocrinology is a specialization in the field of medicine that focuses on the treatment of endocrine system disorders. Endocrinologists—medical doctors who specialize in this field—are experts in treating diseases associated with hormonal systems, ranging from thyroid disease to diabetes. Endocrine surgeons treat endocrine disease through the removal of the affected endocrine gland or tissue. Some patients experience health problems as a result of the normal decline in hormones that can accompany aging. These patients can consult with an endocrinologist to weigh the risks and benefits of hormone replacement therapy intended to boost their natural levels of reproductive hormones. In addition to treating patients, endocrinologists may be involved in research to improve the understanding of endocrine system disorders and develop new treatments for these diseases (Betts et al., 2013).

- A **thyroid specialist** is an endocrinologist whose sub specialty is focused on the treatment and disorders of the thyroid gland such as hypothyroidism (too low secretion) and hyperthyroidism (too high secretion).
- A **diabetes specialist** is an endocrinologist whose sub specialty is focused on the treatment of diabetic conditions.

Procedures

Thyroid Scan

This procedure is designed to check the status of the thyroid. In a thyroid scan, a radioactive compound is given and localized in the thyroid gland (Giorgi & Cherney, 2018). To learn more about a thyroid scan, visit HealthLine: Thyroid Scan [New Tab].

Radioactive iodine uptake

Thyroid function evaluated by injecting radioactive iodine and then measuring how much is removed from the blood by the thyroid (MedlinePlus, 2022). To learn more about a radioactive iodine update test, visit Medline Plus: Radioactive Iodine Uptake [New Tab].

Blood Serum Testing

Blood testing to determine the concentration and the presence of various endocrine hormones in the blood. These tests include the following levels: calcium, cortisol, electrolytes, FSH, GH, glucose, insulin, parathyroid hormones, T3, T4, testosterone, and TSH. All of these can be evaluated with blood serum tests (Betts et al., 2013).

Endocrine Surgical Procedures

Most of the surgeries and procedures performed with the endocrine system involve removal of a gland or an incision into the gland. Once an endocrine gland is surgically removed due to a tumor or enlargement, hormone replacement treatment is required. Medication is required to artificially or synthetically replace the hormone produced by the gland and the function it regulates (Betts et al., 2013).

Attribution

Notes

1. 1.palpitations, 2.menstrual, 3.elevated, 4.conjunctival, 5.antibodies, 6.side effects, 7.medications, 8.discontinue

2. 1.diabetes, 2.metabolic, 3.palpitations, 4.neuropathy, 5.congestive, 6.rhythm, 7.pulses, 8.edema, 9.sugars, 10.diuretics, 11.vascular disease

Vocabulary & Check Your Knowledge

Endocrine System Vocabulary

Autocrine

Chemical signal that elicits a response in the same cell that secreted it.

Endocrine gland

Tissue or organ that secretes hormones into the blood and lymph without ducts such that they may be transported to organs distant from the site of secretion.

Endocrine system

Cells, tissues, and organs that secrete hormones as a primary or secondary function and play an integral role in normal bodily processes.

Epinephrine

Also known as adrenaline, is a hormone and neurotransmitter and produced by the adrenal glands.

Exocrine system

Cells, tissues, and organs that secrete substances directly to target tissues via glandular ducts.

Histamine

Involved in the inflammatory response and typically causes itching.

Hormone

Secretion of an endocrine organ that travels via the bloodstream or lymphatics to induce a response in target cells or tissues in another part of the body.

Neurotransmitter

Chemicals acting as signaling molecules that enable neurotransmission.

Norepinephrine

A natural chemical in the body that acts as both a stress hormone and neurotransmitter (a substance that sends signals between nerve cells). It's released into the blood as a stress hormone when the brain perceives stress.

Paracrine

Chemical signal that elicits a response in neighbouring cells; also called paracrine factor.

Permeability

Membrane that causes it to allow liquids or gases to pass through it.

Proliferation

Rapid increase in numbers.

Synthesis

The production of chemical compounds by reaction from simpler materials.

Endocrine System Reinforcement Activity

Endocrine System Reinforcement Activity (Text version)

1. Endocrine glands _____[Blank 1].
    a. secrete chemical messengers that travel in the bloodstream
    b. secrete hormones that travel through a duct to the target organs
    c. release neurotransmitters into the junction between two neurons (synaptic cleft)
    d. include sebaceous glands and sweat glands
2. Chemical signaling that affects neighboring cells is called _____[Blank 2].
    a. autocrine
    b. paracrine
    c. endocrine
    d. neuron
3. Graves disease is _____[Blank 3].
    a. a condition marked by a disorder of the pancreas, resulting in high levels of glucose in the blood.
    b. a condition marked by low levels of thyroid hormones that results in weight gain, cold sensitivity, and reduced mental activity.
    c. a condition marked by a disorder of the thyroid gland, resulting in hyperthyroidism.
    d. a condition marked by high levels of thyroid hormones that results in weight loss, profuse sweating, and increased heart rate.
4. In the endocrine system _____[Blank 4].
    a. the distance travelled by hormones is always short
    b. hormones are secreted into the extracellular fluid
    c. the response time is always fast
    d. the glands release their secretions through ducts

Check your answers: [1]

Activity source: Endocrine System Reinforcement Activity by Tiffany Hunt, from *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY- 4.0. /Text version added.

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Notes

1. 1. a) secrete chemical messengers that travel in the bloodstream, 2. b) paracrine, 3. c) a condition marked by a disorder of the thyroid gland, resulting in hyperthyroidism, 4. b) hormones are secreted into the extracellular fluid,

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CHAPTER 18: ONCOLOGY

Building a Medical Terminology Foundation 2e by Kimberlee Carter; Marie Rutherford; and Connie Stevens

Please visit the web version of *Building a Medical Terminology Foundation 2e* to access the complete book, interactive activities and ancillary resources.

18.1 - Introduction to Oncology

Learning Objectives

- Describe oncology and explore the physiology and activity of cancerous and non-cancerous growths
- Analyze, translate, and define medical terms and common abbreviations of oncology
- Practice the spelling and pronunciation of oncology terminology
- Identify the medical specialties associated with the oncology and explore common diseases, disorders, diagnostic tests, pharmacology, and procedures

Oncology Word Parts

Prefix

- **ana-** (up, apart)
- **apo-** (away from)
- **dys-** (abnormal; difficult)
- **ecto-** (outer)
- **endo-** (within)
- **hyper-** (excessive, increase)
- **meta-** (beyond, change)
- **mutat/o-** (to change)
- **neo-** (new)

Combining Form

- **Capsul/o-** (to box)
- **carcin/o-** (cancer)
- **miss/o-** (to send back)

- **mut/a-** (change)
- **path/o-** (disease)
- **nod/o-** (node)
- **onc/o-** (tumour)
- **sarc/o-** (flesh)

Suffix

- **-carcinom** (cancerous tumour of epithelial origin (internal or external lining of the body, i.e., skin, breast, colon))
- **-genesis** (condition of production, origin)
- **-oma** (tumour)
- **-plasia** (condition of formation)
- **-plasm** (formation)
- **-sarcoma** (connective tissue cancer, such as bones, tendons, cartilage, muscle, and fat)
- **-stasis** (standing still)

Introduction to Oncology

Oncology is the study of tumours; oncologists are the people who study tumours. Carcin/o is a medical term that means cancer. All cancers are considered **neoplasms** which means new growth. Cancerous tumours are called **malignant**. A non-cancerous tumour is called **benign** (good); this is determined through a **biopsy** (Bx). A benign tumour often has the suffix -oma at the end of the word. However, a malignant tumour indicates that there is a cancerous growth. Malignant cells usually multiply rapidly, forming a mass of abnormal cells that enlarges, ulcerates and sheds malignant cells that invade surrounding tissues. These terms will usually have the word carcinoma at the end of the word. The medical specialty of oncology primarily treats patients who have cancer.

The suffix -oma means **tumour**, an abnormal tissue mass that forms through uncontrolled cell growth and divides more than it should. The cells also do not die when they should.

Watch **What is Cancer? What Causes Cancer & How is it Treated? (5 min) on YouTube**

What is producing cancer? What are some carcinogens? A **carcinogen** is a cancer-generating/producing substance. Carcin/o means cancer, and the suffix -gen means producing. There are various causes of cancer, yet many are unknown at this time. Bacteria and viruses, diet, hormones, smoking, radiation, alcohol, environment, chemical, and genetics are all potential risk factors and causes of cancers.

Watch [How do cancer cells behave differently from healthy ones? (4 mins) on YouTube]

Oncology Abbreviations

Oncology Abbreviations

- **BCC-** (basal cell carcinoma)
- **BMT-** (bone marrow transplant)
- **BSE-** (breast self-examination)
- **Bx-** (biopsy)
- **CA-** (cancer)
- **CIS-** (carcinoma in situ)
- **FOBT-** (fecal occult blood test)
- **G –** (grade)
- **Mets-** (metastases)
- **SCC-** (squamous cell carcinoma)
- **TNM-** (tumour-nodes-metastases)
- **TSE-** (testicular self-examination)

Activity source: Oncology Word Parts by Connie Stevens, licensed under CC BY- 4.0.

Attribution

18.2 - Oncology Diagnostic Tools

A biopsy examines the lesion, growth or tumour under a microscope to determine the disease. Once the pathologist determines the issue is malignancy, then grading, staging and metastasis are evaluated.

Grading, Staging and Metastasis

Tumours are also graded as per growth and staged as per the cancer cell spreading.

Grading: Pathologists need to know how different a cancer cell is from a normal one: this is called grading. It is a measure of the severity of cancer. Grading ranges from I to IV, or low grade and high grade. Generally, a lower grade represents a more favourable prognosis.

- **Staging**: Includes the size and spread of cancer from its original site. If it is determined from a pathology report, it is called **pathologic staging.** If diagnostic techniques determine it, it is called **clinical staging.**
- **TNM staging:** Stands for tumour, node, metastasis.
- **T**– indicates the size of the primary tumour and the degree of spread into nearby tissues (local invasion)
- **N**– indicates whether or not cancer has spread to nearby lymph nodes, the size of the nodes that contain cancer, and how many lymph nodes are affected.
- **M**– The cancer cells have spread to other organs, called metastasis or Mets.

Once the TNM is determined for particular cancer, an overall stage is determined. The stage ranges from 0 to IV (0–4). These numbers help identify whether the cancer is early or advanced. The higher the number, the more advanced cancer:

- **stage 0** –carcinoma in situ (cancer appears only at the site and has not spread).
- **stages I and II** –the cancer is limited to the organ or location where it began, or it may have spread to a nearby structure (localized spread).
- **stage III** –cancer has spread further into a surrounding structure or to the regional lymph nodes (regional spread).
- **stage IV** –cancer has spread to a distant site in the body (metastatic spread).

Watch How is Cancer Staged? (4 min) on YouTube

Attribution

18.3 - Oncology Diseases, Disorders, Treatment

Cancers within Body Systems

Carcinomas make up most of all cancers and are malignant tumours of epithelial tissues. Epithelial tissue line the body surfaces, including those of glands and organs, therefore, carcinomas make up most glandular cancers and are often found in the breast, stomach, uterus, tongue, and skin. The tumours are labelled according to where the malignancy or the primary tumour is housed.

Sarcomas originate in the connective or supportive tissue of the body, such as the muscles, tendons, fat, joints, and bones. They are named by adding the suffix -oma, meaning tumour, to the end of the combining word.

Leukemias are cancer of blood-forming tissues. **Lymphomas** are cancerous tumours of the lymph nodes. In comparison, **myeloma** is a cancerous tumour arising from the hematopoietic portion of the bone marrow.

Endocrine system

Cancers commonly occur in the endocrine system. Many such as thyroid cancer, can be treated by surgically removing the gland. The client must take a synthetic version of the necessary hormones.

Pancreatic cancer is almost always fatal because no effective treatments are currently available (McDonnell et al., 2019).

Female Reproductive system

When looking at the female reproductive system, many organs can be susceptible to cancer: breast, uterine, ovarian, and cervical cancer.

Fibroids tend to be benign (non-cancerous) but should be monitored to ensure their growth does not change. A hormonal disturbance usually causes these growths.

Breast Cancer

Breast cancer is common in females; however, males can get breast cancer, and make up less than 1% of all breast cancers. Breast cancer may be detected through breast self-examination. Breast self-examination (BSE) is crucial in determining if a person's breast lumps or bumps are growing or have changed (Sessa et al., 2023).

There are different types of breast cancers, including:

- Cancer which begins in the milk ducts (**ductal carcinoma**). Most male breast cancer is ductal carcinoma.
- Cancer which begins in the milk-producing glands (**lobular carcinoma**). This type is rare in men because they have few lobules in their breast tissue.
- Other rarer types of breast cancer include Paget's disease of the nipple and inflammatory breast cancer.

Gastrointestinal

The gastrointestinal system has many different types of cancer. They include the esophagus, the stomach, the pancreas, the rectum, or the liver (Faigel & Rodriguez, 2022). A typical test conducted is the **fecal occult blood test (FOBT)**. It is a test done on the stool. It is looking for hidden or occult blood within the fecal matter.

Integumentary System

Skin cancer is quite common due to exposure to the sun and other radiation. When looking at the ABCDE of cancer:

- A is the lesion is asymmetrical
- B is the rough-edged borders, which determines if the lesion has spread
- C is the colour. What colour is the tumour?
- D is the diameter. Is the lesion growing in width?
- E is the lesion elevated or evolving

Basal cell carcinoma (BCC) is the most common type of skin cancer.

Squamous cell carcinoma affects the squamous epithelium layer of the skin.

Melanoma, often called malignant melanoma is a deadly cancer. The colour black means melan/o, -oma means tumour.

People who are at the highest risk tend to be those who are fair-skinned. Light skin contains less melanin, which allows the absorption of radiation. The elderly, who have endured a lifetime of sunlight exposure, are also at higher risk. The use of sunscreen and avoidance of prolonged exposure to the sun not only reduces the damage to the skin but prevents the development of skin cancer (Thanh et al., 2020).

Dermatofibroma is a fibrous tumour of the skin.

Lymphatic System

Lymphoma is any tumour or a mass within the lymph node. Hodgkin's lymphoma is a malignant disease of the lymph nodes.

Male Reproductive System

When looking at the male reproductive system, a male may have cancer of the testicles, penis, or prostate gland.

Testicular self-examinations (TSE) are essential to determine a tumour and its growth.

As men age, their prostate will overgrow, and it is important to have a biopsy done to determine if the prostate is benign or cancerous. Prostate cancer is typically slow-growing, and most men will die with the cancer, not from cancer.

As men age as early as 40 years of age, they may experience the symptoms of benign prostatic hyperplasia (BPH), which is extremely common. It is a benign, non-cancerous growth which may have the same symptoms as prostate cancer, therefore, a biopsy should be conducted to determine if the enlargement is malignant or benign.

The treatment for testicular cancer is to perform an orchidectomy. It is an aggressive and primary surgical approach to treating testicular cancer. If the patient wants to father children, several semen samples can be stored for possible future use before the orchidectomy (Kaufman et al., 2019)

Musculoskeletal

Sarc/o is connective tissue

Oste/o is bone.

Leimy/o is smooth muscle, such as areas within the abdomen, uterus and blood vessels.

The musculoskeletal carcinomas treatment varies and can include a bone marrow transplant, radiation, and chemotherapy.

Urinary System

Within the urinary system, a person may have kidney or bladder cancer.

A congenital kidney cancer called a Wilms tumour is not detected until a child grows. The child is born with a tumour, and as the toddler grows and starts to walk, it is noted that the child's abdomen is protruding significantly. That is because the kidneys, which are at the back of the body, have enlarged due to the tumour. The enlarged kidneys push the abdomen forward. The child may have a low-grade fever without a known cause. This cancer can be deadly if not caught early, and often children will die from this disease (Aldrink et al., 2019)

Pharmacology

There are many different types of cancer medications. These include **alkylating agents, antimetabolites, and plant alkaloids.**

Physicians use cancer medications alone or in combination with other treatments, such as radiation therapy. The best type and combination will depend on several factors, including the disease progression and the patient's overall health.

Treatment for cancer

The most commonly used methods for cancer treatment include surgery, radiation therapy, and chemotherapy (treatment with chemicals). Newer methods of immunotherapy use substances that stimulate the immune system. Hormone therapy may be effective against certain types of tumours. When there are no active signs of the disease, the cancer is said to be in remission.

Attribution

Vocabulary & Check Your Knowledge

Oncology Vocabulary

Basal Cell carcinoma (BCC)

The most common type of skin cancer.

Benign

A non-cancerous tumour.

Benign prostatic hyperplasia (BPH)

A common, benign, non-cancerous growth which may have the same symptoms as prostate cancer.

Biopsy (Bx)

A diagnostic procedure that examines the lesion, growth or tumour under a microscope to determine the disease.

Carcinogen

A cancer-generating/producing substance.

Carcinomas

Malignant tumours of epithelial tissues that make up most of all cancers.

Dermatofibroma

A fibrous tumour of the skin.

Ductal carcinoma

A form of breast cancer which begins in the milk ducts. Most male breast cancer is ductal carcinoma.

Fecal occult blood test (FOBT)

A test done on the stool, looking for hidden or occult blood within the fecal matter.

Fibroids

Benign (non-cancerous) growths in the female reproductive system usually caused by a hormonal disturbance.

Hodgkin's lymphoma

A malignant disease of the lymph nodes.

Lobular carcinoma

A breast cancer which begins in the milk-producing glands.

Leukemias

Cancer of blood-forming tissues.

Lymphoma

Any tumour or a mass within the lymph node.

Malignant

A cancerous tumour.

Melanoma

Often called malignant melanoma; a deadly skin cancer.

Myeloma

A cancerous tumour arising from the hematopoietic portion of the bone marrow.

Orchidectomy

An aggressive and primary surgical approach to treating testicular cancer.

Paget's disease

A rare type of breast cancer affecting the nipple.

Pancreatic cancer

A cancer of the endocrine system that is almost always fatal because no effective treatments are currently available.

Sarcomas

Cancers that originate in the connective or supportive tissue of the body, such as the muscles, tendons, fat, joints, and bones.

Squamous cell carcinoma

A cancer that affects the squamous epithelium layer of the skin.

Tumour

An abnormal tissue mass that forms through uncontrolled cell growth and divides more than it should. The cells also do not die when they should.

Wilms tumour

A congenital kidney cancer often not detected until a child grows.

Oncology Reinforcement Activity

Oncology Reinforcement Activity (Text version)

1. A tumour _____[Blank 1].

    a. is an injury of the nervous system.
    b. is a function of the endocrine system.
    c. is a medical specialty that primarily treats infections.
    d. is an abnormal tissue mass that forms through uncontrolled cell growth and divides more than it should.

2. Some potential risk factors and causes of cancers include _____[Blank 2].

    a. a healthy lifestyle.
    b. bacteria and viruses, diet, hormones, smoking, radiation, alcohol, environment, chemicals, and genetics.
    c. a healthy and balanced diet.
    d. regular exercise.

3. Cancerous growths or tumours can be diagnosed by _____[Blank 3].

    a. aggressive chemical treatments.
    b. a biopsy to examine the lesion, growth or tumour under a microscope to determine the disease.
    c. performing a series of radiation treatments.
    d. administering oral antibiotics to the patient.

4. Lymphoma is _____[Blank 4].

    a. any tumour or a mass within the lymph node.
    b. a type of cancer occurring in the endocrine system.
    c. a type of cancer that primarily affects the blood.
    d. a cancer that affects the bone marrow.

Check your answers: [1]

Attribution

Notes

1. 1. d) is an abnormal tissue mass that forms through uncontrolled cell growth and divides more than it should, 2. b) bacteria and viruses, diet, hormones, smoking, radiation, alcohol, environment, chemicals, and genetics, 3. b) a biopsy to examine the lesion, growth or tumour under a microscope to determine the disease., 4. a) any tumour or a mass within the lymph node

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CHAPTER 19: MENTAL HEALTH

Building a Medical Terminology Foundation 2e by Kimberlee Carter; Marie Rutherford; and Connie Stevens

Please visit the web version of *Building a Medical Terminology Foundation 2e* to access the complete book, interactive activities and ancillary resources.

19.1 - Introduction to Mental Health

Learning Objectives

- Define mental health and mental illness
- Analyze, translate, and define medical terms and common abbreviations used with mental health
- Practice the spelling and pronunciation of mental health terminology
- Identify the medical specialties associated with the mental health and explore common diseases, disorders, pharmacology, diagnostic tests and procedures

Introduction to Mental Health

The World Health Organization (WHO) defines **mental health** as a state of well-being in which an individual realizes their abilities can cope with everyday stresses of ones' life, work productively, and contribute to their community (WHO, 2022), whereas a mental illness/disorder/condition impacts the inability to cope with the everyday stressors.

A **mental disorder** is an abnormal condition of the brain or the mind that affects how a person feels, behaves, or relates to others or their surroundings. In most cases, the exact cause of a mental condition is unknown. There are various possible contributing factors, including genetics, environmental and chemical changes in the brain, use of certain drugs and psychological, social, and cultural conditions. Our role in mental health is to be nonjudgmental, not to judge the patient, but to seek to understand what is happening with the patient. Their behaviours may be out of control and require medical attention or treatment.

The ICD, the international classification of disease, and the DSM, the diagnostic and statistical manual of mental disorders, work together to look at socially accepted conditions and treatment options for conditions. A newer ailment added is gaming addiction. Manuals will change based on what is socially acceptable and what is happening culturally at that time, which impacts a person's ability to function with their activities of daily living (ADL) (Grant & Chamberlain, 2016).

Watch Emotion, Stress, and Health: Crash Course Psychology #26 (10 min) on YouTube

Psychology is the study of human behaviour and thought processes of the mind; it studies understanding how

humans interact with their physical environment and each other. A **psychologist** is a person who specializes in the study of the mind (WHO, 2022).

Psychiatry deals with the diagnosis, treatment and prevention of mental disorders. A **psychiatrist** is one who specializes in the treatment of the mind.

Watch Intro to Psychology: Crash Course Psychology #1 (10 min) on YouTube

Mental Health Word Parts

Prefix

- **acro-** (heights, extremes, extremities)
- **an-** (no, not, without)
- **bi-** (two)
- **dis-** (apart)
- **dys-** (bad, difficult, painful, abnormal)
- **eu-** (good)
- **ex-** (outward)
- **para-** (near, beside, abnormal)

Combining Form

- **affect–** (emotional reaction)
- **agor/a-** (marketplace)
- **ambul/o-** (to move)
- **amnes/o-** (forgetful)
- **anxi/o–** (fear, worry)
- **aut/o–** (self)
- **centr/o-** (centre)
- **compuls/o–** (drive, compel)
- **cycl/o–** (cycle)
- **delus/o–** (false belief, to cheat)
- **ech/o-** (sound)
- **fab/o-** (story)
- **hallucinat/o–** (to wander in mind)
- **hedon/o-** (pleasure)
- **Iatr/o-** (treatment)
- **klept/o –** (to steal, stealing)

- **ment/o-** (mind , do not confuse with chin)
- **narc/o–** (sleep, stupor)
- **neur/o-** (nerve)
- **obsess/o–** (besieged by thought)
- **path/o-** (disease)
- **phil/o–** (attraction)
- **phor/o-** (carry, bear, state)
- **psych/o**, **thym/o**, **phren/o** – (mind)
- **pyr/o-** (fire)
- **schiz/o–** (divide, split)
- **soci/o-** (society)
- **somat/o–** (body)
- **somn/o-** (sleep)

Suffix

- **-ia**, **-ism** (condition)
- **-iatrist** (one who specializes in the treatment)
- **-lepsy** (seizure)
- **-mania** (condition of madness; frenzy; excessive excitement)
- **-phobia** (condition of fear)
- **-thymia** (condition of the mind)
- **-orexia** (appetite)

Activity source: Mental Health Word Parts by Connie Stevens, licensed under CC BY- 4.0. / Text version.

Mental Health Medical Terms

Mental Health Abbreviations

- **ADL** (Activities of Daily living)
- **BD** or **BP** (Bipolar disorder)
- **BDD** (Body dysmorphic disorder)
- **CBT** (Cognitive-behavioural therapy)
- **DSM-5** (Diagnostic and Statistical Manual of Mental Health Disorders)
- **DTs** (Delirium tremens)

- **ECT** (Electroconvulsive therapy)
- **GAD** (generalized anxiety disorder)
- **ICD** (International Classification of Diseases)
- **ID** (intellectual disability)
- **OCD** (obsessive-compulsive disorder)
- **ODD** (oppositional defiant disorder)
- **PD** (panic disorder *also personality disorder)
- **PTSD** (post-traumatic stress disorder)
- **SAD** (seasonal affective disorder)

Activity source: Mental Health Abbreviations by Connie Stevens, licensed under CC BY 4.0. / Text version.

Attribution

19.2 - Mental Health Diagnostic Tests

The Diagnostic and Statistical Manual of Mental Disorders (DSM) is the resource used by healthcare professionals in much of the world to diagnose mental disorders. The DSM contains descriptions of the conditions, symptoms, and other criteria for diagnosing mental disorders (DSM 5, 2022).

Psychiatrists rely on two types of patient evaluations: clinical interviews and psychological testing. A mental health professional conducts the interviews and questions to identify the patient's symptoms, thoughts, feelings, and behaviours (MDS 5, 2022).

Some of the main psychological tests include collection and analysis with the use of the following tools (this is an example of the tools, it is not an inclusive list):

1. Patient Health Questionnaire (PHQ-9) – a most common screening tool to identify depression
2. Columbia-Suicide Severity Rating Scale (C-SSRS) – used to assess suicide risk
3. GAD7 – a screening tool to measure symptom severity for the four most common anxiety disorders (generalized anxiety disorder (GAD), panic disorder (PD), social phobia(s), and post-traumatic stress disorder (PTSD) (DSM 5, 2022).

Attribution

19.3 - Mental Health Diseases and Disorders

Mental Disorders

A mental disorder is a condition or illness that causes disruptions with mental processes impacting how an individual functions.

Mental Disorders Signs and Symptoms

Mental disorders can affect adults and children. They are often chronic, growing progressively worse if not assessed, managed, or treated. Symptoms may begin in childhood or adolescence, including excessive, irrational fear or dread. Everyone is unique, and individuals' signs and symptoms will interfere with their ability to cope and may impact others. Some of the symptoms that may be included in mental and behavioural health may include the following, which are defined.

Watch Psychological Disorders: Crash Course Psychology #28 (10 min) on YouTube

Common Mental Health Disorders

- **Mood disorders** affect your emotional state, focusing on how you feel, from extreme sadness to extreme happiness.
- **Substance and Addictive disorders:** continued use of substances that affect the person in negative ways and, once addicted, lead to compulsive behaviours.
- **Anxiety disorders** occur when a person responds to something with fear or dread and has a severe stress response that may include various physical reactions, such as trouble focusing, irritability, rapid heat rate, and muscle discomfort.
- **Personality disorders** involve disruptive patterns of thinking, behaviour, and mood related to others.
- **Behavioural disorders** are described as disruptive patterns of conduct. Persistent and repetitive behaviours that impair a person's functioning often cause distress in others around them.
- **Eating disorders** are complex. These conditions can be related to societal expectations, unrealistic role models, a warped image of themselves in the mirror, trauma, or fear of obesity, among other things.
- **Neurodevelopmental disorders** are a group of conditions that have affected how the brain and nervous system develop. The disorder can cause changes in thinking, feeling, language, and physical abilities.
- **Delusional disorders** are conditions where the individual has repetitive false or fixed beliefs that are not factual.

Mood Disorders

Bipolar disorder is a manic-depressive disease that causes extreme shifts in a person's mood and energy and impacts one's ability to carry out activities of daily living (ADL). Bipolar disorder may be characterized by cycling mood changes between mania or hypomania and the severe lows of depression (IBPF, 2022).

Substance and Addictive Disorders

Alcoholism is chronic condition characterized by compulsive and excessive alcohol consumption.

Drug addiction is a condition that affects a person's mood and behaviour, which leads to the inability to control the use of legal or illegal drug usage.

This list highlights terms of reference related to substance and addictive disorders:

- **Intoxication** means the process of putting poison in; the poison may include drugs or alcohol.
- **Delirium Tremens** (DT) are acute, seizure-like episodes that are sometimes even fatal. They are related to stopping excessive alcohol or drug after long periods of intake.
- **Withdrawal** is not as severe as DT, but it is still a state where the person is attempting to come down from having the drug or alcohol over a long time.
- **Tolerance** is when the person becomes accustomed to the drug or the alcohol, therefore, they need a higher amount. We see that with crystal meth, it is an extreme high and an extreme drop, therefore, the patient craves more.

Mania is also known as manic syndrome. It is a mental and behavioural condition characterized by an elevated state of arousal, such as excessive excitement, or frenzy. Associated with this condition are unmanaged impulses. A common impulse is kleptomania, the impulse to steal, or pyromania, the frenzy or impulse to set fires.
Seasonal Affective Disorder (SAD) is a form of depression that appears related to the fluctuations in the client's exposure to natural sunlight. This occurs in countries where there is limited seasonal sunlight.
Suicide is the willful ending of one's own life. There is no clear suicide type, meaning no one can predict who will take their life. Always seek medical attention when considering or discussing suicide.

Depression can be demonstrated in many different forms and extremes. When you look at the word depression, it means the process of feeling down:

- De- means down
- press means thought or emotion
- -ion means the process of
- The word impression would mean bringing forward or to boost the emotion or thought
- The word expression would mean the outward displaying the thought or the emotion
- The word oppression would be to keep others down

Anxiety Disorders

Anxiety is the state of feeling uneasiness, apprehension, worry or dread. It may be an involuntary or a reflexive reaction of the body to stress. Anxiety can be a typical stress reaction and can help a person deal with a tense situation, such as studying harder for an exam (Perotta, 2019).

Generalized anxiety disorder (GAD) is anxiety which is not related to a specific situation; it is an uneasiness, apprehension, worry or dread reaction to various non-specific situations. Signs and symptoms may include nervousness, sweating, lightheadedness, dizziness, and palpitations (Perotta, 2019).

Panic disorder is a type of anxiety disorder, often called panic attacks. It causes feelings of terror that occur suddenly and repeatedly without any warning. Clients with this disorder cannot predict when the attack will occur and may develop intense anxiety between episodes, worrying about when and where the next panic attack will occur. When having a panic attack, the client may feel sweaty, flushed, chilled, faint, weak, or dizzy. Their hands may feel tingly or numb. They may experience nausea, chest pain or a smothering sensation, or fear of impending doom and loss of control. The client may generally believe that they are having a heart attack or losing their mind, or are on the verge of death (Canada, 2022).

Phobias are a condition of irrational fear. The person cannot rationalize the fear away. The client's fear is real, even if it seems irrational to others. The clients can attend cognitive behavioural therapy to help them to manage the phobia.

Acrophobia is the irrational fear of heights:

- acro means height
- phobia means abnormal fear

Agoraphobia is the abnormal fear of the marketplace or leaving home:

- agora means marketplace
- phobia means abnormal fear

Claustrophobia is the abnormal fear of enclosed spaces:

- claustr/o means enclosed spaces
- phobia means the abnormal fear

Anthropophobia is a social phobia, thus an abnormal fear of man:

- anthrop/o means man
- phobia means abnormal fear

Post-traumatic stress disorder (PTSD) occurs after a traumatic event. It is an extended emotional response with flashbacks, nightmares, and often insomnia.

Personality Disorders

Antisocial personality disorder pertains to behaviours that are against legal or social norms:

- anti means against
- socio means society
- -al means pertaining to
- dis means apart

Borderline personality disorder may exhibit impulsive, unpredictable, and inappropriate responses to a situation.

Dissocial personality disorder often looks at going against societal expectations. They disagree with social norms or obligations. They do not have empathy for others. They get frustrated easily. They blame others and will not change their behaviour.

Dissociative identity disorder is a condition where the person has two or more distinct personalities. It was historically and commonly known as the older term split personality disorder. Disassociation is a defence mechanism where normal mental processes separate from consciousness. With dissociative disorder, a severe disturbance or trauma causes changes in the client's memory, consciousness, identity, and awareness of oneself and one's environment (Canada, 2022).

Narcissistic personality disorder is where a person has an abnormal sense of self-importance.

Behavioural Disorders

Attention deficit hyperactivity disorder ADHD is a syndrome where there are impulsive behaviours. A child with ADHD is not able to concentrate, as they have a very short attention span.

Oppositional defiant disorder ODD is a condition in which an individual may appear hostile, disobedient, aggressive, or defiant.

Obsessive-Compulsive disorder (OCD) is a reoccurring preoccupation of an irresistible drive, such as checking locks, curling irons, skin picking, hoarding, or excessive hand washing. OCD often involves persistent, unwelcome thoughts or images or the urgent need to engage in certain rituals that the person cannot control. The rituals are performed to try to prevent or get rid of the compulsions (Canada, 2022).

Nymphomania is a condition of madness where a woman wants to achieve orgasm, whereas for a man, it is called satyriasis: a male's uncontrollable sexual desire.

Philia is a condition of attraction or obsessive love. An example is paraphilia: an abnormal condition of being attracted to abnormal sexual perversions. Another example is pedophilia, where there is an obsessive sexual attraction to children.

Eating Disorders

Anorexia is a condition that is characterized as a relentless drive for thinness. As a medical term, it is translated to mean "without appetite." This condition tends to be seen to occur more frequently in women.

- an- means without
- -orex means appetite
- -ia means condition.

Bulimia nervosa tends to occur higher in males. It is where a person binges on food and then vomits or uses high doses of laxatives (Udo & Grilo, 2019).

Neurodevelopmental Disorders

Autism spectrum disorder (ASD) is an abnormal social interaction; it may impact a child's communication. The child may have repetitive behaviours. The disorder varies from child to child.

Asperger's disorder is a disorder that impacts social interaction without delay in language.

Delusional Disorders

Paranoia is inappropriate or suspicious behaviour in which one believes that somebody is invading their rights or has exaggerated feelings of persecution. The client may have highly exaggerated or unwarranted mistrust or suspiciousness.

Schizophrenia causes the patient to live within a fantasy world, where they have inappropriate thoughts which come out as behaviour. When you break down the word, **schiz/o** means split, and **phrenia** is a condition of the mind, however, that is not entirely true. Often with schizophrenia, the patient may have delusions or illusions. These may be increased within specific social situations. Schizophrenia is not caused by stress, but both conditions impact daily functioning (Valle, 2020).

Attribution

19.4 - Mental Health Therapeutic Interventions

Therapeutic Interventions

A therapeutic intervention is an aspect of mental healthcare that aims to address and support various physical, mental, emotional, or behavioral issues in individuals managing a mental health disease or disorder.

Abstinence is the self-governing and a self-enforced restraint from indulging in pleasurable activities, such as addictions.

Addiction/Rehabilitation centres assist with the withdrawal from dependency on substances. The purpose is to enable the patient to confront substance dependence and stop substance misuse.

Counselling (1:1, group, family) is a collaborative effort between the counsellor and client. Professional counsellors help clients to identify ones' goals and potential options/solutions to problems which have caused emotional turmoil, seeking to improve coping skills and promote behavioural change to achieve optimal mental health (American Counseling Association, 2022).

Electroconvulsive therapy (ECT) is a procedure occasionally used for cases of prolonged severe depression. This controversial treatment/therapy involves the placement of electrodes on one or both sides of a patient's head. The patient receives a muscle relaxant and anaesthesia. A low-level voltage is triggered and creates a convulsive seizure. It remains controversial, as critics of this treatment state that it is not a more effective way to treat severe depression than using drugs (Van Dierman et al., 2020).

Harm reduction philosophy is 'an evidence-based, client-centred approach that helps to reduce the health or social harms associated with addiction or substance use without requiring people who use substances to abstain or stop (CMHA, 2022). For more information, go to Canadian Mental Health Association – Harm Reduction website [New Tab]. A **Needle Exchange Program (NEP)** is one method of harm reduction. NEPs, also known as syringe services programs or needle-syringe programs, provide new and sterile syringes to drug users to reduce the risk of spreading communicable diseases. Some programs provide medical treatment for infectious diseases, substance use disorder treatment referrals, and naloxone treatment. For more information, about the American Additions Centers – Needle Exchange Programs website.

Watch Biomedical Treatments: Crash Course Psychology #36 (11 min) on YouTube

Pharmacology

As a therapeutic intervention a psychiatrist may prescribe psychotropic medications to manage a client's symptoms. Psychotropic medications are not a cure, however, they are more effective when combined with psychotherapy. Medications are often classified based on their action in the body. A psychiatrist may prescribe medications from a several different classifications to treat mental health conditions.

This list provides examples of medication classifications used in psychiatric medicine as well as the activity of the medication.

- neuroleptic to control hallucinations or delusions
- antidepressant: pertaining to stopping depression
- anti-anxiety: against anxiety
- anti-psychotic: pertaining to against psychosis
- stimulants: pertaining to stimulate; help manage unorganized behaviour
- mood-stabilizer help regulate extreme emotions

Psychotherapy

Psychotherapy is a method of treating mental disorders using psychological techniques instead of physical methods. It can involve talking, interpreting, listening, rewarding, and role-playing. It can include different types of psychotherapy, such as cognitive behavioural therapy, family therapy, group therapy, play therapy, art therapy, hypnosis, and psychoanalysis (AMA, 2022).

Attribution

Vocabulary & Check Your Knowledge

Mental Health Vocabulary

Addiction

The process of the misuse of medications, alcohol, or illegal substances.

Antisocial personality disorder

Behaviours that are against legal or social norms.

Anxiety

The state of feeling uneasiness, apprehension, worry or dread.

Autism spectrum disorder

An abnormal social interaction that may impact communication.

Bipolar Disorder

A manic-depressive disease that causes extreme shifts in a person's mood and energy.

Dementia

The progressive loss of memory where someone may lose touch with reality, seem confused and develop a personality change.

Delirium

A state of confusion that is an irrational, agitated state.

Diagnostic and Statistical Manual of Mental Disorders (DSM)

The resource used by healthcare professionals in much of the world to diagnose mental disorders. The DSM contains descriptions of the conditions, symptoms, and other criteria for diagnosing mental disorders.

Dissociative identity disorder

A condition where the person has two or more distinct personalities. It was historically and commonly known as the older term split personality disorder.

Generalized anxiety disorder (GAD)

Anxiety which is not related to a specific situation; it is an uneasiness, apprehension, worry or dread reaction to various non-specific situations.

Hallucination

An unreal sensory perception with no external cause; it is not real. However, the client claims they can see, hear, touch, taste, or talk to this sensation.

Mania

A condition of madness, excessive excitement, or frenzy.

Mental health

A state of well-being in which an individual realizes their abilities, can cope with everyday stresses of ones' life, work productively, and contribute to their community.

Mental disorder

An abnormal condition of the brain or the mind that affects how a person feels, behaves, or relates to others or their surroundings.

Narcissistic personality disorder

When a person has an abnormal sense of self-importance.

Obsessive-Compulsive Disorder (OCD)

A reoccurring preoccupation of an irresistible drive, such as checking locks, curling irons, skin picking, hoarding or excessive hand washing.

Panic disorder

A type of anxiety disorder, often called panic attacks. It causes feelings of terror that occur suddenly and repeatedly without any warning.

Phobias

A condition of irrational fear.

Post-traumatic Stress Disorder (PTSD)

Occurs after a traumatic event. It is an extended emotional response with flashbacks, nightmares, and often insomnia.

Seasonal Affective Disorder (SAD)

A form of depression that appears related to the fluctuations in the client's exposure to natural sunlight.

Psychiatry

Deals with the diagnosis, treatment and prevention of mental disorders.

Psychiatrist

One who specializes in the treatment of the mind.

Psychology

The study of human behaviour and thought processes of the mind; it studies understanding how humans interact with their physical environment and each other.

Psychologist

A person who specializes in the study of the mind.

Psychotherapy

A method of treating mental disorders using psychological techniques instead of physical methods. It can involve talking, interpreting, listening, rewarding, and role-playing.

Psychosis

An abnormal condition of the mind accompanied by hallucinations or delusions.

Schizophrenia

A condition that causes the patient to live within a fantasy world where they have inappropriate thoughts that come out as behaviour. Often with schizophrenia, the patient may have delusions or illusions.

Somnambulism

The condition of sleepwalking.

Suicide

The willful ending of one's own life. There is no clear suicide type, meaning no one can predict who will take their life. Always seek medical attention when considering or discussing suicide.

Tolerance

When a person becomes accustomed to a drug or the alcohol, therefore, they need a higher amount.

Withdrawal

A state where a person is attempting to come down from having a drug or alcohol over a long time.

Mental Health Reinforcement Activity

Mental Health Reinforcement Activity (Text version)

1. Psychology _____[Blank 1].

a. is a medical specialty focused on childhood diseases.
b. is the study of infectious diseases.
c. is the study of human behaviour and thought processes of the mind.
d. include sebaceous glands and sweat glands

2. The Diagnostic and Statistical Manual of Mental Disorders (DSM) _____[Blank 2].

   a. is the resource used by healthcare professionals in much of the world to diagnose mental disorders.
   b. is a manual related to nutrition and healthy eating.
   c. a manual that provides statistical analysis of epidemiology.
   d. is a guideline for the treatment of childhood cancer.

3. Anxiety is_____[Blank 3].

   a. the state of feeling uneasiness, apprehension, worry or dread.
   b. a treatment for common forms of skin cancer.
   c. the feeling that one is going to vomit.
   d. an infectious disease.

4. Withdrawal is _____[Blank 4].

   a. a diagnostic test for colon cancer.
   b. an unusual presentation of a skin infection.
   c. a state where a person is attempting to come down from having a drug or alcohol over a long time.
   d. a symptom related to an endocrine disorder.

Check your answers: [1]

Activity source: Mental Health Reinforcement Activity by Open Learning at Conestoga College, licensed under CC BY 4.0.

Attribution

Notes

1. 1. c) is the study of human behaviour and thought processes of the mind, 2. a)is the resource used by healthcare professionals in much of the world to diagnose mental disorders, 3. a) the state of feeling uneasiness, apprehension, worry or dread, 4. c) a state where a person is attempting to come down from having a drug or alcohol over a long time.

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Glossary

angioscopy

process of viewing the interior of arteries

hemothorax

blood in the chest cavity

Leukocyte

White blood cell(s)

pathogen

substance or agent that produces disease

psychiatrist

Specialist who studies the mind

testicular

pertaining to the testicles

5.25 liters of blood

The volume of blood ejected by the ventricle in one minute is called the cardiac output

70 mL blood per contraction

The amount of blood ejected from the ventricle in one contraction is called the stroke volume.

basal cell

cuboidal-shaped stem cell

Orchiectomy

Excision of a testicle

Abduction

away from the midline of the body

abduction

Movement away from the mid line of the body

ABG

Arterial blood gas. This test measures blood pH, oxygen and CO2 levels in a sample of arterial blood, usually taken from the wrist

ablation

Using extreme heat or extreme cold to destroy cells in part of the heart which were causing abnormal rhythms.

acanthosis nigricans

disorder that causes darkening and thickening of the skin on the neck, groin, underarms, or skin folds

acrochordons

skin tags, teardrop-sized pieces of skin that can be as large as raisins and are typically found in the armpits or neck area

acronymns

Terms derived from the first letters of a phrase and are spoken as if they are a word on their own.

adaptive immune response

Specific immune mechanisms (against a specific pathogen) which take time to develop

adduction

Movement toward the midline of the body

adenocarcinoma

Cancer that starts in the mucous glands

adipocytes

fat cells

adipose

fat

adventitial

The outermost layer of the wall of a blood vessel

AIDS

Acquired immunodeficiency syndrome, caused by infection with the HIV virus

allergens

antigens that evoke type 1 hypersensitivity (allergy) responses

alveolar duc

a tube composed of smooth muscle and connective tissue (Betts. et al., 2013)

amenorrhea

absence of periods

amniocentesis

surgical puncture (using a needle) to remove amniotic fluid for sampling.

amniorrhexis

Rupture of the amniotic sac

ampulla

A sac-like enlargement of a canal or duct

anaphylactic shock

Also called anaphylaxis. An inhaled, ingested or injected (bee sting) allergen causes a significant drop in blood pressure along with contractions of smooth muscles of the airways

anastomoses

connections between two blood vessels (singular: anastomosis)

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 (Betts, et al 2013)

androgens

male hormones

anemia

Lack of (without) sufficeint healthy red blood cells in the blood

aneurism

ballooning of a blood vessel caused by a weakening of the wall (DeSaix, et al., 2013)

aneurysm

Weakening of the wall of a blood vessel, causing it to thin and balloon out, and possibly eventually burst, resulting in internal bleeding

angina pectoris

chest pain

angiogram

an x-ray of the coronary blood vessels using a special catheter and an injection of dye

angioplasty

a balloon-tip catheter is fed through a blood vessel up to the site of the narrowing, the balloon is inflated to re-open the artery. A stent is sometimes placed at the site to reinforce the arterial wall and to prevent re-occlusion.

ankylosis

abnormal condition of stiffness

anoxia

without oxygen

antagonistic

in opposition to each other

antepartum

before childbirth

anterior

pertaining to the front

Anteriorly

Pertaining to front

anti-B antibodies

proteins that will mount an immune response against B antigens

anti-virals

treatments that work effectively against a virus.

antiandrogens

a group of medications that counteract the effects of male hormones.

antibiotics

Antiobiotics are medications that stop bacterial infections.

Antibodies

also called immunoglobulins, proteins produced by B lymphocytes in response to a non-self antigen

Antigens

A substance that provokes an immune response. This happens because the immune system sees the antigen as foreign, or 'non-self" (does not belong in that body)

antihypertensives

class of medications used to treat high blood pressure

antipsychotic

against (modifying) psychosis

antiretrovirals

treatment that works against the virus replication

apical

Relating to or denoting an apex.

apoptosis

programmed cell death

appendicular

Pertaining to appendages

Arrhythmias

absence of a regular heart rhythm

Arteries

Blood vessels that transport blood away from the heart.

arterioles

A very small artery that leads to a capillary

arteriosclerosis

hardening of arteries

artery

Blood vessel that carries blood away from the heart. Thick walled that can withstand the high pressure of blood ejected from the heart (DeSaix, et al., 2013)

arthralgia

painful joint(s)

Arthritis

Inflammation of the joints

arthrodesis

surgical fusion of a joint through ossification of bones

arthroscope

Instrument that contains a small camera on a tube with a light. This is a tool used to view the inside of a joint.

articulations

Also known as joints. It is where bones meet bones or bones meet joints.

asymptomatic

pertaining to without symptoms

asystole

a complete absence of electrical activity in the heart, which is represented by a flat line on ecg

atherosclerosis

a hardening of the arteries that involves the accumulation of plaque

atypical

not typical

auscultation

listening to the heart using a stethoscope

autocrine

a cell secretes a hormone or chemical messenger.

autoinoculation

self inoculation

autonomic

unconsciously regulates

AV

atrioventricular: the area of the heart where the atria and ventricles meet

AV valves

Atrioventricular valves: mitral (bicuspid) valve allows blood to flow from left atrium to left ventricle, tricuspid valve allows blood to flow from right atrium to right ventricle

avascular

without blood vessels

axilla

armpit

axons

the long threadlike part of a nerve cell along which impulses are conducted from the cell body to other cells.

baroreceptors

specialized cells that sense changes in blood pressure

Barrier defenses

The body's first line of defense against pathogens, a physical barrier to keep pathogens out of the body

Bartholin's glands

Also known as greater vestibular glands they are responsible to secrete mucus to keep the vestibular area moist

benign

noncancerous, harmless

bicarbonate

A by-product of the body's metabolism

bilateral

pertaining to both sides

bilobed

two lobes

binocular

pertaining to two or both eyes

biopsy

process of viewing living tissue to examine for presence, cause or extend of disease

brachial artery

large artery in the upper arm near the biceps muscle

bradycardia

pertaining to a slow heart (rate)

brain

bronchiectasis

Walls of the bronchi are thickened out (expanded) with inflammation and infection because cilli can no longer sweep out debris leading to dyspnea.

bronchodilators

substance that dilates the bronchi and bronchioles

Bulbourethral

(also, Cowper's glands) glands that secrete a lubricating mucus that cleans and lubricates the urethra prior to and during ejaculation

calyces

a cuplike cavity or structure

Cancer

abnormal cells in the body dividing uncontrollably.

capillaries

A microscopic channel that supplies blood to the tissues through perfusion

carbohydrates

The sugars, starches and fibers found in fruits, grains, vegetables and milk products.

carcinogenic

causing cancer

cardiac

pertaining to the heart

cardiac cycle

The combination of one complete relaxation or filling phase (diastole) and one complete contraction or ejection phase (systole)

cardiac muscle

Is the heart muscle also known as the myocardium. Its appearance is similar to skeletal muscle. It pumps blood and gives the heart beat.

cardiac notch

is an indentation on the surface of the left lung

Cardiac output

Cardiac output is the measurement of blood flow from the heart through the ventricles, and is usually measured in liters per minute. Any factor that causes cardiac output to increase, by elevating heart rate or stroke volume or both, will elevate blood pressure and promote blood flow.

cardiac tamponade

The pericardial sac surrounding the heart has filled with blood or other fluid and the resulting pressure is preventing the heart from beating effectively

cardiac troponin

the regulatory protein for muscle contraction

Cardiogenic

Cardio=pertaining to the heart
genic=originating from, created by
Cardiogenic means originating from the heart

cardiology

Study of the heart

carina

ridge of cartilage that separates the two main bronchi

carotid artery

large artery in the neck

CD4 T cells

CD4 is the receptor that HIV uses to get inside T cells and reproduce. CD4+ helper T cells play an important role in T cell immune responses and antibody responses. (Betts et al., 2013)

celiac disease

Inflammation of the intestines caused by exposure to gluten (https://www.cdc.gov/ibd/what-is-IBD.htm)

central nervous system (CNS)

includes the brain and spinal cord

centrifuged

A centrifuge is a common piece of laboratory equipment used to spin test tubes at a high speed in order to separate components in a liquid by weight.

cerebrospinal

Produced by the brain is a colourless fluid that cushions the brain and spinal cord.

cerebrum

region of the adult brain that is responsible for higher neurological functions such as memory, emotion, and consciousness

cervicitis

Inflammation of the cervix

cervix

opening to the uterus

cessation

Stop/stopping

chemoreceptors

cells that sense changes in chemical levels

chemotaxis

Movement in response to chemicals; a phenomenon in which injured or infected cells and nearby leukocytes emit the equivalent of a chemical “911” call, attracting more leukocytes to the site.

cholecystolithotripsy

surgical crushing of stones in the common bile duct

cholecystorrhaphy

suturing of the gall bladder for repair

choledocholithiasis

Condition of stones in the common bile duct

chondromalacia

softening of cartilage

chorionic villus sampling

A small piece of placenta is taken and tested to determine potential for birth differences

chronic

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

chronic inflammation

Chronic inflammation is ongoing inflammation that can be caused by foreign bodies, persistent pathogens, and autoimmune diseases such as rheumatoid arthritis (Betts et al., 2013)

cisterna chyli

A sac-like chamber that receives lymph from the lower abdomen, pelvis, and lower limbs by way of the left and right lumbar trunks and the intestinal trunk. (Betts et al, 2013)

clubbing of the fingers and toes

broadening of the nails and exaggerated curvature of the nails

coelomic

cavities that do not open to the outside

colitis

inflammation of the colon

colpopexy

surgical fixation of they vagina by suturing it to the abdominal wall

combining form

A word root with a combining form vowel.

combining form vowel

The combining form vowel is used to join word parts and to ease pronunciation.
The most common combining form vowel is an "o" but sometimes it is an "i" or an "e".

compliance

the ability of the blood vessels to dilate and constrict as needed

conducting zone

The major functions of the conducting zone are to provide a route for incoming and outgoing air, remove debris and pathogens from the incoming air, and warm and humidify the incoming air. Several structures within the conducting zone perform other functions as well. The epithelium of the nasal passages, for

example, is essential to sensing odors, and the bronchial epithelium that lines the lungs can metabolize some airborne carcinogens (Betts, et al., 2013).

congenital

present at birth

convex

Curved outwards

coronary

pertaining to the arteries that supply the heart

coronary artery bypass graft (CABG)

In a coronary bypass procedure, a non-vital superficial vessel from another part of the body (often the great saphenous vein) or a synthetic vessel is inserted to create a path around the blocked area of a coronary artery.

coronary heart disease

also called coronary artery disease (CAD); the blood vessels that supply blood to the myocardium become hardened and narrowed, impairing the delivery of oxygen to the heart muscle

cranioschisis

Congenital fissure of the skull. The bones of the skull fail to close.

creatine kinase MB

an enzyme that catalyzes the conversion of creatine to phosphocreatine, consuming ATP

Crohn disease

A type of inflammatory bowel disease

Cryptorchidism

Undescended testicle

cryptorchism

undescended testes that don't drop before birth

crypts

Histologically, tonsils do not contain a complete capsule, and the epithelial layer invaginates deeply into the interior of the tonsil to form tonsillar crypts. (DeSaix et al., 2013)

CT

Computerized tomography: a special 3-dimensional x-ray, also called CAT=Computerized Axial Tomography

cyanosis

abnormal condition of blue (bluish colour, lips, and nail beds) caused by deoxygenation.

cyanotic

pertaining to abnormal discolouration of blue (bluish colour, lips and nail beds) caused by deoxygenation.

cytokines

chemical that sends a message from one cell to another

cytoplasm

substance that composes cells

cytotoxic

cell-killing

Deamination

The removal of an amino group from a molecule.

debridement

excision of damaged tissue or foreign object.

deep lymphatic vessels

Lymphatic vessels of the organs

defensins

The lysozyme enzyme and proteins which have antibacterial properties (Betts, et al., 2013)

dehydrate

lose a large amount of water from the body

dehydration

loss of fluids/water is greater than what is taken in.

dendritic

Pertaining to dendrites

dermatologic

pertaining to dermatology

dermatome

instrument used to cut skin

dermatopathology

Study of diseases of the skin.

dermis

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

detrusor

A muscle which forms a layer of the wall of the bladder

diabetes mellitus

An endocrine system disorder in which the pancreas does not produce insulin or the cells of the body do not respond to insulin. This results in high levels of glucose in the blood.

dialysis

The process of removing substances, purifying, adding, and then returning the purified substance.

An example is hemodialysis, blood is removed from an artery, purified through dialysis, vital substances added, and then the blood is returned through a vein.

diapedesis

dia- = “through”; -pedan = “to leap”

diaphoresis

sweating

diaphragm

A flat, dome shaped muscle located at the base of the lungs and thoracic cavity

diastolic pressure

The diastolic pressure is the lower value (usually about 80 mm Hg) and represents the arterial pressure of blood during ventricular relaxation, or diastole.

diplopia

double vision

distal

Away from the center of the body or from the point of attachment

diuresis

Condition of increased production of urine

dorsad

toward the back

douching

washing the vagina with fluid

ductus arteriosus

connection between pulmonary trunk and aorta in the fetal heart

dysmenorrhea

painful periods

dyspareunia

painful intercourse

dyspepsia

difficult digestion

dysphagia

difficulty swallowing

dyspnea

difficult breathing

dystocia

difficult birth

dysuria

painful urination

ECG

ECG/EKG both these abbreviations mean electrocardiogram or a recording of the electrical impulses in the heart

echocardiography

process of using sound to record the heart

edema

swelling

electrocardiogram

radiographic image of electrical activity in the heart

electrocardiograph

instrument used to record electrical activity within the heart

electrocardiography

process of recording electrical activity of the heart

electrophysiology

The study of electrical properties of cells and tissues

eleiden

clear protein rich in lipids

embolus

a freely moving piece of a substance (plaque or blood clot) that travels through the circulation until it blocks a smaller blood vessel, cutting of the supply of oxygen to the tissue

emulsification

The process of breaking down the fat into smaller blood cells which makes it easy for enzymes to function and digest food.

endocardium

innermost layer of the heart

endocrinology

The study of endocrine glands and hormones

endometrium

The innermost layer containing a connective tissue lining covered by epithelial tissue that lines the lumen.Provides the site of implantation for a fertilized egg
Sheds during menstruation if no egg is fertilized.

endoscopy

Process of viewing internally

endothelium

the lining of the lumen of a blood vessel

endotracheal

pertaining to within the trachea

epidermis

outer layer of skin, made of closely packed epithelial cells

epididymal

Pertaining to the epididymis

epididymis

(plural = epididymides) coiled tubular structure in which sperm start to mature and are stored until ejaculation

Epididymitis

swelling of the epididymis

epiglottis

The epiglottis, attached to the thyroid cartilage, is a very flexible piece of elastic cartilage that covers the opening of the trachea (Betts. et al., 2013)

epinephrine

also known as adrenaline, is a hormone and neurotransmitter and produced by the adrenal glands

epiphyses

the ends of long bones, singular is epiphysis

EPO

Erythropoietin is a hormone produced by the kidneys that plays an important role in the homeostasis of red blood cells levels in the body

eponyms

Terms that are named after a place or person.

equilibrium

balance

erythroblastosis fetalis

HDN: Hemolytic Disease of the Newborn. Discussed in the chapter about Blood, this is a immune reaction between maternal and fetal blood due to the Rh antigen.

erythrocytes

red blood cells

erythrocytopenia

abnormal reduction in number of (healthy) red blood cells produced

erythrocytosis

abnormal condition of excessive production of red blood cells

esophageal

Pertaining to the esophagus

eupnea

normal breathing

exacerbation

increase in severity of a problem

excises

remove by cutting out

excretion

Waste is eliminated from an organism. In vertebrates this is primarily carried out by the lungs, kidneys and skin.

exocrine

to secrete externally, directly or through a duct

exocytosis

Molecules are transported out of cells. A form of active transport

expiration

exhalation or the process of causing air to leave the lungs

external nose

The external nose consists of the surface and skeletal structures that result in the outward appearance of the nose and contribute to its numerous functions

extramedullary hemopoiesis

hemopoiesis outside the medullary cavity of adult bones

fascia

fibrous tissue

fauces

The **fauces** is the opening at the connection between the oral cavity and the oropharynx

fibroelastic membrane

a flexible membrane that closes the posterior surface of the trachea, connecting the C-shaped cartilages

fibromyalgia

pain in the fibrous tissues of muscles

filler

additional words that makes the definition complete.

foramen ovale

opening between right and left atria, which is normal in the fetal heart

fornix

superior portion of the vagina

frostbite

Conservation of the body core heat results in the skin actually freezing

fundus

A part of a hollow organ

Gametes

haploid reproductive cells that contribute genetic material to form an offspring

gastrectomy

surgical removal of (part or all of) the stomach.

gastromegaly

enlarged stomach

gastroscopy

process of viewing the stomach

Genetic recombination

the combining of gene segments from two different pathogens

glossopharyngeal

pertaining to tongue and throat

glottis

The glottis is composed of the vestibular folds, the true vocal cords, and the space between these folds (Betts et al, 2013)

gonads

reproductive organs (testes in men and ovaries in women) that produce gametes and reproductive hormones

graft-versus-host disease

GVHD: in bone marrow transplants; occurs when the transplanted cells (the 'graft') mount an immune response against the recipient's (the 'host') tissue

great vessels

The great vessels include the superior vena cava, inferior vena cava, aorta and pulmonary trunk.

gynecologist

Specialist in the study and treatment of the female reproductive system

gynecology

The study of the female reproductive system

Gynecomastia

growth in the breasts

hard palate

located at the anterior region of the nasal cavity and is composed of bone

HDL

high-density lipoprotein, often referred to as 'good' cholesterol

heart murmur

an abnormal heart sound

heart rate

The number of times the heart contracts in one minute.

hematemesis

The vomiting of blood

hematocrit

A lab test which measures the percentage red blood cells in a sample of whole blood. It represents how much of the person's blood is made up of red blood cells, by volume.

hematopoiesis

The process in which the body produces blood.

hemicolectomy

excision of half of the colon

hemiparesis

slight paralysis of one side of the body (right or left)

Hemolysis

Breaking apart of the erythrocyte cell membrane, allowing its contents to leak out

hemopoiesis

also called hematopoiesis; from the Greek root haima- = “blood”; -poiesis = “production”

hemopoietic growth factors

Chemical messengers which promote the proliferation and differentiation of formed elements and include erythropoietin, thrombopoietin, colony-stimulating factors, and interleukins.

hemorrhage

excessive or uncontrolled bleeding from the blood vessels

hemostasis

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

hiatal

Location where the diaphragm has a small opening (hiatus) through which the esophagus passes before connecting.

hilum

A concave region where blood vessels, lymphatic vessels, and nerves also enter the lungs

hirsuitism

excess hair all over the body

histamine

Involved in the inflammatory response and typically causes itching.

HIV

Human Immunodeficiency Virus. An infectious disease, usually transmitted via blood or sexual fluids. It attacks the immune system and can lead to full-blown AIDS

homeostasis

biological process that results in stable equilibrium

hydrocele

swelling of the scrotum cause by fluid collection in the sheath surrounding the testicle

Hydrostatic

Relating to the equilibrium of liquids and the pressure exerted by liquid at rest.

hypercholesterolemia

higher than normal levels of cholesterol in the blood

hyperlipidemia

Excessive fat in the blood

hyperplasia

excessive development or growth

hyperpnea

forced breathing or breathing that is excessive

hypersensitivities

Reacting to something that would not normally evoke a reaction

hypertension

High blood pressure

hyperthyroidism

state of excessive production of thyroid hormone

hypertrophy

excessive development; increase in the size of cells but not the number of cells

hypodermis

Literally means below the dermis. The layer of the skin below the dermis that is composed mainly of loose connective and fatty tissues

hypoglycemia

deficient sugar in the blood

hypothalamic

a region of the forebrain below the thalamus

hypothalamus

a collection of nucleic nerve tissue - has function in both the autonomic and endocrine systems - regulates homeostasis

hypothyroidism

Underactive thyroid gland, insufficient production of thyroid hormones (T3 and T4)

Hypovolemic

hypo=below, lower than normal, volemic=pertaining to volume (in this case, the volume of blood in the body)

hypoxemia

low blood oxygen levels

hypoxia

literally: 'lower than normal amount of oxygen to tissues'. Hypoxia means that a tissue is not getting enough oxygen to survive and cell death is likely.

hysterectomy

Surgical removal of the uterus

hysteroscope

instrument used to visualize the uterus

immunity

After an infection, memory cells remain in the body for a long time and can very quickly mount an immune response against the same pathogen if it tries to re-infect. This protects us from getting diseases from the same pathogen over again.

implantable cardioverter defibrillators

ICD, an electronic implant that provides an automatic shock to convert a dangerous heart rhythm to a normal heart rhythm

induration

a firm, raised reddened patch of skin

infarct

cells and tissues that have died, often due to a complete disruption in the blood and oxygen supply

infection

invasion by disease causing organisms

inferior

pertaining to below

inferior vena cava

One of the two largest veins in the body. It carries deoxygenated blood from the torso and legs back to the heart.

innate immune response

Fast-acting non-specific immune mechanisms that are present from birth

Inspiration

inhalation or process of breathing air into the lungs

interatrial septum

the wall separating the right and left atria.

Intercellular

Between cells

intercostal

pertaining to between the ribs

interferons

Early induced proteins made in virally infected cells that cause nearby cells to make antiviral proteins (Betts et al., 2013)

internal nose

nasal cavity

Interstitial

Between cells of the tissues, often used interchangeably with 'intercellular'

interstitial fluid

Fluid that has leaked out of blood capillaries into the tissue spaces

interstitial space

Spaces between individual cells in the tissues (Betts et al., 2013)

interventricular septum

The wall of myocardium that separates the right and left ventricles

Intracellular

Inside the cell membrane or within the cell

intramuscular

pertaining to within the muscle

intravenous

pertaining to within the vein

ischemia

Insufficient blood and oxygen to cells of an organ. These cells are starving for oxygen, but they are still alive.

ischemic

ischemia is a condition in which cells receive insufficient amounts of blood and oxygen

jaundice

yellowing

jaundiced

Yellow coloured

Juvenile Rheumatoid Arthritis

Rheumatoid Arthritis that affects children causing swelling and stiffness of the joints. Also referred to as juvenile idiopathic arthritis.

keloid

formation of a raised or hypertrophic scar

keratinocytes

cells that manufacture and store the protein keratin

kinesthesia

body movement

labia

lips of the mouth

lacteals

The lymphatic vessels of the small intestine which absorb digested fats

laparoscopy

process of viewing internal organs

laparotomy

incision into the abdominal cavity

laryngeal

pertaining to the larynx

laryngopharynx

which borders the oropharynx, trachea, and esophagus (De Saix, et al., 2013)

larynx

The larynx is a cartilaginous structure inferior to the laryngopharynx that connects the pharynx to the trachea and helps regulate the volume of air that enters and leaves the lungs (Betts. et al., 2013) AKA the voice box

lateral

pertaining to the side

LDL

low-density lipoprotein, often referred to as 'bad' cholersterol

lethargy

Periods of weakness

leukemia

A cancer involving an abundance of leukocytes. It may involve only one specific type of leukocyte from either the myeloid line (myelocytic leukemia) or the lymphoid line (lymphocytic leukemia). In chronic leukemia,

mature leukocytes accumulate and fail to die. In acute leukemia, there is an overproduction of young, immature leukocytes. In both conditions the cells do not function properly (Betts, et al., 2013)

leukocytes

also spelled leucocyte, these are white blood cells

leukoderma

white skin

leukopoiesis

formation of white blood cells

lingual

pertaining to the tongue

lingual tonsils

collection of lymphatic tissue located in the lamina propria of the root of the tongue

lipoid

resembling fat

literally

follows the rules exactly

lumbago

lower back pain

lumen

A hollow passageway through which blood flows

lupus

An autoimmune disease in which the body mounts an immune response against its own tissues, causing chronic inflammation and tissue damage

Lymph

Lymph is the term used to describe interstitial fluid once it has entered the lymphatic system (Betts et al., 2013)

lymphatic system

A series of vessels, tissues and organs that remove interstitial fluid from the tissues and return it the blood, transport dietary lipids and carry out several important immune functions (DeSaix et al., 2013)

lymphatic trunks

Large lymphatic vessels that collect lymph from smaller lymphatic vessels and empty it into the blood via lymphatic ducts (Betts et al., 2013)

lymphocytes

lymph cells, a type of white blood cell

lymphoid

Resembling lymph or lymphatic tissues

Lymphoma

Lymphoma is a form of cancer in which masses of malignant T and/or B lymphocytes collect in lymph nodes, the spleen, the liver, and other tissues. These leukocytes do not function properly, and the patient is vulnerable to infection. (Betts. et al., 2013)

macrocephalous

pertaining to an exceptionally large head or cranium

macrophage

A type of white blood cell that engulfs bacteria, foreign particles and damaged cells

macrophages

a type of leukocyte (usually a monocyte) that has the ability to ingest and destroy other cells or pathogens

malabsorption

A disorder that occurs when people are unable to absorb nutrients from their diets

maldigestion

Poor breakdown of food

malignant

cancerous

mammoplasty

surgical repair of the breast particularly after a mastectomy

mastectomy

Excision of breast(s) and or breast tissue

mechanoreceptors

A sensory neuron that responds to mechanical pressure

medulla

An inner region of specific structure such as the kidneys

medulla oblongata

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

Meissner corpuscle

tactile corpuscle that responds to light and touch, touch receptor

Meissner corpuscles

Tactile corpuscles that responds to light and touch, touch receptors.

melanocyte

cell that produces the pigment melanin

melanocytes

Specialized cells that produce melanin which is a dark pigment responsible for colouration of skin and hair.

melanoma

tumour that develops in the melanocytes

mental disorder

A behaviour or mental pattern causing impairment of functioning.

mental health

mental health encompasses, psychological, emotional, and social well being

metacarpal bones

The bones that extend beyond the carpal bones of the wrist but before the phalanges of the fingers.

metastasis

Cancer spreads from one part of the body into another

metastasize

Production of cells that can mobilize and establish tumors in other organs of the body

metastasized

cancer spreads from one area to another area

MHC

Major Histocompatibility Complex molecules, also called Human Leukocyte Antigen (HLA) are protein structures found on the outside of cells that help the immune system recognize non-self antigens

microcephalus

small head

microscope

instrument to view small particles by enlarging the particles

mitochondria

An organelle found in large numbers in most cells.

mitral valve

Also known as the bicuspid valve

modern language terms

Terms from the English language.

MRI

Magnetic Resonance Imaging: Highly detailed images produced using a strong magnet and radio waves

Mucosal

Mucous membranes line body cavities that open to the outside world, including the respiratory tract, gastrointestinal tract, urinary tract and reproductive tracts

multipara

many births, refers to a woman who has birthed two or more live babies

Muscular Dystrophy

It is a term used to describe a group of more than 100 neuromuscular disorders characterized by progressive deterioration of muscle strength.

myalgia

pain in the muscles

myasthenia gravis

grave or serious muscle weakness

nasal cavity

The inside of your nose.

nasopharynx

The nasopharynx serves as an airway and is continuous with the nasal cavity

necrosis

tissue death

neonate

new birth/ newborn - birth to four weeks.

nephroptosis

prolapsed kidney

nephrostomy

creation of artificial opening between the kidney and the skin

nerves

Collection of neurons; nerve cells

Neurosensory

Relating to afferent nerves

neurotransmitter

chemicals acting as signaling molecules that enable neurotransmission.

neurotransmitters

Chemical messengers which transmit signals across a chemical synapse from one neuron to another neuron/nerve cell.

nociceptors

Sensory neurons that respond to pain

nocturia

Urinating at night (usually excessive)

nomenclature

naming conventions

norepinephrine

A natural chemical in the body that acts as both a stress hormone and neurotransmitter (a substance that sends signals between nerve cells). It's released into the blood as a stress hormone when the brain perceives stress.

nulligravida

no pregnancies

obstetrician

Specialist in obstetrics

occlusion

blocked/blockage

olfaction

sense of smell

oligohydramnios

less then expected (amount) of amnion fluid

oligomenorrhea

Infrequent or irregular periods

omentum

Fatty tissue that stretches over the abdomen, plays a role in immune response and the growth of certain cancers

oncologist

Specialist who studies and treats cancer

oocyte

female gamete

oophorectomy

surgical removal of the fallopian/uterine tubes

ophthalmoplegia

paralysis of eye muscle(s)

opsonization

An antibody or an antimicrobial protein binds to a pathogen, thereby marking it as a target for phagocytes.

orchiectomy

Excision/removal of the testicle.

oropharynx

The oropharynx is a passageway for both air and food and borders the nasopharynx and the oral cavity (Betts, et al., 2013)

osmolarity

the concentration of a solution

Osmosis

A process by which molecules of a solvent tend to pass through a membrane from a less concentrated solution into a more concentrated one.

osteoarthritis

Inflammation of bones and joints

osteomalacia

Softening of the bone(s)

osteoporosis

abnormal condition of bones that are porous.

otalgia

Pain in the ear

otitis externa

Inflammation of the external ear. Aka. swimmer's ear.

otitis media

inflammation of the middle ear

ovaries

female gonads

pacemaker

An electronic implant that initiates a heart beat

pachyderma

thick or thickened skin

Pacinian corpuscle

lamellated corpuscle that responds to vibration

palatine tonsils

a pair of soft tissue masses located at the rear of the throat (pharynx)

palpations

A feeling in the chest that may be caused by an irregular heart rhythm

pancytopenia

abnormal reduction or deficiency in all blood cell types

papillary layer

underlying dermal layer

paracrine

relating to or denoting a hormone which has effect only in the vicinity of the gland secreting it

parasympathetic

rest and relaxation phase

parathyroid glands

four small endocrine glands that are located beside the thyroid gland

pathogens

disease causing agents

pelviscopic

visual examination of the pelvis

percutaneous

pertaining to through the skin

perfusion

The delivery of blood to an area/tissue/organ

pericardial fluid

pericardial fluid is a serous fluid which allow the 2 layers of serous pericardium to slide smoothly against each other as the heart beats

peripheral arterial disease

obstruction of vessels in peripheral regions of the body

peripheral nervous system (PNS)

all nervous tissue that is outside of the brain and spinal cord

peripheral vision

pertaining to the outer sides of the field of vision

permeability

membrane that causes it to allow liquids or gases to pass through it.

pH

pH is a measure of how acidic or alkaline a substance is, as determined by the number of free hydrogen ions in the substance.

phagocytes

Cells that engulf and absorb bacteria and cell particles

phagocytized

also phagocytosed, this is the process by which certain cells are able to 'eat' other cells or substances by engulfing them

pharyngeal

pertaining to the pharynx

pharyngeal tonsils

A pharyngeal tonsil, also called an adenoid, is an aggregate of lymphoid reticular tissue similar to a lymph node that lies at the superior portion of the nasopharynx (De Saix, et al., 2013)

pharynx

The pharynx is a tube formed by skeletal muscle and lined by mucous membrane that is continuous with that of the nasal cavities (Betts, et al., 2013). Also known as the throat.

photophobia

Aversion or sensitivity to light

placenta

the organ of gas and nutrient exchange between the baby and the mother

plaque

a fatty material including cholesterol, connective tissue, white blood cells, and some smooth muscle cells

plasma cells

A type of B lymphocyte that produces antibodies which bind to specific foreign or abnormal antigens, in order to destroy them

plasmapheresis

Process that removes antibodies from the plasma portion of blood

platelets

Blood clotting cells also called thrombocytes.

pneumothorax

An excessive amount of air is present in the thoracic cavity, outside of the lungs, putting pressure on the lungs and interfering with venous return, pulmonary function, and delivery of oxygen to the tissues

polycythemia

a disorder in which too many red blood cells are produced

polycythemia vera

A type of bone marrow disease that causes an excessive production of immature erythrocytes

polymenorrhea

excessive bleeding during one's period

polymyositis

inflammation of many muscles at one time

polyneuropathy

disease of many nerves

polyuria

frequent urination

posterior

pertaining to behind

posteriorly

pertaining to behind

postictal

After a seizure

postnatal

Pertaining to after birth

postpartum

after birth

prefix

Word part at the beginning of a medical term that changes the meaning of the word root.

prenatal

before birth

primary lymphoid organs

Bone marrow and thymus gland.

prognosis

knowledge beforehand. For example stating what the expected outcome is before all the tests are in

proliferate

reproduce rapidly

proliferation

rapid increase in numbers.

prone

face-down

proprioception

body movement

prostaglandins

Any of a group of compounds with varying hormone-like effects.

prostate gland

doughnut-shaped gland at the base of the bladder surrounding the urethra and contributing fluid to semen during ejaculation

proximal

situated nearer to the center of the body or the point of attachment

pseudocyesis

false pregnancy (patient has signs and symptoms of pregnancy but is not pregnant)

pseudostratified

Consisting of closely packed cells which appear to be arranged in layers.

psychiatry

Specialty of the mind

Psychology

The study of human behaviour to understand how humans interact with their physical environment.

puerperium

Time directly after childbirth

pulmonary artery

artery that arises from the pulmonary trunk

pulmonary embolism

A piece of a blood clot or other substance has broken free from its original location and traveled through the bloodstream to lodge in a smaller vessel in the lungs. This causes an obstruction in that vessel and hypoxia to the tissues supplied by that vessel.

pulmonary trunk

very large artery referred to as a trunk, a term indicating that the vessel gives rise to several smaller arteries

pyloric sphincter

A band of smooth muscle at the junction between the pylorus of the stomach and the duodenum of the small intestine

pyosalpinx

Fallopian tube fills with pus

quadrate

A square or rectangular.

rebels

word parts that do not fit within the language rules

renal papillae

The apex of the renal pyramid

renal pyramids

Renal pyramids are kidney tissues that are shaped like cones.

respiratory zone

the respiratory zone includes structures that are directly involved in gas exchange (Betts, et al., 2013)

reticulated

net like

rhabdomyosarcoma

malignant cancer of the skeletal muscles

rheumatoid arthritis

An autoimmune disorder in which the body mounts an immune response against its own joint tissues, causing inflammation and damage to the joints

rhinoplasty

surgical repair of the nasal cavity

rhinorrhagia

Excessive bleeding from the nasal cavity (nose bleed) also called epistaxis

rhinorrhea

excessive flow or discharge from the nasal cavity (runny nose)

rickets

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

roots of the great vessels

The part of each great vessel (aorta, pulmonary trunk, inferior vena cava, superior vena cava) that connects to the base of the heart

S. aureus

Staphylococcus aureus is a bacteria that is commonly found in minor skin infections, as well as in the nose of some healthy people

scar

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

SCID

Severe combined immunodeficiency disease. Patients have essentially no adaptive (specific) immune system due to genetic defects which affect B cells and T cells

sclera

the white of the eye

scrotum

external pouch of skin and muscle that houses the testes

semen

ejaculatory fluid composed of sperm and secretions from the seminal vesicles, prostate, and bulbourethral glands

seminiferous tubules

tube structures within the testes where spermatogenesis occurs

septal cartilage

the flexible portion you can touch with your fingers (Betts, et al., 2013)

seroconversion

Seroconversion is the reciprocal relationship between virus levels in the blood and antibody levels. As the antibody levels rise, the virus levels decline, and this is a sign that the immune response is being at least partially effective. Partially, because in many diseases, seroconversion does not necessarily mean a patient is getting well.(Betts et al., 2013)

serous

You may recall that serous membranes throughout the body are folded back on themselves, which results in a double-layered membrane separated by serous fluid. The serous membrane surrounding the lungs is called pleura, The serous membrane surrounding the abdominopelvic organs is called peritoneum.

sickle cell disease

Also called sickle cell anemia: A genetic disorder involving the production of an abnormal type of hemoglobin which delivers less oxygen to tissues and causes erythrocytes to assume a sickle (or crescent) shape

silent disorder

a disease or disorder that often lacks signs or symptoms

silent MIs

A myocardial infarction without symptoms. The patient may not know that they are having an MI.

sinus rhythm

This is the rhythm set by the heart's pacemaker, the sinoatrial node and is usually approximately 60-90 beats per minute in a resting adult.

skeletal muscle

Also known as striated muscles. Skeletal muscles are responsible for voluntary muscle movement.

smooth muscle

Also known as visceral muscles. Smooth muscle is mainly associated with the walls of internal organs. Smooth muscles are responsible for involuntary muscle movement.

soft palate

located at the posterior portion of the nasal cavity and consists of muscle tissue

solutes

the minor component in a solution

sperm

male gamete (spermatozoon)

Spermatogenesis

Process of producing sperm

spermatogonia

diploid precursor cells that become sperm (singular = spermatogonium)

sphygmomanometer

a blood pressure cuff attached to a measuring device, or gauge

spirometry

Process of measuring the function of the lungs by measuring inhalation and exhalation of breath

stratified squamous epithelium

Cells arranged in layers upon a basal membrane

stratum basale

deepest layer of the epidermal

stratum lucidum

smooth translucent layer of the epidermis

subcutaneous

pertaining to below the skin

suffix

A word part added to the end of a word that changes the meaning of the word root.

superficial lymphatics

lymphatic vessels of the subcutaneous tissues of the skin

superior

pertaining to above

superior vena cava

One of the two largest veins in the body. It carries deoxygenated blood from the head and upper extremities back to the heart.

superiorly

pertaining to below

supine

face up

suprascapular

pertaining to above the scapula

sympathetic

flight or fight response

sympathetic nervous system

fight or flight responses

symphysis

growing together

syncope

fainting

syndrome

A group of symptoms that occur (run together) that are associated with a specific disease or pathology.

synthesis

the production of chemical compounds by reaction from simpler materials.

systemic lupus erythematosus

SLE is an autoimmune disease in which the immune system recognizes its own cell antigens as being "non-self" and mounts an immune response against them. As a result, many body tissues and vital organs become chronically inflamed and damaged. (https://www.cdc.gov/lupus/facts/detailed.html#sle)

systolic pressure

The systolic pressure is the higher value (typically around 120 mm Hg) and reflects the arterial pressure resulting from the ejection of blood during ventricular contraction, or systole.

tachycardia

condition of a fast heart (rate)

teratogen

Substance or agent that produces or causes malformations

testes

male gonads (singular = testis)

testicle

male gonad (testes=plural)

testitis

Inflammation of the testicles

thalassemia

An inherited condition typically occurring in individuals from the Middle East, the Mediterranean, African, and Southeast Asia, in which maturation of the RBCs does not proceed normally. The most severe form is called Cooley's anemia.

thermometer

instrument used to measure temperature

thermoreceptors

specialized neurons that respond to changes in temperature

thrombocytes

also called platelets, these are cell fragments that aid in blood clotting

thrombocytosis

A condition in which there are too many platelets

thrombolysis

dissolution of a blood clot

thrombosis

formation of unwanted blood clots

thymic involution

shrinking of the thymus due to age

thymocytes

lymphocytes that develop into T-cells in the thymus gland

tissue rejection

Also called organ rejection. The recipient's immune system recognizes the transplanted tissue, the graft, as non-self and mounts an immune response against it, ultimately destroying it.

tissue typing

The determination of MHC molecules in the tissue to be transplanted to better match the donor to the recipient

trachea

The trachea (windpipe) extends from the larynx toward the lungs

transdermal

pertaining to across the skin

triceps

Arm muscle has three attachment points (lateral, medial and long) that join the humerus and scapula to the ulna

tympanic membrane

ear drum

umami

Umami is a Japanese word that means delicious taste, and is often translated to mean savory

unilateral

pertaining to one side

ureterostenosis

constriction or narrowing of the ureter

urethritis

inflammation of the urethra

uvula

The uvula is a small bulbous, teardrop-shaped structure located at the apex of the soft palate (Betts, et al., 2013)

vaccine

A vaccine is a killed or weakened pathogen or its components that, when administered to a healthy individual, leads to the development of immunological memory (a weakened primary immune response) without causing much in the way of symptoms (DeSaix et al., 2013)

valve

specialized structure that ensures one-way flow of blood

vas deferen

(also, ductus deferens) duct that transports sperm from the epididymis through the spermatic cord and into the ejaculatory duct; also referred as the vas deferens

vas deferens

vasa vasorum

literally means vessels of vessels

vascularized

has numerous blood vessels

vasoconstrict

The smooth muscle layer in the blood vessel wall contracts, causing the vessel diameter to narrow. This increases blood pressure in the vessel.

vasodilate

The smooth muscle layer in the wall of the blood vessel relaxes, allowing the vessel to widen. This decreases blood pressure in the vessel.

vasospasm

blood vessels contract involuntarily (vasoconstriction) resulting in restricted blood flow

vein

A blood vessel that conducts blood toward the heart. In comparison to an artery a vein is thin-walled with irregular lumen (DeSaix, et al., 2013)

veins

Blood vessels that carry blood back to the heart.

venous stasis

blood in the veins, particularly in the legs, remains stationary for long periods

venules

Extremely small vein

Vessel Compliance

Compliance is the ability of any compartment to expand to accommodate increased content. The greater the compliance of an artery, the more effectively it is able to expand to accommodate surges in blood flow without increased resistance or blood pressure.

visceral

pertaining to internal organs

Viscosity

Viscosity is the thickness of fluids that affects their ability to flow

visual acuity

sharpness of vision

vitro fertilization

assisted reproductive technology

Voiding

Excrete (waste matter)

wheal and flare response

a soft, pale swelling at the site surrounded by a red zone (Betts et al., 2013)

word root

the foundational meaning of a word.

zygote

Process of fertilization is complete and results in a single-celled diploid zygote with all the genetic instructions it needs to develop into a human.

Update & Change Log

Update & Change Log

August 2, 2024 – Building a Medical Terminology Foundation 2e published

- Chapters divided into sections.
- New chapters added to the resource: Chapter 18 and 19.
- Addition of chapter review worksheets (Word docs).
- Reference section created for each chapter inclusive of new links and update any references in text.
- Figure and image numbering updated for all chapters; image description links updated.
- Broken links repaired with new links or new sources, reference updated.
- Accessibility and user experience updates throughout book
- Text versions of H5P added to improve accessibility & offline/PDF user experience
- H5p activities updated, and errata identified, and corrections made:
    - Statement added to Medical Reports as not intended to represent actual format of reports.
    - Respiratory system
        - Definition of Hilum: The first part is the definition of Carina.
        - Carina: The carina is a ridge of cartilage that separates the two main bronchi.
        - Hilum: The hilum is a ridge of cartilage that separates the two main bronchi. A concave region where blood vessels, lymphatic vessels, and nerves also enter the lungs.
    - Urinary system dialogue
        - renogram, pyelolithotomy, glomerulonephritis.
        - the term for VCUG voiding cystourethrogram and it should be void cystourethrogram.
        - one of the dialogue cards, on both sides: ureterostenosis.
    - Male Reproductive dialogue cards
        - Rection should be resection.
- Addition and adaptation of updated H5P activities from Medical Terminology by Grimm et al. New dialogue cards added to several chapters and audio recorded:
    - Chapter 2 – Medical Language Within the Context of Anatomy and Physiology (3 dialogue cards added)
    - Chapter 3 – Integumentary (39 dialogue cards added).
    - Chapter 5 – Urinary (4 dialogue cards added).
    - Chapter 6 – Male Reproductive Word parts (30 dialogue cards added).
    - Chapter 7 – Female Reproductive Not easily broken down (17 dialogue cards added).
    - Chapter 8 – Obstetrics Not easily broken down (9 dialogue cards added).
    - Chapter 13 – Skeletal System Abbreviations accordion added.

April 2024

- H5p activities updated, and errata identified, and corrections made:
  - Statement added to Medical Reports as not intended to represent actual format of reports.
  - Respiratory system
    - Definition of Hilum: The first part is the definition of Carina.
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August 4, 2020

- Original Publication Building a Medical Terminology Foundation