CHAPTER 8: OBSTETRICS

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

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8.1 - Introduction to Obstetrics

Learning Objectives

- Identify the common processes in obstetrics and explore procedures, diagnostics tests and common complications related to obstetrics
- Describe the specialty of obstetrics and other medical specialties associated with obstetrics
- Analyze, translate, and define medical terms and common abbreviations of obstetrics
- Practice the spelling and pronunciation of obstetric terminology

Obstetric Word Parts

Review the list of word parts to memorize for obstetrics:

Prefix

- **ante**– (before)
- **dys**– (painful, laboured, difficult)
- **micro**– (small)
- **multi**– (many)
- **neo**– (new)
- **nulli**– (none)
- **post**– (after)
- **pre**– (before)

Combining Form

- **amni/o** (amnion, amniotic fluid)
- **cephal/o** (head)
- **chori/o** (chorion)

- **embry/o** (embryo)
- **esophag/o** (esophagus)
- **fet/i** (fetus, unborn offspring)
- **fet/o** (fetus, unborn offspring)
- **gravid/o** (pregnancy)
- **lact/o** (milk)
- **nat/o** (birth)
- **omphal/o** (umbilicus, navel)
- **par/o** (to bear, labour, childbirth, give birth to)
- **part/o** (to bear, labour, childbirth, give birth to)
- **prim/i** (first)
- **pseud/o** (false)
- **puerper/o** (childbirth)
- **pylor/o** (pylorus, pyloric sphincter)
- **terat/o** (malformations)

Suffix

- –**a** (no meaning, noun ending)
- –**al** (pertaining to)
- –**amnios** (amnion, amniotic fluid)
- –**cyesis** (pregnancy)
- –**e** (noun ending, no meaning)
- –**gen** (substance that produced, agent that produced)
- –**genic** (producing, originating, causing)
- –**graphy** (process of recording)
- –**ic** (pertaining to)
- –**is** (noun suffix, no meaning)
- –**itis** (inflammation)
- –**logist** (specialist who studies and treats, physician who studies and treats)
- –**logy** (study of)
- –**oid** (resembling)
- –**oma** (tumour)
- –**rrhea** (discharge, flow)
- –**rrhexis** (rupture)
- –**stenosis** (constriction, narrowing)
- –**tocia** (birth, labour)
- –**tomy** (incision, cut into)
- –**um** (noun ending, no meaning)
- –**us** (noun ending, no meaning)

Introduction to Obstetrics

Obstetrics is a specialty that is concerned with the mother and fetus during pregnancy, childbirth, and the immediate postpartum period. Obstetricians study obstetrics and gynecology and are referred to as OB/GYN (Obstetrics and Gynecology).

Watch Reproductive System, Part 4 – Pregnancy & Development: Crash Course Anatomy & Physiology #43 (11 min)

Obstetrics Medical Terms

Obstetrics Medical Terms (Text version)
Practice the following words related to obstetrics by breaking into word parts and pronouncing. Audio recordings of word pronunciations are available through the online book.

1. **amnionitis**
    - amnion/itis
    - *rebel does not follow the rules
    - inflammation of the amnion
2. **oligohydramnios**
    - olig/o/hydr/amnios
    - scanty amnion water
    - a condition where there is minimal amniotic fluid within the placental sac. This can restrict the fetus from movement and growth
3. **polyhydramnios**
    - poly/hydr/amnios
    - much amnion water
4. **amniotomy**
    - amni/o/tomy
    - incision into the amnion to induce labour
5. **amniocentesis**

- amni/o/centesis
- surgical puncture into the amnion to remove a small amount of fluid for testing. The fluid is tested for potential fetal abnormalities

6. **amniochorial**
    - amni/o/chori/al
    - pertaining to the amnion and chorion
7. **amniorrhea**
    - amni/o/rrhea
    - discharge (escape) of amniotic fluid
8. **amniorrhexis**
    - amni/o/rrhexis
    - rupture of the amnion
9. **microcephalus**
    - micr/o/cephal/us
    - small head
10. **chorioamnionitis**
    - chori/o/amnion/itis
    - inflammation of the chorion and amnion
11. **choriocarcinoma**
    - chori/o/carcinoma
    - cancerous tumour of the chorion
12. **embryogenic**
    - embry/o/genic
    - producing an embryo
13. **embryoid**
    - embry/oid
    - resembling an embryo
14. **transesophageal fistula**
    - trans/esophag/eal fistula
    - abnormal passageway between the trachea and esophagus
15. **fetal**

- fet/al
- pertaining to the fetus

16. **gravida**
    - gravid/a
    - pregnant (woman)
    - Note, that this is referring to a woman who is or has been pregnant regardless of outcome
17. **multigravida**
    - multi/gravid/a
    - many pregnancies
    - A woman who has been pregnant two or more times regardless of outcome
18. **lactic**
    - lact/ic
    - pertaining to milk
19. **lactogenic**
    - lact/o/genic
    - producing milk
20. **lactorrhea**
    - lact/o/rrhea
    - discharge of milk
21. **natal**
    - nat/al
    - pertaining to birth
22. **neonate**
    - neo/nate
    - newborn
    - (infant from birth to four weeks of age)
23. **neonatologist**
    - neo/nat/o/logist
    - physician who studies and treats disorders of the newborn
24. **neonatology**
    - neo/nat/o/logy
    - study of the newborn

25. **postnatal**
    - post/nat/al
    - pertaining to after birth
    - (reference to the newborn)
26. **prenatal**
    - pre/nat/al
    - pertaining to before birth
27. **omphalitis**
    - omphal/itis
    - inflammation of the umbilicus
28. **omphalocele**
    - omphal/o/cele
    - herniation of the umbilicus
29. **multipara**
    - multi/par/a
    - many births
30. **nullipara**
    - nulli/par/a
    - no pregnancies
    - a woman who has never been pregnant
31. **para**
    - par/a
    - a woman who has given birth to an offspring after 20 weeks, live or stillborn
32. **postpartum**
    - post/part/um
    - after childbirth
    - referring to the mother
33. **antepartum**
    - ante/part/um
    - before childbirth
    - referencing the mother
34. **intrapartum**

- intra/part/um
- within (during) labour and delivery

35. **primigravida**

    - primi/gravid/a
    - first pregnancy

36. **primipara**

    - primi/par/a
    - first birth

37. **pseudocyesis**

    - pseud/o/cyesis
    - false pregnancy

38. **puerperal**

    - puerper/al
    - pertaining to immediately after childbirth

39. **puerpera**

    - puerper/a
    - childbirth

40. **pyloric stenosis**

    - pylor/ic stenosis
    - narrowing of the pylorus or pyloric sphincter

41. **teratogen**

    - terat/o/gen
    - agent producing malformations
    - (in a developing embryo)such as chemicals, viruses and environmental factors

42. **teratogenic**

    - terat/o/genic
    - producing malformations

43. **teratology**

    - terat/o/logy
    - the study of malformations

44. **dystocia**

- dys/tocia
- labour that is difficult

45. **hysterorrhexis**
    - hyster/o/rrhexis
    - rupture of the uterus
46. **episiotomy**
    - episi/o/tomy
    - incision into the vulva
47. **pelvic sonography**
    - pelv/ic son/o/graphy
    - process of recording sound pertaining to the pelvis
48. **amenorrhea**
    - a/men/o/rrhea
    - absence of menstrual flow
49. **hyperemesis gravida**
    - hyper/emesis gravida
    - Excessive vomiting during pregnancy
50. **neonatal**
    - neo/nat/al
    - pertaining to newborn
51. **nulligravida**
    - null/i/gravida
    - A woman who has never been pregnant
52. **episiotomy**
    - episi/o/tomy
    - Incision into the vulva to widen the vaginal opening to prevent ripping or tearing of the perineum during delivery

Fertilization

Fertilization occurs when a **sperm** and an **oocyte** (egg) combine. Each of these reproductive cells is a haploid cell containing half of the genetic material needed to form a human being; their combination forms a single diploid cell. This new single cell is called a **zygote**.

Most of the time, a woman releases a single egg during an ovulation cycle.

- In approximately 1 percent of ovulation cycles, two eggs are released and both are fertilized.
    - Two zygotes form, implant, and develop, resulting in the birth of **dizygotic (or fraternal) twins**. Because dizygotic twins develop from two eggs fertilized by two sperm, they are no more identical than siblings born at different times.
- Less common, one zygote can divide into two separate offspring during early development. This results in the birth of **monozygotic (or identical) twins**.

A full-term pregnancy lasts approximately 270 days (approximately 38.5 weeks) from conception to birth. Because it is easier to remember the first day of the last menstrual period (LMP) than to estimate the date of conception, obstetricians set the due date as 284 days (approximately 40.5 weeks) from the LMP. This assumes that conception occurred on day 14 of the woman's cycle, which is usually a good approximation. The 40 weeks of an average pregnancy are usually discussed in terms of three trimesters, each approximately 13 weeks. During the second and third trimesters, the pre-pregnancy uterus is about the size of a fist and grows dramatically to contain the fetus, causing a number of anatomical changes in the mother.

Stages of Childbirth

The process of childbirth can be divided into three stages (see Figure 8.1):

- Stage 1: cervical dilation
- Stage 2: expulsion of the newborn
- Stage 3: after birth

For vaginal birth to occur, the cervix must dilate fully to 10 cm in diameter, wide enough to deliver the newborn's head. The dilation stage is the longest stage of labour and typically takes 6-12 hours. However, it varies widely and may take minutes, hours, or days, depending in part on whether the mother has given birth before. In each subsequent labour, this stage tends to be shorter.

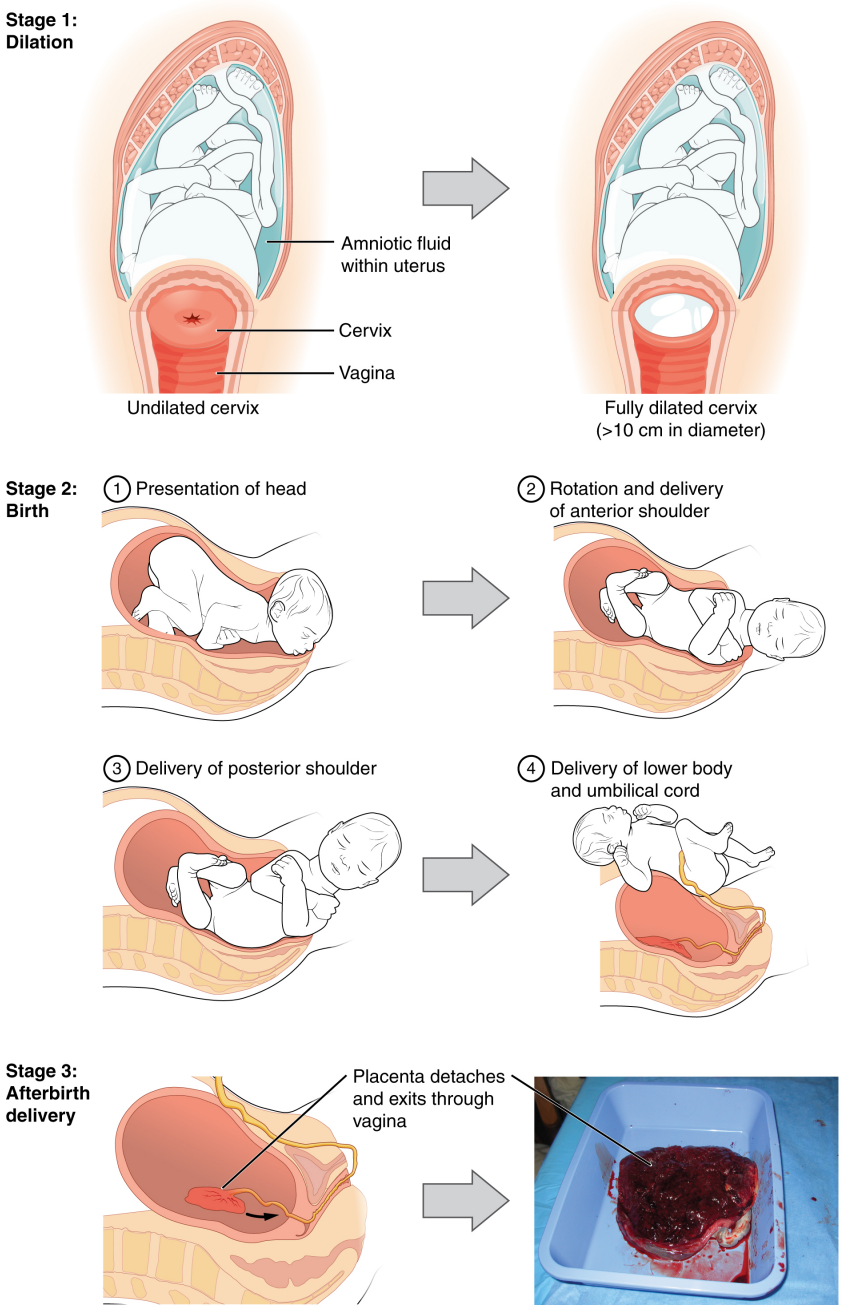

Figure 8.1 Stages of Childbirth. The stages of childbirth include Stage 1, early cervical dilation; Stage 2, full dilation and expulsion of the newborn; and Stage 3, delivery of the placenta and associated fetal membranes. (The position of the newborn's shoulder is described relative to the mother). From Betts, et al., 2013. Licensed under CC BY 4.0. [Fig. 8.1 Image description.]

Concept Check

- How is a **due date** determined?
- Explain the difference between a **monozygotic pregnancy** and a **dizygotic pregnancy**.

Homeostasis in the Newborn: Apgar Score

In the minutes following birth, a newborn must undergo dramatic systemic changes to be able to survive outside the womb. An obstetrician, midwife, or nurse can estimate how well a newborn is doing by obtaining an **Apgar score**. The Apgar score was introduced in 1952 by the anesthesiologist Dr. Virginia Apgar as a method to assess the effects on the newborn of anesthesia given to the labouring mother. Healthcare providers now use it to assess the general well-being of the newborn, whether or not analgesics or anesthetics were used.

The five criteria for the Apgar score (skin colour, heart rate, reflex, muscle tone, and respiration) are assessed and each criterion is assigned a score of 0, 1, or 2. Scores are taken at 1 minute after birth and again at 5 minutes after birth. Each time scores are taken, the five scores are added together. High scores (out of a possible 10) indicate the baby has made the transition from the womb well, whereas lower scores indicate that the baby may be in distress.

The technique for determining an Apgar score is quick and easy, painless for the newborn, and does not require any instruments except for a stethoscope. A convenient way to remember the five scoring criteria is to apply the mnemonic APGAR:

- **A**ppearance (skin colour)
- **P**ulse (heart rate)
- **G**rimace (reflex)
- **A**ctivity (muscle tone)
- **R**espiration

Of the five Apgar criteria, heart rate and respiration are the most critical. Poor scores for either of these measurements may indicate the need for immediate medical attention to resuscitate or stabilize the newborn. In general, any score lower than 7 at the 5-minute mark indicates that medical assistance may be needed. A total score below 5 indicates an emergency situation. Normally, a newborn will get an intermediate score of 1 for some of the Apgar criteria and will progress to a 2 by the 5-minute assessment. Scores of 8 or above are normal.

Check Your Knowledge of Obstetrics Medical Terms and Abbreviations

Obstetrics Medical Terms Not Easily Broken into Word Parts

Obstetrics Words Not Easily Broken into Word Parts (Text version)

1. **abortion (AB) (ă-BOR-shŏn)**
    - termination of the pregnancy before the fetus is viable
2. **abruptio placentae (ă-BRŬP-shē-ō plă-SENT-ā)**
    - pre-mature separation of the placenta from the uterine wall
3. **Apgar score (AP-gar skōr)**
    - Evaluation of a newborn's physical condition within one to five minutes after birth, which was developed by and named for Virginia Apgar (making this an eponym).
4. **Breech (brēch)**
    - The position of the fetus is feet first. Ideally, the position of the fetus should be head first.
5. **Cesarean section (CS, C-section) (si-ZAR-ē-ăn SEK-shŏn)**
    - Delivery of the fetus through an abdominal incision
6. **cephalic presentation (sĕ-FAL-ĭk prē-zen-TĀ-shŏn)**
    - birth position in which any part of the head emerges first
7. **Cephalic version (sĕ-FAL-ĭk VĔR-zhŏn)**
    - pertaining to turning the head; this procedure is done on the fetus when they are in the head-down position.
8. **cerclage (sĕr-KLĂZH)**
    - Suturing of the cervix to prevent dilation and premature delivery
9. **colostrum (kŏ-LOS-trŭm)**
    - thin, milky fluid secreted by the breast during pregnancy and the first few days after delivery
10. **congenital anomaly (kŏn-JĔN-ĭ-tăl ă-NOM-ă-lē)**

- abnormality present at birth

11. **eclampsia (e-KLAMP-sē-ă)**
    - a serious condition in pregnancy with hypertension; patients are at risk of coma, convulsions and even death.
12. **Ectopic pregnancy (ek-TOP-ik PREG-năn-sē)**
    - Pregnancy occurring outside the uterus, commonly in the fallopian tube.
13. **Induction (in-DŬK-shŏn)**
    - The process of bringing on or starting labour. This may be done with a membrane sweep or through the use of IV oxytocin
14. **in vitro fertilization (IVF) (in VĒ-trō fĕrt-ĭl-ĭ-ZĀ-shŏn)**
    - method of fertilizing human ova outside the body and placing the zygote in the uterus
15. **lactation (lak-TĀ-shŏn)**
    - secretion of milk
16. **lochia (LŌ-kē-ă)**
    - vaginal discharge after birth
17. **meconium (mē-KŌ-nē-ŭm)**
    - first stool of the newborn
18. **midwife (MĬD-wīf)**
    - individual who practices midwifery
19. **craniocerebral**
    - practice of assisting in childbirth
20. **Obstetrician (ob-stĕ-TRISH-ăn)**
    - Physician who specializes in obstetrics
21. **Obstetrics (OB) (ŏb-STE-triks)**
    - medical specialty dealing with pregnancy, childbirth, and puerperium
22. **parturition (păr-tū-RĬSH-ŭn)**
    - act of giving birth
23. **placenta previa (plă-SENT-ā PRĒ-vē-ă)**

- abnormally low implantation of the placenta on the uterine wall, can result in hemorrhage and a c- section

24. **preeclampsia (prē-ĕ-KLAMP-sē-ă)**
    - The abnormal condition in pregnancy where the patient experiences hypertension, edema and proteinuria is called, but with no convulsions. Can progress to eclampsia.
25. **premature infant (prē-mă-CHŪR IN-fănt)**
    - infant born before completing 37 weeks of gestation (also called preterm infant)
26. **puerperium (pū-ĕr-PĒ-rē-ŭm)**
    - period from delivery until the reproductive organs return to normal (approximately six weeks)
27. **quickening (KWĬK-ĕn-ĭng)**
    - first feeling of movement of the fetus in utero by the pregnant woman
28. **stillborn (STIL-bōrn)**
    - an infant that is born dead

Obstetrics Abbreviations

Review the list of common abbreviates below.

Obstetrics Common Abbreviations

- **AB** (abortion)
- **AFP** (Alpha-fetoprotein test)
- **AI** (artificial insemination)
- **CS, C-section** (cesarean section)
- **CVS** (chorionic villus sampling)
- **DOB** (date of birth)

- **EDD** (expected or estimated date of delivery)
- **FAS** (fetal alcohol syndrome)
- **IVF** (in vitro fertilization)
- **LMP** (last menstrual period)
- **multip** (multipara)
- **NB** (newborn)
- **OB** (obstetrics)
- **primip** (primipara)
- **RDS** (respiratory distress syndrome)
- **VBAC** (vaginal birth after cesarean section)
- **ZIFT** (Zygote intrafallopian transfer)

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

Obstetrics Pathology Report

Obstetrics- Pathology Report (Text version)
Use the words below to fill in the pathology report:

- salpingectomy
- ectopic
- ultrasound
- fallopian
- tube
- clots
- cassettes
- microscopic
- pregnancy

OBSTETRICS – PATHOLOGY REPORT

PATIENT NAME: Bonnie PERRY
AGE: 34
SEX: Female
DOB: May 3
PATIENT ID: 900132

DATE OF ADMISSION AND SURGERY: June 14
ADMITTING DIAGNOSIS: Ectopic pregnancy
SURGEON: Adam Vance, MD, OB/GYN

PATHOLOGY ID: Specimen No. 05-S-899
SPECIMEN RECEIVED: June 14 Specimen Reported: June 18
SURGICAL PROCEDURE: Right partial _____[Blank 1].

CLINICAL HISTORY: This 34-year-old white female had an _____[Blank 2] pregnancy as proven by pelvic _____[Blank 3].

TISSUE RECEIVED: Right fallopian tube.

GROSS DESCRIPTION: The specimen designated right _____[Blank 4] tube was examined reveals the presence of a fallopian tube measuring 5.9 cm in length and 2.3 cm in average diameter. Sectioning of the _____[Blank 5] shows it to be distended with blood _____[Blank 6] and possible field tissue. The sections were taken, and placed in three _____[Blank 7], A through C, for embedding.

MICROSCOPIC DESCRIPTION: _____[Blank 8] examination performed.

MICROSCOPIC DIAGNOSIS: Ruptured tubal _____[Blank 9].

_____
Joseph Gibbs, MD, Anatomic & Clinical Pathology

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]

Activity source: Obstetrics- Pathology Report by Heather Scudder, from *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY- 4.0. / Text version added.

Image Descriptions

Figure 8.1 image description: This multi-part figure shows the different stages of childbirth. The top panel shows dilation of the cervix (undilated vs fully dilated), the middle panel shows birth (presentation of the head, rotation and delivery of anterior shoulder, delivery of posterior shoulder, delivery of lower body and umbilical cord), and the bottom panel shows afterbirth delivery. [Return to Figure 8.1].

Attribution

Notes

1. 1.salpingectomy, 2.ectopic, 3.ultrasound, 4.fallopian, 5.tube, 6. clots, 7.cassettes, 8. Microscopic, 9.pregnancy

8.2 - Procedures Related to Obstetrics

In Vitro Fertilization (IVF)

IVF, which stands for **in vitro fertilization**, is an assisted reproductive technology. *In vitro*, which in Latin translates to *in glass*, refers to a procedure that takes place outside of the body. There are many different indications for IVF. For example, a woman may produce normal eggs, but the eggs cannot reach the uterus because the uterine tubes are blocked or otherwise compromised. A man may have a low sperm count, low sperm motility, sperm with an unusually high percentage of morphological abnormalities, or sperm that are incapable of penetrating the zona pellucida of an egg. Figure 8.2 illustrates the steps involved in IVF.

Did You Know?

According to Health Canada, one in six Canadian couples have struggled with conceiving (Fertility, 2019).

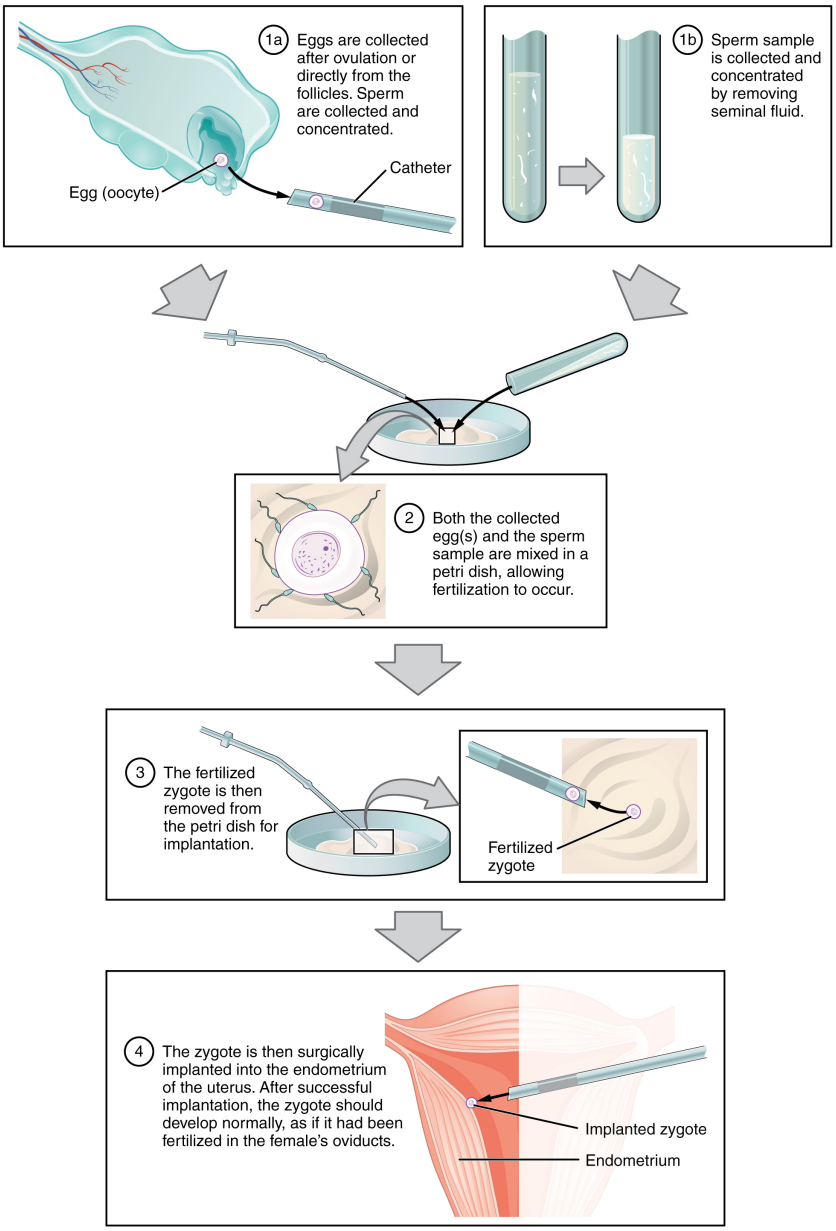

Figure 8.2 IVF. In vitro fertilization involves egg collection from the ovaries, fertilization in a petri dish, and the transfer of embryos into the uterus. From Betts, et al., 2013. Licensed under CC BY 4.0. [Fig. 8.2 Image description.]

Prenatal Screening and Diagnostic Testing

Approximately 4% of Canadian babies are born with a congenital anomaly. The most common anomalies include structural heart defects, cleft lip/palate, or anomalies like Down syndrome. Prenatal testing may include blood work, ultrasound, **chorionic villus sampling** (CVS) and **amniocentesis** (Genetics Education Canada Knowledge Organization, 2019). To learn more about prenatal screening tests, visit GECKO's Guide to Understanding Prenatal Screening Tests [PDF].

Image Descriptions

Figure 8.2 image description: This multi-part figure shows the different steps of in vitro fertilization. The top panel shows how the oocytes and the sperm are collected and prepared (text reads: 1a) eggs are collected after ovulation or directly from the follicles. Sperm are collected and concentrated. 1b) Sperm sample is collected and concentrated by removing seminal fluid). The next panel shows the sperm and oocytes being mixed in a petri dish (text labels read: 2) both the collected eggs and the sperm sample are mixed in a petri dish, allowing fertilization to occur). The panel below that shows the fertilized zygote being prepared for implantation (text labels read: 3a) the fertilized zygote is then removed from the petri dish for implantation. 3b) fertilized zygote). The last panel shows the fertilized zygote being implanted into the uterus (text label reads: 4) The zygote is then surgically implanted into the endometrium of the uterus. After successful implantation, the zygote should develop normally, as if it had been fertilized in the female's oviducts). [Return to Figure 8.2].

Attribution

Vocabulary & Check Your Knowledge

Obstetrics Vocabulary

Abortion

Termination of a pregnancy before the fetus is viable.

Alpha-fetoprotein test (AFP)

A maternal blood test to detect potential fetal abnormalities such as neural tube defects or multiple pregnancies; The AFP is taken between 14 and 19 weeks gestation.

Amenorrhea

Absences of the flow of menses, no period; one of the first signs of pregnancy or menopause.

Amniocentesis

Surgical puncture to remove a small amount of amniotic fluid through a needle via the abdomen. The fluid is tested for any potential fetal abnormalities.

Artificial insemination

A process where the semen is introduced into the vagina by mechanical means, thus called artificial.

Breech

The position of the fetus is feet first. Ideally, the position of the fetus should be headfirst for a safer delivery.

Caesarian section (CS, c-section)

Delivery of the fetus through an abdominal incision.

Cephalopelvic disproportion

A condition where the infant's head is larger than the pelvic outlet and therefore will require a c-section.

Cerclage

A suture inserted into the cervix to prevent dilation and prevention miscarriage. The suture is removed when the fetus is full-term and allows the vaginal delivery to proceed.

Cephalic version

Pertaining to turning the head; this procedure is done on the fetus when they are in the head-down position.

Chorionic villus sampling

A small piece of placenta is taken and tested to determine potential for birth defects.

Dilation and curettage (D&C)

A procedure where the cervix is dilated (widened) and a curette (a sharp instrument) is used to remove the lining of the uterus. This procedure is conducted when there is abnormal bleeding from the uterus and also to remove any products of conception, for example following an incomplete miscarriage or abortion.

Eclampsia

A very serious condition in pregnancy with hypertension; patients are at high risk of coma, convulsions, and even death.

Ectopic pregnancy

The embryo implants any other place but the inner endo-uterine lining.

Episiotomy

A procedure where an incision is made to widen the vaginal opening to prevent ripping or tearing of the perineum during delivery.

Gestation

The process of being pregnant.

Gestational Diabetes

The condition or developing diabetes during pregnancy. The newborn tend to be large at delivery and the mother is monitored closely for weight gain and glucose testing. The goal is to balance the sugars so the fetus is not too large for a vaginal delivery.

Gestational Hypertension

A condition where there is an increase in blood pressure during pregnancy. Blood pressure is monitoring closely during pregnancy for the safety of the mother and infant.

Hyperemesis

Excessive vomiting during pregnancy.

Hyperemesis Gravidarum

Hyperemesis can occur with any pregnant women, even a woman who miscarries. Often these women may require hospitalization for fluid and electrolyte intake.

Induction

The process of bringing on or starting labour. This may be done with a membrane sweep or through the use of IV oxytocin.

In vitro Fertilization (IVF)

A process where the ova is fertilized outside the body and then implanted into the uterus.

Meconium Staining

When the fetus defecates while in utero; the first defecation is called meconium, it is black and sticky. If the infant inhales the meconium upon delivery or through the birth canal, the meconium can be aspirated into the lungs and stick to the lung tissue. The newborn will have problems breathing and go into distress. The newborn's umbilical cord will be stained a brownish colour.

Natal

Pertaining to born.

Neonatal

Pertaining to the newborn. For example neonatal record, neonatal unit

Non-stress test

Test conducted on the pregnant woman to assess the fetal heart rate (FHR).

Nulligravida

A woman who has never been pregnant.

Obstetrician

The person who specializes in the study of obstetrics and gynecology and are referred to as OB/GYN Obstetrics and Gynecology.

Oligohydramnios

A condition where there is minimal amniotic fluid within the placental sac. Too little fluid can restrict the fetus from movement and growth.

Oocyte

Female gamete.

Oxytocia

A rapid birth.

Placenta Abruptio or Abruptio Placenta

Occurs when the placenta prematurely becomes detached from the uterine wall. This is a medical emergency and requires an immediate c-section to safe both the woman and infants lives. the infant will not be getting oxygen from the mother and the mother may hemorrhage.

Placenta Previa

Occurs when the placenta partially or completely covers the cervical os (opening).

Polyhydramnios

A condition where there is excessive amniotic fluid in the placenta. The delivery will be a c-section to prevent bleeding during delivery of the fetus.

Preeclampsia

The abnormal condition in pregnancy where the patient experiences hypertension, edema and proteinuria.

Primigravida

First pregnancy.

Sperm

Male gamete (spermatozoon).

Vaginal Birth Following a C-Section

Having a vaginal delivery after a previous c-section delivery.

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.

Zygote Intrafallopian Transfer (ZIFT)

Mixing of the ova and sperm in a laboratory. Fertilization is confirmed to grow into zygotes and then are inserted into the Fallopian tubes (Healthwise Staff, 2018).

Obstetrics Glossary Reinforcement Activity

Obstetrics Glossary Reinforcement Activity (Text version)

1. Termination of a pregnancy before the fetus is viable is called _____[Blank 1].
    a. Abortion
    b. Amniocentesis
    c. Gestation
2. The abnormal condition in pregnancy where the patient experiences hypertension, edema and proteinuria is called _____[Blank 2].
    a. Hyperemesis Gravida
    b. Preeclampsia
    c. Dystocia
3. When the embryo implants any other place but the inner endo-uterine lining it is called a(n) _____[Blank 3].

a. Ectopic pregnancy
b. Placenta Previa
c. Zygote intrafallopian transfer

4. A condition where the infant's head is larger than the pelvic outlet and therefore will require a c-section is called _____[Blank 4].

   a. Cephalopelvic disproportion
   b. Cephalic version
   c. Induction

5. A test conducted on the pregnant woman to assess the fetal heart rate is called _____[Blank 5].

   a. Alpha-fetoprotein test
   b. Non-stress test
   c. Meconium staining

Check your Answers: [1]

Attribution

Notes

1. 1. Abortion, 2. Preeclampsia, 3. Ectopic pregnancy, 4. Cephalopelvic disproportion, 5.Non-stress test,

References

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CHAPTER 9: CARDIOVASCULAR SYSTEM - HEART

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.

9.1 - Introduction to the Heart

Learning Objectives

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

Cardiovascular System – Heart Word Parts

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

Prefix

- **a-** (absence of, without)
- **bi-** (two)
- **brady-** (slow)
- **endo-** (within, in)
- **epi-** (on, upon, over)
- **hypo-** (below, deficient)
- **hyper-** (above, excessive)
- **inter-** (between)
- **pan-** (all, total)
- **peri-** (surrounding, around)
- **tachy-** (fast, rapid)
- **tri-** (three)

Combining Form

- **atri/o** (atrium)
- **cardi/o/** (heart)
- **ech/o** (sound)
- **electr/o** (electricity)
- **symptomat/o** (symptom)
- **valv/o** (valve)
- **valvul/o** (valve)
- **ventricul/o** (ventricle)

Suffix

- **-ac** (pertaining to)
- **-apheresis** (removal)
- **-ar** (pertaining to)
- **-centesis** (surgical puncture to aspirate fluid)
- **-ectomy** (excision, surgical removal)
- **-genic** (producing, originating, causing)
- **-gram** (record, radiographic image)
- **-graph** (instrument used to record)
- **-graphy** (process of recording, radiographic imaging)
- **-ia** (condition of, diseased state, abnormal state)
- **-ic** (pertaining to)
- **-itis** (inflammation)
- **-lysis** (loosening, dissolution, separating)
- **-megaly** (enlarged, enlargement)
- **-logist** (specialist, physician who studies and treats)
- **-oma** (tumour)
- **-osis** (abnormal condition)
- **-tomy** (cut into, incision)
- **-ous** (pertaining to)
- **-pathy** (disease)
- **-penia** (abnormal reduction in number)
- **-pexy** (surgical fixation, suspension)
- **-plasty** (surgical repair)
- **-poiesis** (formation)
- **-sclerosis** (hardening)
- **-scope** (instrument used to view)
- **-scopy** (process of viewing)
- **-stasis** (stop, stopping, controlling)
- **-stenosis** (narrowing, constriction)

Activity source: Cardiovascular System Heart Word Parts by Kimberlee Carter, from *Building a Medical*

Introduction to the Heart

The heart is a fist-sized vital organ that has *one* job: to pump blood. If one assumes an average **heart rate** of 75 beats per minute, a human heart would beat approximately 108,000 times in one day, more than 39 million times in one year, and nearly 3 billion times during a 75-year lifespan. At rest, each of the major pumping chambers of the heart ejects approximately **70 mL blood per contraction** in an adult. This would be equal to **5.25 liters of blood** per minute and approximately 14,000 liters per day. Over one year, that would equal 10,000,000 liters of blood sent through roughly 100,000 km of blood vessels. In order to understand how that happens, it is necessary to understand the anatomy and physiology of the heart.

Watch **The Heart, Part 1 – Under Pressure: Crash Course Anatomy & Physiology #25 (10 min)**

Cardiovascular System – Heart Medical Terms

Cardiovascular System – Heart Medical Terms (Text Version)
Practice the following cardiovascular system – heart medical terms by breaking into word parts and pronouncing.

1. **endocarditis**
    - end/o/card/itis
    - Inflammation of the inner (lining) of the heart
2. **echocardiogram**
    - ech/o/cardi/o/gram
    - a record (using) sound of the heart
3. **bradycardia**
    - brady/card/ia
    - condition of slow heart (rate)

4. **electrocardiograph**
    - electr/o/cardi/o/graph
    - instrument used to record the electrical (activity) of the heart
5. **tachycardia**
    - tachy/card/ia
    - condition of fast/rapid heart (rate)
6. **pericardiocentesis**
    - peri/cardi/o/centesis
    - Surgical puncture to aspirate fluid from the (sac) surrounding the heart
7. **electrocardiogram**
    - electr/o/cardi/o/gram
    - a record of electrical (activity) of the heart
8. **electrocardiography**
    - electr/o/cardi/o/graphy
    - process of recording the electrical (activity) of the heart
9. **valvulitis**
    - valvul/itis
    - inflammation of a valve
10. **pericarditis**
    - peri/card/itis
    - inflammation of the (sac) surrounding the heart
11. **asymptomatic**
    - a/symptomat/ic
    - pertaining to without symptoms
12. **myocarditis**
    - my/o/card/itis
    - inflammation of the muscle of the heart
13. **cardiomegaly**
    - cardi/o/megaly
    - enlarged heart
14. **atherosclerosis**

- ather/o/scler/osis
- abnormal condition of plaque (build up) causing constriction

15. **valvuloplasty**
    - valvul/o/plasty
    - surgical repair of a valve
16. **Cardiologist**
    - Cardi/o/logist
    - A physician who studies and treats diseases of the heart
17. **cardiac**
    - cardi/ac
    - pertaining to the heart
18. **cardiology**
    - cardi/o/logy
    - study of the heart
19. **atrioventricular**
    - atri/o/ventricul/ar
    - pertaining to the atrium and ventricle
20. **cardiogenic**
    - cardi/o/genic
    - originating in the heart
21. **cardiomyopathy**
    - cardi/o/my/o/pathy
    - disease of the heart muscle

Activity source: Cardiovascular System – Heart 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.

Attribution

derivative of Betts et al., which can be accessed for free from *Anatomy and Physiology (OpenStax)*. Adaptations: dividing Cardiovascular System – Heart chapter content into sub-chapters.

9.2 - Anatomy of the Heart

Location

The human heart is located within the thoracic cavity, between the lungs in the space known as the **mediastinum**. Figure 9.1 shows the position of the heart within the thoracic cavity. Within the mediastinum, the heart is separated from the other mediastinal structures by a tough membrane known as the pericardium, or pericardial sac, and sits in its own space called the **pericardial cavity**. The **great vessels**, which carry blood to and from the heart, are attached to the superior surface of the heart, which is called the base. The base of the heart is located at the level of the third costal cartilage. The inferior tip of the heart is called the apex. The apex lies just to the left of the sternum between the junction of the fourth and fifth ribs.

Concept Check 1

- On the diagram below (Figure 9.1), locate the **mediastinum**, the **pericardial cavity**, the **base** of the heart and the **apex** of the heart.
- Locate the largest vein in the body **superior vena cava**.

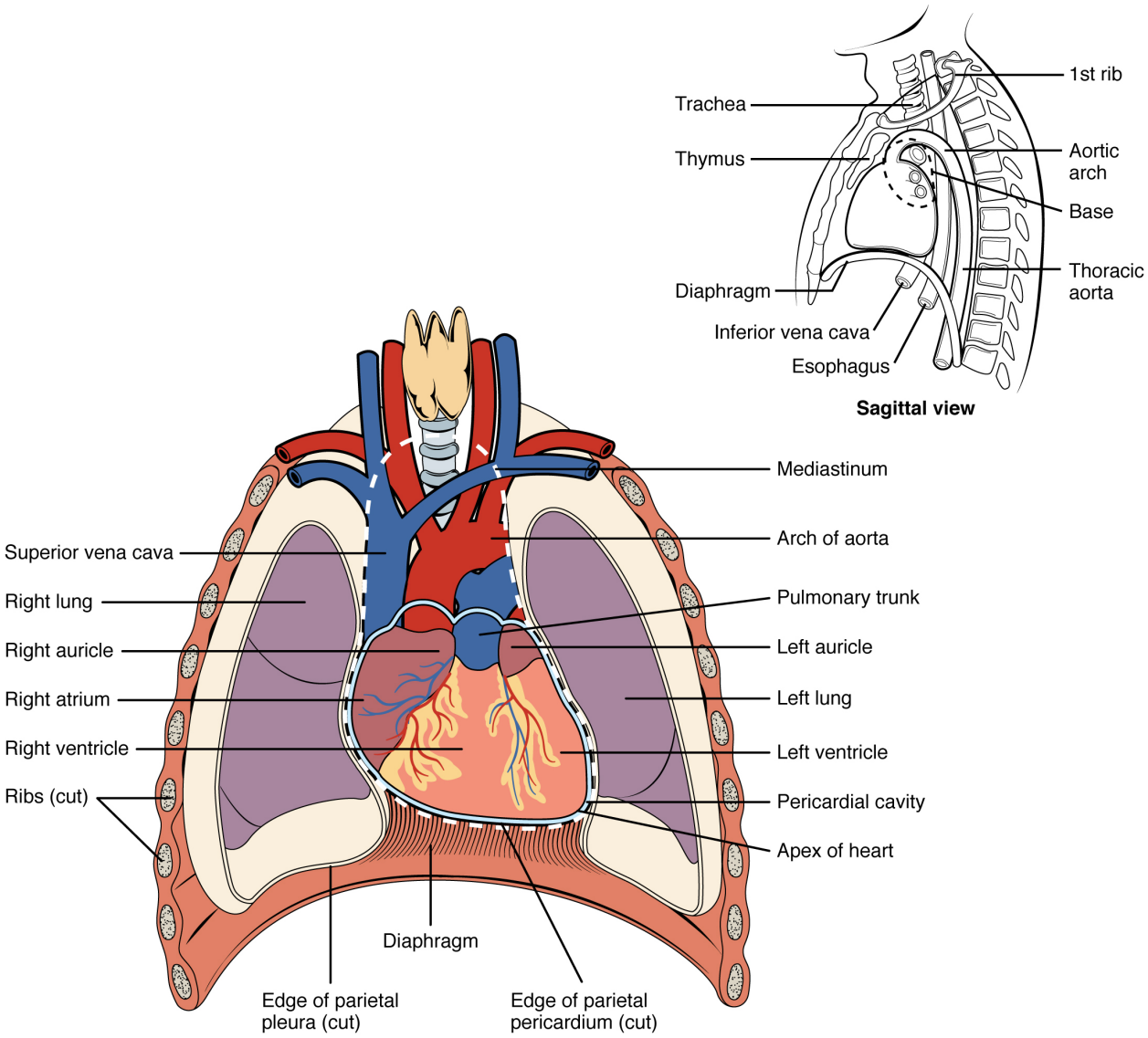


Figure 9.1. Position of the Heart in the Thorax. The heart is located within the thoracic cavity, medially between the lungs in the mediastinum. It is about the size of a fist, is broad at the top, and tapers toward the base. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 9.1 Image description.]

Membranes and Layers of the Heart Walls

The heart and the **roots of the great vessels** are surrounded by a membrane known as the **pericardium** or **pericardial sac (Figure 9.2)**. The pericardium consists of two distinct sub layers:

- The sturdy outer fibrous pericardium is made of tough, dense connective tissue that protects the heart and holds it in position.
- The inner **serous** pericardium is separated by the **pericardial cavity** and contains pericardial fluid. It consists of two layers:

    - the outer **parietal pericardium**, which is fused to the fibrous pericardium.
    - the inner **visceral pericardium**, or **epicardium**, which is fused to the heart and forms the outer layer of the heart wall.

The walls of the heart consist of three layers:

- The outer **epicardium**, which is another name for the visceral pericardium mentioned above.
- The thick, middle **myocardium**, which is made of muscle tissue and gives the heart its ability to contract.
- The inner **endocardium**, which lines the heart chambers and is the main component of the heart valves.

Concept Check 2

- Look at Figure 9.2 below, and name the layers of the heart wall and surrounding membranes, starting with the innermost layer.
- As shown on the diagram, suggest why the **myocardium** layer is thicker than the **endocardium** layer.

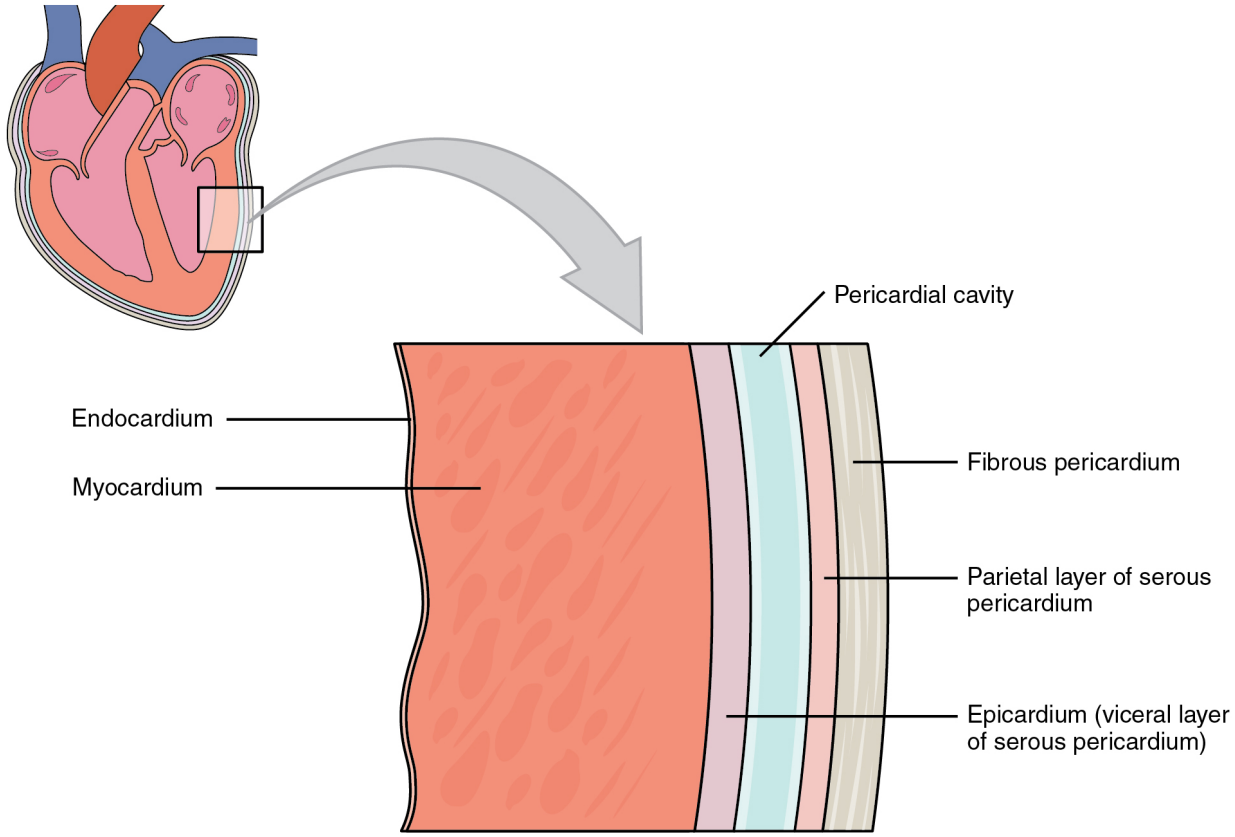


Figure 9.2. Pericardial Membranes and Layers of the Heart Wall. The pericardial membrane that surrounds the heart consists of three layers and the pericardial cavity. The heart wall also consists of three layers. The pericardial membrane and the heart wall share the epicardium From Betts et al., 2013. Licensed under CC BY 4.0. [Fig 9.2 Image description.]

Internal Structures of the Heart

The heart consists of four chambers:

- The upper chambers are the right and left **atria** (singular: atrium).
- The lower chambers are the right and left **ventricles** (singular: ventricle).

The **interventricular septum** is a muscular wall that separates the right and left ventricles. The interatrial septum separates the right and left atria.

The atrium and ventricle on each side of the heart are separated by an atrioventricular (AV) valve:

- The right AV valve, or **tricuspid valve,** separates the right atrium and right ventricle.
- The left AV valve, or **bicuspid valve,** separates the left ventricle and the left atrium. This valve is also called the **mitral valve.**

There are also two semilunar valves:

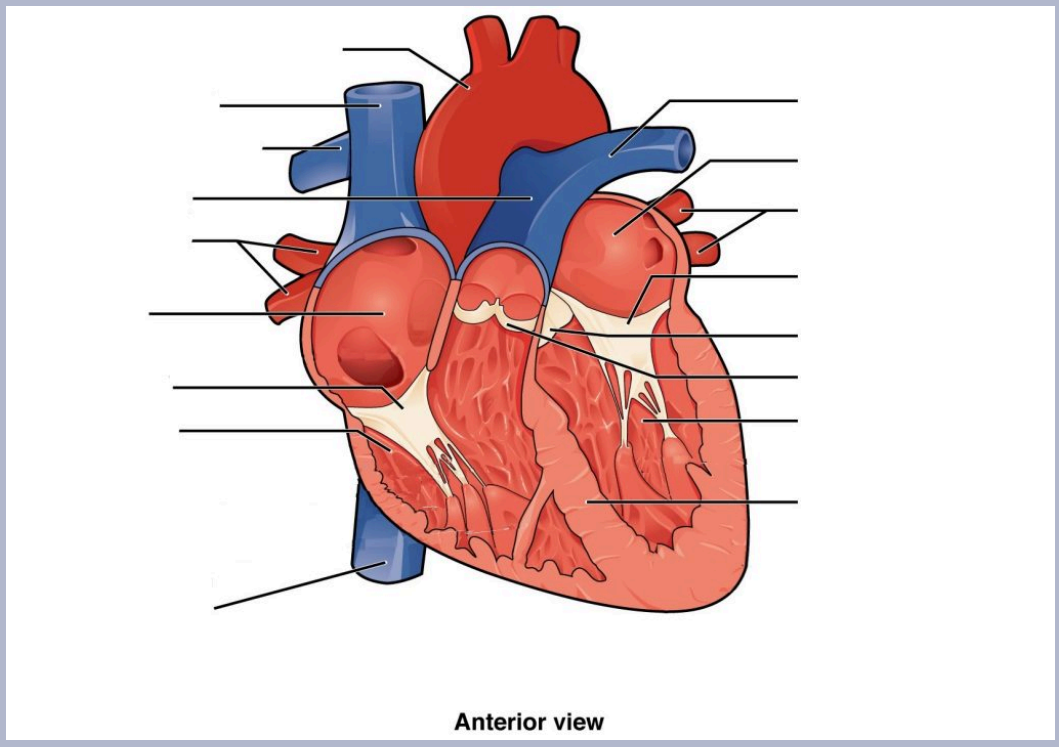
- The **pulmonary valve** separates the right ventricle from the pulmonary trunk.
- The **aortic valve** separates the left ventricle from the aorta (De Saix, et al., 2013).

Anatomy Labeling Activity

Cardiovascular System: The Heart Anatomy (Text Version)

Label the diagram with correct words listed below:

1. Aortic valve
2. Mitral (bicuspid) valve
3. Aorta
4. Pulmonary trunk
5. Tricuspid valve
6. Interventricular septum
7. Inferior vena cava
8. Left pulmonary artery
9. Right atrium
10. Left pulmonary veins
11. Left atrium
12. Right ventricle
13. Right pulmonary veins
14. Right pulmonary artery
15. Pulmonary valve
16. left ventricle
17. Superior vena cava



Anterior view

Cardiovascular System: The Heart Anatomy Diagram (Text Version)

This diagram shows the heart with an anterior view. The view shows from (from top, clockwise): the largest artery in the body known as the _____[Blank 1]. The _____[Blank 2] is shown which is the only vein in the body to carry oxygenated blood. The heart is divided into four chambers the_____[Blank 3] is one of the four chambers of the heart it is in the upper left portion of the heart. The _____[Blank 4] also know as the bicuspid valve contains to cusps or flaps and is positioned between the left atrium and lower left ventricle. The _____[Blank 5] is a structure

located between the aorta and _____[Blank 6] of the heart which is the left lower chamber of the heart. The _____[Blank 7] is a thick wall of tissue divided the right side of the heart from the left. The _____[Blank 8] lies between the right atrium and pulmonary artery. The _____[Blank 9] is a large vein that carries deoxygenated blood to the heart. The _____[Blank 10] is the lower right chamber of the heart. The _____[Blank 11] lies between the right ventricle and the _____[Blank 12] which is the upper right chamber of the heart. The _____[Blank 13] transfer oxygenated blood from the lungs to the heart. The _____[Blank 14] is part of the _____[Blank 15] and transfers deoxygenated blood to the lungs. The _____[Blank 16] a large vein that returns deoxygenated blood from systemic circulation to the right atrium of the heart.

Check your answers: [1]

Activity source: Cardiovascular System: The Heart 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.

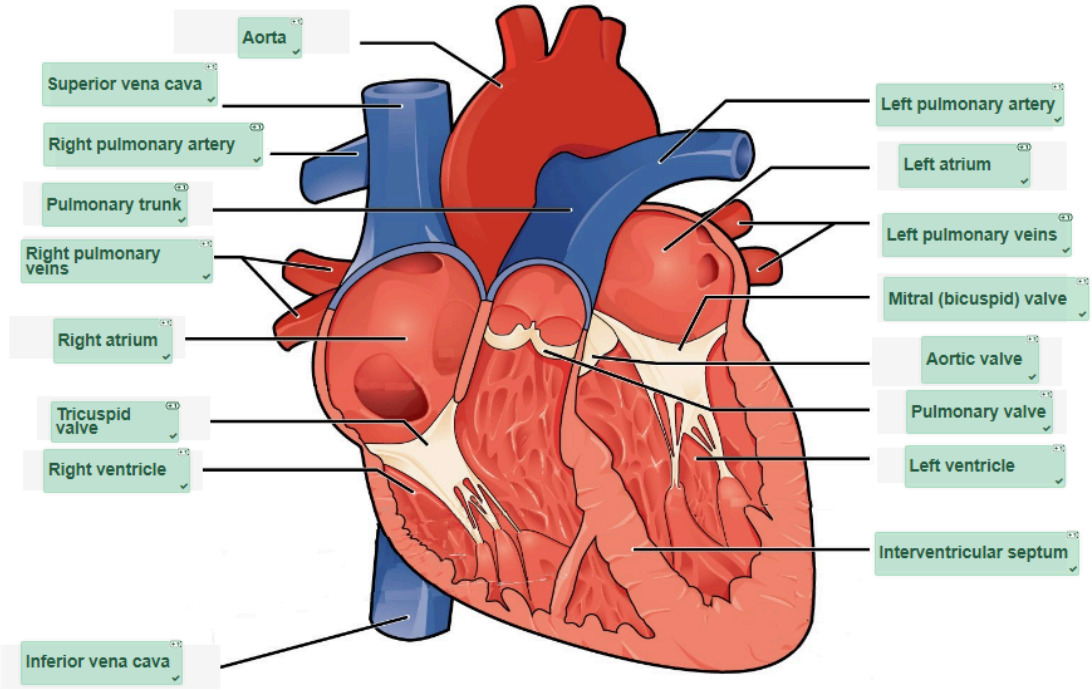
Image Descriptions

Figure 9.1 image description: This diagram shows the location of the heart in the thorax (sagittal and anterior views). The sagittal view labels read (from top, clockwise): first rib, aortic arch, thoracic arch, esophagus, inferior vena cava, diaphragm, thymus, trachea. The anterior view labels read (from top, clockwise): mediastinum, arch of aorta, pulmonary trunk, left auricle, left lung, left ventricle, pericardial cavity, apex of heart, edge of parietal pericardium, diaphragm, edge of parietal pleura, ribs, right ventricle, right atrium, right auricle, right lung, superior vena cava. [Return to Figure 9.1].

Figure 9.2 image description: This image shows a magnified view of the structure of the heart wall. Labels read (from top, clockwise): pericardial cavity, fibrous pericardium, parietal layer of serous pericardium, epicardium (visceral layer of serous pericardium), myocardium, endocardium. [Return to Figure 9.2].

Attribution

Notes



1. **Check your answers: Cardiovascular System: The Heart Anatomy Diagram (Text Version)**This diagram shows the heart with an anterior view. The view shows from (from top, clockwise): the largest artery in the body known as the **aorta**. The **left pulmonary vein** is shown which is the only vein in the body to carry oxygenated blood. The heart is divided into four chambers the **left atrium** is one of the four chambers of the heart it is in the upper left portion of the heart. The **mitral valve** also know as the bicuspid valve contains to cusps or flaps and is positioned between the left atrium and lower left ventricle. The **aortic valve** is a structure located between the aorta and **left ventricle** of the heart which is the left lower chamber of the heart. The **interventricular septum** is a thick wall of tissue divided the right side of the heart from the left. The **pulmonary valve** lies between the right atrium and pulmonary artery. The **inferior vena cava** is a large vein that carries deoxygenated blood to the heart. The **right ventricle** is the lower right chamber of the heart. The **tricuspid valve** lies between the right ventricle and the **right atrium** which is the upper right chamber of the heart. The **right pulmonary veins** transfer oxygenated blood from the lungs to the heart. The **pulmonary trunk** is part of the **right pulmonary artery** and transfers deoxygenated blood to the lungs. The **superior vena cava** a large vein that returns deoxygenated blood from systemic circulation to the right atrium of the heart.

9.3 - Physiology of the Heart

In order for the heart to do its job of pumping blood to the lungs and to the body, nutrients and oxygen must be supplied to the cells of the heart. The heart also needs to coordinate its contractions so that all parts are working together to pump blood effectively. To understand how all of this works together to give the heart its ability to pump blood, we will examine three interdependent aspects of heart function.

1. Circulation through the heart: blood is pumped by the heart in order to provide oxygen and nutrients to every cell in the body.
2. The heart as an organ (coronary blood supply): the heart is an organ, made of cells and tissues which require their own blood supply.
3. The heart's electrical conduction system: the heart is able to independently generate and transmit instructions to the myocardium, in order to make it contract and pump the blood.

1. Circulation Through the Heart: The Heart as a Pump

The heart pumps blood to two distinct but linked circulatory systems called the pulmonary and systemic circuits. The **pulmonary circuit** transports blood to and from the lungs, where it picks up oxygen and drops off carbon dioxide. The **systemic circuit** transports freshly oxygenated blood to virtually all of the tissues of the body and returns relatively deoxygenated blood and carbon dioxide to the heart to be sent back to the pulmonary circulation.

Did You Know?

The heart sounds heard through a stethoscope are the sounds of the four heart valves opening and closing at specific times during one cardiac cycle.

1. Blood that is carrying carbon dioxide and waste products from the body tissues is returned to the **right atrium** via the **superior vena cava** and the **inferior vena cava**.
2. From the right atrium, the deoxygenated blood moves through the **tricuspid valve** into the right ventricle.
3. The **right ventricle** pumps deoxygenated blood through the **pulmonary valve** into the **pulmonary trunk**, which splits into the **right and left pulmonary arteries**, leading toward the lungs. These arteries branch many times before reaching the **pulmonary capillaries**, where gas exchange occurs: carbon dioxide exits the blood and oxygen enters. The pulmonary arteries are the only arteries in the postnatal body that carry deoxygenated blood. Did you notice that they are often coloured blue on diagrams of the heart?
4. Freshly oxygenated blood returns from the lungs to the **left atrium** via the **pulmonary veins**. These veins

are the only postnatal veins in the body that carry highly oxygenated blood and are often coloured red on heart images.

5. From the left atrium, the blood moves through the **mitral valve** into the **left ventricle.**
6. The left ventricle pumps blood through the **aortic valve**, into the **aorta**, delivering blood to all parts of the body.

Concept Check 1

- On Figure 9.3 below, use your finger to trace the pathway of blood flowing through the right side of the heart, naming each each of the following structures as you encounter them: superior and inferior venae cavae, right atrium, tricuspid valve, right ventricle, pulmonary valve, right and left pulmonary arteries.
- Suggest what would happen if the **aorta** experienced a blockage or constriction.

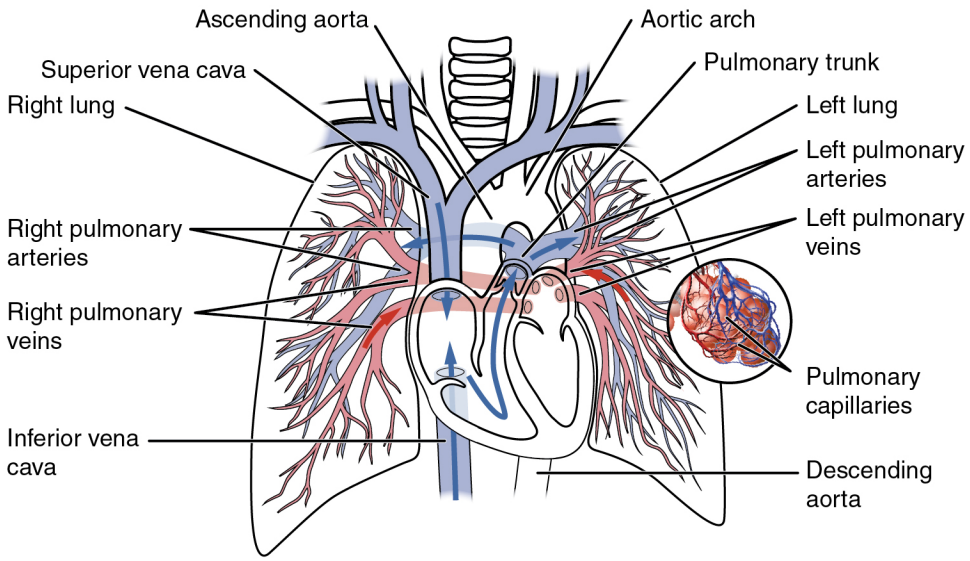


Figure 9.3. Pulmonary Circuit Blood exiting from the right ventricle flows into the pulmonary trunk, which bifurcates into the two pulmonary arteries. These vessels branch to supply blood to the pulmonary capillaries, where gas exchange occurs within the lung alveoli. Blood returns via the pulmonary veins to the left atrium. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 9.3 Image description.]

Pulmonary Circuit

Blood exiting from the right ventricle flows into the pulmonary trunk, which bifurcates into the two pulmonary arteries. These vessels branch to supply blood to the pulmonary capillaries, where gas exchange occurs within the lung alveoli. Blood returns via the pulmonary veins to the left atrium.

Concept Check 2

- On Figure 9.4 below, use your finger to trace the pathway of blood flowing through the left side of the heart, naming each of the following structures as you encounter them: right and left pulmonary veins, left atrium, mitral valve, left ventricle, aortic valve, aorta.

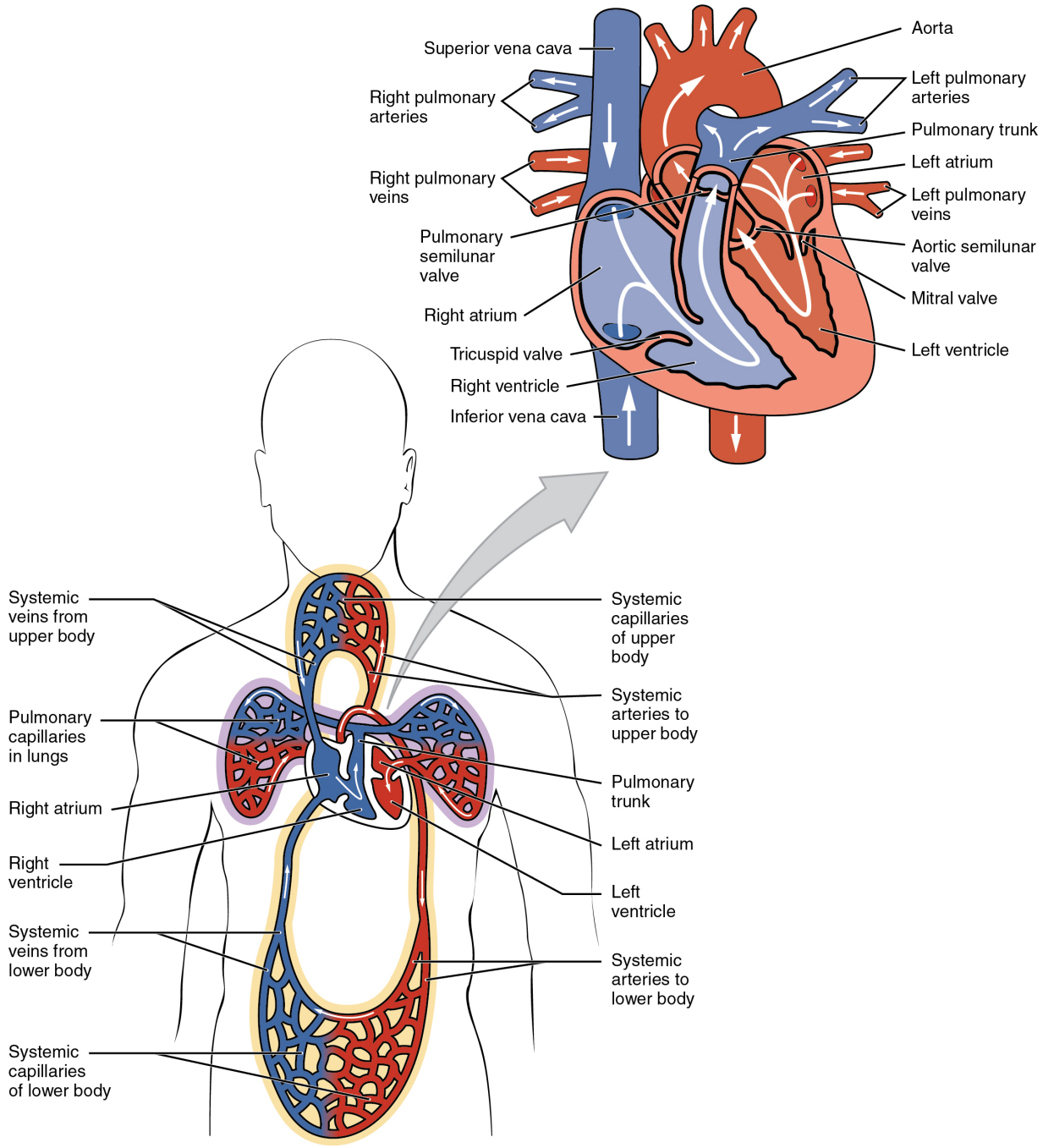


Figure 9.4. Dual System of the Human Blood Circulation. Blood flows from the right atrium to the right ventricle, where it is pumped into the pulmonary circuit. The blood in the pulmonary artery branches is low in oxygen but relatively high in carbon dioxide. Gas exchange occurs in the pulmonary capillaries (oxygen into the blood, carbon dioxide out), and blood high in oxygen and low in carbon dioxide is returned to the left atrium. From here, blood enters the left ventricle, which pumps it into the systemic circuit. Following exchange in the systemic capillaries (oxygen and nutrients out of the capillaries and carbon dioxide and wastes in), blood returns to the right atrium and the cycle is repeated. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 9.4 Image description.]

Cardiac Cycle

The process of pumping and circulating blood is active, coordinated, and rhythmic. Each heartbeat represents one cycle of the heart receiving blood and ejecting blood.

- **Diastole** is the portion of the cycle in which the heart is relaxed and the atria and ventricles are filling with blood. The AV valves are open so that blood can move from the atria to the ventricles.
- **Systole** is the portion of the cycle in which the heart contracts, AV valves slam shut, and the ventricles eject blood to the lungs and to the body through the open semilunar valves. Once this phase ends, the semilunar valves close in preparation for another filling phase.

2. The Heart as an Organ: The Coronary Blood Supply

Myocardial cells require their own blood supply to carry out their function of contracting and relaxing the heart in order to pump blood. Their own blood supply provides nutrients and oxygen and carry away carbon dioxide and waste. These functions are provided by the coronary arteries and coronary veins.

Concept Check 3

On the image (Figure 9.5) below, locate the three main coronary arteries:

- **Anterior interventricular artery** (more commonly known as the **left anterior descending artery, or LAD**)
- **Circumflex artery (Cx)**
- **Right coronary artery (RCA)**

Follow the path of each of these three arteries to try to determine which parts of the myocardium each artery (along with its many smaller branches) supplies with blood.

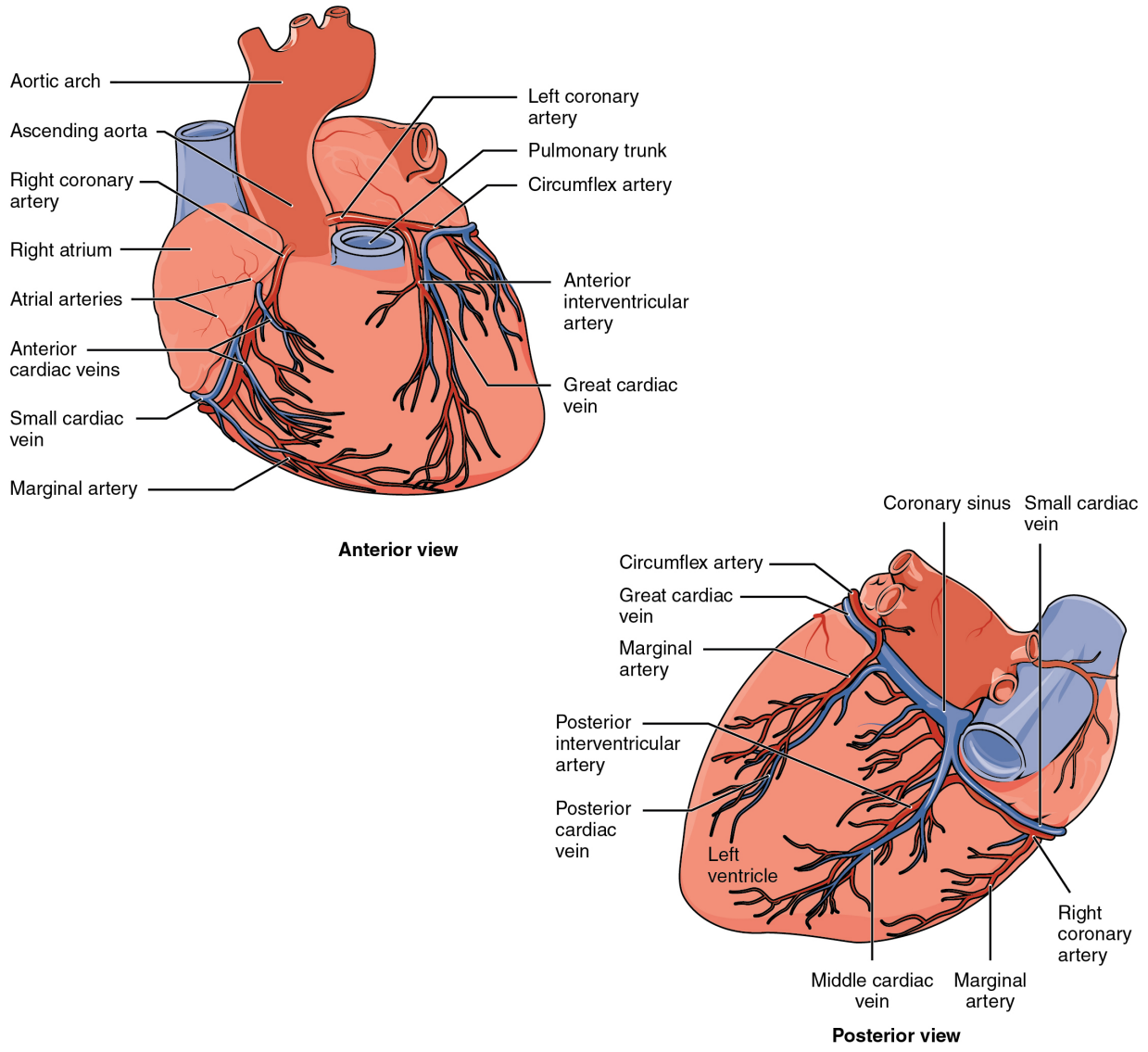


Figure 9.5 Coronary Circulation. The anterior view of the heart shows the prominent coronary surface vessels. The posterior view of the heart shows the prominent coronary surface vessels. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 9.5 Image description.]

3. The Heart's Electrical Conduction System

In order for all parts of the heart to work together to beat regularly and effectively, the heart has its own electrical system, which initiates and conducts each heartbeat through the entire myocardium. Specialized groups of heart cells perform this function all on their own, without requiring messages from the central nervous system.

Watch [The Heart, Part 2 – Heart Throbs: Crash Course Anatomy & Physiology #26 (9:30 min) on YouTube]

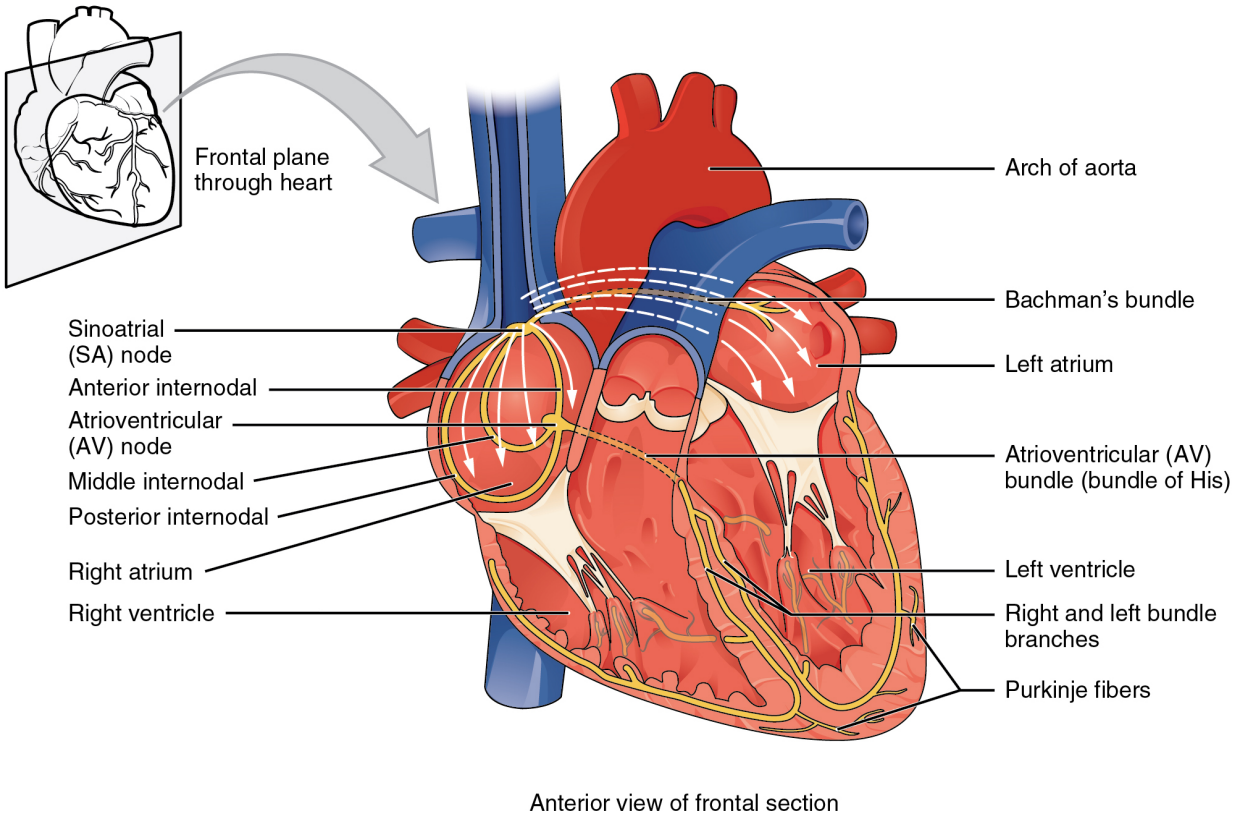


Figure 9.6. Conduction System of the Heart. Specialized conducting components of the heart include the sinoatrial node, the internodal pathways, the atrioventricular node, the atrioventricular bundle, the right and left bundle branches, and the Purkinje fibers. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 9.6 Image description.]

Concept Check 4

- On the image (Figure 9.6) above, trace the electrical impulse generated by the heart's pacemaker (the **sinoatrial node**, or **SA node**) through the rest of the conduction system, including the **atrioventricular (AV) node**, the **atrioventricular bundle (bundle of His)**, the **right and left bundle branches**, and the **Purkinje fibers**.

We can detect and record the electrical activity of the heart's conduction system using an electrocardiogram (ECG or EKG). Figure 9.7 shows the electrical impulse originating in the SA node (step 2) and travelling through the heart's conduction system, allowing the heart to complete one cardiac cycle. Each waveform on the ECG tracing represents electricity moving through and affecting a different part of the heart. Did you notice that the **AV valves** close when the electrical impulse reaches the ventricles, just before systole occurs?

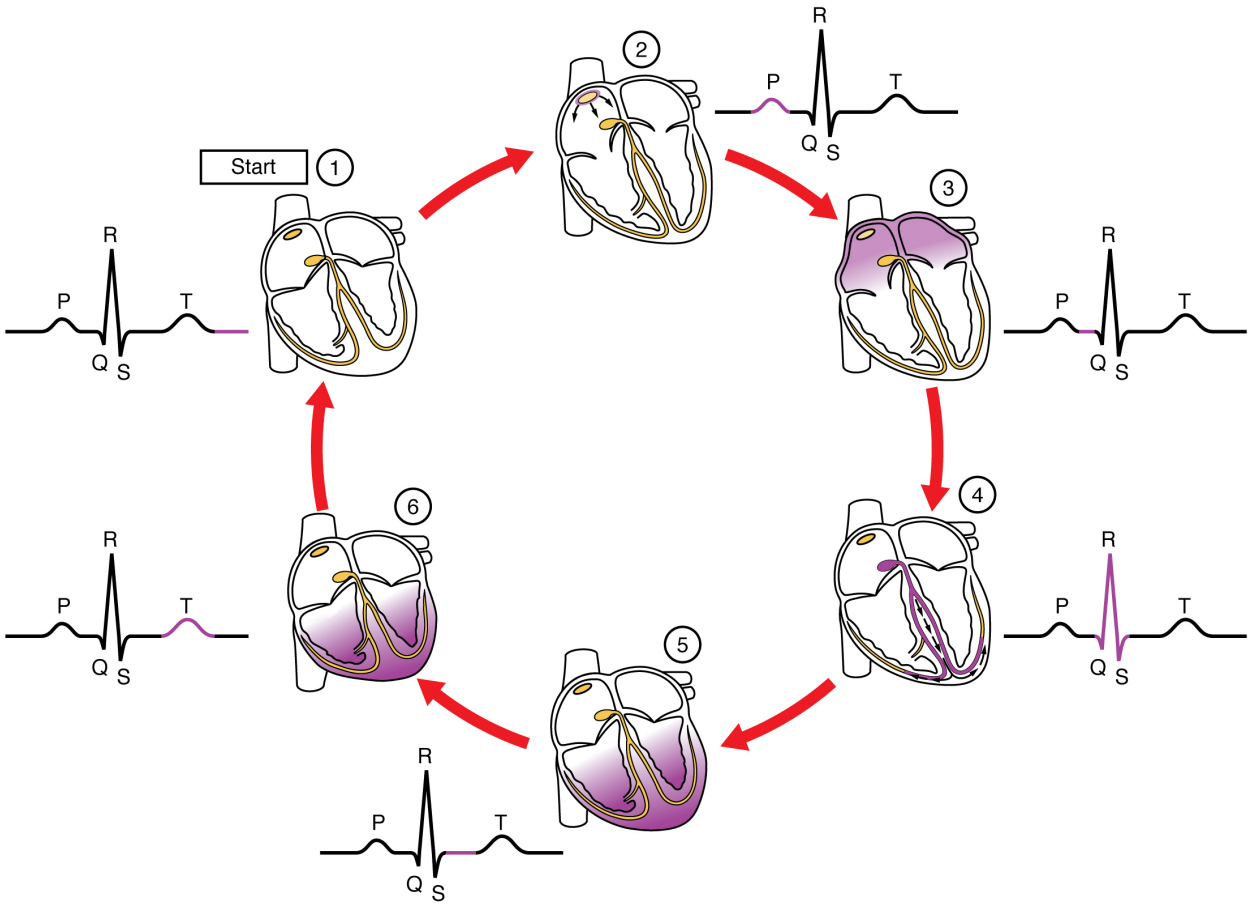


Figure 9.7. ECG Tracing Correlated to the Cardiac Cycle. This diagram correlates an ECG tracing with the electrical and mechanical events of a heart contraction. Each segment of an ECG tracing corresponds to one event in the cardiac cycle. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 9.7 Image description.]

Heart Medical Terms and Abbbreviations

Cardiovascular System – Heart Terms Not Easily Broken Down

Cardiovascular System – Heart Terms Not Easily Broken Down (Text Version)
Practice the following c**ardiovascular system** words by breaking into word parts and pronouncing.

1. **arrhythmia**
    - deviation in the normal pattern (rhythmn) of a heartbeat
2. **congenital**
    - present at birth
3. **stethoscope**
    - An instrument used to hear heart and lung sounds
4. **aneurysm**
    - localized dilation of the wall of a blood vessel
5. **diastole**
    - Phase in the cardiac cycle where heart muscles relax allowing the chambers to fill with blood.
6. **bruit**
    - abnormal blowing, swishing heart sound heard on auscultation
7. **syncope**
    - brief lapse in consciousness (faint)
8. **auscultation**
    - listening to a patient's heart sounds
9. **occlude**
    - block or close tightly
10. **sphygmomanometer**

- instrument used to measure blood pressure

11. **diaphoresis**
    - profuse (excessive) sweating
12. **myocardial infarction (MI)**
    - heart attack, caused by lack of blood flow and oxygen to the heart
13. **systole**
    - Phase in cardiac cycle when ventricles contract and eject blood

Activity source: Cardiovascular System – Heart not easily broken down by Kimberlee Carter, from *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY- 4.0. /Text version added.

Heart Abbreviations

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

Cardiovascular System – Heart Common Abbreviations

- **ACS** (acute coronary syndrome)
- **AFib** (atrial fibrillation)
- **AV** (atrioventricular)
- **BP** (blood pressure)
- **CABG** (coronary artery bypass graft)
- **CAD** (coronary artery disease)
- **CCU** (coronary care unit, cardiac care unit)
- **CPR** (cardiopulmonary resuscitation)
- **DVT** (deep vein thrombosis)
- **ECG, EKG** (electrocardiogram)
- **ECHO** (echocardiogram)
- **HF** (Heart Failure)
- **HHD** (hypertensive heart disease)
- **HTN** (hypertension)

- **IV** (intravenous)
- **MI** (Myocardial Infarction)
- **PAD** (peripheral artery disease)
- **PTCA** (percutaneous tranluminal coronary angioplasty)
- **SPECT** (single-photon emission computed tomography)
- **TEE** (transesophageal echocardiogram)

Activity source: Cardiovascular System – Heart Common Abbreviations by Kimberlee Carter, from *Building a Medical Terminology Foundation*, licensed under CC BY 4.0./ Text version added.

Image Descriptions

Figure 9.3 image description: This diagram shows the network of blood vessels in the lungs. Labels read (from top, clockwise (left-side of the body): aortic arch, pulmonary trunk, left lung, left pulmonary arteries, left pulmonary vein, pulmonary capillaries, descending aorta, (right side of body) inferior vena cava, right pulmonary veins, right pulmonary arteries, right lung, superior vena cava, ascending aorta. [Return to Figure 9.3].

Figure 9.4 image description: The top panel shows the human heart with the arteries and veins labeled (from top, clockwise): aorta, left pulmonary arteries, pulmonary trunk, left atrium, left pulmonary veins, aortic semilunar valve, mitral valve, left ventricle, inferior vena cava, right ventricle, tricuspid valve, right atrium, pulmonary semilunar valve, right pulmonary veins, right pulmonary arteries, superior vena cava. The bottom panel shows a rough map of the the human circulatory system. Labels read (from top, clockwise): systemic capillaries of upper body, systemic arteries to upper body, pulmonary trunk, left atrium, left ventricle, systemic arteries to lower body, systemic capillaries of lower body, systemic veins from lower body, right ventricle, right atrium, pulmonary capillaries in lungs, systemic veins from upper body. [Return to Figure 9.4].

Figure 9.5 image description: The top panel of this figure shows the anterior view of the heart while the bottom panel shows the posterior view of the heart. The different blood vessels are labeled. Anterior view labels (from top of diagram, clockwise): left coronary artery, pulmonary trunk, circumflex artery, anterior interventricular artery, great cardiac vein, small cardiac vein, anterior cardiac veins, atrial arteries, right atrium, right coronary artery, ascending aorta, aortic arch. Posterior view labels (from top of diagram, clockwise): coronary sinus, small cardiac vein, right coronary artery, marginal artery, middle cardiac vein, posterior cardiac vein, posterior interventricular artery, marginal artery, great cardiac vein, circumflex artery. [Return to Figure 9.5].

Figure 9.6 image description: This image shows the anterior view of the frontal section of the heart with the major parts labeled. Labels read (from top of diagram, clockwise) arch of aorta, Bachman's bundle, atrioventricular bundle (bundle of His), left ventricle, right and left bundle branches, Purkinje fibers, right ventricle, right atrium, posterior intermodal, middle intermodal, atrioventricular node, anterior intermodal, Sinoatrial node. [Return to Figure 9.6].

Figure 9.7 image description: This diagram shows the six different stages of heart contraction and relaxation along with the stages in the QT cycle. [Return to Figure 9.7].

Attribution

Except where otherwise noted, this chapter is adapted from "Cardiovascular System – Heart" 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 Cardiovascular System – Heart chapter content into sub-chapters.

9.4 - Heart Diseases, Disorders and Diagnostic Testing

Cardiomyopathy

The heart of a well-trained athlete can be considerably larger than the average person's heart. This is because exercise results in an increase in muscle cells called **hypertrophy**. Hearts of athletes can pump blood more effectively at lower rates than those of non-athletes. However, when an enlarged heart is not the result of exercise, it may be due to **hypertrophic cardiomyopathy**. The cause of an abnormally enlarged heart muscle is unknown, but the condition is often undiagnosed and can cause sudden death in apparently otherwise healthy young people (Betts et al., 2013).

Other types of cardiomyopathy include:

- **Dilated cardiomyopathy**, which also has an unknown cause and is seen in people of any age. In this disorder, one of the ventricles of the heart is larger than normal.
- **Arrhythmogenic cardiomyopathy**, an inherited condition which results in irregular heart rhythms.
- **Restrictive cardiomyopathy**, which is a complication of other conditions that cause the myocardium to scar or stiffen (Centers for Disease Control and Prevention, 2023).

Cardiomyopathy may also be caused by myocardial infarctions, myocardial infections, pregnancy, alcohol or cocaine abuse, autoimmune and endocrine diseases. Because the myocardium is responsible for contracting and pumping blood, patients with cardiomyopathy experience impaired heart function which may lead to heart failure (Centers for Disease Control and Prevention, 2023). To learn more about cardiomyopathy, visit the CDC's cardiomyopathy web page [New Tab].

Heart Failure

Heart failure is defined as the inability of the heart to pump enough blood to meet the needs of the body. It is also called **congestive heart failure (CHF)**. This condition causes swelling in the lower extremities and shortness of breath due to a buildup of fluid in the lungs. It may be caused by cardiomyopathy and it may lead to **hypertension** and heart valve disorders (Heart & Stroke, n.d.). To learn more, visit the Heart & Stroke's congestive heart failure web page [New Tab].

Valvular Heart Disease

The four heart valves open and close at specific times during the cardiac cycle in order to ensure that blood flows in only one direction through the heart. This requires that these valves open and close completely. Infections

such as rheumatic disease or bacterial endocarditis can affect the heart valves and result in scar tissue formation which interferes with valve function. Other causes of heart valve disease include: congenitally malformed valves, autoimmune diseases, and other cardiovascular diseases, such as aortic aneurysms and atherosclerosis (Centers for Disease Control and Prevention, 2019).

Concept check

Do you remember the **names** and **locations** of the 4 heart valves?

Heart valve disease may be asymptomatic or cause **dyspnea**, **arrhythmias**, fatigue, and other symptoms. It is often detected when a **heart murmur** is heard through a stethoscope (Centers for Disease Control and Prevention, 2019).

- **Mitral Valve Prolaspse**
  - The mitral (bicuspid) valve is diseased or malformed and is not able to close completely, allowing the regurgitation of blood back into the left atrium during systole. Because some of the blood goes back into the atrium, insufficient blood is pumped out of the ventricle into the systemic circulation. This inability to close properly and the resulting regurgitation may also be found in other heart valves (Centers for Disease Control and Prevention, 2019).
- **Aortic Stenosis**
  - The aortic valve is narrowed and hardened, preventing it from opening fully and allowing sufficient blood to travel to the systemic circulation. Any heart valve can be stenosed, but this disorder most often affects the aortic valve (Centers for Disease Control and Prevention, 2019).

Visit the CDC's page on valvular heart disease [New Tab] to learn more.

Aneurysms

An aneurysm is a defect in the wall of an artery in which the wall becomes thin and weak and starts to balloon out as blood pulses against the vessel wall. This can happen to any artery and even to the myocardial walls. Aneurysms sometimes occur in the portion of the aorta that is in the thorax (see Figure 9.8). If these aneurysms start to leak between layers of the vessel wall, the condition is known as aortic dissection. If an aortic or cardiac aneurysm bursts, there is sudden, massive internal bleeding (Centers for Disease Control and Prevention, 2021).

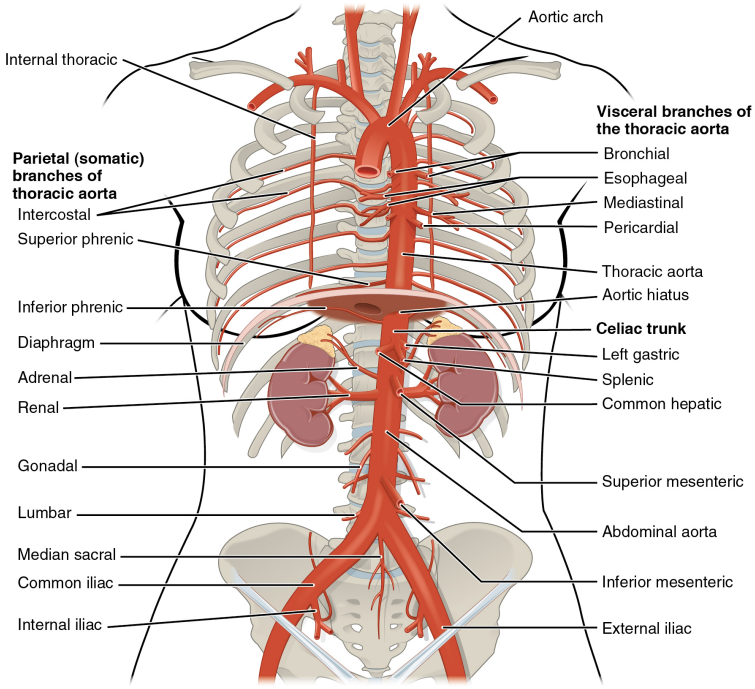


Figure 9.8. Arteries of the Thoracic and Abdominal Regions The thoracic aorta gives rise to the arteries of the visceral and parietal branches. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 9.8 Image description.]

People who smoke, have **hypertension**, **hypercholesterolemia**, and/or **atherosclerosis** have an increased risk of developing aneurysms. Having a family history of aneurysms or certain genetic diseases may also increase a person's risk of developing an aneurysm.

Aneurysms are often asymptomatic and may be detected incidentally during diagnostic tests that are being done for other reasons. They are sometimes repaired surgically and sometimes treated with medications such as **antihypertensives** (Centers for Disease Control and Prevention, 2021; Tittley, n.d.). Visit the Canadian Society for Vascular Surgery's page on thoracic aortic aneurysms [New Tab] to learn more.

Heart Defects

Fetal circulation is different from **postnatal** circulation. There are 2 extra openings in the fetal heart: the **foramen ovale** and the **ductus arteriosus**, which allow blood circulation that bypasses the immature fetal lungs. The fetal blood is reoxygenated by the mother's lungs and transported between mother and fetus via the placenta. These two openings usually close around the time of birth (Betts, et al., 2013).

Septal defects are commonly first detected through **auscultation**. Unusual heart sounds may be detected because blood is not flowing and valves are not closing correctly. Medical imaging is ordered to confirm or rule out a diagnosis. In many cases, treatment may not be needed.

- **Patent ductus arteriosus** is a congenital condition in which the ductus arteriosus fails to close. If untreated, the condition can result in congestive heart failure.
- **Patent foramen ovale** is one type of atrial septal defect (ASD) due to a failure of the hole in the **interatrial septum** to close at birth.
    - As much as 20 – 25 percent of the general population may have a patent foramen ovale; most have the benign, asymptomatic version, but in extreme cases, a surgical repair is required to close the opening permanently.
- **Tetralogy of Fallot** is a congenital condition that may also occur from exposure to unknown environmental factors; it occurs when there is an opening in the **interventricular septum** caused by blockage of the pulmonary trunk, normally at the pulmonary semilunar valve. This allows blood that is relatively low in oxygen from the right ventricle to flow into the left ventricle and mix with the blood that is relatively high in oxygen.
    - Symptoms include a distinct heart murmur, low blood oxygen percent saturation, **dyspnea**, **polycythemia**, **clubbing of the fingers and toes**, and in children, difficulty in feeding or failure to grow and develop.
    - It is the most common cause of **cyanosis** following birth. Other heart defects may also accompany this condition, which is typically confirmed by **echocardiography** imaging.
- In the case of severe septal defects, including both tetralogy of fallot and patent foramen ovale, failure of the heart to develop properly can lead to a condition commonly known as a **blue baby**. Regardless of normal skin pigmentation, individuals with this condition have an insufficient supply of oxygenated blood, which leads to **cyanosis**, especially when active (Betts et al., 2013).

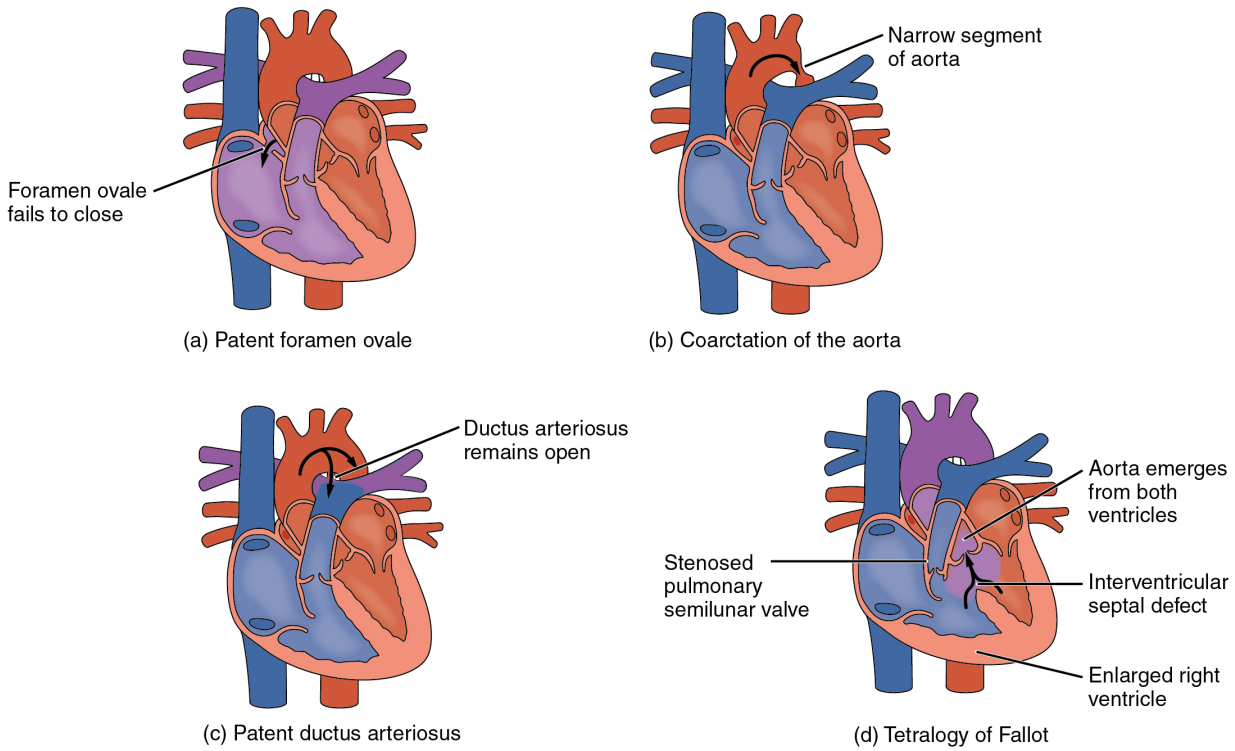


Figure 9.9. Congenital Heart Defects. (a) A patent foramen ovale defect is an abnormal opening in the interatrial septum, or more commonly, a failure of the foramen ovale to close. (b) Coarctation of the aorta is an abnormal narrowing of the aorta. (c) A patent ductus arteriosus is the failure of the ductus arteriosus to close. (d) Tetralogy of Fallot includes an abnormal opening in the interventricular septum. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 9.9 Image description.]

Diseases of the Coronary Circulation

Coronary Artery Disease (CAD)

Coronary artery disease occurs when the buildup of **plaque** in the coronary arteries obstructs the flow of blood and decreases **compliance** of the vessels. This condition is called **atherosclerosis**. As the disease progresses and coronary blood vessels become more and more narrow, cells of the myocardium become **ischemic**, which causes symptoms of **angina pectoris** in some patients. If untreated, coronary artery disease can lead to MI.

The image below shows the blockage of coronary arteries on an **angiogram** (Betts et al., 2013).

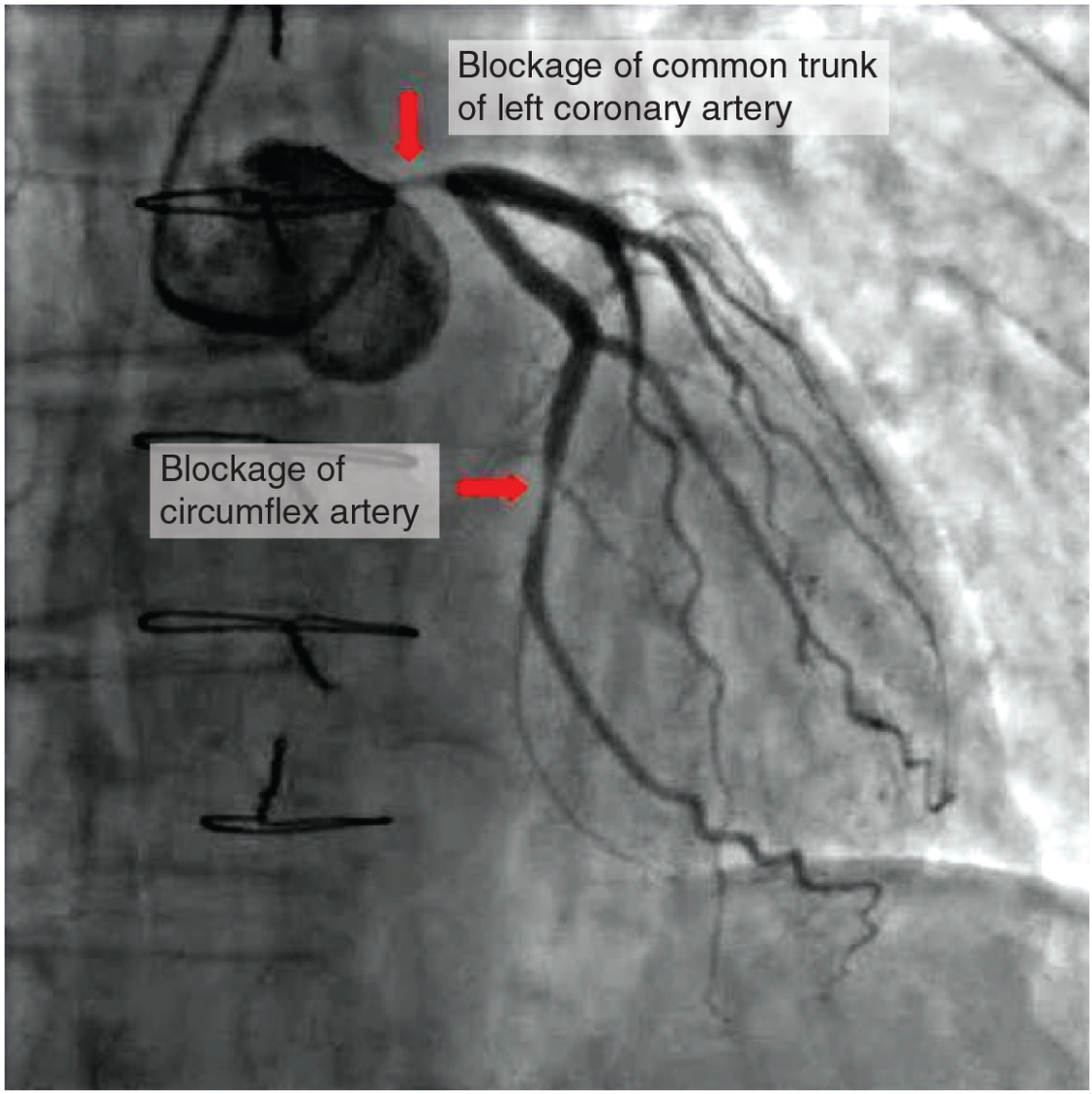


Figure 9.10. Angiogram of Atherosclerotic Coronary Arteries. In this coronary angiogram (X-ray), the dye makes visible two occluded coronary arteries. Such blockages can lead to decreased blood flow (ischemia) and insufficient oxygen (hypoxia) delivered to the cardiac tissues. If uncorrected, this can lead to cardiac muscle death (myocardial infarction). From Betts et al., 2013. Licensed under CC BY 4.0.

CAD is progressive and chronic. Risk factors include smoking, family history, **hypertension**, obesity, diabetes, high alcohol consumption, lack of exercise, stress, and **hyperlipidemia**. Treatments may include medication, changes to diet and exercise, angioplasty with a balloon catheter, insertion of a stent, or coronary artery bypass graft (CABG) (Betts et al., 2013).

- **Angioplasty** is a procedure in which the **occlusion** is mechanically widened with a balloon. A specialized catheter with an expandable tip is inserted into a blood vessel in the arm or leg, and then directed to the site of the occlusion. At this point, the balloon is inflated to compress the plaque material and to open the vessel to increase blood flow. Once the balloon is deflated and retracted, a stent consisting of a specialized mesh is typically inserted at the site of occlusion to reinforce the weakened and damaged walls and prevent re-occlusion.
- **Coronary bypass surgery (Coronary artery bypass graft CABG)** is a surgical procedure which grafts a replacement vessel obtained from another part of the body to bypass the occluded area (Betts et al., 2013).

Myocardial Infarction

Myocardial infarction (MI) is the medical term for a heart attack.

An MI normally results from a lack of blood flow to a region of the heart, resulting in death of the cardiac muscle cells. An MI often occurs when a coronary artery is blocked by the buildup of atherosclerotic plaque. It can also occur when a piece of an atherosclerotic plaque breaks off and travels through the coronary arterial system until it lodges in one of the smaller vessels. MIs may be triggered by excessive exercise, in which the partially occluded artery is no longer able to pump sufficient quantities of blood, or severe stress, which may induce spasm of the smooth muscle in the walls of the vessel (Betts et al., 2013).

Did You Know 1?

It is estimated that between 22 and 64 percent of myocardial infarctions are **silent MIs**.

In the case of **acute MI (AMI)**, there is often sudden pain beneath the sternum (retrosternal pain) called angina pectoris, often radiating down the left arm in males but not in female patients. Other common symptoms include **dyspnea**, **palpitations**, nausea and vomiting, **diaphoresis**, anxiety, and **syncope**. Many of the symptoms are shared with other medical conditions, including anxiety attacks and simple indigestion, so differential diagnosis is critical (Betts et al., 2013).

An MI can be confirmed by examining the patient's **ECG**.

Other diagnostic tests include:

- **echocardiography**
- **CT**
- **MRI**
- Common blood tests indicating an MI include elevated levels of **creatine kinase MB** and **cardiac troponin**, both of which are released by damaged cardiac muscle cells (Betts et al., 2013)

MIs may induce dangerous heart rhythms and even cardiac arrest. Important risk factors for MI include coronary artery disease, age, smoking, high blood levels of **LDL**, low levels of **HDL**, **hypertension**, **diabetes mellitus**, obesity, lack of physical exercise, chronic kidney disease, excessive alcohol consumption, and use of illegal drugs (Betts et al., 2013).

Diseases of the (Electrical) Conduction System

Arrhythmia

Did You Know 2?

Arrhythmia does *not* mean an absence of a heartbeat! That would be **asystole**, or flat line!
Arrhythmia is defined as the absence of a *regular* rhythm, meaning that the heart rate is either too fast, too slow or just irregular.

The heart's natural pacemaker, the sinoatrial (SA) node, initiates an electrical impulse 60-90 times per minute in a resting adult. This impulse travels through the heart's conduction system in order to ensure a smooth, coordinated pumping action. This electrical activity can be detected and recorded through the skin using an **electrocardiograph**. **Arrhyhmias** may occur when the SA node fails to initiate an impulse, or when the conduction system fails to transmit that impulse through the heart.

In the event that the electrical activity of the heart is severely disrupted, cessation of electrical activity or fibrillation may occur. In fibrillation, the heart beats in a wild, uncontrolled manner, which prevents it from being able to pump effectively.

- **Atrial fibrillation** is a serious condition, but as long as the ventricles continue to pump blood, the patient's life may not be in immediate danger.
- **Ventrical fibrillation** is a medical emergency that requires life support, because the ventricles are not effectively pumping blood. Left untreated, ventricular fibrillation may lead to brain death.

The most common treatment is **defibrillation**, which uses special paddles to apply a charge to the heart from an external electrical source in an attempt to establish a normal sinus rhythm. A defibrillator effectively stops the heart so that the SA node can trigger a normal conduction cycle. **External automated defibrillators (EADs)** are being placed in areas frequented by large numbers of people, such as schools, restaurants, and airports. These devices contain simple and direct verbal instructions that can be followed by non-medical personnel in an attempt to save a life (Betts et al., 2013).

Abnormal Heart Rates

Bradycardia is the condition in a which resting adult heart rate drops below 60 bpm. A client exhibiting symptoms such as weakness, fatigue, dizziness, **syncope**, chest discomfort, palpitations or respiratory distress may indicate that the heart is not providing sufficient oxygenated blood to the tissues. If the patient is not exhibiting symptoms, then bradycardia is not considered clinically significant. The term **relative bradycardia** may be used with a patient who has a HR in the normal range but is still suffering from these symptoms. Most patients remain asymptomatic as long as the HR remains above 50 bpm.

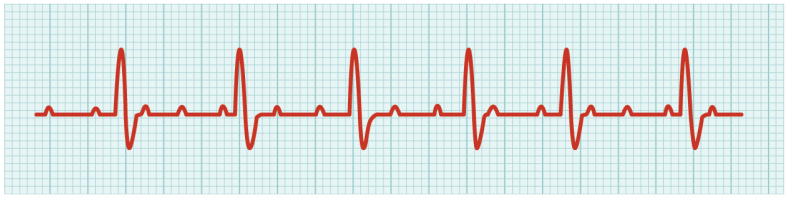
Tachycardia is the condition in which the resting rate is above 100 bpm. Tachycardia is not normal in a resting patient and may be detected in pregnant women or individuals experiencing extreme stress. Some individuals may remain **asymptomatic**, but when present, symptoms may include dizziness, shortness of breath, rapid pulse, heart palpitations, chest pain, or syncope. Treatment depends upon the underlying cause, but may include medications, **implantable cardioverter defibrillators**, **ablation**, or surgery (Betts et al., 2013).

Heart Block

A **heart block** refers to an interruption in the normal conduction pathway. Heart blocks are generally named after the part of the conduction system that is causing the problem. For example, bundle branch blocks occur within either the left or right atrioventricular bundle branches.

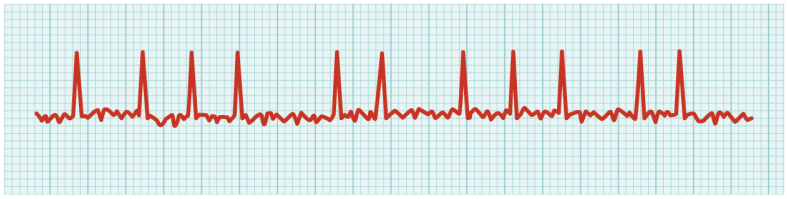
AV blocks are often described by degrees. A **first-degree or partial block** indicates a delay in conduction between the SA and AV nodes. A **second-degree or incomplete block** occurs when some impulses from the SA node reach the AV node and continue, while others do not. In the **third-degree or complete block**, there is no correlation between atrial activity and ventricular activity. This means that none of the impulses generated by the SA node get transmitted to the rest of the heart and the AV node must take over as the primary pacemaker, initiating contractions at 40–60 beats per minute, which is adequate to maintain consciousness.

In order to speed up the heart rate and restore full **sinus rhythm**, a cardiologist can implant an **artificial pacemaker**, which delivers electrical impulses to the heart muscle to ensure that the heart continues to contract and pump blood effectively. These artificial pacemakers are programmable by the cardiologists and can either provide stimulation temporarily upon demand or on a continuous basis. Some devices also contain built-in defibrillators (Betts et al., 2013).



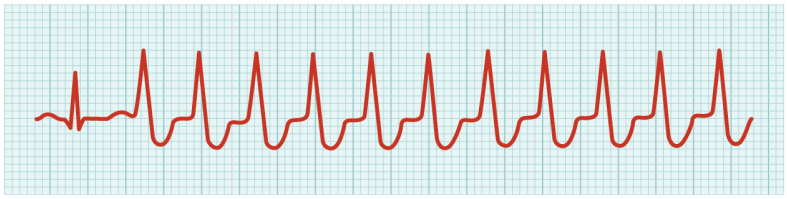
Note how half of the P waves are not followed by the QRS complex and T waves while the other half are.
Question: What would you expect to happen to heart rate (pulse)?

(a) Second-degree (partial) block



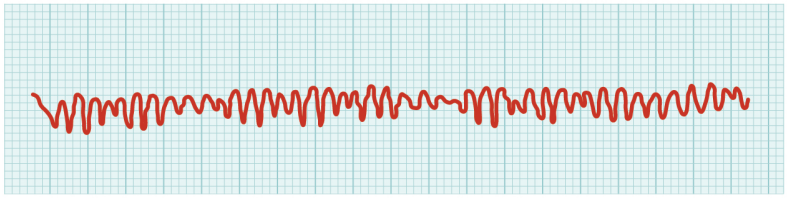
Note the abnormal electrical pattern prior to the QRS complexes. Also note how the frequency between the QRS complexes has increased.
Question: What would you expect to happen to heart rate (pulse)?

(b) Atrial fibrillation



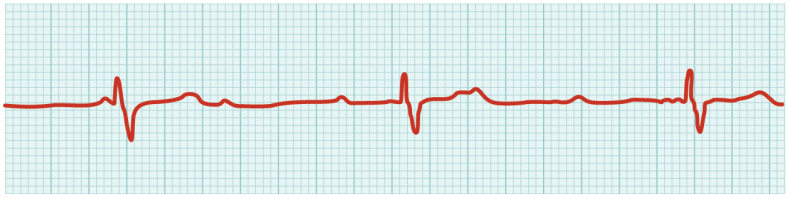
Note the unusual shape of the QRS complex, focusing on the "S" component.
Question: What would you expect to happen to heart rate (pulse)?

(c) Ventricular tachycardia



Note the total lack of normal electrical activity.
Question: What would you expect to happen to heart rate (pulse)?

(d) Ventricular fibrillation



Note that in a third-degree block some of the impulses initiated by the SA node do not reach the AV node while others do. Also note that the P waves are not followed by the QRS complex.
Question: What would you expect to happen to heart rate (pulse)?

(e) Third-degree block

Figure 9.11. Common ECG Abnormalities. (a) In a second-degree or partial block, one-half of the P waves are not followed by the QRS complex and T waves while the other half are. (b) In atrial fibrillation, the electrical pattern is abnormal prior to the QRS complex, and the frequency between the QRS complexes has increased. (c) In ventricular tachycardia, the shape of the QRS complex is abnormal. (d) In ventricular fibrillation, there is no normal electrical activity. (e) In a third-degree block, there is no correlation between atrial activity (the P wave) and ventricular activity (the QRS complex). From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 9.11 Image description.]

Cardiovascular System – Consultation Report

Cardiovascular System – Consultation Report (Text version)

Fill in the consultation report with the words listed below:

- shortness
- ECG
- implant
- embolism
- BP
- venous
- CBC and Diff
- hypercholesterolemia
- cardiovascular
- hypertension,
- WBC
- bradycardia
- intravenous

PATIENT NAME: Lorna GILBERT

AGE: 52

SEX: Female

DOB: February 27

DATE OF CONSULTATION: June 12

REQUESTING PHYSICIAN: Trevor Sharpe, MD, Family Medicine

CONSULTING PHYSICIAN: Kevin Palmer, MD, Cardiology

HISTORY: This 52-year-old female was referred to our cardiology clinic by her family physician Dr. Trevor Sharpe. She had visited her physician last month with complaints of persistent fatigue, dizziness, light-headedness, fainting, and an inability to exercise without experiencing _____[Blank 1] of breath. She claims that she is otherwise healthy; however, there is a history of _____[Blank 2] diseases in her family. Her father had developed DVT during a long flight and subsequently suffered from pulmonary _____[Blank 3]. Her mother had idiopathic intracranial _____[Blank 4] and died from MI at a relatively young age. The patient has 3 siblings, 2 of them suffering from hypertension and _____[Blank 5].

LABORATORY DATA: The laboratory results show normal _____[Blank 6]. Hemoglobin, Hct, _____[Blank 7] count, and platelet count are within normal range. The patient's PT and partial thromboplastin time are normal.

ALLERGIES: She is not allergic to any medications.

PHYSICAL EXAMINATION: Today the patient is alert and oriented but feels completely exhausted. She is also complaining of a mild chest pain. Her _____[Blank 8]- is 180/110. Heart rate is in the high 50s with irregular rate and rhythm. NECK: is supple, without jugular _____[Blank 9] distention or bruits. LUNGS: are clear, without wheezing, rhonchi, or rales.

IMPRESSION: I suspect the patient suffers from _____[Blank 10] and needs a pacemaker to regulate her heart rhythms. However, given the significant history of cardiovascular disorders in her family, I will order more tests before making a definite diagnosis.

PLAN: I will admit the patient to a telemetry bed and monitor her for 48 hours. If her chest pain worsens, she will be moved to CCU and will be treated with _____[Blank 11] nitroglycerin. An _____[Blank 12] has also been ordered to confirm bradycardia. If the ECG results confirm

my speculations, the patient will be scheduled for a pacemaker _____[Blank 13] as soon as possible.

_____
Kevin Palmer, MD, Cardiology

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 and Procedures Related to the Heart

Cardiologists and Cardiovascular Surgeons

Cardiologists are medical doctors that specialize in diagnosing and treating heart disease non-invasively. Cardiovascular/thoracic surgeons provide surgical treatments for the heart and other thoracic organs (Canadian Medical Association, 2019). To learn more about these specialists, please visit the CMA's Canadian Specialy Profiles web page [New Tab].

Cardiology Technologists

Cardiology Technologists complete a college training program and perform diagnostic tests such as **electrocardiography**, stress testing, Holter monitor testing, ambulatory blood pressure testing, as well as **pacemaker** monitoring and programming (Canadian Society of Cardiology Technologists, n.d.). Please visit the Canadian Society of Cardiology Technologists web page [New Tab] for more information.

Cardiovascular Perfusionists

Cardiovascular perfusionists complete a college training program and are responsible for operation of the heart-lung bypass machine during open heart surgery. They also monitor the patient's vitals, adminstering IV

fluids, and other drugs (Michener Institute of Education, n.d.). Please visit the Michener Institute's Cardiovasular Perfusion program page [New Tab] for more information.

Image Descriptions

Figure 9.8 image description: This diagram shows the arteries in the thoracic and abdominal cavity. Visceral branches of the thoracic aorta labels (from top): bronchial, esophageal, mediastinal, pericardial, thoracic aorta, aortic hiatus, celiac trunk, left gastric, splenic, common hepatic, superior mesenteric, abdominal aorta, inferior mesenteric, external iliac. Parietal (somatic) branches of thoracic aorta labels (from top): intercostal, superior phrenic, inferior phrenic, diaphragm, adrenal, renal, gonadal, lumbar, medial sacral, common iliac, internal iliac. [Return to Figure 9.8].

Figure 9.9 image description: This diagram shows the structure of the heart with different congenital defects. The top left panel shows patent foramen ovale (label reads foramen ovale fails to close), the top right panel shows coarctation of the aorta (label reads narrow segment of aorta), the bottom left panel shows patent ductus ateriosus (label reads Ductus arteriosus remains open) and the bottom right shows tetralogy of fallot (labels read aorta emerges from both ventricles, interventricular septal defect, enlarged right ventricle, stenosed pulmonary semilunar valve). [Return to Figure 9.9].

Figure 9.11 image description: In this image the QT cycle for different heart conditions are shown. From top to bottom, the arrhythmias shown are second-degree partial block (text reads: Note how half of the P waves are not followed by the QRS complex and T waves while the other half are. Question: what would you expect to happen to heart rate?), atrial fibrillation (text reads: Note the abnormal electric pattern prior to the QRS complexes. Also note how the frequency between the QRS complexes has increased. Question: What t would you expect to happen to heart rate?), ventricular tachycardia (text reads: Note the unusual shape of the QRS complex, focusing on the S component. Question: What would you expect to happen to heart rate?), ventricular fibrillation (text reads: Note the total lack of normal electrical activity. Question: What would you expect to happen to heart rate?), and third degree block (text reads: Note that in a third-degree block some of the impulses initiated by the SA node do not reach the AV node while others do. Also note that the P waves are not followed by the QRS complex. Question: What would you expect to happen to heart rate?). [Return to Figure 9.11].

Attribution

Notes

1. 1. shortness 2. cardiovascular 3. embolism 4. hypertension 5. hypercholesterolemia 6. CBC and Diff 7. WBC 8. BP 9. venous 10. bradycardia 11. intravenous 12. ECG 13. implant

Vocabulary & Check Your Knowledge

Cardiovascular System – Heart Vocabulary

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.

Ablation

Using extreme heat or extreme cold to destroy cells in part of the heart which were causing abnormal rhythms.

Angina Pectoris

Chest pain.

Angiogram

An x-ray of the coronary blood vessels using a special catheter and an injection of dye.

Antihypertensives

Class of medications used to treat high blood pressure.

Arrhythmias

Absence of a regular heart rhythm.

Asymptomatic

Pertaining to without symptoms.

Atherosclerosis

A hardening of the arteries that involves the accumulation of plaque.

Auscultation

Listening to the heart using a stethoscope.

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.

Bradycardia

Pertaining to a slow heart (rate).

Cardiac Troponin

The regulatory protein for muscle contraction.

Clubbing of the fingers and toes

Broadening of the nails and exaggerated curvature of the nails.

Compliance

The ability of the blood vessels to dilate and constrict as needed.

Congenital

Present at birth.

Creatine Kinase MB

An enzyme that catalyzes the conversion of creatine to phosphocreatine, consuming ATP.

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). Typically caused by low oxygenation.

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.

Diaphoresis

Sweating.

Ductus Arteriosus

Connection between pulmonary trunk and aorta in the fetal heart.

Dyspnea

Difficult breathing.

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.

Electrocardiograph

Instrument used to record electrical activity within the heart.

Foramen Ovale

Opening between right and left atria, which is normal in the fetal heart.

Great Vessels

The great vessels include the superior vena cava, inferior vena cava, aorta and pulmonary trunk.

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.

Hypercholesterolemia

Higher than normal levels of cholesterol in the blood.

Hyperlipidemia

Excessive fat in the blood.

Hypertension

High blood pressure.

Implantable Cardioverter Defibrillators (ICD)

An electronic implant that provides an automatic shock to convert a dangerous heart rhythm to a normal heart rhythm.

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.

Interatrial Septum

The wall separating the right and left atria.

Interventricular Septum

The wall of myocardium that separates the right and left ventricles.

Ischemic

Ischemia is a condition in which cells receive insufficient amounts of blood and oxygen.

LDL

Low-density lipoprotein, often referred to as 'bad' cholesterol.

Mitral Valve

Also known as the bicuspid valve.

MRI

Magnetic Resonance Imaging: Highly detailed images produced using a strong magnet and radio waves.

Pacemaker

An electronic implant that initiates a heart beat.

Palpitations

A feeling in the chest that may be caused by an irregular heart rhythm.

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.

Plaque

A fatty material including cholesterol, connective tissue, white blood cells, and some smooth muscle cells.

Polycythemia

A disorder in which too many red blood cells are produced.

Pulmonary Trunk

Very large artery referred to as a trunk, a term indicating that the vessel gives rise to several smaller arteries.

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.

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.

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.

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.

Syncope

Fainting.

Tachycardia

Condition of a fast heart (rate).

Cardiovascular System – Heart Glossary Reinforcement Activity

Cardiovascular System – Heart Glossary Reinforcement Activity (Text version)

1. _____[Blank 1] is the ability of the blood vessels to dilate and constrict as needed.
    a. Compliance
    b. LDL
    c. Syncope
2. A disorder in which too many red blood cells are produced is called _____[Blank 2].
    a. Mitral valve
    b. Polycythemia
    c. Great vessels
3. _____[Blank 3] is difficult breathing.
    a. Dyspnea
    b. Pacemaker
    c. Roots of the Great Vessels
4. A condition in which cells receive insufficient amounts of blood and oxygen is called

_____[Blank 4].

a. Diaphoresis
b. Ischemic
c. Serous

5. Using extreme heat or extreme cold to destroy cells in part of the heart which were causing abnormal rhythms is called _____[Blank 5].

a. Congenital
b. Ablation
c. Cyanosis

Check your Answers: [1]

Activity source: Cardiovascular System – Heart 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. Compliance, 2. Polycythemia, 3. Dyspnea, 4. Ischemic, 5. Ablation

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CHAPTER 10: CARDIOVASCULAR SYSTEM - BLOOD VESSELS AND BLOOD

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.

10.1 - Introduction to the Blood Vessels and Blood

Learning Objectives

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

Blood Vessels and Blood Word Parts

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

Prefix

- **a-** (absence of, without)
- **pan**– (all, total)
- **epi**– (on, upon, over)
- **inter**– (between)
- **peri**– (surrounding, around)
- **endo**– (within, in)
- **hypo**– (below, deficient)
- **hyper**– (above, excessive)
- **poly**– (many, much)

Combining Form

- **angi/o** (vessel, blood vessel)
- **aort/o** (aorta)
- **arteri/o** (artery)
- **ather/o** (fatty plaque)
- **cyt/o** (cell)
- **hemat/o** (blood)
- **hem/o** (blood)
- **isch/o** (deficiency, blockage)
- **lymph/o** (lymph, lymph tissue)
- **lymphaden/o** (lymph node, lymph tissue)
- **myel/o** (bone marrow, spinal cord)
- **phleb/o** (vein)
- **plasm/o** (plasma)
- **therm/o** (heat)
- **thromb/o** (clot)
- **thym/o** (thymus gland)
- **splen/o** (spleen)
- **ven/o** (vein)

Suffix

- **-ac** (pertaining to)
- **-apheresis** (removal)
- –**ar** (pertaining to)
- –**centesis** (surgical puncture to aspirate fluid)
- **-ectomy** (excision, surgical removal)
- **-emia** (in the blood)
- **-genic** (producing, originating, causing)
- **-gram** (record, radiographic image)
- **-graph** (instrument used to record)
- **-graphy** (process of recording, radiographic imaging)
- **-ia** (condition of, diseased state, abnormal state)
- **-ic** (pertaining to)
- **-itis** (inflammation)
- **-logist** (specialist who studies and treats)
- **-logy** (specialty)
- **-lysis** (loosening, dissolution, separating)
- **-megaly** (enlarged, enlargement)
- **-logist** (specialist, physician who studies and treats)
- **-oma** (tumour)
- **-osis** (abnormal condition)
- **-tomy** (cut into, incision)
- **-ous** (pertaining to)

- **-pathy** (disease)
- **-penia** (abnormal reduction in number)
- **-pexy** (surgical fixation, suspension)
- **-plasty** (surgical repair)
- **-poiesis** (formation)
- **-sclerosis** (hardening)
- **-stenosis** (narrowing, constriction)
- –**scope** (instrument used to view)
- **-scopy** (process of viewing)
- **-stasis** (stop, stopping, controlling)
- **-stenosis** (narrowing, constriction)

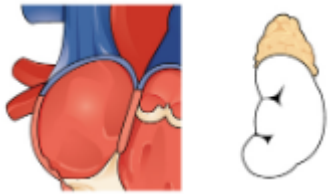
Activity source: Cardiovascular System – Blood Word Parts by Kimberlee Carter, from *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY- 4.0. /Text version added.

Introduction to the Blood Vessels and Blood

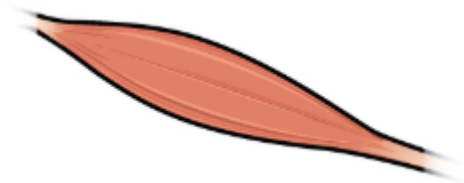
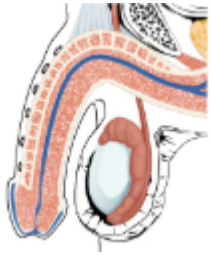
Our large, complex bodies need blood to deliver nutrients to and remove wastes from our trillions of cells. The heart, as discussed in the previous chapter, pumps blood throughout the body in a network of blood vessels. Together, these three components—blood, heart, and vessels—make up the cardiovascular system.

Virtually every cell, tissue, organ, and system in the body is impacted by the circulatory system. This includes the generalized and more specialized functions of transport of materials, capillary exchange, maintaining health by transporting white blood cells and various immunoglobulins (antibodies), hemostasis, regulation of body temperature, and helping to maintain **acid-base** balance. Table 10.1 summarizes the important relationships between the circulatory system and the other body systems.

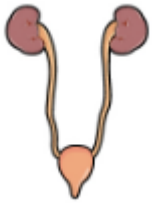
Table 10.1 Interaction of the Circulatory System with Other Body Systems. A table depicting the various body systems and the role of the circulatory system in each. Adapted from Betts, et al., 2013. Licensed under CC BY 4.0.

System	Role of Circulatory System
Digestive  *Digestive System*	Absorbs nutrients and water; delivers nutrients (except most lipids) to liver for processing by hepatic portal vein; provides nutrients essential for hematopoiesis and building hemoglobin.
Endocrine  *Endocrine System*	Delivers hormones: atrial natriuretic hormone (peptide) secreted by the heart atrial cells to help regulate blood volumes and pressures; epinephrine, ANH, angiotensin II, ADH, and thyroixine to help regulate blood pressure; estrogen to promote vascular health in women and men.

System	Role of Circulatory System
Integumentary  *Integumentary System*	Carries clotting factors, platelets, and white blood cells for hemostasis, fighting infection, and repairing damage; regulates temperature by controlling blood flow to the surface, where heat can be dissipated; provides some coloration of integument; acts as a blood reservoir.
Lymphatic  *Lymphatic System*	Transports various white blood cells, including those produced by lymphatic tissue, and immunoglobulins (antibodies) throughout the body to maintain health; carries excess tissue fluid not able to be reabsorbed by the vascular capillaries back to the lymphatic system for processing.

System	Role of Circulatory System
Muscular  *Muscular System*	Provides nutrients and oxygen for contraction; removes lactic acid and distributes heat generated by contraction; muscular pumps aid in venous return; exercise contributes to cardiovascular health and helps to prevent atherosclerosis.
Nervous  *Nervous System*	Produces cerebrospinal fluid (CSF) within choroid plexuses;contributes to blood-brain barrier; cardiac and vasomotor centers regulate cardiac output and blood flow through vessels via the autonomic system.
Reproductive  *Reproductive System*	Aids in erection of genitalia in both sexes during sexual arousal; transports gonadotropic hormones that regulate reproductive functions.

System	Role of Circulatory System
Respiratory  *Respiratory System*	Provides blood for critical exchange of gases to carry oxygen needed for metabolic reactions and carbon dioxide generated as byproducts of these processes.
Skeletal  *Skeletal System*	Provides calcium,phosphate, and other minerals critical for bone matrix; transports hormones regulating buildup and absorption of matrix including growth hormone (somatotropin), thyroid hormone, calcitronins, and parathryoid hormones; erythropoietin stimulates myeloid cell hematopoiesis; some level of protection for select vessels by bony structures.

System	Role of Circulatory System
Urinary  *Urinary System*	Delivers 20% of resting circulation to kidneys for filtering, reabsorption of useful products, and secretion of excesses; regulates blood volume and pressure by regulating fluid loss in the form of urine and by releasing the enzyme renin that is essential in the renin-angiotensin-aldosterone mechanism.

Watch [Blood Vessels, Part 1 – Form and Function: Crash Course Anatomy & Physiology #27 (10 min) on YouTube]

Cardiovascular System – Blood Vessels and Blood Medical Terms

Cardiovascular System – Blood, medical terms (Text Version)
Practice the following cardiovascular system words by breaking into word parts and pronouncing.

1. **angioscope (angi/o/scope)**
    - Instrument used for visual examination of blood vessels
2. **arteriogram(arteri/o/gram)**
    - radiographic image of an artery
3. **phlebectomy(phleb/ectomy)**
    - excision of a vein
4. **hemolysis(hem/o/lysis)**
    - dissolution of (red) blood (cells)
5. **multiple myeloma(multiple myel/oma)**
    - tumours of the bone marrow
6. **lymphoma (lymph/oma)**
    - tumour of lymphatic tissue (malignant)
7. **thrombocytopenia(thromb/o/cyt/o/penia)**
    - abnormal reduction of (blood) clotting cells
8. **polyarteritis (poly/arter/itis)**
    - Inflammation of many (sites in the) arteries
9. **angioscopy(angi/o/scopy)**
    - visual examination of blood vessels
10. **intravenous (IV) (intra/ven/ous)**

- pertaining to within a vein

11. **thrombophlebitis (thromb/o/phleb/itis)**
    - inflammation of a vein associated with a (blood) clot
12. **pancytopenia (pan/cyt/o/penia)**
    - abnormal reduction of (all) blood cells
13. **plasmapheresis (plasm/apheresis)**
    - removal of plasma
14. **hematopoiesis (hemat/o/poiesis)**
    - formation of blood (cells)
15. **lymphadenopathy (lymphaden/o/pathy)**
    - disease of lymph nodes
16. **thrombosis(thromb/osis)**
    - abnormal condition of (blood) clot
17. **venogram (ven/o/gram)**
    - radiographic image of a vein
18. **hematology (hemat/o/logy)**
    - study of blood
19. **aortic stenosis (aort/ic stenosis)**
    - narrowing, pertaining to the aorta
20. **angioplasty (angi/o/plasty)**
    - surgical repair of a blood vessel
21. **aortogram (aort/o/gram)**
    - Radiographic image of the aorta
22. **splenomegaly (splen/o/megaly)**
    - enlarged spleen
23. **thrombolysis (thromb/o/lysis)**
    - dissolution of a (blood) clot

24. **splenopexy (splen/o/pexy)**
    - surgical fixation of the spleen
25. **endarterectomy(end/arter/ectomy)**
    - Rebel does not follow the rules
    - Excision within the artery
26. **hypothermia (hypo/therm/ia)**
    - condition of (body) temperature that is below (normal)
27. **thrombus (thromb/us)**
    - (blood) clot (attached to the interior wall of artery or vein)
28. **hematologist (hemat/o/logist)**
    - Physician who specializes and treats blood disorders
29. **thymoma (thym/oma)**
    - tumour of the thymus gland
30. **hematoma (hemat/oma)**
    - tumour composed of blood
31. **arteriosclerosis (arteri/o/sclerosis)**
    - hardening of the arteries
    - hardening of fatty plaque (on arterial wall)
32. **thymectomy (thym/ectomy)**
    - excision of the thymus gland
33. **angioma (angi/oma)**
    - tumour composed of blood vessels
34. **atherosclerosis (ather/o/sclerosis)**
    - hardening of fatty plaque
35. **lymphadenitis (lymphaden/itis)**
    - inflammtion of lymph nodes
36. **myelopoiesis (myel/o/poiesis)**
    - formation of bone marrow

37. **angiography(angi/o/graphy)**
    - radiographic imaging of blood vessels
38. **angiostenosis (angi/o/stenosis)**
    - narrowing of a blood vessel
39. **hemostasis (hem/o/stasis)**
    - stoppage of bleeding
40. **leukocytopenia (leuk/o/cyt/o/penia)**
    - abnormal reduction of white (blood) cells
41. **splenectomy (splen/ectomy)**
    - Excision of the spleen
42. **phlebotomy (phleb/o/tomy)**
    - incision into a vein
43. **phlebitis(phleb/itis)**
    - inflammation of a vein
44. **erythrocytopenia (erythr/o/cyt/o/penia)**
    - abnormal reduction of red (blood) cells
45. **atherectomy (ather/ectomy)**
    - Excision of fatty plaque

Activity source: "Cardiovascular System – Blood, medical terms" by Kimberlee Carter, licensed under CC BY- 4.0 from "Cardiovascular System – Blood Vessels and Blood" in Building a Medical Terminology Foundation by Kimberlee Carter and Marie Rutherford, licensed under CC BY- 4.0. / Converted to Text.

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Except where otherwise noted, this chapter is adapted from "Cardiovascular System – Blood Vessels and Blood" 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 Cardiovascular System – Blood Vessels and Blood chapter content into sub-chapters.

10.2 - Anatomy of the Blood Vessels

Blood pumped by the heart flows through a series of vessels known as arteries, arterioles, capillaries, venules, and veins before returning to the heart.

Overview of Blood Vessels

- **Arteries** transport blood away from the heart and branch into smaller vessels, forming arterioles.
- **Arterioles** distribute blood to capillary beds, the sites of exchange with the body tissues.
- A **capillary**is a microscopic channel that supplies blood to the tissues themselves, a process called **perfusion.**
    - Exchange of gases and other substances occurs in the capillaries between the blood and the surrounding cells and their tissue fluid (interstitial fluid).
    - For capillaries to function, their walls must be leaky, allowing substances to pass through.
    - Capillaries lead back to small vessels known as **venules.**
- **Venules** are small **veins** that converge into larger veins.
- A **vein** is a blood vessel that conducts blood toward the heart.
    - Compared to arteries, veins are thin-walled vessels with large and irregular lumens.
    - Larger veins are commonly equipped with valves that promote the unidirectional flow of blood toward the heart and prevent backflow toward the capillaries caused by the inherent low blood pressure in veins as well as the pull of gravity.
    - Other ways in which the body assists the transport of venous blood back to the heart involve contractions of skeletal muscles in the extremities (see figure below), as well as pressure variations caused by breathing motion in the chest.

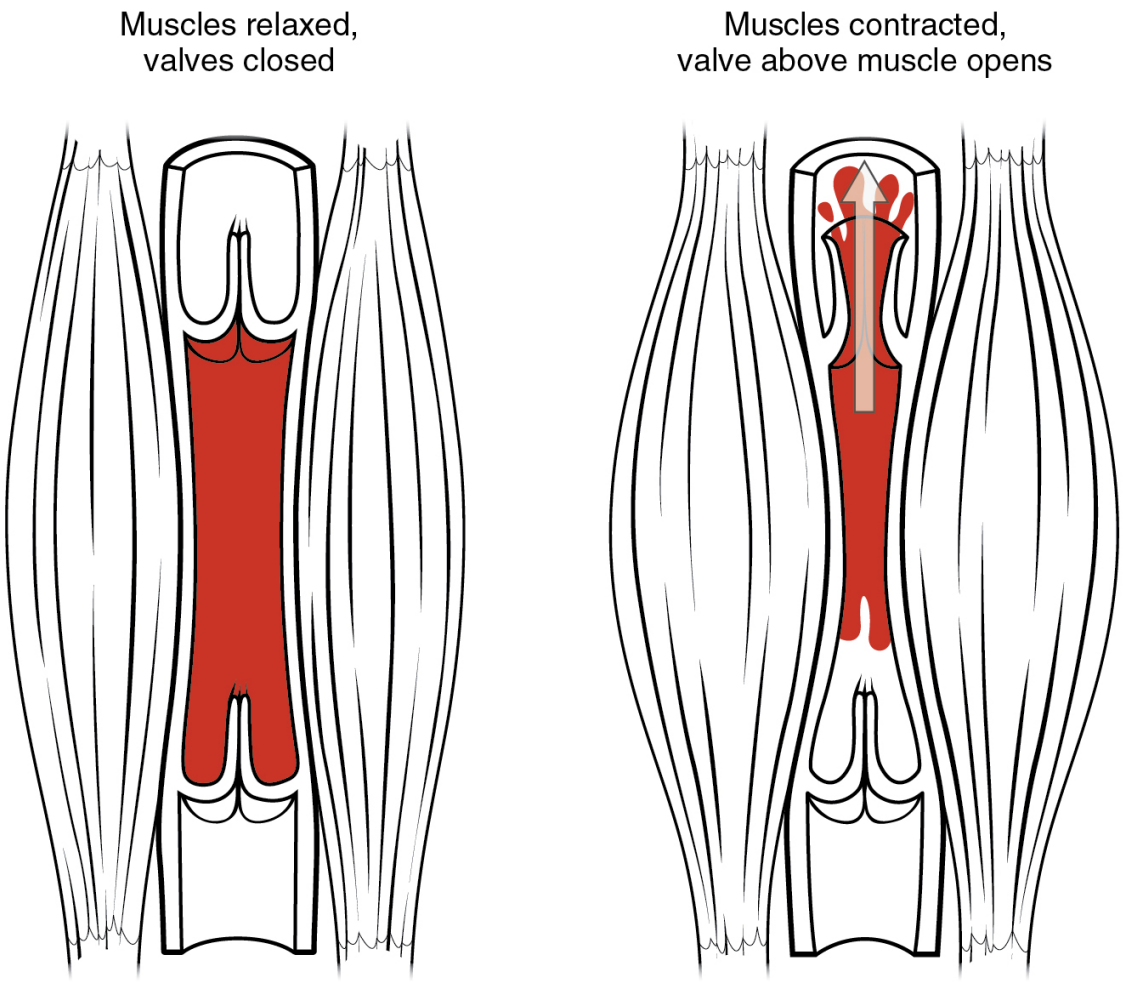

Figure 10.1 Skeletal Muscle Pump. The contraction of skeletal muscles surrounding a vein compresses the blood and increases the pressure in that area. This action forces blood closer to the heart where venous pressure is lower. Note the importance of the one-way valves to assure that blood flows only in the proper direction. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 10.1 Image description.]

Concept Check 1

- Select the correct bolded word: arteries always carry blood **away from/towards** the heart.
- Select the correct bolded word: veins always carry blood a**way from/towards** the heart.

Both arteries and veins have the same three distinct tissue layers, called **tunics**, for the garments first worn by ancient Romans. From the most interior layer to the outer, these tunics are the **tunica intima,** the **tunica media**, and the **tunica externa**. The smooth muscle in the middle layer, the tunica media, provides the vessel with the ability to **vasoconstrict** and **vasodilate** as needed to ensure sufficient blood flow.

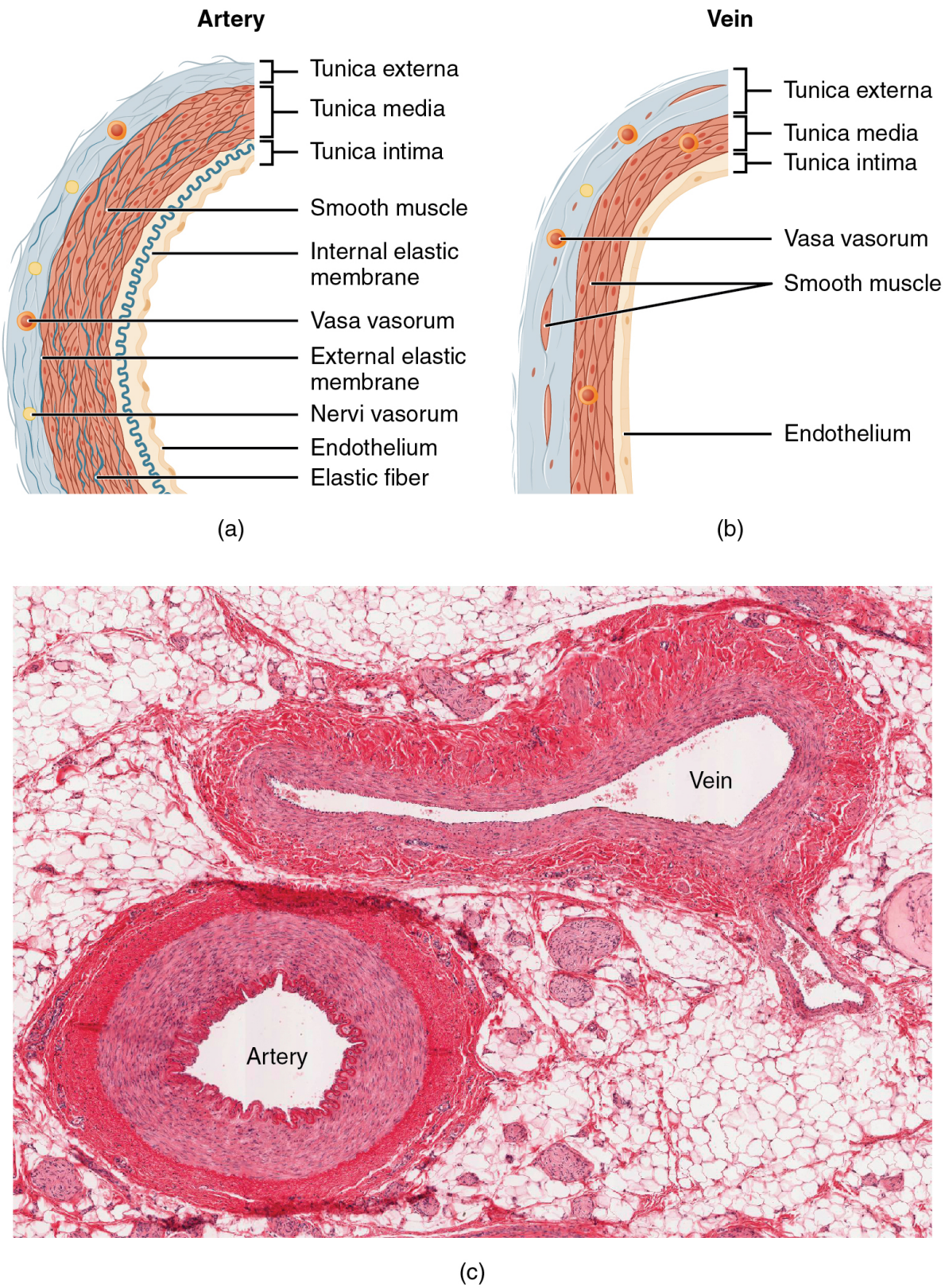

Figure 10.2 Structure of Blood Vessels. (a) Arteries and (b) veins share the same general features, but the walls of arteries are much thicker because of the higher pressure of the blood that flows through them. (c) A micrograph shows the relative

differences in thickness. LM × 160. (Micrograph provided by the Regents of the University of Michigan Medical School © 2012). From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 10.2 Image description.]

The table below compares the features of arteries and veins.

Table 10.2. Comparison of Arteries and Veins. From Betts et al., 2013. Licensed under CC BY 4.0.

Characteristic	Arteries	Veins
Direction of blood flow	Conducts blood away from the heart	Conducts blood toward the heart
General appearance	Rounded	Irregular, often collapsed
Pressure	High	Low
Wall thickness	Thick	Thin
Relative oxygen concentration	Higher in systemic arteries Lower in pulmonary arteries	Lower in systemic veins Higher in pulmonary veins
Valves	Not present	Present most commonly in limbs and in veins inferior to the heart

The Major Arteries and Veins in the Human Body

Many arteries and veins share the same names, parallel one another throughout the body, and are very similar on the right and left sides of the body. For example, you will find a pair of **femoral** arteries and a pair of femoral veins, with one vessel on each side of the body. In contrast, some vessels closer to the midline of the body, such as the aorta, are unique and not paired. Names of vessels may change with location. Like a street that changes name as it passes through an intersection, an artery or vein can change names as it passes an anatomical landmark. For example, the left **subclavian** artery becomes the **axillary** artery as it passes into the axillary region, and then becomes the **brachial** artery as it enters the upper arm. The next two diagrams illustrate the major arteries and veins in the human body.

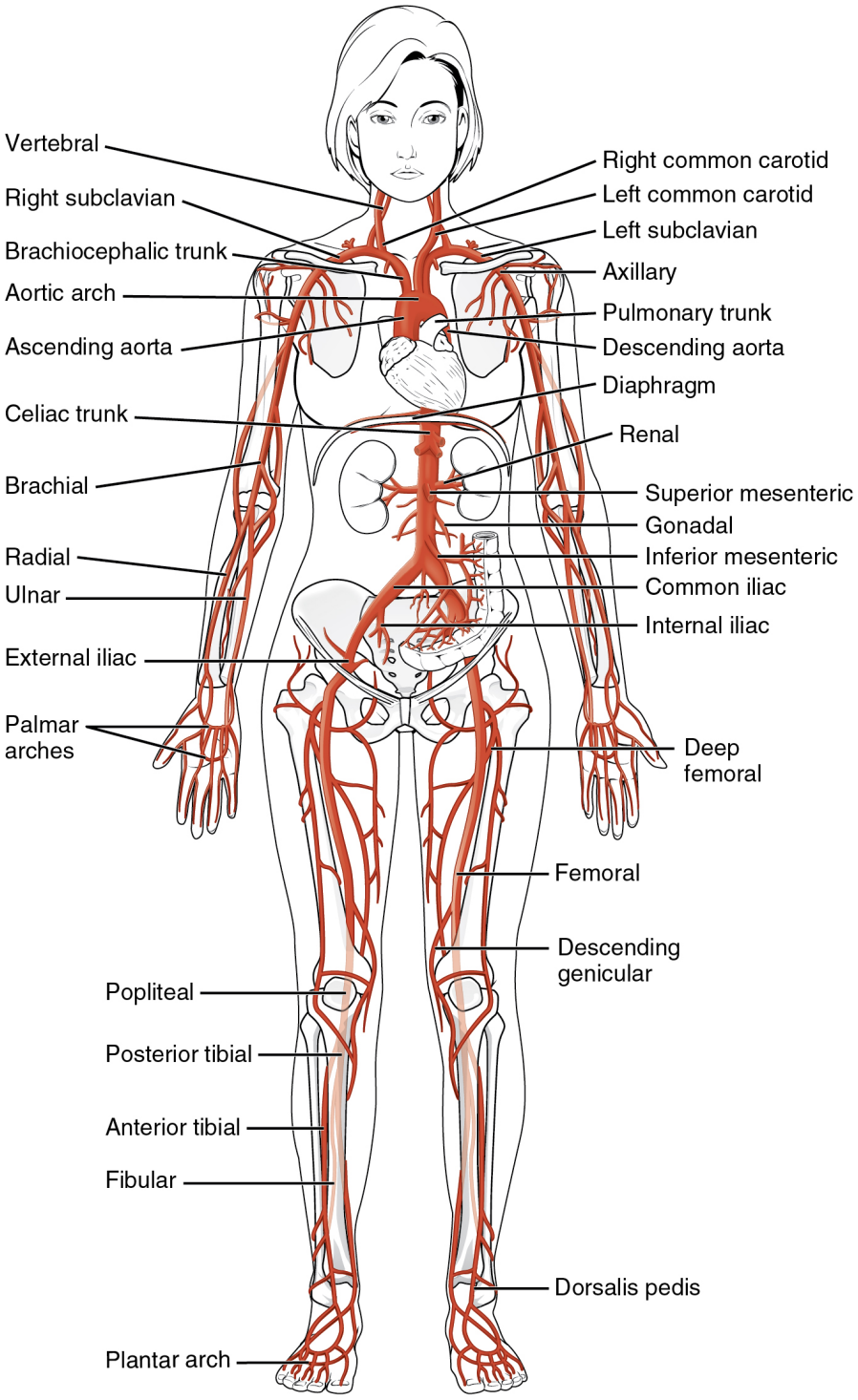

Figure 10.3 Systemic Arteries. The major systemic arteries shown here deliver oxygenated blood throughout the body. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 10.3 Image description.]

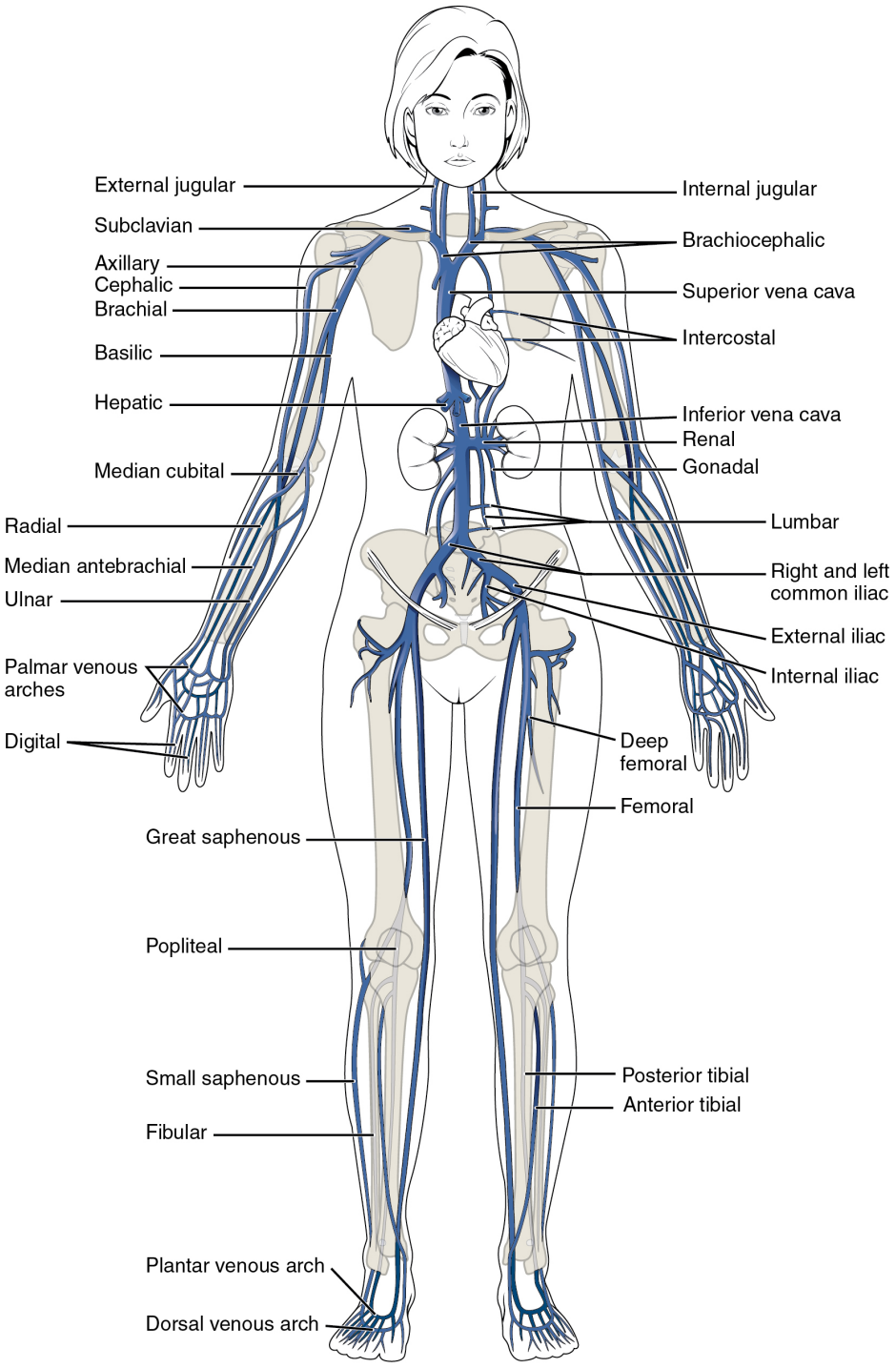

Figure 10.4 Major Systemic Veins of the Body. The major systemic veins of the body are shown here in an anterior view. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 10.4 Image description.]

Concept Check 2

- Without looking back at the images of the main arteries and veins of the body, can you **name** and **locate** 3 arteries and 3 veins in your body?

Image Descriptions

Figure 10.1 image description: The left panel shows the structure of a skeletal muscle vein pump when the muscle is relaxed, and the right panel shows the structure of a skeletal muscle vein pump when the muscle is contracted.[Return to Figure 10.1].

Figure 10.2 image description: The top left panel of this figure shows the ultrastructure of an artery (labels read from top: tunica externa, tunica media, tunica intima, smooth muscle, internal elastic membrane, vasa vasorum, external elastic membrane, nervi vasorum, endothelium, elastic fiber), and the top right panel shows the ultrastructure of a vein (labels read from top: tunica exerna, tunica media, tunica intima, vasa vasorum, smooth muscle, endothelium). The bottom panel shows a micrograph with the cross sections of an artery and a vein. [Return to Figure 10.2].

Figure 10.3 image description: The major arteries in the human body. Labels read (from top, clockwise) right common carotid, left common carotid, axillary, pulmonary trunk, descending aorta, diaphragm, renal, superior mesenteric, gonadal, inferior mesenteric, common iliac, internal iliac, deep femoral, femoral, descending genicular, doraslis pedis, plantar arch, fibular, anterior tibial, posterial tibial, popliteal, palmer arches, exernal iliac, ulnar, radial, brachial, celiac trunk, ascending aorta, aortic arch, brachiocephalic trunk, right subclavian, vertebral. [Return to Figure 10.3].

Figure 10.4 image description: The major veins in the human body. Labels read (from top, clockwise) internal jugular, brachiocephalic, superior vena cava, intercostal, inferior vena cava, gonadal, lumbar, right and left common iliac, external iliac, internal iliac, deep femoral, femoral, posterior tibial, anterior tibial, dorsal venous arch, plantar venous arch, fibular, small saphenous, popliteal, great saphenous, digital, palmar venous arches, ulnar, median antebrachial, medial cubital, hepatic, basilic, brachial, cephalic, axillary, subclavian, externa jugular. [Return to Figure 10.4].

Attribution

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10.3 - Physiology of the Blood & Blood Vessels

Physiology of the Blood Vessels

Arteries and veins transport blood in two distinct circuits: the **systemic circuit** and the **pulmonary circuit**. Systemic arteries provide blood rich in oxygen to the body's tissues. The blood returned to the heart through systemic veins has less oxygen, since much of the oxygen carried by the arteries has been delivered to the cells. In contrast, in the pulmonary circuit, arteries carry blood low in oxygen exclusively to the lungs for gas exchange. Pulmonary veins then return freshly oxygenated blood from the lungs to the heart to be pumped back out into systemic circulation.

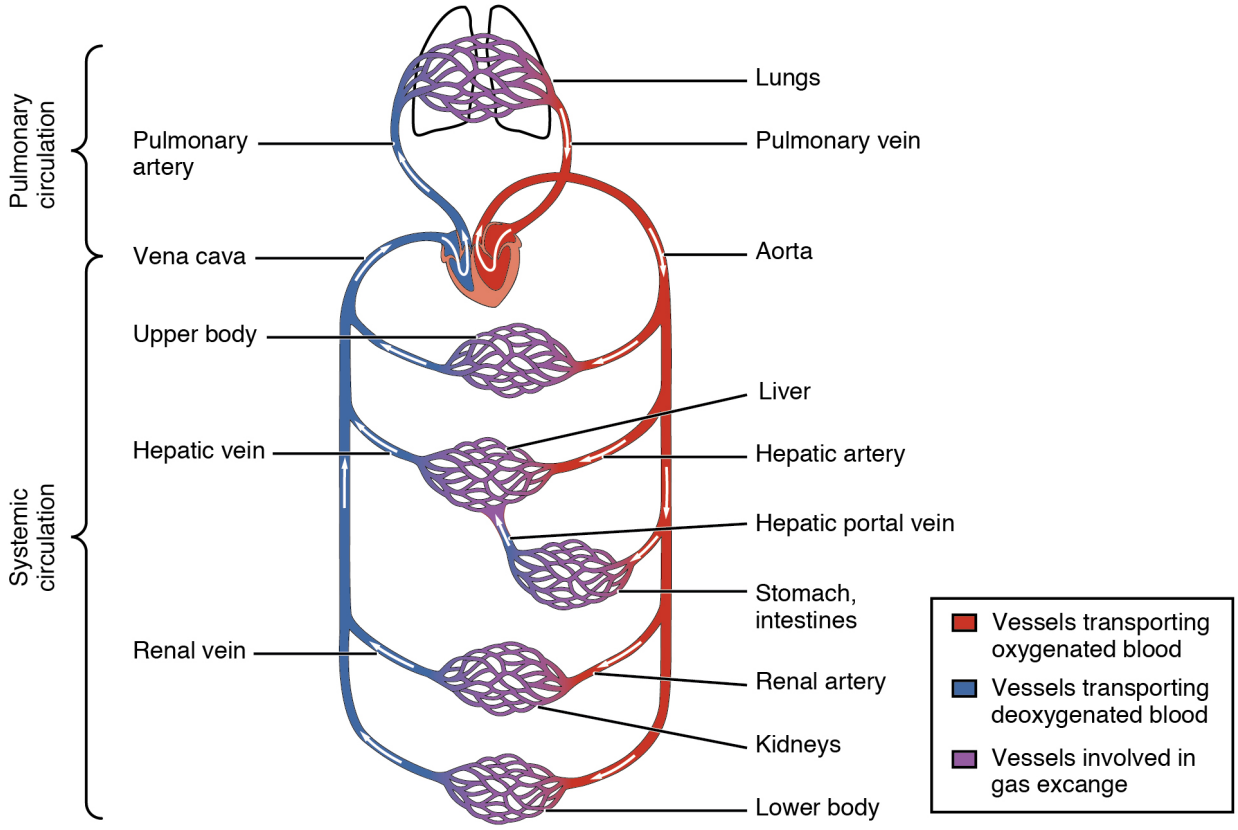


Figure 10.5 Cardiovascular Circulation. The pulmonary circuit moves blood from the right side of the heart to the lungs and back to the heart. The systemic circuit moves blood from the left side of the heart to the head and body and returns it to the right side of the heart to repeat the cycle. The arrows indicate the direction of blood flow, and the colors show the relative levels of oxygen concentration. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 10.5 Image description.]

Blood Pressure

Blood pressure is the force exerted by blood upon the walls of the blood vessels or the chambers of the heart.

Blood pressure may be measured in capillaries and veins, as well as the vessels of the pulmonary circulation; however, the general term 'blood pressure' refers to the pressure of blood flowing in the arteries of the systemic circulation. Blood pressure is one of the critical parameters measured on virtually every patient in every healthcare setting. The technique used today was developed more than 100 years ago by a pioneering Russian physician, Dr. Nikolai Korotkoff. Turbulent blood flow through the vessels can be heard as a soft ticking while measuring blood pressure; these sounds are known as **Korotkoff sounds**. Blood pressure is measured in mm Hg and is usually obtained from the **brachial artery** using a **sphygmomanometer** and a stethoscope. Blood pressure is recorded as **systolic pressure** over **diastolic pressure.**

Did You Know 1?

120/80 mm Hg is a normal, healthy blood pressure. **60-100** beats per minute is a normal, resting, adult pulse.

Five variables influence blood flow and blood pressure:

- **Cardiac output**
- **Vessel Compliance**
- Volume of the blood
- **Viscosity** of the blood
- Blood vessel length and diameter

Pulse

Each time the heart ejects blood forcefully into the circulation, the arteries must expand and then **recoil** to accommodate the surge of blood moving through them. This expansion and recoiling of the arterial wall is called the **pulse** and allows us to measure **heart rate**. Pulse can be palpated manually by placing the tips of the fingers across an artery that runs close to the body surface, such as the radial artery or the common carotid artery. These sites and other pulse sites are shown in the figure below.

Both the rate and the strength of the pulse are important clinically. A high or irregular pulse rate can be caused by physical activity or other temporary factors, but it may also indicate a heart condition. The pulse strength indicates the strength of ventricular contraction and cardiac output. If the pulse is strong, then systolic pressure is high. If it is weak, systolic pressure has fallen, and medical intervention may be warranted.

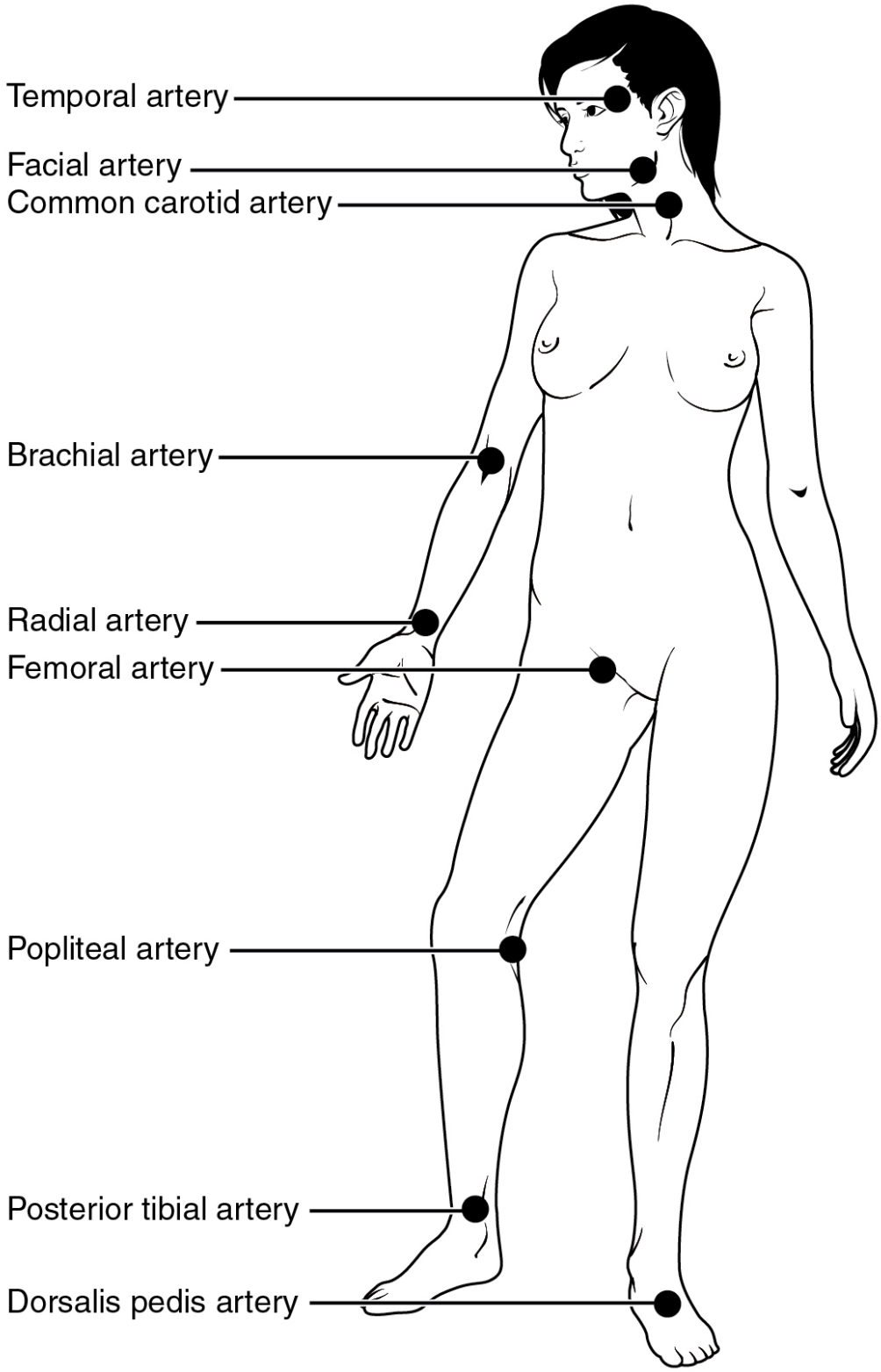


Figure 10.6 Pulse Sites. The pulse is most readily measured at the radial artery, but can be measured at any of the pulse points shown. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 10.6 Image description.]

The Composition (Anatomy) of Blood and the Functions of the Components

Blood is a connective tissue made up of cellular elements and an extracellular matrix. The cellular elements are referred to as the **formed elements and** include **red blood cells (RBCs)**, **white blood cells (WBCs)**, and **platelets**. The extracellular matrix, called **plasma**, makes blood unique among connective tissues because it is fluid. This fluid, which is mostly water, perpetually suspends the formed elements and enables them to circulate throughout the body within the cardiovascular system.

Did You Know 2?

Blood constitutes approximately 8% of adult body weight.

In the laboratory, blood samples are often **centrifuged** in order to separate the components of blood from one another (see the figure below). **Erythrocytes** are the heaviest elements in blood and settle at the very bottom of the tube. Above the erythrocyte layer we see the **buffy coat**, a pale, thin layer of **leukocytes** and **thrombocytes**, which together make up less than 1% of the sample of whole blood. Above the buffy coat is the blood plasma, normally a pale, straw-colored fluid, which constitutes the remainder of the sample.

In normal blood, about 45 percent of a sample is erythrocytes, which is referred to as the **hematocrit**. The hematocrit of any one sample can vary significantly, however, about 36–50 percent, according to gender and other factors. Not counting the buffy coat, which makes up less than 1% of the blood, we can estimate the mean plasma percentage to be the percent of blood that is not erythrocytes: approximately 55%.

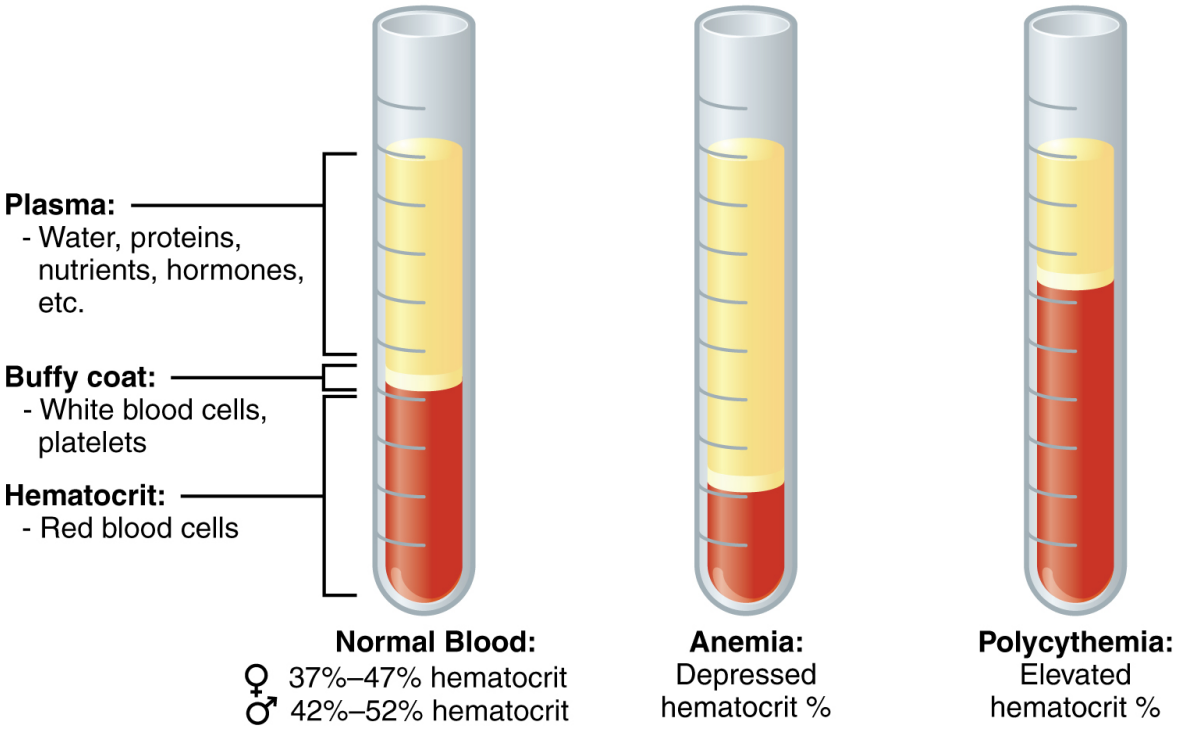


Figure 10.7 Composition of Blood. The cellular elements of blood include a vast number of erythrocytes and comparatively fewer leukocytes and platelets. Plasma is the fluid in which the formed elements are suspended. A sample of blood spun in a centrifuge reveals that plasma is the lightest component. It floats at the top of the tube separated from the heaviest elements, the erythrocytes, by a buffy coat of leukocytes and platelets. Hematocrit is the percentage of the total sample that is comprised of erythrocytes. Depressed and elevated hematocrit levels are shown for comparison. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 10.7 Image description.]

The table below provides a useful summary of the components of blood and their functions.

Table 10.3 a &b – Major Blood Components: . This table displays the components of blood and their associated functions. Adapted from Betts et al., 2013. Licensed under CC BY 4.0.

Table 10.3a Major Blood Components: Plasma 46-63 percent of blood

Subcomponent and % of Component	Type and % (Where appropriate)	Site of production	Major function(s)
Water 92 percent	Fluid	Absorbed by intestinal tract or produced by metabolism	Transport medium
Plasma protein – Albumin	Albumin 54 – 60 percent	Liver	Maintain osmotic concentration, transport lipid molecules
Plasma protein – Alpha Globulins	Globulins (35 – 38 percent overall)	Alpha globulins – liver	Transport, maintain osmotic concentration
Plasma protein – Beta globulins	Globulins 35 – 38 percent (35 – 38 percent overall)	Beta globulins – liver	Transport, maintain osmotic concentration
Plasma protein – Gamma Globulins	Globulins 35 – 38 percent (35 – 38 percent overall)	Gamma globulins (immunoglobulins) – plasma cells	Immune responses
Plasma protein – Fibrinogen	Fibrinogen 4 – 7 percent	Liver	Blood clotting in hemostasis

Subcomponent and % of Component	Type and % (Where appropriate)	Site of production	Major function(s)
Regulatory proteins < 1 percent	Hormones and enzymes	Various sources	Regulate various body functions
Other solutes 1 percent	Nutrients, gases, and wastes	Absorbed by intestinal tract, exchanged in respiratory system, or produced by cells	Numerous and varied

Table 10.3b Major Blood Components. Formed elements 37 – 54 percent

Subcomponent and % of Component	Type and % (Where appropriate)	Site of production	Major function(s)
Erythrocytes 99 percent	Erythrocytes	Red bone marrow	Transport gases, primarily oxygen and some carbon dioxide
Leukocytes < 1 percent Platelets < 1 percent (overall)	Granular Leukocytes: neutrophils eosinophils basophils	Red bone marrow	Nonspecific immunity
Leukocytes < 1 percent Platelets < 1 percent (overall)	Agranular leukocytes: lymphocytes	Lymphocytes: bone marrow and lyphatic tissue	Lymphocytes: specific immunity
Leukocytes < 1 percent Platelets < 1 percent (overall)	Agranular leukocytes: monocytes	Monocytes: redbone marrow	Monocytes: nonspecific immunity
Platelets < 1 percent	n/a	Megakaryocytes: Red Bone Marrow	Hemostasis

Concept Check 1

Use the table above to answer these questions:

- What substance makes up *most* of the plasma?
- What are some general functions of plasma and its components?
- What is the function of **erythrocytes**?
- What is the overall function of **leukocytes**? (Hint: which word appears in all 3 chart cells that list leukocyte functions?)
- What is the function of **platelets**?

Blood Plasma

Like other fluids in the body, plasma is composed primarily of water. In fact, it is about 92% water. Dissolved or suspended within this water is a mixture of substances, most of which are proteins. The major components of plasma and their functions are summarized in the table above.

Formed Elements (Erythrocytes, Leukocytes, Thrombocytes)

Table 10.4a below summarizes the main facts about the formed elements in blood. Table 10.4b shows a more in-depth look at Leukocytes (white blood cells).

Table 10.4a Summary of Formed Elements in Blood. Adapted from Betts et al., 2013. Licensed under CC BY 4.0.

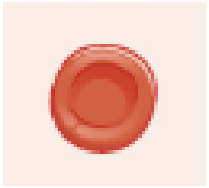
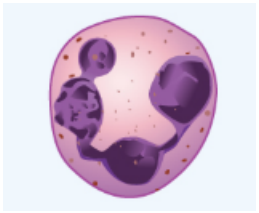
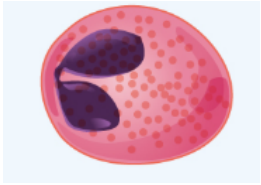
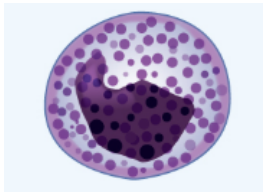
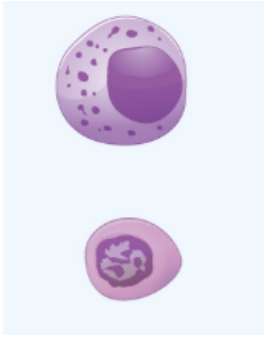
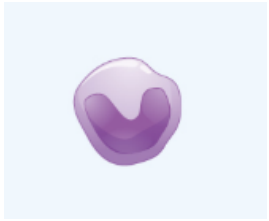
Formed Element	Major Subtypes	Number Present per Microliter (μL) and Mean Range	Appearance in a Standard Blood Smear	Summary of Functions	Comments
Erythrocytes (red blood cells)  *Red Blood Cell*	n/a	5.2 million (4.4-5.0 million)	Flattened biconcave disk; no nucleus; pale red colour	Transport oxygen and some carbon dioxide between tissues and lungs	Lifespan of approximately 120 days
Leukocytes (white blood cells)	n/a	7000 (5000 – 10,000)	Obvious dark-staining nucleus	All function in body defenses	Exit capillaries and move into tissues; lifespan of usually a few hours or days
Platelets  *Platelete Cells*	n/a	350,000 (150,000 – 500,000)	Cellular fragments surrounded by a plasma membrane and containing granules; purple stain	Hemostasis plus release growth factors for repair and healing of tissue	Formed from megakaryocytes that remain in the red bone marrow and shed platelets into circulation

Table 10.4b Leukocytes (white blood cells) in Blood. Adapted from Betts et al., 2013. Licensed under CC BY 4.0.

Major Subtypes	Number Present per Microliter (µL) and Mean Range	Appearance in a Standard Blood Smear	Summary of Functions	Comments
Granulocytes including neutrophils, eosinophils, and basophils	**4360 (1800-9950)**	**Abundant granules in cytoplasm; nucleus normal lobed**	**Nonspecific (innate) resistance to disease**	**Classified accordi**
Neutrophils  *Neutrophil Cell*	4150 (1800-7300)	Nuclear lobes increase with age; pale lilac granules	Phagocytic; particularly effective against bacteria. Release cytotoxic chemicals from granules	Most common leu
Eosinophils  *Eosinophils Cell*	165 (0-700)	Nucleus generally two-lobed; bright red-orange granules	Phagocytic cells; particularly effective with antigen-antibody complexes. Release antihistamines. Increase in allergies and parasitic infections	Lifespan of minut

Basophils  *Basophil Cell*	44 (0-150)	Nucleus generally two-lobed but difficult to see due to presence of heavy, dense, dark purple granules	Promotes inflammation	Least common leu
Agranulocytes including lymphocytes and monocytes	**2640 (1700-4950)**	**Lack abundant granules in cytoplasm; have a simple-shaped nucleus that may be indented**	**Body defenses**	**Group consists of**
Lymphocytes  *Lymphocytes Cell*	2185 (1500-4000)	Spherical cells with a single often large nucleus occupying much of the cell's volume; stains purple; see in large (natural killer cells) and small (B and T cells) variants	Primarily specific (adaptive) immunity; T cells directly attack other cells (cellular immunity). B cells release antibodies (humoral immunity); natural killer cells are similar to T cells but nonspecific	Initial cells origina in lymphatic tissu exposure to a patl exposure; lifespar

Monocytes  *Monocytes Cell*	455 (200-950)	Largest leukocyte with an indented or horseshoe-shaped nucleus	Very effective phagocytic cells engulfing pathogens or worn out cells; also serve as antigen-presenting cells (APCs) for other components of the immune system	Produced in red b leaving circulatio

Hemopoiesis/Hematopoiesis

The lifespan of the formed elements is very brief. Although one type of leukocyte (memory cells) can survive for years, most **erythrocytes**, **leukocytes**, and **platelets** normally live only a few hours to a few weeks. Thus, the body must form new blood cells and platelets quickly and continuously, a process known as **hemopoiesis**.

In children, hemopoiesis can occur in the medullary cavity of long bones; in adults, the process is largely restricted to the cranial and pelvic bones, the vertebrae, the sternum, and the proximal **epiphyses** of the femur and humerus. Throughout adulthood, the liver and spleen maintain their ability to generate the formed elements. This process is referred to as **extramedullary hemopoiesis**. When a disease such as bone cancer destroys the bone marrow, causing hemopoiesis to fail, extramedullary hemopoiesis may be initiated .

All formed elements arise from stem cells of the red bone marrow, called **hemopoietic stem cell**, or **hemocytoblast**. Hemopoiesis begins when the hemopoietic stem cell is exposed to appropriate chemical stimuli collectively called **hemopoietic growth factors**, which prompt it to divide and differentiate. One daughter cell remains a hemopoietic stem cell, allowing hemopoiesis to continue. The other daughter cell becomes either of two types of more specialized stem cells. Follow the chart below from top to bottom to learn how stem cells become mature formed elements of blood.

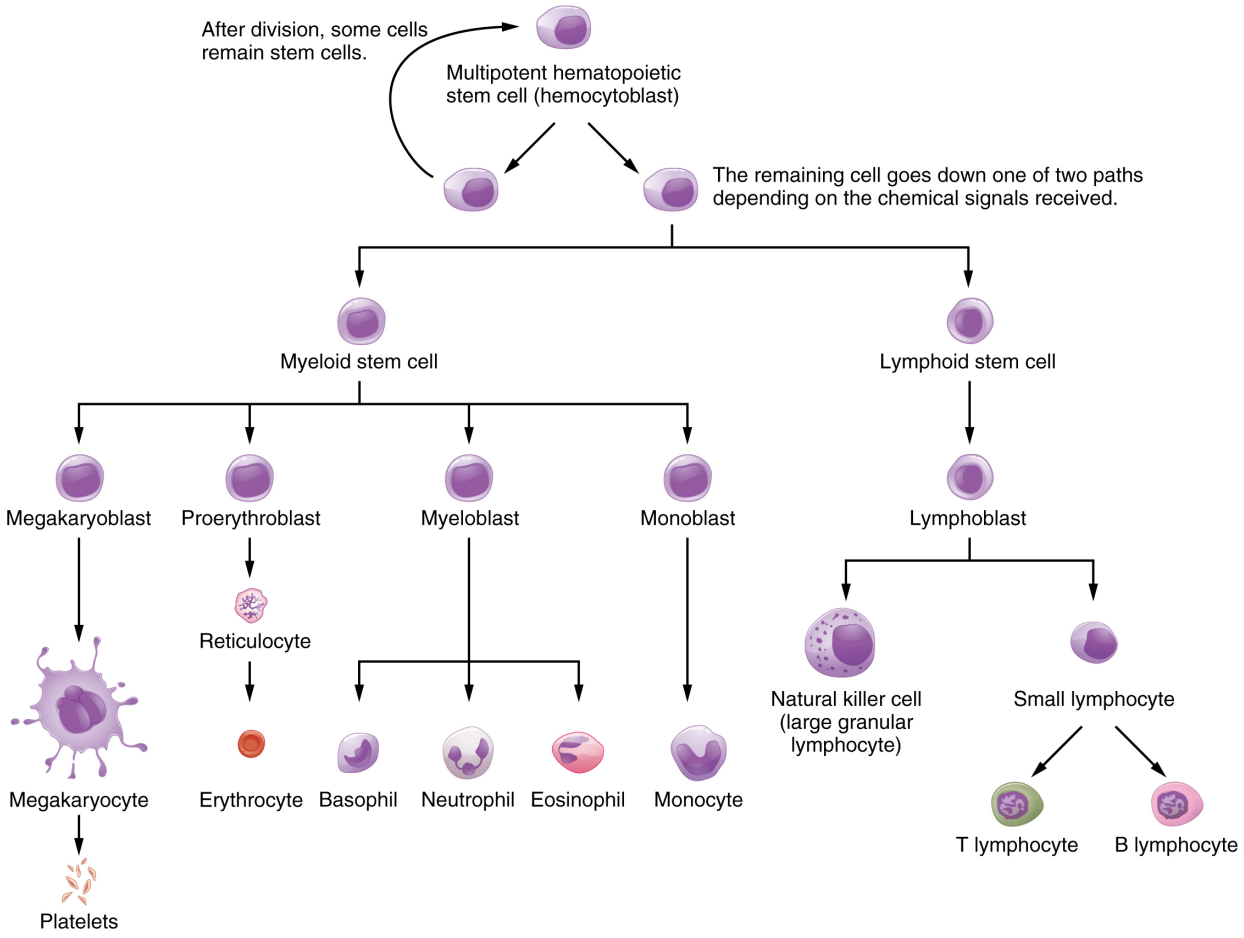


Figure 10.8 Hematopoietic System of Bone Marrow. Hemopoiesis is the proliferation and differentiation of the formed elements of blood. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 10.8 Image description.]

Erythrocytes

The most abundant formed elements in blood, erythrocytes are basically sacs packed with an oxygen-carrying compound called hemoglobin. Production of erythrocytes in the red bone marrow occurs at the staggering rate of more than 2 million cells per second. For this production to occur, raw materials including iron, copper, zinc B-vitamins, glucose, lipids, and amino acids must be present in adequate amounts. Erythrocytes live only 120 days on average, and thus must be continually replaced. Worn-out erythrocytes are **phagocytized** by **macrophages** and their hemoglobin is broken down. The breakdown products are recycled or removed as wastes.

Figure 10.9 Shape of Red Blood Cells. Erythrocytes are biconcave discs with very shallow centers. This shape optimizes the ratio of surface area to volume, facilitating gas exchange. It also enables them to fold up as they move through narrow blood vessels. From Betts et al., 2013. Licensed under CC BY 4.0.

Leukocytes

Leukocytes protect the body against invading microorganisms and body cells with mutated DNA, and they clean up debris, thus they are a major component of the body's defenses against disease. Figure 13.10 shows the different types of leukocytes.

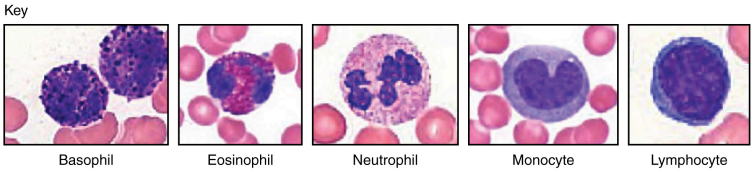


Figure 10.10 Leukocytes. (Micrographs provided by the Regents of University of Michigan Medical School © 2012). From Betts et al., 2013. Licensed under CC BY 4.0.

Concept Check 2

- What is **hemoglobin**?
- Can you name the 5 types of **leukocytes**?

Leukocytes routinely leave the bloodstream to perform their **defensive** functions in the body's tissues, where they are often given distinct names, such as **macrophage** or **microglia**, depending on their function. As shown in Figure 1 below, they leave the capillaries—the smallest blood vessels—or other small vessels through a process known as **emigration** or **diapedesis** in which they squeeze through adjacent cells in a blood vessel wall.

Once they have exited the capillaries, some leukocytes will take up fixed positions in lymphatic tissue, bone marrow, the spleen, the thymus, or other organs. Others will move about through the tissue spaces, sometimes wandering freely, and sometimes moving toward the direction in which they are drawn by chemical signals, a mechanism known as **positive chemotaxis.**

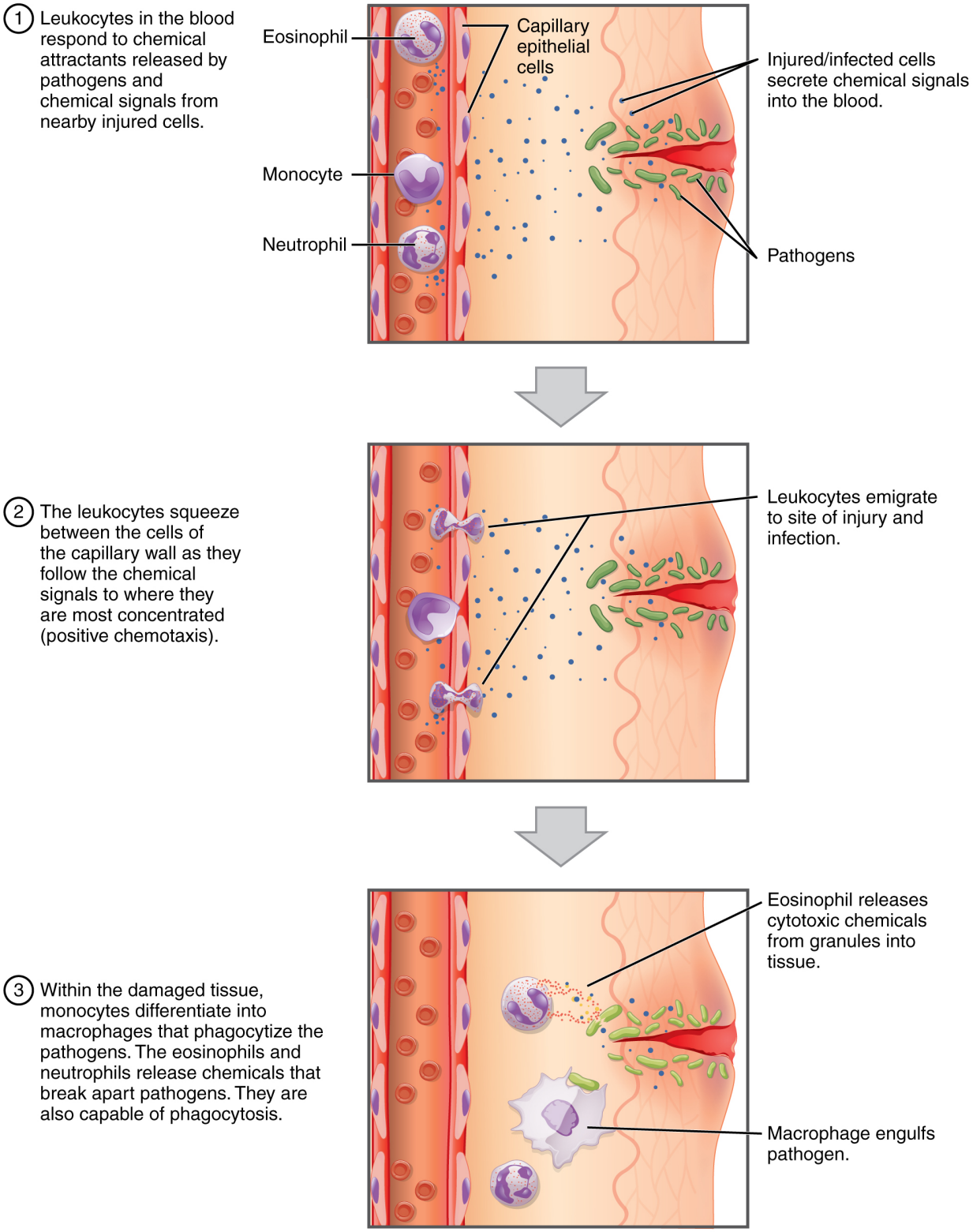


Figure 10.11 Emigration. Leukocytes exit the blood vessel and then move through the connective tissue of the dermis toward the site of a wound. Some leukocytes, such as the eosinophil and neutrophil, are characterized as granular leukocytes. They release chemicals from their granules that destroy pathogens; they are also capable of phagocytosis. The monocyte differentiates into a macrophage that then phagocytizes the pathogens. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 10.11 Image description.]

Lymphocytes

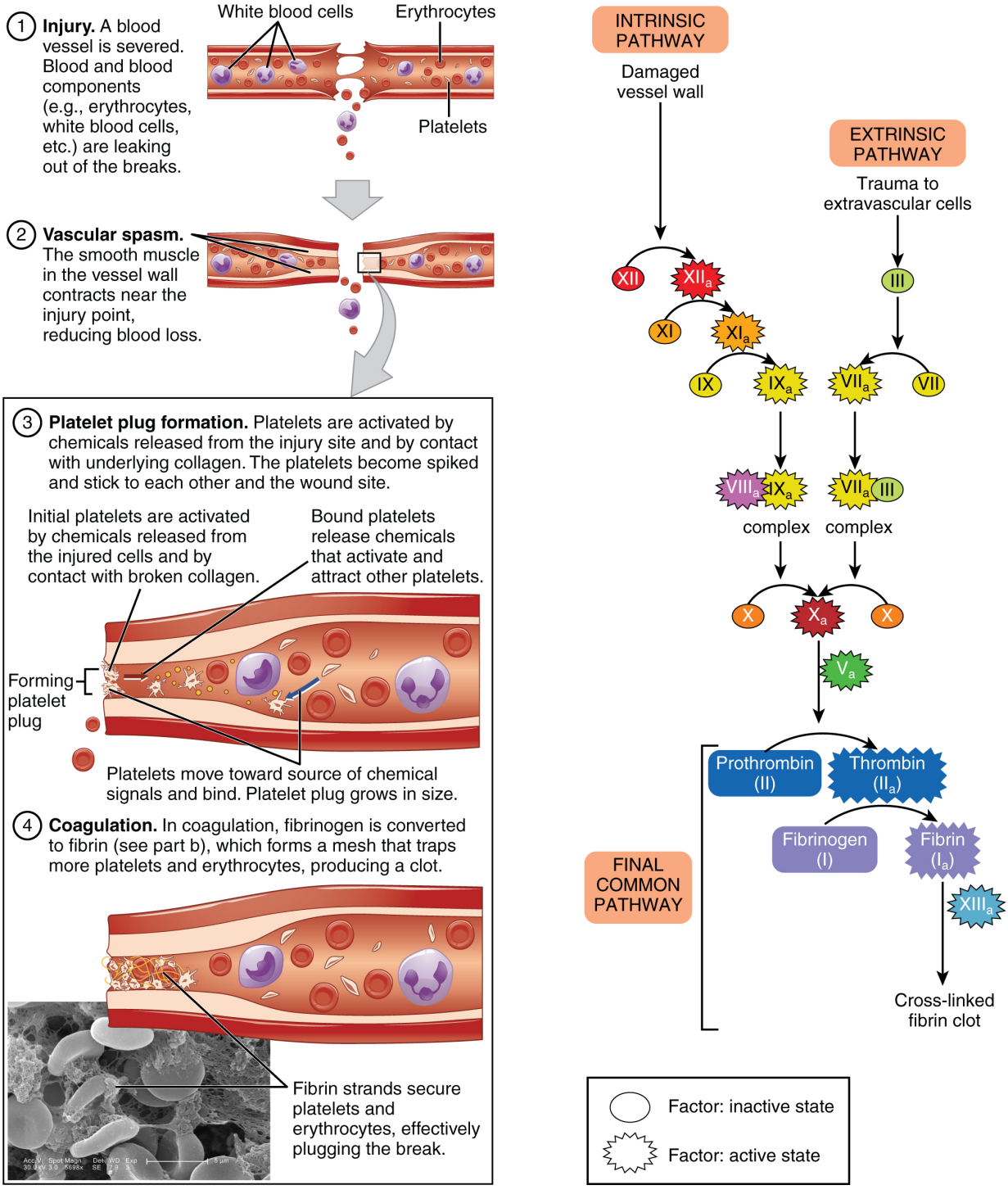
Lymphocytes are one of the types of leukocytes and will be discussed in more detail here, since they tie into the next chapter which discussed the body's defenses The three major groups of lymphocytes include natural killer cells, B cells, and T cells.

- **Natural killer (NK) cells** are capable of recognizing cells that do not express "self" proteins on their plasma membrane or that contain foreign or abnormal markers. These "non-self" cells include cancer cells, cells infected with a virus, and other cells with atypical surface proteins.
- **B lymphocytes (B cells)** and **T lymphocytes (T cells)**, play prominent roles in defending the body against specific pathogens (disease-causing microorganisms) and are involved in specific immunity. B cells undergo a maturation process in the bone marrow, whereas T cells undergo maturation in the thymus. This site of the maturation process gives rise to the name B and T cells.
  - **Plasma cells**, a type of B cell, produce the antibodies or immunoglobulins that bind to specific foreign or abnormal components of plasma membranes.
  - **T cells** provide immunity by physically attacking foreign or diseased cells.
  - **Memory cells** are a variety of both B and T cells that form after exposure to a pathogen and mount rapid responses upon subsequent exposures. Unlike other leukocytes, memory cells live for many years.

Platelets

After entering the circulation, approximately one-third of the newly-formed platelets migrate to the spleen for storage for later release in response to any rupture in a blood vessel. They then become activated to perform their primary function, which is to limit blood loss. Platelets remain only about 10 days, then are **phagocytized** by **macrophages**.

Platelets are key players in **hemostasis**, the process by which the body seals a ruptured blood vessel and prevents further loss of blood. Although rupture of larger vessels usually requires medical intervention, hemostasis is quite effective in dealing with small, simple wounds. There are three steps to the process: vascular spasm, the formation of a platelet plug, and coagulation (blood clotting). Failure of any of these steps will result in **hemorrhage.** The figure below summarizes the steps of hemostatis.



(a) The general steps of clotting

(b) Fibrin synthesis cascade

Figure 10.12 Hemostasis. (a) An injury to a blood vessel initiates the process of hemostasis. Blood clotting involves three steps. First, vascular spasm constricts the flow of blood. Next, a platelet plug forms to temporarily seal small openings in the vessel. Coagulation then enables the repair of the vessel wall once the leakage of blood has stopped. (b) The synthesis of fibrin in blood clots involves either an intrinsic pathway or an extrinsic pathway, both of which lead to a common pathway. (credit a: Kevin MacKenzie). From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 10.12 Image description.]

Fibrinolysis is the process in which a clot is degraded in a healing vessel. An **anticoagulant** is any substance that opposes coagulation. Several circulating plasma anticoagulants play a role in limiting the coagulation process to the region of injury and restoring a normal, clot-free condition of blood.

Concept Check 3

- Can you explain what happens in each step of **hemostasis**?
- Describe an **anticoagulant**.

Physiology of Blood

Although carrying oxygen and nutrients to cells and removing wastes from cells is the main function of blood, it is important to realize that blood also serves in defense, distribution of heat, and maintenance of homeostasis.

Transportation

- Nutrients from the foods you eat are absorbed in the digestive tract. Most of these travel in the bloodstream directly to the liver, where they are processed and released back into the bloodstream for delivery to body cells.
- Oxygen from the air you breathe diffuses into the blood, which moves from the lungs to the heart, which then pumps it out to the rest of the body.
- Endocrine glands scattered throughout the body release their products, called **hormones**, into the bloodstream, which carries them to distant target cells.
- Blood also picks up **cellular wastes** and byproducts, and transports them to various organs for removal. For instance, blood moves carbon dioxide to the lungs for **exhalation** from the body, and various waste products are transported to the kidneys and liver for excretion from the body in the form of urine or bile.

Defense

- Leukocytes protect the organism from disease-causing bacteria, cells with **mutated** DNA that could multiply to become cancerous, or body cells infected with viruses.
- When damage to the vessels results in bleeding, blood platelets and certain proteins dissolved in the plasma, interact to block the ruptured areas of the blood vessels involved. This protects the body from

further blood loss.

Homeostasis

- If you were exercising on a warm day, your rising core body temperature would trigger several homeostatic mechanisms, including increased transport of blood from your core to your body periphery, which is typically cooler. As blood passes through the vessels of the skin, heat would be dissipated to the environment, and the blood returning to your body core would be cooler. In contrast, on a cold day, blood is diverted away from the skin to maintain a warmer body core. In extreme cases, this may result in frostbite.
- Blood helps to regulate the water content of body cells.
- Blood also helps to maintain the chemical balance of the body. Proteins and other compounds in blood act as buffers, which thereby help to regulate the **pH** of body tissues. The pH of blood ranges from 7.35 to 7.45.

Concept Check 4

These three terms all sound similar. Can you explain them by breaking down the word parts?

- Hemostasis
- Homeostasis
- Hemopoiesis

Blood Types

In order to understand blood types, it is important to understand several terms that relate to the body's **immune** functions (discussed in detail in the next chapter).

- **Antigens** are substances that the body does not recognize as belonging to itself ("self") and that therefore trigger a **defensive response** from the leukocytes of the immune system. Many people have antigens on the surfaces of their red blood cells. More than 50 antigens have been identified on erythrocyte membranes, but the most significant in terms of their potential harm to patients are classified in two groups: the ABO blood group and the Rh blood group.
- **Antibodies** are proteins which are produced by **plasma cells** in response to a "non-self" antigen being

present in the body. Antibodies attach to the antigens on the plasma membranes of the erythrocytes in a blood transfusion and cause them to adhere to one another.

- Agglutination refers to the resulting clumps of red blood cells that are formed in such an antigen-antibody reaction. These clumps can block small blood vessels, thereby cutting of the supply of oxygen and nutrients to the tissues.
- **Hemolysis**, or the breakdown of the erythrocyte's cell membrane, takes place as the clumps of red cells start to degrade. The resulting release of the cell's contents, mainly hemoglobin, into the bloodstream can cause kidney failure.

ABO Blood Group

ABO blood types are **genetically** determined. Each type is determined by the presence or absence of certain **antigens** on the individual's red blood cell membrane, as well as the presence or absence of certain **antibodies**. Normally the body must be exposed to a **foreign antigen** before an antibody can be produced. This is not the case for the ABO blood group, in which some blood types come preloaded with their own set of antibodies against another type. The table below shows the ABO blood group as well as the universal donor and recipient in relation to blood transfusions.

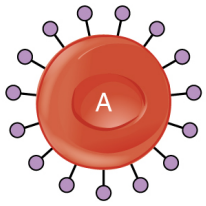
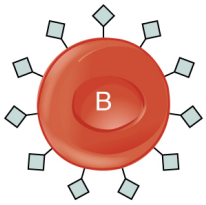
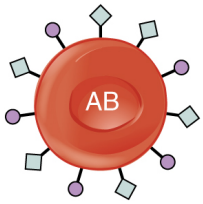
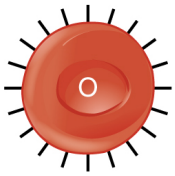
	Blood Type			
	A	B	AB	O
Red Blood Cell Type				
Antibodies in Plasma	 Anti-B	 Anti-A	None	 Anti-A and Anti-B
Antigens in Red blood Cell	 A antigen	 B antigen	 A and B antigens	None
Blood Types Compatible in an Emergency	A, O	B, O	A, B, AB, O (AB^+ is the universal recipient)	O (O is the universal donor)

Figure 10.13 ABO Blood Groups. From Betts et al., 2013. Licensed under CC BY 4.0.

- Blood Type A
  - People whose erythrocytes have **A antigens** on their erythrocyte membrane surface.
  - People who have type A blood, without any prior exposure to incompatible blood, have preformed **anti-B antibodies** circulating in their blood. These antibodies will cause a serious immune reaction if they encounter blood that has B antigens.
- Blood Type B
  - People whose erythrocytes have **B antigens.**
  - People with type B blood have preformed **anti-A antibodies.**
- Blood Type AB
  - People can also have **both A and B antigens** on their erythrocytes, in which case they are blood type AB.
  - Individuals with type AB blood, **do not have preformed antibodies** to either A or B antigens.
- Blood Type O
  - People with **neither A nor B antigens** are designated blood type O.
  - People with type O blood have **both anti-A and anti-B antibodies** circulating in their blood plasma.

Rh Blood Group

The **Rh blood group** is classified according to the presence or absence of a second erythrocyte **antigen** identified as Rh. Those who have the Rh D antigen present on their erythrocytes are described as Rh positive (Rh^+) and those who lack it are Rh negative (Rh^-). Note that the Rh group is distinct from the ABO group, so any individual, no matter their ABO blood type, may have or lack this Rh antigen. When identifying a patient's blood type, the Rh group is designated by adding the word positive or negative to the ABO type. For example, A positive (A^+) means ABO group A blood with the Rh antigen present, and AB negative (AB^-) means ABO group AB blood without the Rh antigen.

Hemolytic Disease of the Newborn (HDN)

Antibodies to the Rh antigen are produced only in Rh^- individuals after exposure to the antigen. This process, called sensitization, occurs following a transfusion with Rh-incompatible blood or, more commonly, with the birth of an Rh^+ baby to an Rh^- mother.

- In a **first pregnancy**, problems are rare, since the baby's Rh^+ cells rarely cross the **placenta**. However, during or immediately after birth, the Rh^- mother can be exposed to the baby's Rh^+ cells (Figure below). Research has shown that this occurs in about 13–14 percent of such pregnancies. After exposure, the mother's immune system begins to generate anti-Rh antibodies.
- In a **second pregnancy**, if a mother should conceive a Rh^+ baby, the Rh antibodies she has produced can cross the placenta into the fetal bloodstream and destroy the fetal RBCs. This condition is known as **hemolytic disease of the newborn (HDN)** or erythroblastosis fetalis. This may cause anemia in mild cases, but the agglutination and hemolysis can be so severe that without treatment the fetus may die in the womb or shortly after birth.

- A drug known as RhoGAM, short for Rh immune globulin, can temporarily prevent the development of Rh antibodies in the Rh^- mother, thereby averting this potentially serious disease for the fetus. RhoGAM antibodies destroy any fetal Rh^+ erythrocytes that may cross the placental barrier. RhoGAM is normally administered to Rh^- mothers during weeks 26–28 of pregnancy and within 72 hours following birth.

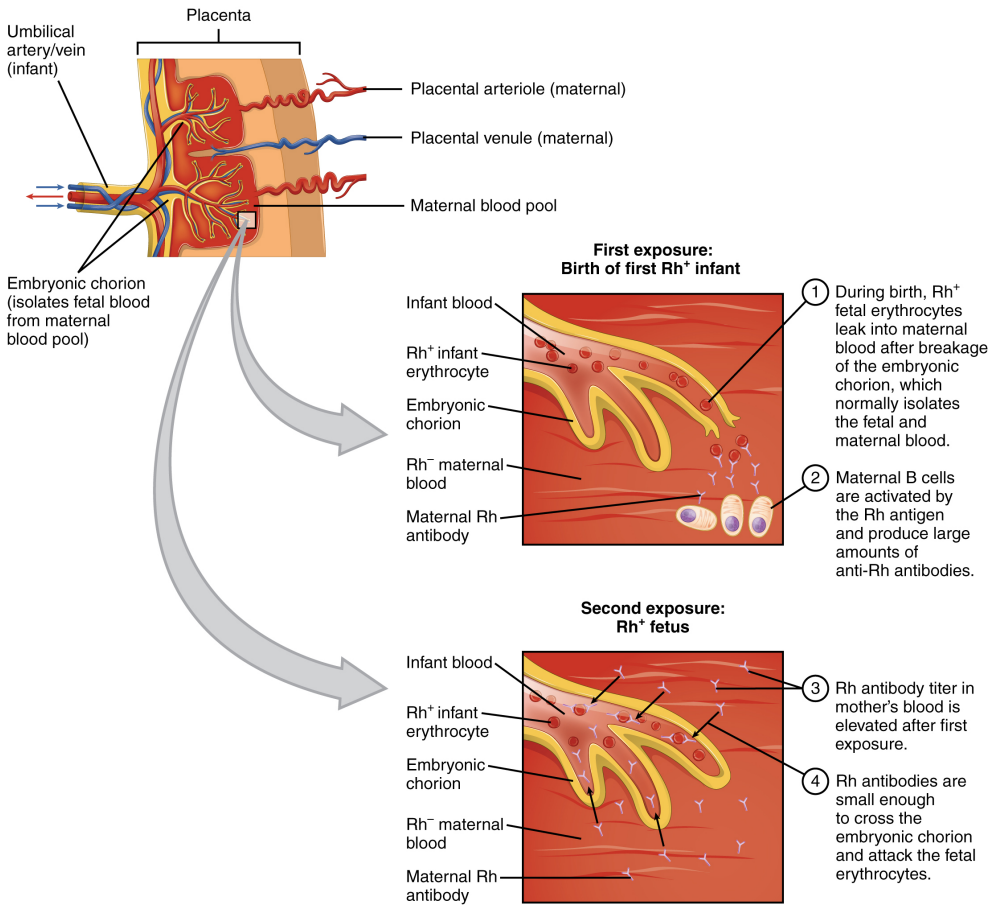


Figure 10.14 Erythroblastosis Fetalis. The first exposure of an Rh− mother to Rh+ erythrocytes during pregnancy induces sensitization. Anti-Rh antibodies begin to circulate in the mother's bloodstream. A second exposure occurs with a subsequent pregnancy with an Rh+ fetus in the uterus. Maternal anti-Rh antibodies may cross the placenta and enter the fetal bloodstream, causing agglutination and hemolysis of fetal erythrocytes. From Betts et al., 2013. Licensed under CC BY 4.0.

Blood Transfusions

Figure 10.15 is an example of a commercially produced "bedside" card which enables quick typing of both a recipient's and donor's blood before transfusion. The card contains three reaction sites or wells. One is coated with an anti-A antibody, one with an anti-B antibody, and one with an anti-D antibody (tests for the presence of Rh factor D). Mixing a drop of blood and saline into each well enables the blood to interact with a preparation of type-specific antibodies, also called anti-seras. Agglutination of RBCs in a given site indicates a positive identification of the blood antigens, in this case A and Rh antigens for blood type A+. To avoid serious and potentially fatal immune reactions, the donor's and recipient's blood types must match

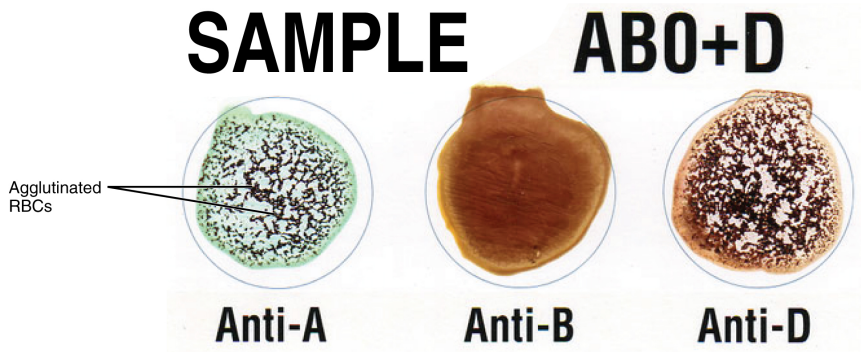


Figure 10.15. Cross Matching Blood Types. From Betts et al., 2013. Licensed under CC BY 4.0.

To avoid transfusion reactions, it is best to transfuse only matching blood types; that is, a type B^+ recipient should ideally receive blood only from a type B^+ donor and so on. That said, in emergency situations, when acute **hemorrhage** threatens the patient's life, there may not be time for cross matching to identify blood type. In these cases, blood from a **universal donor** may be transfused.

Blood Vessel Medical Terms Word Parts

Blood Vessel Medical Terms Not Easily Broken into Word Parts

Cardiovascular System – Blood Terms Not Easily broken down (Text Version)
Practice the following cardiovascular blood terms by breaking into word parts and pronouncing.

1. **phlebotomist**
    - A specially trained person who draws blood or injects IV fluids
2. **anaphylaxis**
    - exaggerated reaction to a previously encountered antigen may start out as mild reaction but can quickly become severe resulting in anaphylactic shock
3. **anemia**
    - reduction in number of erythrocytes

4. **immunodeficiency**
    - deficient immune response caused by immune system dysfunction brought on by disease or immune suppressive drugs.
5. **ischemia**
    - condition of deficient blood flow due to a constriction or obstruction of a blood vessel
6. **sepsis**
    - toxic condition due to spread of bacteria or their toxins from an infection

Activity source: "Cardiovascular System – Blood Terms Not Easily Broken Down" by Kimberlee 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 10.5 image description: This diagram shows how oxygenated and deoxygenated blood flow through the major organs in the body. Pulmonary circulation involves the lungs, pulmonary artery and vein, vena cava, and aorta. Systemic circulation involves the upper body, hepatic vein, renal vein, aorta, liver, hepatic artery, hepatic portal vein, stomach, intestines, renal artery, kidneys, and lower body. [Return to Figure 10.5].

Figure 10.6 image description: The pulse points as shown on a woman's body. Labels read (from top) temporal artery, facial artery, common carotid artery, brachial artery, radial artery, femoral artery, popliteal artery, posterior tibial artery, dorsalis pedis artery. [Return to Figure 10.6].

Figure 10.7 image description: This figure shows three test tubes with a red and yellow liquid in them. The left panel shows normal blood, the center panel shows anemic blood and the right panel shows polycythemic blood. Labels indicate plasma (water, proteins, nutrients, hormones etc.), buffy coat (white blood cells, platelets), and hematocrit (red blood cells). [Return to Figure 10.7].

Figure 10.8 image description: This flowchart shows the pathways in which a multipotent hemotopoietic stem cell differentiates into the different cell types found in blood. From the top (multipotent hematopoietic stem cell can divide and some cells remain stem cells, while the remaining cell goes down one of two paths depending on the chemical signals received: myleoid stem cell or lymphoid stem cell. A myeloid stem cell then can become either a megakaryoblast (which then turns into a magakaryocyte, then becomes platelets), or it can become a proerythroblas (which then becomes a reticulocyte, then becoming an erythrocite), or it can become a myeloblast (which then becomes either a basophil, neutrophil, eosinophil), or it can become a monoblast (which then becomes a monocyte). If the cell becomes a lymphoid stem cell, it then becomes a lymphoblas, which then becomes either a natural killer cell or a small lymphocyte (either T or B lymphocyte). [Return to Figure 10.8].

Figure 10.11 image description: This figure shows how leukocytes respond to chemical signals from injured cells. The top panel shows chemical signals sent out by the injured cells (text labels read: 1) Leukocytes in the

blood respond to chemical attractants released by pathogens and chemical signals from nearby injured cells). The middle panel shows leukocytes migrating to the injured cells (text labels read: 2) the leukocytes squeeze between the capillary wall as they follow the chemical signals to where they are most concentrated (positive chemotaxis)). The bottom panel shows macrophages phagocytosing the pathogens (text label reads: 3) Within the damaged tissue, monocytes differentiate into macrophages that phagocytize the pathogens. The eosinophils and neutrophils release chemicals that break apart pathogens. They are also capable of phagocytosis). [Return to Figure 10.11].

Figure 10.12 image description: This figure details the steps in the clotting of blood. Each step is shown along with a detailed text box describing the steps on the left. On the right, a signaling pathway shows the different chemical signals involved in the clotting process. The steps described: 1. Injury: a blood vessel is severed. Blood and blood components (e.g. erythrocytes, white blood cells, etc.) are leaking out of the breaks. 2. Vascular spasm: the smooth muscle in the vessel wall contracts near the injury point reducing blood loss. 3. Platelet plug formation: platelets are activated by chemicals released from the injury site and by contact with underlying collagen. The platelets become spiked and stick to each other and the wound site. Initial platelets are activated by chemicals released from the injured cells and by contact with broken collagen. Bound platelets release chemicals that activate and attract other platelets. Platelets move toward source of chemical signals and bind. Platelet plug grows in size. 4. Coagulation. In coagulation, fibrinogen is converted to fibrin (see part b), which forms a mesh that traps more platelets and erythrocytes, producing a clot. Part B Fibryn synthesis cascade: Intrinsic pathway (damaged vessel wall), Extrinsic pathway (trauma to extravascular cells), final common pathway (cross-linked fibrin clot). [Return to Figure 10.12].

Attribution

10.4 - Blood Vessels Diseases, Disorders and Diagnostic Testing

Common Diseases and Disorders of Blood Vessels and/or Blood

Arteriosclerosis

Arteriosclerosis is normally defined as the more generalized loss of **compliance**, "hardening of the arteries," whereas **atherosclerosis** is a more specific term for the build-up of **plaque** in the walls of the vessel and is a specific type of arteriosclerosis.

When arteriosclerosis causes vessel compliance to be reduced, pressure and resistance within the vessel increase. This is a leading cause of **hypertension** and **coronary heart disease**, as it causes the heart to work harder to overcome this resistance. Any artery in the body can be affected by these pathological conditions, and individuals who have pathologies like coronary artery disease may also be at risk for other vascular injuries, like strokes or peripheral arterial disease.

Atherosclerosis is a type of arteriosclerosis in which **plaques** form when circulating triglycerides, cholesterol and other substances seep between the damaged endothelial lining cells and become trapped within the artery wall, resulting in narrowed arteries and impaired blood flow (see Figure 10.16) (Betts et al., 2013).

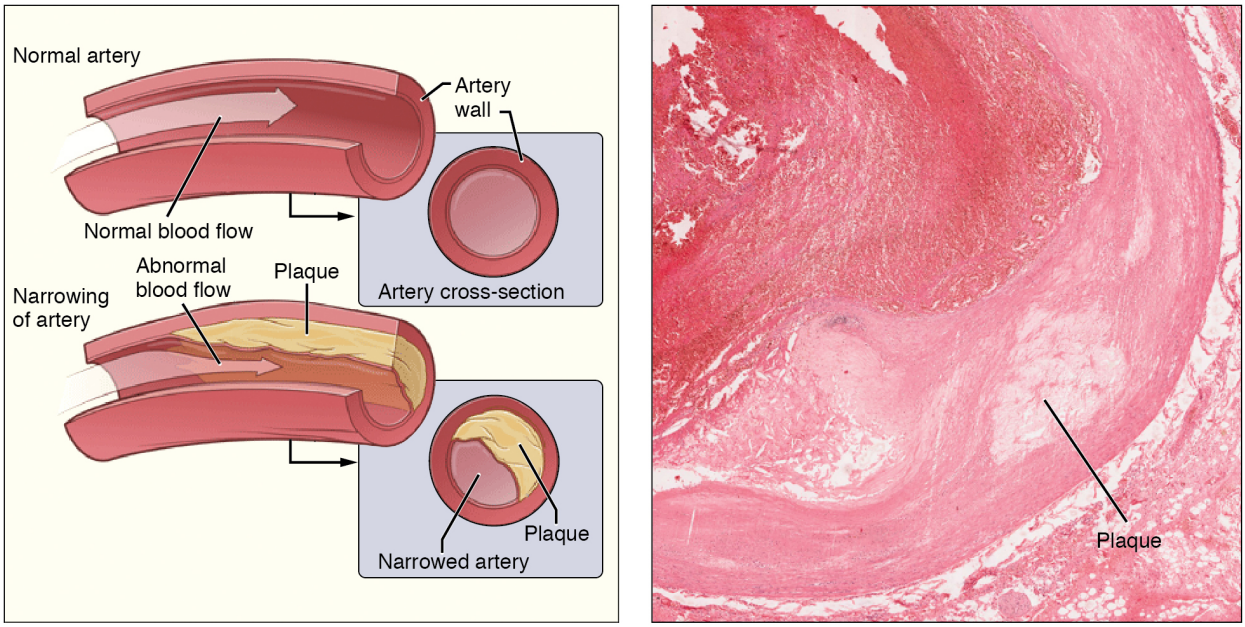


Figure 10.16 Atherosclerosis. (a) Atherosclerosis can result from plaques formed by the buildup of fatty, calcified deposits in an artery. (b) Plaques can also take other forms, as shown in this micrograph of a coronary artery that has a buildup of connective tissue within the artery wall. LM × 40. (Micrograph provided by the Regents of University of Michigan Medical School © 2012). From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 10.16 Image description.]

Sometimes a plaque can rupture, causing microscopic tears in the artery wall that allow blood to leak into the tissue on the other side. When this happens, platelets rush to the site to clot the blood. This clot can further obstruct the artery and—if it occurs in a coronary or cerebral artery—cause a sudden heart attack or stroke. Alternatively, plaque can break off and travel through the bloodstream as an **embolus** until it blocks a more distant, smaller artery.

Peripheral arterial disease (PAD, also called peripheral vascular disease, PVD), occurs when atherosclerosis affects arteries in the legs. A major risk factor for both arteriosclerosis and atherosclerosis is advanced age, as the conditions tend to progress over time. There is also a distinct genetic component, and pre-existing hypertension and/or diabetes also greatly increase the risk. However, obesity, poor nutrition, lack of physical activity, and tobacco use all are major risk factors.

Treatment of atherosclerosis includes lifestyle changes, such as weight loss, smoking cessation, regular exercise, and adoption of a diet low in sodium and saturated fats. Medications to reduce cholesterol and blood pressure may be prescribed. For blocked coronary arteries, **angioplasty** or **coronary artery bypass graft (CABG)** surgery may be warranted. In an carotid endarterectomy, plaque is surgically removed from the walls of a the **carotid artery**, which is the main source of oxygenated blood for the brain (Betts et al., 2013).

Edema and Varicose Veins

Despite the presence of valves and the contributions of other anatomical and physiological adaptations that assist in moving blood through veins, over the course of a day, some blood will inevitably pool, especially in the lower limbs, due to the pull of gravity. Any blood that accumulates in a vein will increase the pressure within it, which can then be reflected back into the smaller veins, venules, and eventually even the capillaries. This increased pressure in the capillaries will push of fluids out of the capillaries and into the interstitial fluid, causing a condition called **edema**.

Most people experience a daily accumulation of tissue fluid, especially if they spend much of their work life on their feet (like most health professionals). However, clinical edema goes beyond normal swelling and requires medical treatment. Edema has many potential causes, including **hypertension** and heart failure, severe protein deficiency, renal failure, and many others. In order to treat edema, which is a sign rather than a discrete disorder, the underlying cause must be diagnosed and alleviated.

Figure 10.17 Varicose Veins. Varicose veins are commonly found in the lower limbs. (credit: Image by Thomas Kriese, CC BY 2.0). From Betts et al., 2013.

Edema may be accompanied by varicose veins, especially in the superficial veins of the legs (see Figure 10.17). This disorder arises when defective valves allow blood to accumulate within the veins, causing them to distend, twist, and become visible on the surface of the skin. Varicose veins may occur in both sexes, but are more common

in women and are often related to pregnancy. More than simple cosmetic blemishes, varicose veins are often painful and sometimes itchy or throbbing. Without treatment, they tend to grow worse over time. The use of support hose, as well as elevating the feet and legs whenever possible, may be helpful in alleviating this condition (Betts, et al., 2013).

Hypertension

Hypertension is defined as chronic and persistent blood pressure measurements of 140/90 mm Hg or above. Pressures between 120/80 and 140/90 mm Hg are defined as prehypertension. Hypertension is typically a **silent disorder** and patients may fail to recognize the seriousness of their condition and fail to follow their treatment plan, putting them at risk for a heart attack or stroke. Hypertension may also lead to an **aneurysm**, **peripheral arterial disease**, chronic kidney disease, or heart failure (Betts et al., 2013).

Hemorrhage

Minor blood loss is managed by **hemostasis** and repair. Hemorrhage is a loss of blood that cannot be controlled by hemostatic mechanisms. Initially, the body responds to hemorrhage by initiating mechanisms aimed at increasing blood pressure and maintaining blood flow. Ultimately, however, blood volume will need to be restored, either through physiological processes or through medical intervention. If blood loss is less than 20 percent of total blood volume, fast-acting homeostatic mechanisms causing increased cardiac output and vasoconstriction would usually return blood pressure to normal and redirect the remaining blood to the tissues. Blood volume will then need to be restored via slower-acting homeostatic mechanisms to increase body fluids and erythrocyte production (Betts et al., 2013).

Circulatory Shock

The loss of too much blood may lead to **circulatory shock**, a life-threatening condition in which the circulatory system is unable to maintain blood flow to adequately supply sufficient oxygen and other nutrients to the tissues to maintain cellular metabolism. It should not be confused with emotional or psychological shock. Typically, the patient in circulatory shock will demonstrate an increased heart rate but decreased blood pressure. Urine output will fall dramatically, and the patient may appear confused or lose consciousness. Unfortunately, shock is an example of a positive-feedback loop that, if uncorrected, may lead to the death of the patient (Betts et al., 2013).

There are several recognized forms of shock:

- **Hypovolemic shock** in adults is typically caused by hemorrhage, although in children it may be caused by fluid losses related to severe vomiting or diarrhea.
- **Cardiogenic shock** results from the inability of the heart to maintain cardiac output. Most often, it results from a myocardial infarction (heart attack), but it may also be caused by arrhythmias, valve disorders, cardiomyopathies, cardiac failure, or simply insufficient flow of blood through the cardiac vessels.
- **Vascular shock** occurs when arterioles lose their normal muscular tone and dilate dramatically. It may arise

from a variety of causes, and treatments almost always involve fluid replacement and medications, called inotropic or pressor agents, which restore tone to the muscles of the vessels.

- **Anaphylactic shock** is a severe allergic response that causes the widespread release of histamines, triggering vasodilation throughout the body.
- **Obstructive shock**, as the name would suggest, occurs when a significant portion of the vascular system is blocked. It is not always recognized as a distinct condition and may be grouped with cardiogenic shock, including **pulmonary embolism** and **cardiac tamponade**. Treatments depend upon the underlying cause and, in addition to administering fluids intravenously, often include the administration of anticoagulants, removal of fluid from the pericardial cavity, or air from the thoracic cavity, and surgery as required. The most common cause is a **pulmonary embolism**. Other causes include stenosis of the aortic valve, cardiac tamponade, and a **pneumothorax** (Betts et al., 2013).

Blood Disorders

Erythrocyte Disorders

Changes in the levels of RBCs can have significant effects on the body's ability to effectively deliver oxygen to the tissues (Betts et al., 2013).

Did You Know?

'O2 sat' or 'percent sat' is the percent saturation, that is, the percentage of hemoglobin sites occupied by oxygen in a patient's blood.

Anemia

The size, shape, and number of erythrocytes, and the number of hemoglobin molecules can have a major impact on a person's health. When the number of RBCs or hemoglobin is deficient, the general condition is called **anemia**. There are more than 400 types of anemia.

Anemia can be broken down into three major groups: those caused by blood loss, those caused by faulty or decreased RBC production, and those caused by excessive destruction of RBCs. In addition to these causes, various disease processes also can lead to anemias. These include chronic kidney diseases often associated with

a decreased production of **EPO**, **hypothyroidism**, some forms of cancer, **lupus**, and **rheumatoid arthritis** (Betts, et al., 2013).

Blood Loss Anemias:

Causes:

- Bleeding from wounds or other lesions, including ulcers, hemorrhoids, inflammation of the stomach (gastritis), and some cancers of the gastrointestinal tract.
  - The excessive use of aspirin or other nonsteroidal anti-inflammatory drugs such as ibuprofen can trigger ulceration and gastritis.
- Excessive menstruation and loss of blood during childbirth.

Anemias Caused by Faulty or Decreased RBC Production:

- **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.
- **Iron deficiency anemia**
  - The most common type of anemia and results when the amount of available iron is insufficient to allow production of sufficient heme.
- **Vitamin deficiency anemia** (Generally insufficient vitamin B12 and folate).
- **Megaloblastic anemia** involves a deficiency of vitamin B12 and/or folate, often due to inadequate dietary intake.
- **Pernicious anemia** is caused by poor absorption of vitamin B12 and is often seen in patients with **Crohn's disease**, surgical removal of the intestines or stomach (common in some weight loss surgeries), intestinal parasites, and **AIDS**.
- **Aplastic anemia** is the condition in which myeloid stem cells are defective or replaced by cancer cells, resulting in insufficient quantities of RBCs being produced. This condition by be inherited or it may be triggered by radiation, medication, chemotherapy, or infection.
- **Thalassemia** is an inherited condition typically occurring in individuals from the Middle East, the Mediterranean, Africa, and Southeast Asia, in which maturation of the RBCs does not proceed normally. The most severe form is called Cooley's anemia (Betts et al., 2013).

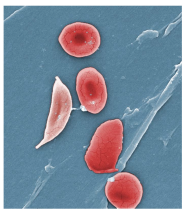


Figure 10.18 Sickle Cells. (credit: Image by Janice Haney Carr, PDM). From Betts et al., 2013. [Image description.]

Polycythemia

Polycythemia is an elevated RBC count and is detected in a patient's elevated **hematocrit** percentage in a complete blood cell testing. It can occur transiently in a person who is dehydrated; when water intake is inadequate or water losses are excessive, the plasma volume falls. As a result, the hematocrit rises. A mild form of polycythemia is chronic but normal in people living at high altitudes. Some elite athletes train at high elevations specifically to induce this phenomenon. Finally, a type of bone marrow disease called polycythemia vera causes

an excessive production of immature erythrocytes. Polycythemia vera can dangerously elevate the **viscosity** of blood, raising blood pressure and making it more difficult for the heart to pump blood throughout the body. It is a relatively rare disease that occurs more often in men than women, and is more likely to be present in elderly patients those over 60 years of age (Betts et al., 2013).

Platelet Disorders/Clotting Disorders

Thrombocytosis

Thrombocytosis is a condition in which there are too many platelets. This may trigger **thrombosis**, a potentially fatal disorder. A **thrombus** (plural = thrombi) is an aggregation of platelets, erythrocytes, and even WBCs typically trapped within a mass of fibrin strands. While the formation of a clot is a normal step in **hemostasis**, thrombi can form within an intact or only slightly damaged blood vessel, adhering to the vessel wall and decreasing or obstructing the flow of blood (Betts et al., 2013).

Thrombophilia

Thrombophilia, also called hypercoagulation, is a condition in which there is a tendency to form thrombosis. This may be an inherited disorder or may be caused by other conditions including **lupus**, immune reactions to heparin, **polycythemia vera**, **thrombocytosis**, **sickle cell disease**, pregnancy, and even obesity.

When a portion of a thrombus breaks free from the vessel wall and enters the circulation, it is referred to as an **embolus**. An embolus that is carried through the bloodstream can be large enough to block a vessel critical to a major organ. When it becomes trapped, an embolus is called an **embolism**. In the heart, brain, or lungs, an embolism may accordingly cause a heart attack, a stroke, or a pulmonary embolism (Betts et al., 2013).

Thrombocytopenia

Thrombocytopenia is a condition in which there is an insufficient number of platelets, possibly leading to ineffective blood clotting and excessive bleeding (Betts et al., 2013).

Hemophilia

Hemophilia is a group of related genetic disorders in which certain plasma clotting factors are lacking, inadequate or nonfunctional. Patients with hemophilia bleed from even minor internal and external wounds and leak blood into joint spaces after exercise and into urine and stool. Regular infusions of clotting factors isolated from healthy donors can help prevent bleeding in hemophiliac patients. At some point, genetic therapy will become a viable option (Betts et al., 2013).

Leukocyte Disorders

Leukopenia

Leukopenia is a condition in which too few leukocytes are produced. If this condition is pronounced, the individual may be unable to ward off disease (Betts et al., 2013).

Leukocytosis

Leukocytosis is excessive leukocyte proliferation. Although leukocyte counts are high, the cells themselves are often nonfunctional, leaving the individual at increased risk for disease (Betts et al., 2013).

Leukemia

Leukemia is 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).

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. As in leukemia, the malignant leukocytes do not function properly, and the patient is vulnerable to infection. Some forms of lymphoma tend to progress slowly and respond well to treatment. Others tend to progress quickly and require aggressive treatment, without which they are rapidly fatal (Betts et al., 2013).

Other Conditions Related to Abnormal Leukocyte Counts

Table 10.5. Conditions Related to Abnormal White Blood Cell Counts. From Betts et al., 2013. Licensed under CC BY 4.0.

Cell Type	Conditions Reltaed to High Counts	Conditions Related to Low Counts
Neutrophil	Infection, inflammation, burns, unusual stress	Drug toxicity, other disorders
Eosinophil	Allergies, parasitic worm infestations, some autoimmune diseases	Drug toxicity, stress
Basophil	Allergies, parasitic infections, hypothyroidism	Pregnancy, stress, hyperthyroidism
Lymphocyte	Viral infections, some cancers	chronic illness, immunosuppression (due to HIV or steroid therapy)
Monocyte	Viral or fungal infections, tuberculosis, some forms of leukemia, other chronic diseases	Bone marrow suppression

Bone Marrow Biopsy/Bone Marrow Transplant

Sometimes, a healthcare provider will order a **bone marrow biopsy**, a diagnostic test of a sample of red bone marrow, or a **bone marrow transplant**, a treatment in which a donor's healthy bone marrow—and its stem cells—replaces the faulty bone marrow of a patient. These tests and procedures are often used to assist in the diagnosis and treatment of various severe forms of anemia, such as **thalassemia** major and **sickle cell anemia**, as well as some types of cancer, specifically leukemia.

In the past, bone marrow sampling or transplant was very painful, as the procedure involved inserting a large-bore needle into the region near the iliac crest of the pelvic bones. Now, direct sampling of bone marrow can often be avoided as stem cells can be isolated in just a few hours from a sample of a patient's blood. The isolated stem cells are then grown in culture using the appropriate **hemopoietic growth factors**, and analyzed or sometimes frozen for later use.

For an individual requiring a transplant, a matching donor is essential to prevent the immune system from destroying the donor cells—a phenomenon known as **tissue rejection**. To treat patients with bone marrow transplants, it is first necessary to destroy the patient's own diseased marrow through radiation and/or chemotherapy. Donor bone marrow stem cells are then infused into the recipient's bloodstream, so that they can establish themselves in the recipient's bone marrow (Betts et al., 2013).

Check Your Knowledge of Cardiovascular System Terms and Abbreviations

Common Cardiovascular System – Blood, Abbreviations

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

Cardiovascular System – Blood Abbreviations

- **aPTT** (activated partial thromboplastin time
- **CBC and Diff** (complete blood count and differential)
- **CPK** (creatine phosphokinase)
- **Hct** (hematocrit)
- **Hgb** (hemoglobin)
- **PT** (prothrombin time)
- **RBC** (red blood cell, erythrocyte)
- **WBC** (white blood cell, leukocyte)

Activity source: Cardiovascular System – Blood Abbreviations by Kimberlee Carter, from *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY- 4.0. / Converted to text.

Cardiovascular System – Consultation Report

Cardiovascular System – Consultation Report (Text version)

Fill in the consultation report with using the following words:

- Angiogram
- defect
- palpitations
- infection
- blood pressure
- coronary

PATIENT NAME: Jack MIRANDA

AGE: 74

SEX: Male

DATE OF CONSULTATION: March 26, 2020

CONSULTING PHYSICIAN: Kevin Palmer, MD, Cardiology

REASON FOR CONSULTATION: Coronary artery disease.

PAST MEDICAL HISTORY

1. Coronary artery disease. He had an NST MI in July 2015. _____[Blank 1] showed three-vessel disease and had PCT of RCA OM1. LAD had 60% stenosis which was no significant by FFR and medical management was recommended. He had a Grade 2 left ventricular function after the MI, but it improved a year later. His last echocardiogram in 2019 showed preserved ejection fraction at 60 with no significant valvular abnormalities and no significant wall motion abnormalities. He had an exercise Myoview in 2018 where he could achieve a workload of 9 Mets without symptoms or electrical changes. Perfusion images showed a wall fixed inferior _____[Blank 2] in keeping with his previous inferior MI.
2. Hypertension.
3. Hypercholesterolemia.
4. Ex-smoker quit in 2016.
5. Rare alcohol.
6. Gout.
7. Chronic lymphocytic leukemia.

MEDICATIONS

Aspirin 81 mg q.d.
Bisoprolol 5 mg q.d.
Candesartan 60 mg q.d.
Atorvastatin 80 mg q.d.
Ezetrol 10 mg q.d.
Allopurinol 300 mg q.d.

HISTORY: Overall, he has been feeling well. He denies any exertional symptoms with usual activity. He walks his dog 20 minutes a day and denies any chest pain, shortness of breath. He denies orthopnea, _____[Blank 3], dizziness presyncope, or syncope.
He was recently hospitalized with a respiratory _____[Blank 4]. He was treated with antibiotics and was discharged 2 days later. He has been feeling better and has gone back to his usual activities.
In regards to his CLL, he has been stable with usual lymphocyte count around 30. No other cytopenia. No splenomegaly. He is being followed with a surveillance strategy with regular CBCs by hematologist.

PHYSICAL EXAMINATION: On physical exam he is alert and oriented in no acute distress, hemodynamically stable, _____[Blank 5] 120/70, heart rate 60 with regular rhythm, there is no evidence of volume overload, lungs are clear. Lab work showed white cell count of 30 with lymphocytes, 25 hemoglobin, 122 platelets, 340 creatinine, 70 EGFR, 75 sodium, 144 potassium, 5.6, A1c 5.4L, DL 1.2.

SUMMARY: Mr. Miranda seems to be stable from the cardiac point of view. He has a history of _____[Blank 6] artery disease with previous MI treated with PCI of RCA and OM1. He has a residual 60% stenosis of LAD that was not significant by FFR. He is on antiplatelet agents, high intensity statin therapy, and the combination of ARB's and beta-blockers. As long as his functional capacity remains stable, we do not need to do a follow up. Exercise treadmill test but should his symptoms change, this should be considered.

PLAN: His blood pressure is well controlled. His LDL is within the goal. There is no history of diabetes. He quit smoking 2016. I made no changed to his current treatment plan and advised him to come back in a year's time and earlier, should symptoms change.

_____
Kevin Palmer, MD, Cardiology

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 and Procedures Related to the Blood Vessels and Blood

Vascular Surgeons

Vascular surgery is a specialty in which the physician treats diseases of the blood and lymphatic vessels. This includes repair and replacement of diseased or damaged vessels, removal of plaque from vessels, minimally invasive procedures, including the insertion of venous catheters, and traditional surgery (Betts et al., 2013; Canadian Society for Vascular Surgery, n.d.). For more information, please visit the Canadian Society for Vascular Surgery website [New Tab].

Hematologists

Hematologists are specialist physicians that diagnose and treat blood disorders. These physicians must be well-versed in a wide array of laboratory procedures, basic medical disciplines, and clinical medicine (Canadian Medical Association, 2019). To learn more about hematologists, visit the Canadian Medical Association's specialty profile on hematology [PDF].

Diagnostic Vascular Technologist

Also known as Canadian Registered Vascular Sonographers (CRVS®), these specialists are technologists that image the vascular system (Sonography Canada, 2021). To learn more, visit the Sonography Canada Credentials web page [New Tab].

Phlebotomist

Phlebotomists are professionals trained to draw blood (phleb- = "a blood vessel"; -tomy = "to cut"). When more than a few drops of blood are required, phlebotomists perform a venipuncture, typically of a surface vein in the arm. They perform a capillary stick on a finger, an earlobe, or the heel of an infant when only a small quantity of blood is required. An arterial stick is collected from an artery and used to analyze blood gases. After collection, the blood may be analyzed by medical laboratories or perhaps used for transfusions, donations, or research (Betts et al., 2013).

Image Descriptions

Figure 10.16 image description: The left panel (a) shows the cross-section of a normal and a narrowed artery. A normal artery has no plaque along the artery walls which means there is normal blood flow. In a narrow artery,

plague forms on the arterial walls causing abnormal blood flow. The right panel (b) shows a micrograph of an artery with plaque in it. [Return to Figure 10.16].

Figure 10.18 image description: This photograph shows red blood cells of a person suffering from sickle cell anemia. Instead of being discoid shaped like healthy blood cells, sickle red blood cells are shaped like a sickle. [Return to Figure 10.18].

Attribution

Notes

1. 1) Angiogram 2) defect 3) palpitations 4) infection 5) blood pressure 6) coronary

Vocabulary & Check Your Knowledge

Cardiovascular System-Blood Vocabulary

ABG

Arterial blood gas. This test measures blood pH, oxygen and CO2 levels in a sample of arterial blood, usually taken from the wrist.

AIDS

Acquired immunodeficiency syndrome, caused by infection with the HIV virus.

Aneurysm

Weakening of the wall of a blood vessel, causing it to thin and balloon out, and possibly eventually burst, resulting in internal bleeding.

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.

Anti-B Antibodies

Proteins that will mount an immune response against B antigens.

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).

Arteries

Blood vessels that transport blood away from the heart.

Arterioles

A very small artery that leads to a capillary.

Arteriosclerosis

Hardening of arteries.

Atherosclerosis

A hardening of the arteries that involves the accumulation of plaque.

Brachial Artery

Large artery in the upper arm near the biceps muscle.

Capillary

A microscopic channel that supplies blood to the tissues through perfusion.

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.

Cardiogenic

Originating from the heart.

Carotid Artery

A large artery in the neck.

Celiac Disease

Inflammation of the intestines caused by exposure to gluten.

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.

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.

Compliance

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.

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.

Crohn Disease

A type of inflammatory bowel disease.

Diapedesis

dia- = "through"; -pedan = "to leap"

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.

Edema

Swelling.

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.

Endothelium

The lining of the lumen of a blood vessel.

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.

Erythrocytes

Red blood cells.

Extramedullary Hemopoiesis

Hemopoiesis outside the medullary cavity of adult bones.

Heart Rate

The number of times the heart contracts in one minute.

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.

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.

Homeostasis

Biological process that results in stable equilibrium.

Hypertension

High blood pressure.

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.

Ischemia

Insufficient blood and oxygen to cells of an organ. These cells are starving for oxygen, but they are still alive.

Leukocytes

White blood cells.

Lupus

An autoimmune disease in which the body mounts an immune response against its own tissues, causing chronic inflammation and tissue damage.

Macrophages

A type of leukocyte (usually a monocyte) that has the ability to ingest and destroy other cells or pathogens.

Medulla Oblongata

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

Perfusion

The delivery of blood to an area/tissue/organ.

Peripheral Arterial Disease

The obstruction of vessels in peripheral regions of the body.

pH

A measure of how acidic or alkaline a substance is, as determined by the number of free hydrogen ions in the substance.

Phagocytized

Also phagocytosed, this is the process by which certain cells are able to 'eat' other cells or substances by engulfing them.

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.

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 Vera

A type of bone marrow disease that causes an excessive production of immature erythrocytes.

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.

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.

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.

Sphygmomanometer

A blood pressure cuff attached to a measuring device, or gauge.

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.

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.

Thrombocytes

Also called platelets, these are cell fragments that aid in blood clotting.

Thrombocytosis

A condition in which there are too many platelets.

Thrombosis

Formation of unwanted blood clots.

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.

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.

Vein

Blood vessels that carry blood back to the heart.

Venules

Extremely small veins.

Vessel Compliance

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.

Viscosity

The thickness of fluids that affects their ability to flow.

Cardiovascular System -Blood Vessels and Blood Glossary

Cardiovascular System -Blood Vessels and Blood Glossary (Text version)

1. Proteins produced by B lymphocytes in response to a non-self antigen are called _____[Blank 1].
    a. Antibodies
    b. Capillaries
    c. Macrophages
2. An autoimmune disorder in which the body mounts an immune response against its own joint tissues, causing inflammation and damage to the joints is referred to as _____[Blank 2].
    a. Rheumatoid Arthritis
    b. Sickle Cell Disease
    c. Crohn Disease

3. 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 is called _____[Blank 3].
    a. Embolus
    b. Perfusion
    c. Perfusion
4. _____[Blank 4] is the thickness of fluids that affects their ability to flow.
    a. Viscosity
    b. Pneumothorax
    c. Thrombosis
5. The process by which the body seals a ruptured blood vessel to prevent further blood loss is called _____[Blank 5].
    a. Homeostasis
    b. Hemostasis
    c. Hemopoiesis

Check your answers: [1]

Activity source: Cardiovascular System -Blood Vessels and Blood Glossary by Tiffany Hunt, from *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY- 4.0. / Converted to Text.

Attribution

Notes

1. 1. Antibodies, 2. Rheumatoid Arthritis, 3. Embolus, 4. Viscosity, 5. Hemostasis

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CHAPTER 11: LYMPHATIC AND IMMUNE 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.

11.1 - Introduction to the Lymphatic and Immune Systems

Learning Objectives

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

Word Parts for the Lymphatic and Immune Systems

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

Prefix

- **a-** (no, not, negates meaning)
- **an-** (no, not, negates meaning)

Combining Form

- **immun/o** (immune, immunity)
- **lymph/o** (lymph, lymph tissue)
- **lymphaden/o** (lymph gland, lymph node)

- **myel/o** (bone marrow, spinal cord)
- **splen/o** (spleen)
- **thym/o** (thymus gland)

Suffix

- **-cyte** (cell)
- –**ectomy** (excision, cut out)
- **-itis** (inflammation)
- **-logist** (specialist, physician who studies and treats)
- **-logy** (study of)
- **-megaly** (enlarged, enlargement)
- **-oid** (resembling)
- **-oma** (tumor, swelling)
- **-osis** (abnormal condition)
- **-pathy** (disease)
- **-rrhaphy** (suturing)

Introduction to the Lymphatic and Immune Systems

The **lymphatic system** is a series of vessels, ducts, and trunks that remove interstitial fluid from the tissues and return it the blood. The lymphatic vessels are also used to transport dietary lipids and cells of the **immune system**. Cells of the immune system, lymphocytes, all come from the hematopoietic system of the bone marrow. Primary lymphoid organs, the bone marrow and thymus gland, are the locations where lymphocytes proliferate and mature. Secondary lymphoid organs are the site in which mature lymphocytes congregate to mount immune responses. Many immune system cells use the lymphatic and circulatory systems for transport throughout the body to search for and then protect against pathogens.

This chapter begins by describing the anatomy and physiology of the lymphatic system, whose immune functions lead us into a discussion of the body's multifaceted defenses, which together make up the immune system. Since the lymphatic system shares organs with a number of other body systems, the pathology discussed near the end of this chapter mainly focuses on disorders of the immune system.

Watch Lymphatic System: Crash Course Anatomy & Physiology #44 (9 min) on YouTube

Lymphatic and Immune Systems Medical Terms

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

1. **autoimmune disease (aut/o/immun/e disease)**
    - A disease caused by the inability for the body to distinguish its own (self) cells from foreign substances, producing antibodies that attacks its own tissues
2. **immune (immun/e)**
    - Resistant to specific pathogens
3. **immunodeficiency (immun/o/deficiency)**
    - deficient immune response cause by the immune system dysfunction
4. **Immunologist (Immun/o/logist)**
    - specialist who studies and treats immune system disorders
5. **immunology (immun/o/logy)**
    - study of disorders of the immune system
6. **phagocytosis (phag/o/cyt/osis)**
    - Process where some white blood cells engulf invading microorganisms

Activity source: "Lymphatic 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.

Attribution

Except where otherwise noted, this chapter is adapted from "Lymphatic and Immune Systems" 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 Lymphatic and Immune Systems chapter content into sub-chapters.

11.2 - Anatomy & Physiology of the Lymphatic System

The lymphatic vessels begin as open-ended capillaries, which feed into larger and larger lymphatic vessels, and eventually empty into the bloodstream. Along the way, the lymph travels through the lymph nodes, which are commonly found near the groin, armpits, neck, chest, and abdomen. Humans have about 500–600 lymph nodes throughout the body (see Figure 11.1). Several organs and tissues that participate in immunity are also part of the lymphatic system.

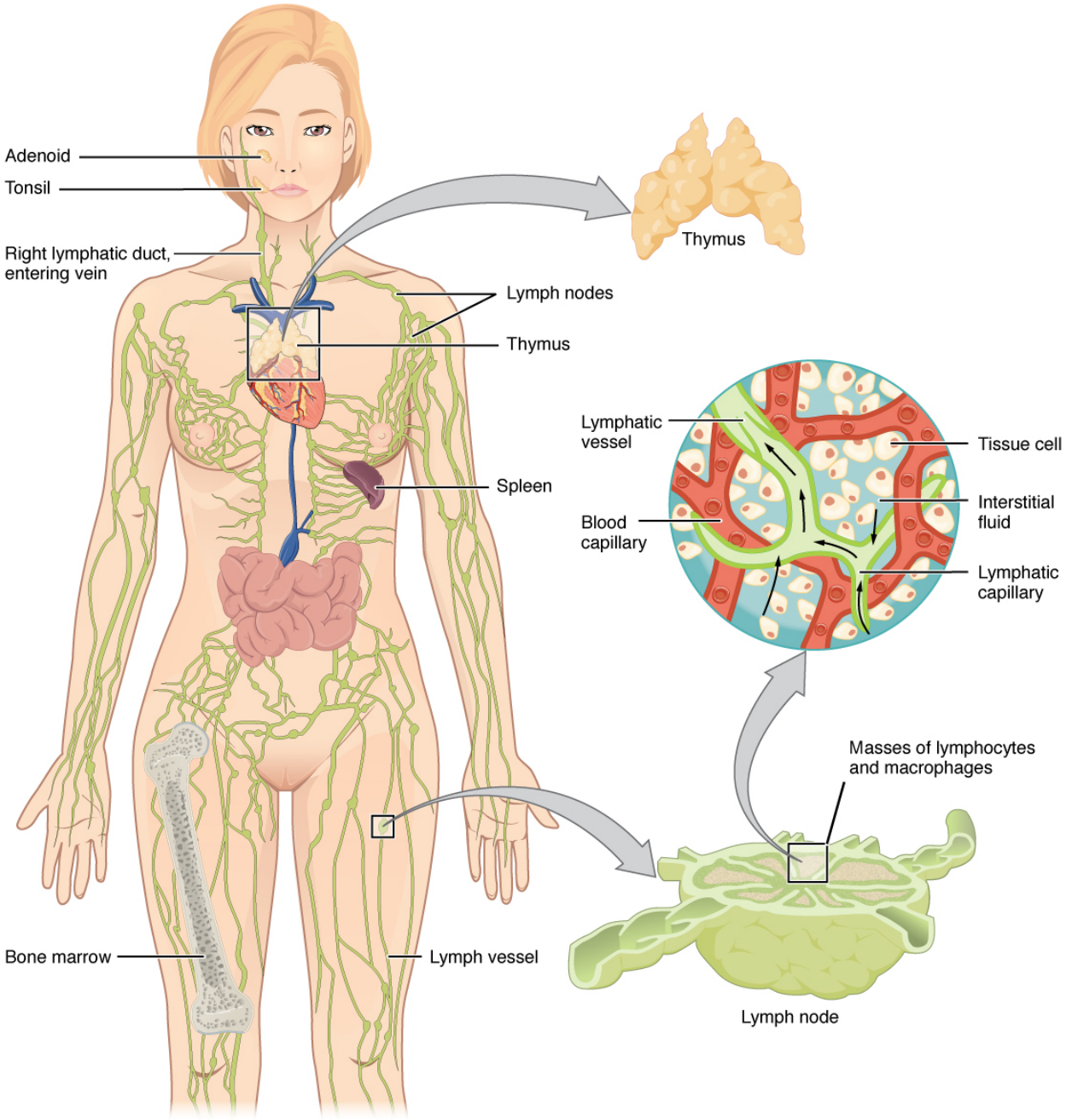


Figure 11.1 Anatomy of the Lymphatic System. Lymphatic vessels in the arms and legs convey lymph to the larger lymphatic vessels in the torso. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 11.1 Image description.]

Lymphatic Capillaries

An important function of the lymphatic system is to return the fluid (lymph) to the blood. **Lymph** may be thought of as recycled blood plasma. Blood pressure causes leakage of fluid from the blood capillaries, resulting in the accumulation of fluid in the **interstitial space**. In humans, 20 liters of plasma is released into the interstitial space

of the tissues each day due to capillary leakage. The blood vessels reabsorb 17 liters of this **interstitial fluid**, leaving three litres in the tissues for the lymphatic system to transport back to the circulation. If the lymphatic system is damaged in some way, such as by being blocked by cancer cells or destroyed by injury, interstitial fluid accumulates in the tissue spaces, causing a condition called lymphedema.

Did You Know 1?

Lymphatic vessels and blood vessels are similar in structure and function. Lymph is not actively pumped by the heart, but is forced through the vessels by the movements of the body muscles (Betts, et al., 2013).

Lymphatic capillaries, also called the terminal lymphatics, are vessels where interstitial fluid enters the lymphatic system to become lymph. Located in almost every tissue in the body, these vessels are interlaced among the arterioles and venules of the circulatory system in the soft connective tissues of the body. See Figure 11.2. Exceptions are the central nervous system, bone marrow, bones, teeth, and the cornea of the eye, which do not contain lymph vessels.

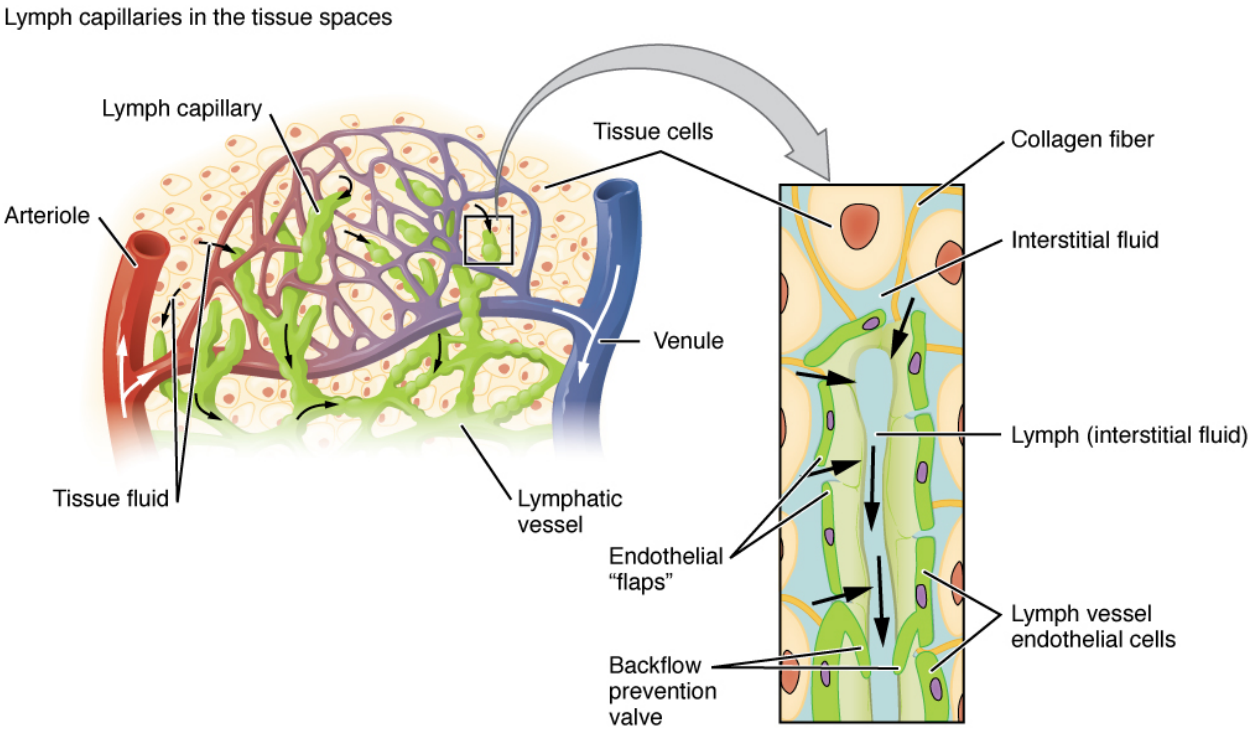


Figure 11.2 Lymphatic Capillaries. Lymphatic capillaries are interlaced with the arterioles and venules of the cardiovascular system. Collagen fibers anchor a lymphatic capillary in the tissue (inset). Interstitial fluid slips through spaces between the overlapping endothelial cells that compose the lymphatic capillary. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 11.2 Image description.]

Larger Lymphatic Vessels, Trunks, and Ducts

The lymphatic capillaries empty into larger lymphatic vessels, which are similar to veins in terms of their three-tunic structure and the presence of valves. These one-way valves are located fairly close to one another, and each one causes a bulge in the lymphatic vessel, giving the vessels a beaded appearance (see Figure 11.2).

In general, **superficial lymphatics** follow the same routes as veins, whereas **deep lymphatic vessels** of the viscera generally follow the paths of arteries. The superficial and deep lymphatics eventually merge to form larger lymphatic structures known as **lymphatic trunks**. On the right side of the body, the right sides of the head, thorax, and right upper limb trunks drain lymph fluid into the right subclavian vein via the **right lymphatic duct** (see Figure 11.3). On the left side of the body, the trunks from the remaining portions of the body drain into the larger **thoracic duct**, which drains into the left subclavian vein. The thoracic duct itself begins just beneath the diaphragm in the **cisterna chyli.**

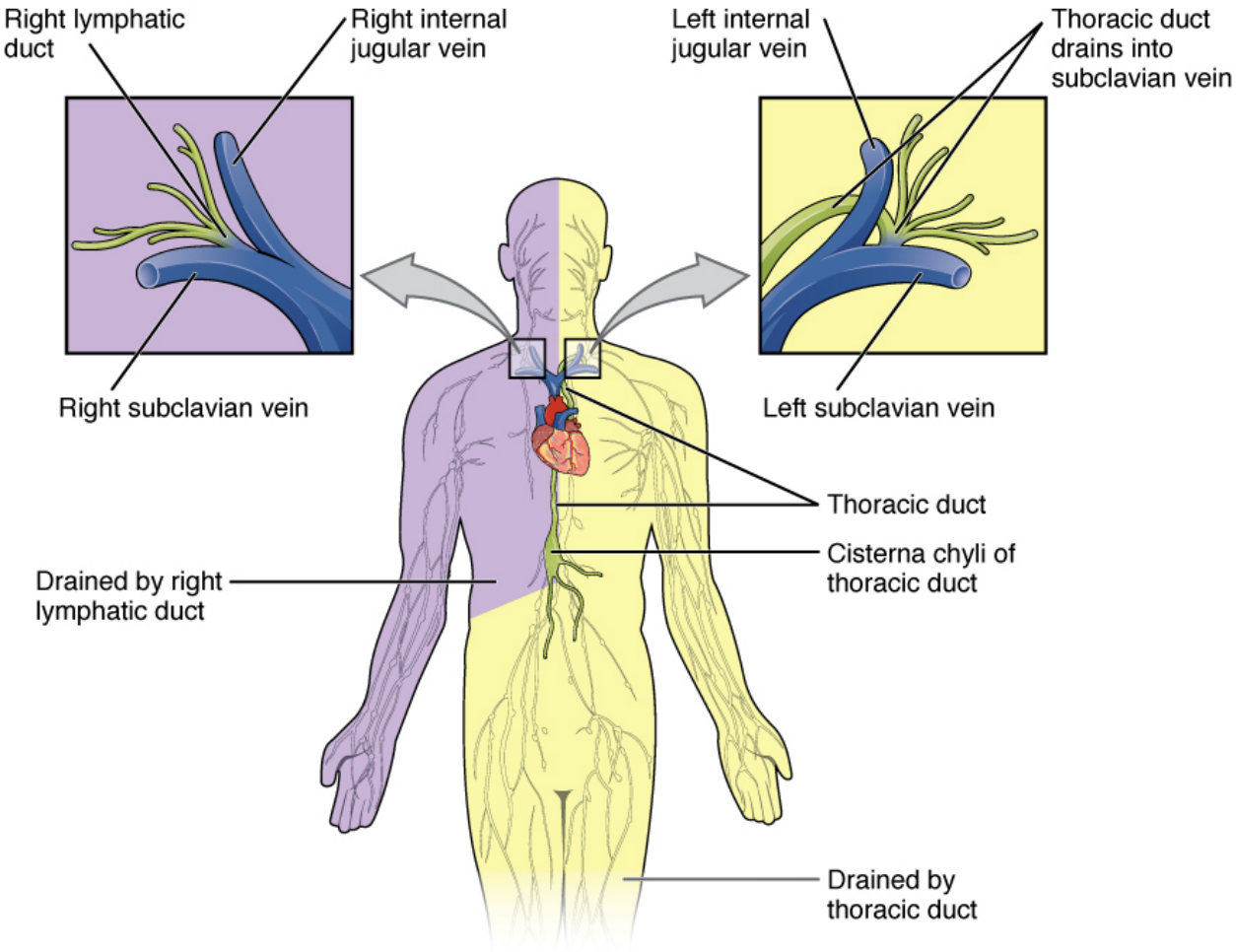


Figure 11.3 Major Trunks and Ducts of the Lymphatic System. The thoracic duct drains a much larger portion of the body than does the right lymphatic duct. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 11.3 Image description.]

Primary Lymphoid Organs

The **primary lymphoid organs** are the bone marrow and thymus gland. The lymphoid organs are where lymphocytes mature, proliferate, and are selected, which enables them to attack pathogens without harming the cells of the body.

- Bone Marrow
  - Recall that all blood cells, including lymphocytes, are formed in the red bone marrow. The B cell undergoes nearly all of its development in the red bone marrow, whereas the immature T cell, called a **thymocyte**, leaves the bone marrow and matures largely in the thymus gland.
- Thymus
  - The **thymus** gland, where T cells mature, is a **bilobed** organ found in the space between the sternum and the aorta of the heart (see Figure 11.4). Connective tissue holds the lobes closely together but also separates them and forms a capsule.
  - The loss of immune function with age is called immunosenescence. One major cause of age-related immune deficiencies is **thymic involution**.
  - The shrinking of the thymus gland begins at birth at a rate of about three percent tissue loss per year. This shrinking continues until 35–45 years of age, then the rate declines to about one percent loss per year for the rest of one's life. At that pace, the total loss of thymic epithelial tissue and **thymocytes** would occur at about 120 years of age. So, in theory, 120 years could be the maximum life span.

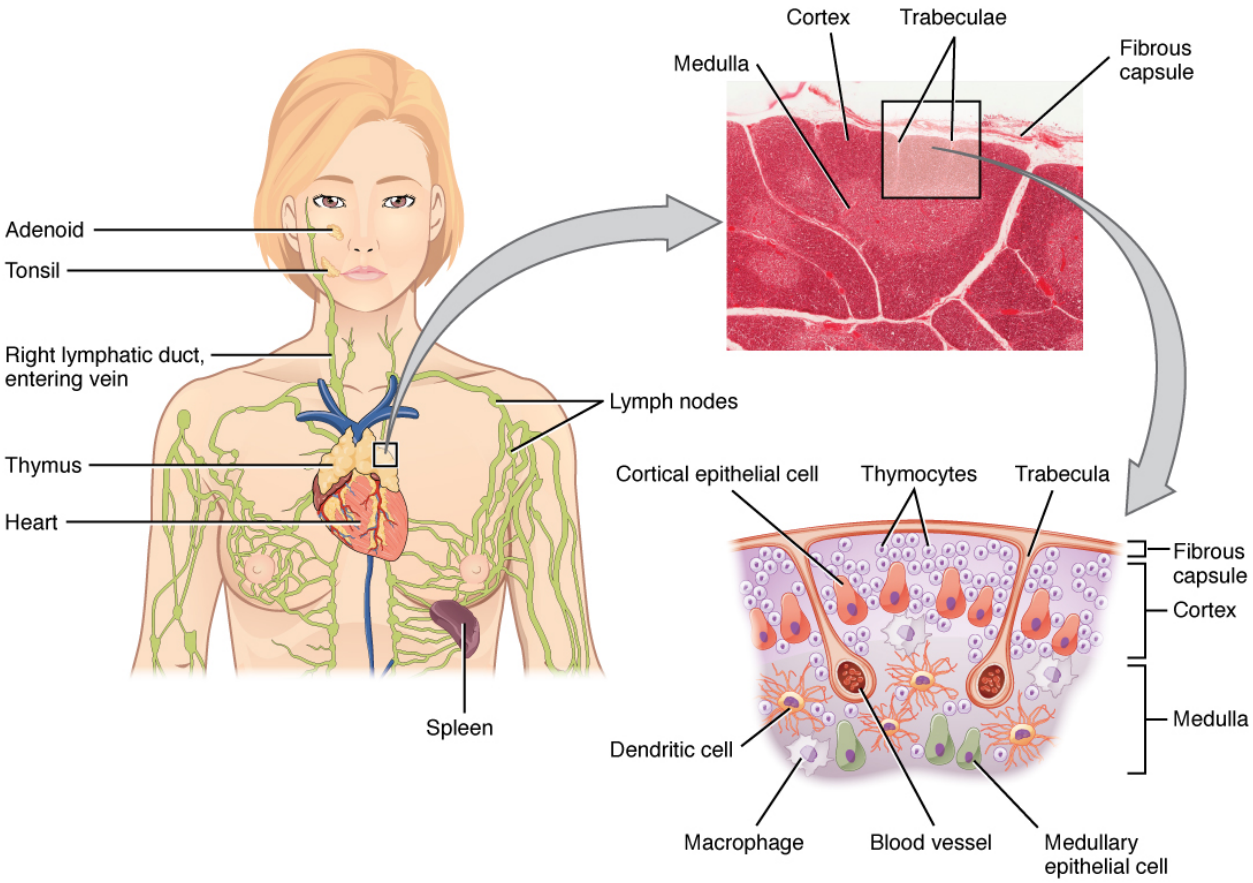


Figure 11.4 Location, Structure, and Histology of the Thymus. The thymus lies above the heart. The trabeculae and lobules, including the darkly staining cortex and the lighter staining medulla of each lobule, are clearly visible in the light micrograph of the thymus of a newborn. LM × 100. (Micrograph provided by the Regents of the University of Michigan Medical School © 2012). From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 11.4 Image description.]

Concept Check

- Do you remember what the suffix "-oid" means?
- Can you explain the term **lymphoid**?

Did You Know 2?

The thymus gland produces a hormone called thymosin and is therefore also considered to be part of the endocrine system.

Secondary Lymphoid Organs

Lymphocytes develop and mature in the **primary lymphoid organs**, but they mount immune responses from the **secondary lymphoid organs,** which include the lymph nodes, spleen, and lymphoid nodules. A **naïve lymphocyte** is one that has left the primary organ, where it learned to function immunologically, and entered a secondary lymphoid organ where it waits to encounter an antigen against which it will mount a response (see Figure 11.5).

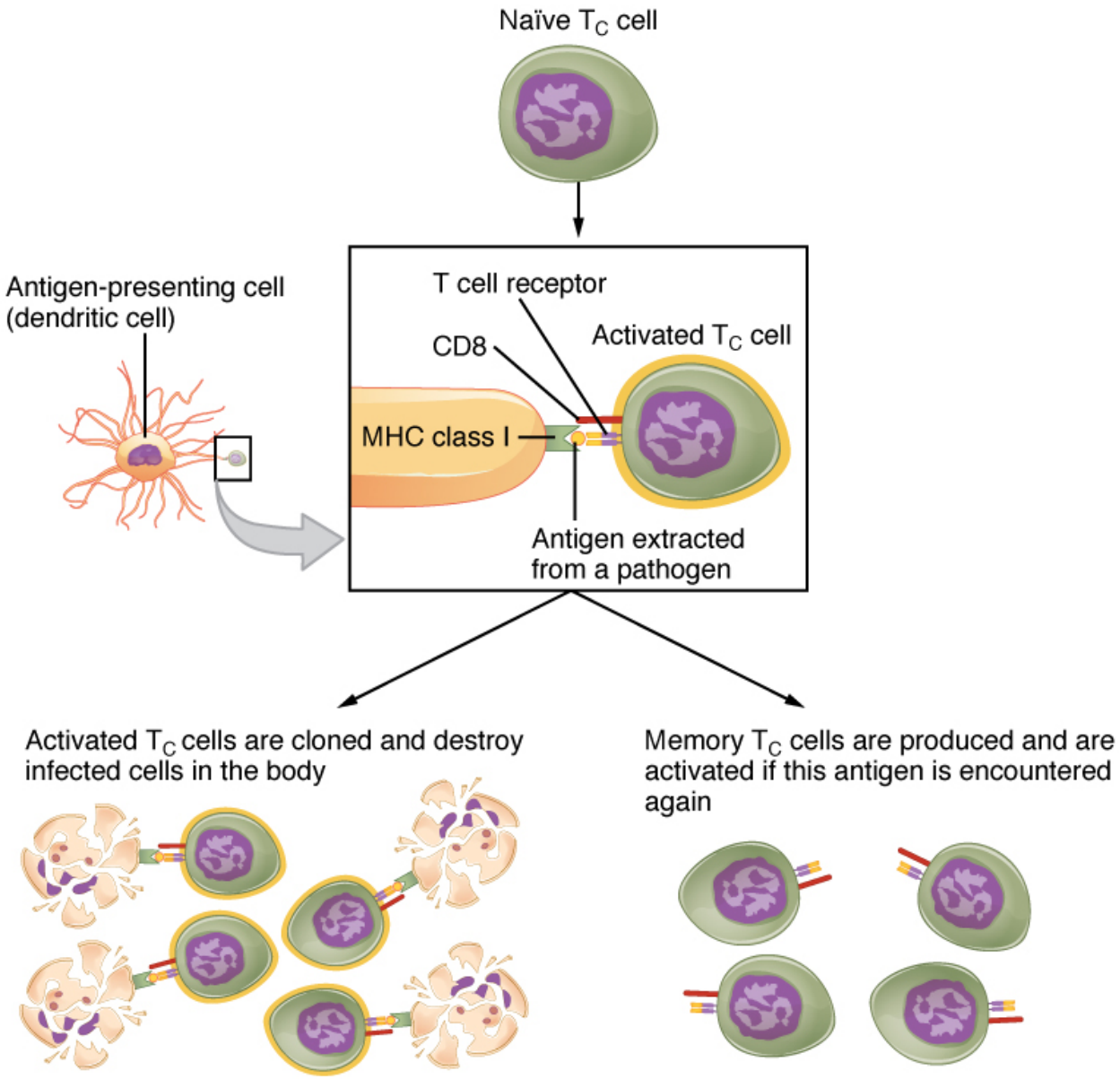


Figure 11.5 Clonal Selection and Expansion of T Lymphocytes. Stem cells differentiate into T cells with specific receptors, called clones. The clones with receptors specific for antigens on the pathogen are selected for and expanded. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 11.5 Image description.]

Lymph Nodes

Lymph nodes function to remove debris and pathogens from the lymph, and are thus sometimes referred to as the "filters of the lymph" (see Figure 11.6). Any bacteria that infect the interstitial fluid are taken up by the lymphatic capillaries and transported to a regional lymph node. Dendritic cells and macrophages within this organ internalize and kill many of the pathogens that pass through, thereby removing them from the body. The lymph node is also the site of **adaptive immune responses** mediated by T cells, B cells, and accessory cells of the adaptive immune system.

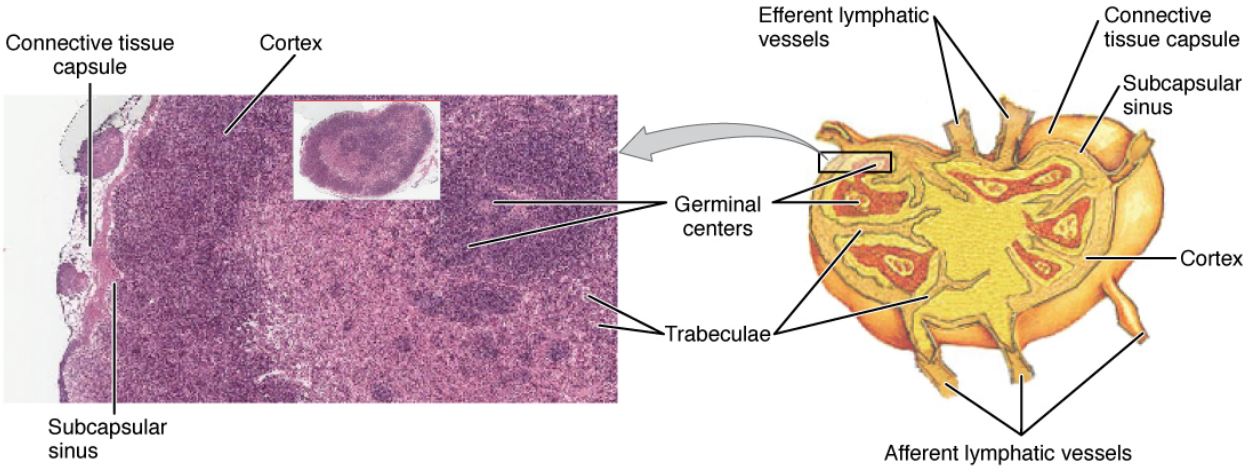


Figure 11.6 Structure and Histology of a Lymph Node. Lymph nodes are masses of lymphatic tissue located along the larger lymph vessels. The micrograph of the lymph nodes shows a germinal center, which consists of rapidly dividing B cells surrounded by a layer of T cells and other accessory cells. LM × 128. (Micrograph provided by the Regents of the University of Michigan Medical School © 2012). From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 11.6 Image description.]

Did You Know 3?

You can live without your spleen. Do you remember the term for "surgical removal of the spleen"?

Spleen

The **spleen** is a vascular organ that is somewhat fragile due to the absence of a capsule. It is about 12 cm long and is attached to the lateral border of the stomach. The spleen is sometimes called the "filter of the blood" because of its extensive vascularization and the presence of macrophages and dendritic cells that remove microbes and other materials from the blood, including dying red blood cells. The spleen also functions as the location of immune responses to blood-borne pathogens.

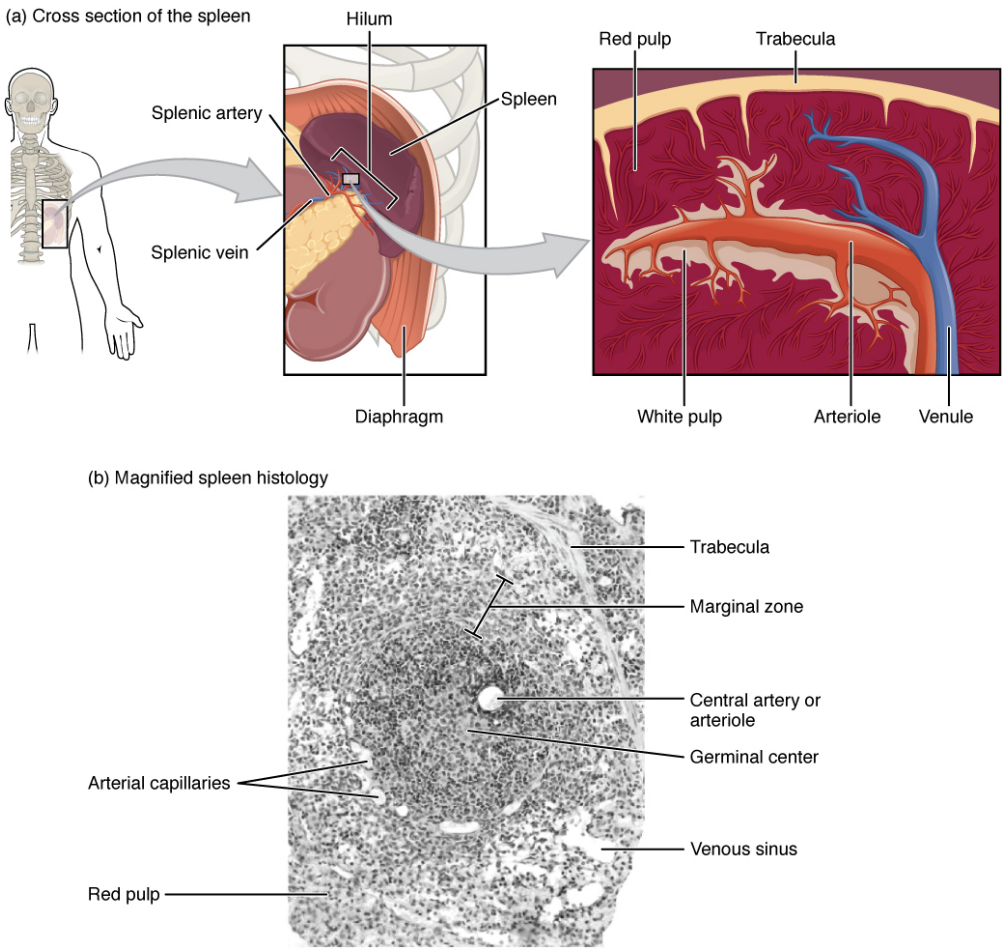


Figure 11.7 Spleen. (a) The spleen is attached to the stomach. (b) A micrograph of spleen tissue shows the germinal center. The marginal zone is the region between the red pulp and white pulp, which sequesters particulate antigens from the circulation and presents these antigens to lymphocytes in the white pulp. EM × 660. (Micrograph provided by the Regents of the University of Michigan Medical School © 2012). From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 11.7 Image description.]

Lymphoid Nodules

The other lymphoid tissues, the **lymphoid nodules**, consist of a dense cluster of lymphocytes without a surrounding fibrous capsule. These nodules are located in the respiratory and digestive tracts, areas routinely exposed to environmental pathogens.

Tonsils are lymphoid nodules located along the inner surface of the pharynx and are important in developing immunity to oral pathogens (see Figure 11.8). The tonsil located at the back of the throat, the pharyngeal tonsil, is sometimes referred to as the adenoid when swollen. Such swelling is an indication of an active immune response to infection. Tonsils have deep grooves called **crypts**, which accumulate all sorts of materials taken into the body through eating and breathing and actually "encourage" pathogens to penetrate deep into the tonsillar tissues where they are eliminated. A major function of tonsils is to help children's bodies recognize, destroy, and develop immunity to common environmental pathogens so that they will be protected in their later lives. Tonsils are

often removed in children who have recurring throat infections since swollen palatine tonsils can interfere with breathing and/or swallowing.

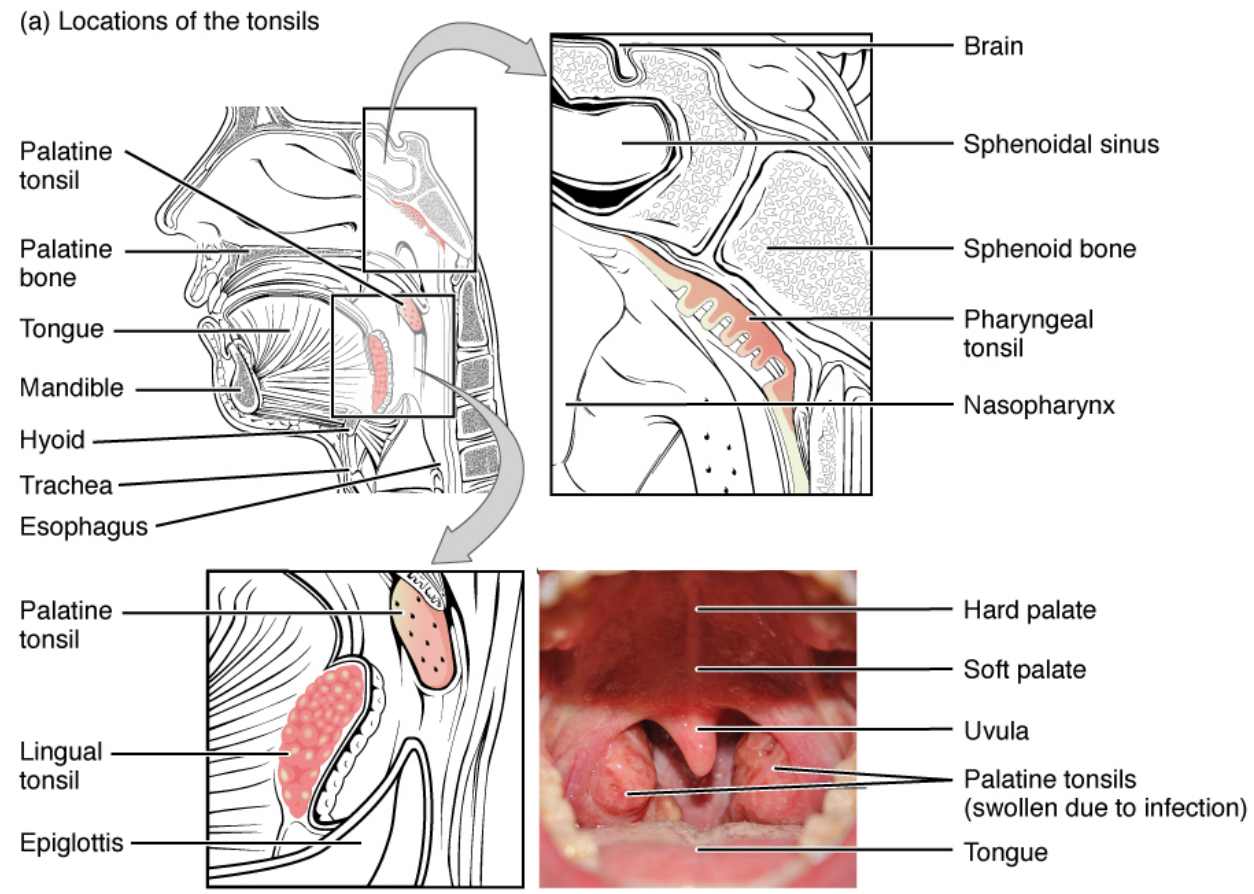


Figure 11.8. Locations and Histology of the Tonsils. (a) The pharyngeal tonsil is located on the roof of the posterior superior wall of the nasopharynx. The palatine tonsils lay on each side of the pharynx. (b) A micrograph shows the palatine tonsil tissue. LM × 40. (Micrograph provided by the Regents of the University of Michigan Medical School © 2012). From Betts et al., 2013. Licensed under

CC BY 4.0. *[Fig. 11.8 Image description.]*

Concept Check

Tonsils are named after their locations.

- Look at the figure above and determine which anatomical structure is closely associated with each set of tonsils and was therefore used to name the tonsils; for example, the **lingual tonsils** are named after the **tongue** (lingula).
- Can you tell which structures were used to name the **palatine tonsils** and the **pharyngeal tonsils**?

Bronchus-associated lymphoid tissue (BALT) consists of lymphoid follicular structures with an overlying epithelial layer found along the bifurcations of the bronchi and between bronchi and arteries. These tissues, in addition to the tonsils, are effective against inhaled **pathogens**.

Mucosa-associated lymphoid tissue (MALT) consists of an aggregate of lymphoid follicles directly associated with mucous membrane. MALT makes up dome-shaped structures found underlying the mucosa of the gastrointestinal tract, breast tissue, lungs, and eyes. Peyer's patches, a type of MALT in the small intestine, are especially important for immune responses against ingested substances (see Figure 11.9). Peyer's patches contain specialized cells that sample material from the intestinal lumen and transport it to nearby follicles so that **adaptive immune responses** to potential **pathogens** can be mounted.

Figure 11.9 Mucosa-associated Lymphoid Tissue (MALT) Nodule. LM × 40. (Micrograph provided by the Regents of the University of Michigan Medical School © 2012). From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 11.9 Image description.]

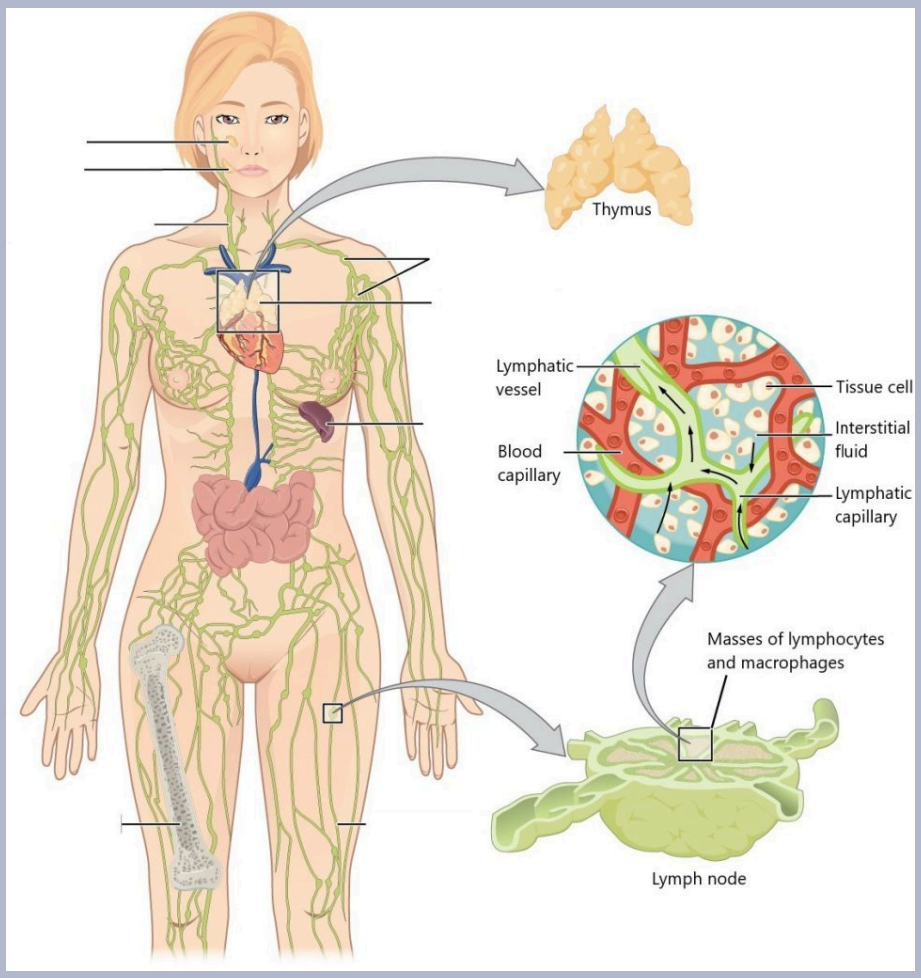
Check Your Knowledge of the Lymphatic System

Anatomy Labeling Activity

Lymphatic System Anatomy (Text Version)

Label the diagram with correct words listed below:

1. Adenoid
2. Lymph nodes
3. Tonsil
4. Thymus
5. Bone marrow
6. Spleen
7. Right lymphatic duct, entering vein
8. Lymph vessel



Lymphatic System Anatomy Diagram (Text Version)

The diagram shows a female human body standing upright, and the entire lymphatic system is shown and labeled (clockwise from top): The _____[Blank 1] is a small gland located in the centre of the chest and it is responsible for supporting the immune function by producing T-cells a type of white blood cell which fights infections and diseases. A collection of oval shaped structures known as _____[Blank 2] serve as filtration units. The _____[Blank 3] is an organ located under the left part of the diaphragm and is responsible for blood filtration. Thin-walled tube known as a _____[Blank 4] carry lymph tissue throughout the body. The _____[Blank 5] is a primary site for T-cell activity in the lymphatic system. The _____[Blank 6] receives lymph fluid from the right side of the head, neck, and thorax, as it drains the venous system. Located at the back of the throat is a fleshy structure known as the _____[Blank 7] and serves as the first line of defence against inhaled harmful substances. Located in the nasopharyngeal region is the _____[Blank 8] which also filter and trap harmful substances from entering the body. The right panel shows magnified images of the thymus and the lymph node. Labels read (clockwise from top): tissue cell, interstitial fluid, lymphatic capillary, blood capillary, lymphatic vessel. Label of lymph node reads masses of lymphocytes and macrophages.

Check your answers [1]

Activity source: Lymphatic System 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.

Image Descriptions

Figure 11.1 image description: The left panel shows a female human body, and the entire lymphatic system is shown Labels read (clockwise from top): thymus, lymph nodes, thymus, spleen, lymph vessel, bone marrow, right lymphatic duct, entering vein, tonsil, adenoid. The right panel shows magnified images of the thymus and the lymph node. Labels read (clockwise from top): tissue cell, interstitial fluid, lymphatic capillary, blood capillary, lymphatic vessel. Label of lymph node reads masses of lymphocytes and macrophages. [Return to Figure 11.1].

Figure 11.2 image description: This image shows the lymph capillaries in the tissue spaces. Labels read (clockwise, from top): lymph capillary, tissue cells, venule, lymphatic vessel, tissue fluid, arteriole). It also shows a magnified image shows the interstitial fluid and the lymph vessels. Labels read (clockwise, from top): collagen fiber, interstitial fluid, lymph, lymph vessel endothelial cells, backflow prevention valve, endothelial flaps. [Return to Figure 11.2].

Figure 11.3 image description: This figure shows the lymphatic trunks and the duct system in the human body. Labels read (clockwise from top) thoracic duct, cisterna chyli of thoracic duct, drained by thoracic duct, drained by right lymphatic duct. Callouts to the left and right show the magnified views of the left and right jugular vein respectively. Labels read (right lymphatic duct): right internal jugular vein, right subclavian vein, right lymphatic duct; (left jugular vein): left internal jugular vein, thoracic duct drains into subclavian vein, left subclavian vein. [Return to Figure 11.3].

Figure 11.4 image description: The left panel of this figure shows the head and chest of a woman and the location of the thymus is marked. Labels read (clockwise, from top) lymph nodes, spleen, heart, thymus, right lymphatic duct entering vein, tonsil, adenoid. The top right panel shows a micrograph of the thymus. Labels read (from left to right): medulla, cortex, trabeculae, fibrous capsule. The bottom right panel shows a magnified view of the structure of the thymus. Labels read (clockwise, from top): thymocytes, trabecula, fibrous capsule, cortex, medulla (layers), medullary epithelial cell, blood vessel, macrophage, dendritic cell, cortical epithelial cell. [Return to Figure 11.4].

Figure 11.5 image description: This flowchart shows the process in which a naïve T cell become activated T cells in the left part of the pathway and memory cells in the right part of the pathway. A naive T cell becomes an activated T cell when an antigen-presenting cell is introduced. The antigen is extracted from a pathogen and then either activated T cells are cloned and destroy the infected cells in the body, and/or memory T cells are produced and are activated if this antigen is encountered again. [Return to Figure 11.5].

Figure 11.6 image description: The left panel of this figure shows a micrograph of the cross section of a lymph node. Labels indicate the connective tissue capsule, cortex, and subcapsular sinus. The right panel shows the structure of a lymph node. Labels indicate (from top, clockwise) the efferent lymphatic vessels, connective tissue capsule, subcapsular sinus, cortex, afferent lymphatic vessels, trabecula, germinal centers. [Return to Figure 11.6].

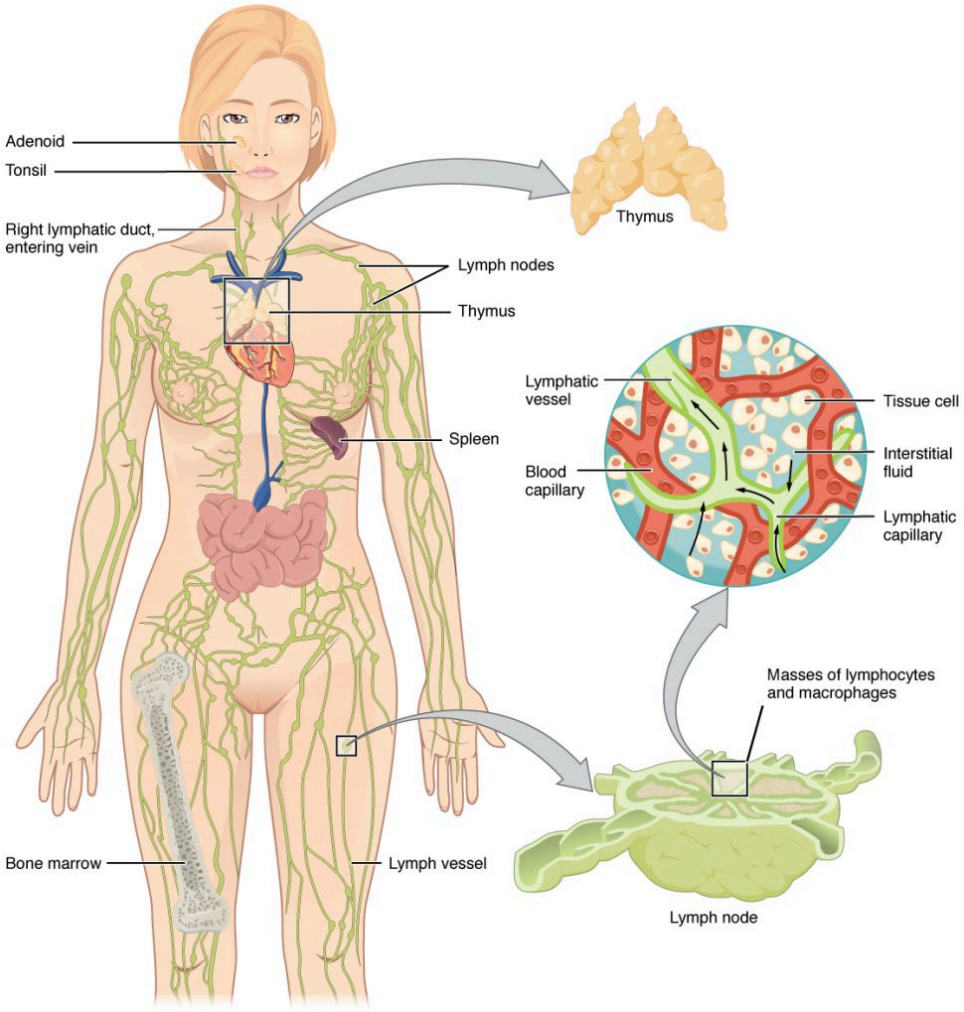
Figure 11.7 image description: The top left panel shows the location of the spleen in the human body. The top center panel shows a close up view of the location of the spleen. Labels read (clockwise, from top): hilum, spleen, diaphragm, splenic vein, splenic artery. The top right panel shows the blood vessels and spleen tissue. Labels read (from left to right, top then bottom) red pulp, trabecula (bottom) white pulp, arteriole, venule. The bottom panel shows a histological micrograph Labels read (clockwise, from top): trabecula, marginal zone, central artery or arteriole, germinal center, venous sinus, red pulp, arterial capillaries. [Return to Figure 11.7].

Figure 11.8 image description: The top panel of this image shows the locations of the tonsils. Labels read (clockwise from top):palatine tonsil, palatine bone, tongue, mandible, hyoid, trachea, esophagus. Callout shows the location of the pharyngeal tonsil. Labels read (from top): brain, sphenoidal sinus, sphenoid bone, pharyngeal tonsil, nasopharynx. Another callout details the location of the palatine tonsil. Labels read (from top): palatine tonsil, lingual tonsil, epiglottis. Another callout shows a photograph of the back of the throat where the tonsils are located. Labels read (from top) hard palate, soft palate, uvula, palatine tonsils (swollen due to infection) and tongue. The bottom panel shows the histological micrograph of the tonsils. Labels read (from top): crpyt, stratified squamous epithelium, germinal centers. [Return to Figure 11.8].

Figure 11.9 image description: This figure shows a micrograph of a mucosa associated lymphoid tissue (MAST) nodule. Labels indicate the mucosa and Peyer's patches (which appear to be dark purple). [Return to Figure 11.9].

Attribution

Notes



1. **Check your answers:**
Lymphatic System Anatomy Diagram (Text Version) The diagram shows a female human body standing upright, and the entire lymphatic system is shown and labeled (clockwise from top): The **thymus** is a small gland located in the centre of the chest and it is responsible for supporting the immune function by producing T-cells a type of white blood cell which fights infections and diseases. A collection of oval shaped structures known as **lymph nodes** serve as filtration units. The **spleen** is an organ located under the left part of the diaphragm and is responsible for blood filtration. Thin-walled tube known as a **lymph vessel** carry lymph tissue throughout the body. The **bone marrow** is a primary site for T-cell activity in the lymphatic system. The **right lymphatic duct entering vein** receives lymph fluid from the right side of the head, neck, and thorax, as it drains the venous system. Located at the back of the throat is a fleshy structure known as the **tonsil** and serves as the first line of defence against inhaled harmful substances. Located in the nasopharyngeal region is the **adenoids** which also filter and trap harmful substances from entering the body. The right panel shows magnified images of the thymus and the lymph node. Labels read (clockwise from top): tissue cell, interstitial fluid, lymphatic capillary, blood capillary, lymphatic vessel. Label of lymph node reads masses of lymphocytes and macrophages.

11.3 - The Organization of the Immune System

The immune system is a collection of barriers, cells, and soluble proteins that interact and communicate with each other in extraordinarily complex ways. The modern model of immune function is organized into a three phases immune response (based on the timing of their effects). Ideally, this response will rid the body of a pathogen entirely (see Figure 11.10).

Think of a primary infection as a race between the pathogen and the immune system:

1. The pathogen bypasses **barrier defenses** and starts to multiply in the host's body.
2. During the first 4 to 5 days, the **innate immune response** will partially control, but not stop the pathogen growth.
3. The slower but more specific and effective **adaptive immune response** gears up and becomes progressively stronger; it will begin to clear the pathogen from the body. This clearance is referred to as **seroconversion**. It should be noted that seroconversion does not necessarily mean a patient is getting well.

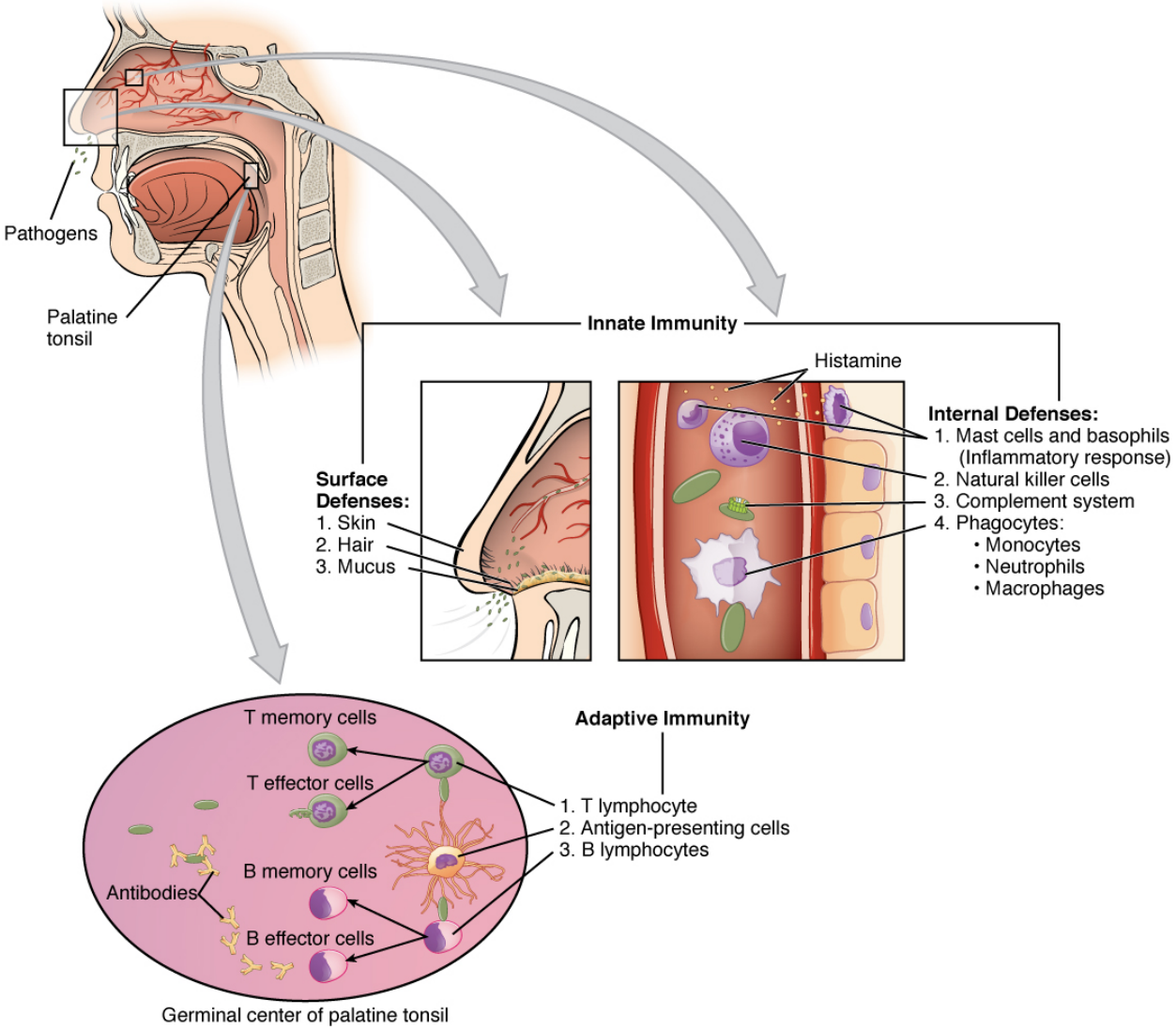


Figure 11.10 Cooperation between Innate and Adaptive Immune Responses. The innate immune system enhances adaptive immune responses so they can be more effective. From Betts et al., 2013. Licensed under CC BY 4.0.

Phase 1: Barrier Defenses

Barrier defenses are part of the body's most basic innate defense mechanisms. They are not a *response* to infections, but rather are continuously working to protect against pathogens by preventing them from entering the body, destroying them after they enter, or flushing them out before they can establish themselves.

Barrier defenses examples:

- **Skin**:
  - Keratinized cells of the surface are too dry for bacteria to grow are continuously sloughed off, along with pathogens that are on their surfaces.

- **Skin (sweat glands, sebaceous glands)**:
  - Lower pH than pathogens prefer, may contain substances that are toxic to pathogens; washing action.
- **Oral cavity (salivary glands):**
  - Lysozyme is an enxyme that destroys bacteria.
- **Stomach:**
  - Low pH, which is fatal to many pathogens.
- **Mucosal:**
  - Traps both microbes and debris, and facilitates their removal.
- **Normal flora (nonpathogenic bacteria):**
  - Prevents pathogens from growing on **mucosal** surfaces.

Phase 2: Innate Immune Response

Innate immune responses are critical to the early control of infections. Whereas barrier defenses are the body's first line of physical defense against pathogens, innate immune responses are the first line of physiological defense. Innate responses occur rapidly, but with less specificity and effectiveness than the adaptive immune response. Within the first few days of an infection, a series of antibacterial proteins are induced, each with activities against certain bacteria. Additionally, **interferons** are induced that protect cells from viruses in their vicinity. Finally, the innate immune response does not stop when the adaptive immune response is developed. In fact, both can cooperate and one can influence the other in their responses against pathogens.

Innate immune responses (and early induced responses) are in many cases ineffective at completely controlling pathogen growth, but they slow pathogen growth and allow time for the adaptive immune response to strengthen and either control or eliminate the pathogen. The innate immune system also sends signals to the cells of the adaptive immune system, guiding them in how to attack the pathogen.

Watch Immune System, Part 1: Crash Course Anatomy & Physiology #45 (9 min) on YouTube

Concept Check 1

Do you know the difference between these terms?

- **Intercellular**
- **Intracellular**
- **Interstitial**

Cells of the Innate Immune Response

Phagocytes: Macrophages and Neutrophils

A phagocyte is a cell that is able to surround and engulf a particle or cell, a process called **phagocytosis**. The phagocytes of the immune system engulf other particles or cells, either to clean an area of debris, old cells, or to kill pathogenic organisms such as bacteria. Macrophages, neutrophils, and dendritic cells are the major phagocytes of the immune system and are the body's fast acting, front line immunological defense against organisms that have breached barrier defenses and have entered the body.

Macrophages not only participate in innate immune responses but have also evolved to cooperate with lymphocytes as part of the adaptive immune response. Macrophages exist in many tissues of the body, either freely roaming through connective tissues or fixed to reticular fibers within specific tissues such as lymph nodes. When pathogens breach the body's barrier defenses, macrophages are the first line of defense.

A **neutrophil** is a phagocytic cell that is attracted via chemotaxis from the bloodstream to infected tissues. contains cytoplasmic granules, which in turn contain a variety of vasoactive mediators such as histamine. Whereas macrophages act like sentries, always on guard against infection, neutrophils can be thought of as military reinforcements that are called into a battle to hasten the destruction of the enemy.

A **monocyte** is a circulating precursor cell that differentiates into either a macrophage or **dendritic cell**, which can be rapidly attracted to areas of infection by signal molecules of inflammation.

Natural Killer Cells

NK cells are a type of lymphocyte that have the ability to induce **apoptosis** in cells infected with pathogens such as *intracellular* bacteria and viruses. If apoptosis is induced before the virus has the ability to synthesize and assemble all its components, no infectious virus will be released from the cell, thus preventing further infection.

Soluble Mediators of the Innate Immune Response

The previous discussions have alluded to chemical signals that can induce cells to change various physiological characteristics, such as the expression of a particular receptor. These soluble factors are secreted during innate or early induced responses, and later during adaptive immune responses.Cytokines and Chemokines

A **cytokine** is a signaling molecule that allows cells to communicate with each other over short distances. Cytokines are secreted into the intercellular space, and the action of the cytokine induces the receiving cell to change its physiology. A **chemokine** is a soluble chemical mediator similar to cytokines except that its function is to attract cells (chemotaxis) from longer distances.

Early Induced Proteins

Early induced proteins are those that are not constitutively present in the body, but are made as they are needed early during the innate immune response. **Interferons** are an example of early induced proteins. Cells infected with viruses secrete interferons that travel to adjacent cells and induce them to make antiviral proteins. Thus, even though the initial cell is sacrificed, the surrounding cells are protected.

Inflammatory Response

The hallmark of the innate immune response is **inflammation**. Stub a toe, cut a finger, or do any activity that causes tissue damage, and inflammation will result, with its four characteristics: **heat, redness, pain,** and **swelling** ("loss of function" is sometimes mentioned as a fifth characteristic). It is important to note that inflammation does not have to be initiated by an infection, but can also be caused by tissue injuries. The release of damaged cellular contents into the site of injury is enough to stimulate the response, even in the absence of breaks in physical barriers that would allow pathogens to enter (by hitting your thumb with a hammer, for example). The inflammatory reaction brings in phagocytic cells to the damaged area to clear cellular debris and encourages the entry of clotting factors to set the stage for wound repair. Inflammation also facilitates the transport of antigen to lymph nodes by dendritic cells for the development of the adaptive immune response.

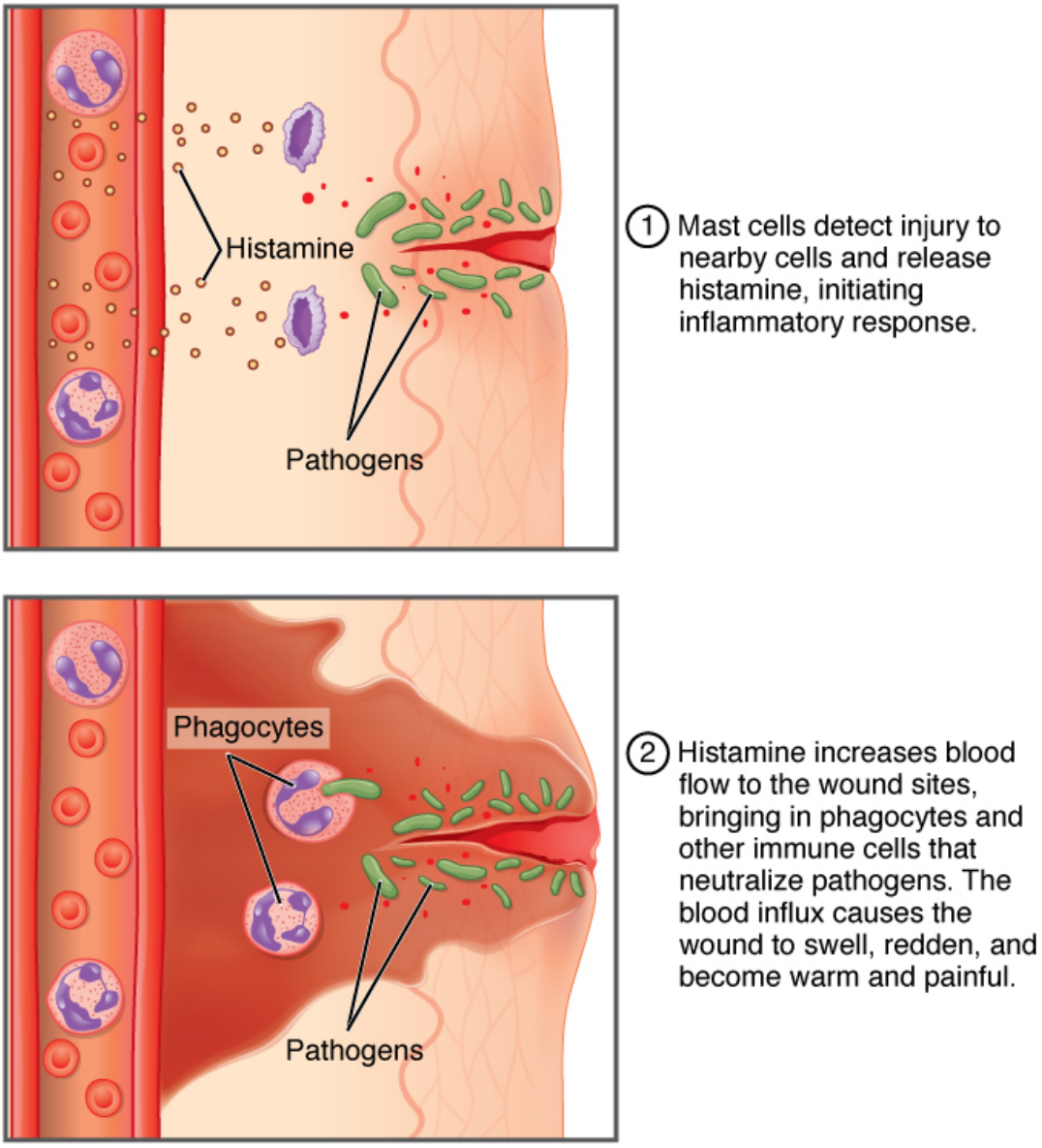


Figure 11.11 Inflammatory Response. From Betts et al., 2013. Licensed under CC BY 4.0.

The above image summarizes the following events in the inflammatory response:

- The released contents of injured cells stimulate the release of substances from **mast cells** including histamine, leukotrienes, and prostaglandins.
- **Histamine** increases blood flow to the area by **vasodilation**, resulting in **heat** and **redness**. Histamine also increases the permeability of local capillaries, causing plasma to leak out and form interstitial fluid, resulting in **swelling**.
- **Leukotrienes** attract neutrophils from the blood by **chemotaxis**.
    - When local infections are severe, neutrophils are attracted to the sites of infections in large numbers, and as they phagocytose the pathogens and subsequently die, their accumulated cellular remains are

visible as pus at the infection site.

- **Prostaglandins** cause vasodilation by relaxing vascular smooth muscle and are a major cause of the **pain** associated with inflammation. Nonsteroidal anti-inflammatory drugs such as aspirin and ibuprofen relieve pain by inhibiting prostaglandin production.

Concept Check 2

- Do you remember the suffix used to describe 'inflammation'?
- Describe what causes the pain associated with inflammation.

Acute inflammation is a short-term innate immune response to an insult to the body. If the cause of the inflammation is not resolved, however, it can lead to **chronic inflammation**, which is associated with major tissue destruction and fibrosis.

Phase 3: Adaptive Immune Response

Watch Immune System, Part 2: Crash Course Anatomy & Physiology #46 (10 min) on YouTube

Benefits of the Adaptive Immune Response

- **Specificity**
  - The ability to specifically recognize and mount a response against almost any pathogen.
  - **Antigens** are recognized by receptors on the surface of B and T lymphocytes.
- **Immunological Memory**
  - The first exposure to a pathogen is called a **primary adaptive response.**
  - Symptoms of a first infection, called primary disease, are always relatively severe because it takes time for an initial adaptive immune response to a pathogen to become effective.
  - Upon re-exposure to the same pathogen, a **secondary adaptive immune response** is generated, which is stronger and faster that the primary response, often eliminating the pathogen before it can cause damage or even symptoms.
  - This secondary response is the basis of **immunological memory**, which gives us **immunity**.

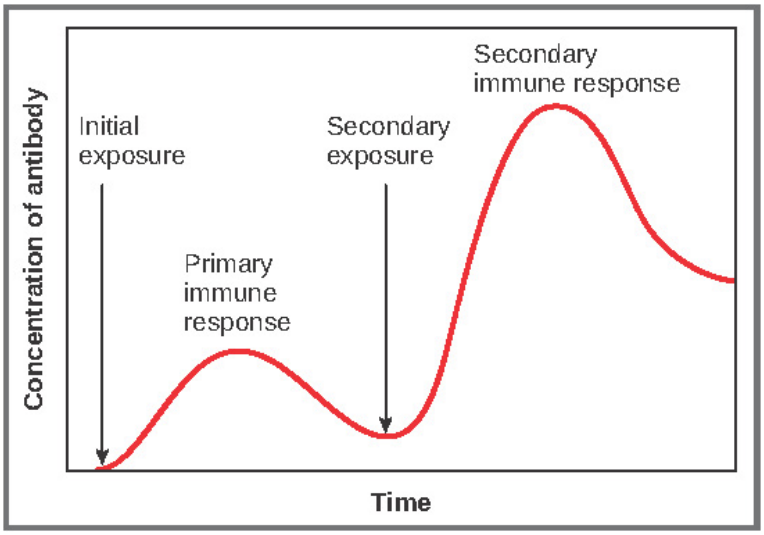


Figure 11.12 Primary and Secondary Antibody Responses. Antigen A is given once to generate a primary response and later to generate a secondary response. When a different antigen is given for the first time, a new primary response is made. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 11.12 Image description.]

- **Self Recognition**
  - The ability to distinguish between self-antigens, those that are normally present in the body, and foreign antigens, those that might be on a potential pathogen.
  - As T and B cells mature, there are mechanisms in place that prevent them from recognizing self-antigen, preventing a damaging immune response against the body. When these mechanisms fail, their breakdown leads to autoimmune diseases.

Lymphocytes: B Cells, T Cells, Plasma Cells

As stated above, lymphocytes are the primary cells of adaptive immune responses. These cells were introduced in the previous chapter and are summarized in the following table:

Table 11.1 Cells of the Adaptive Immune Response. From Betts et al., 2013. Licensed under CC BY 4.0.

Cell Type	Description and Details
Plasma Cell	B cell (lymphocyte) that has been activated through exposure to an **antigen** and produces **antibodies** against that antigen (see the figure below) There are 5 classes of antibodies (IgM, IgG, IgE, IgA, IgD), each functioning in different ways:

IgM promotes chemotaxis, **opsonization**, and cell lysis, making it a very effective antibody against bacteria at early stages of a primary antibody response

IgG is the one that crosses the placenta to protect the developing fetus from disease and exits the blood to the interstitial fluid to fight extracellular pathogens

IgA is the only antibody to leave the interior of the body to protect body surfaces. IgA is also of importance to newborns, because this antibody is present in mother's breast milk (colostrum), which serves to protect the infant

IgE is associated with allergies and **anaphylaxis**

T Cell

Different T cell types have the ability to either secrete soluble factors that communicate with other cells of the adaptive immune response or destroy cells infected with intracellular pathogen.

- Cytotoxic T Cell (Tc) kill target cells by inducing apoptosis using the same mechanism as NK cells: killing a virally infected cell before the virus can complete its replication cycle results in the production of no infectious particles.
- Helper T Cell (Th) release **cytokines**, which help to develop and regulate other immune system cells.
- Suppressor T Cell (also called regulatory T cell) control T Cell response, in order to prevent too many T cells from being formed during an immune response.

Memory B Cell cells and T cells formed during primary exposure to a pathogen (see the figure below) remain in the body for a long time after an infection and are able to mount a fast and effective immune response to a pathogen if it is encountered a second time, preventing the pathogen from causing disease.

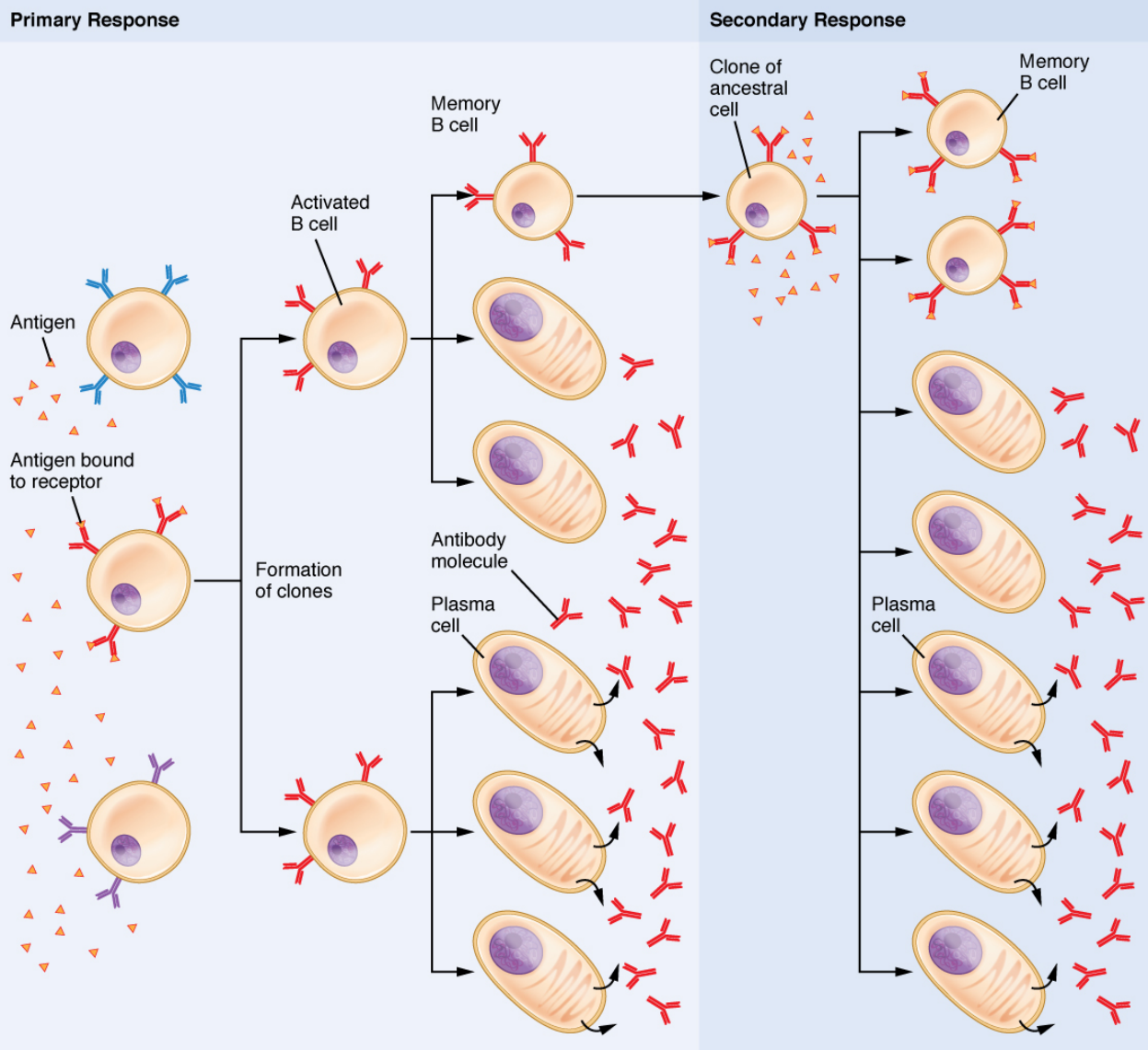


Figure 11.13 Clonal Selection of B Cells. During a primary B cell immune response, both antibody-secreting plasma cells and memory B cells are produced. These memory cells lead to the differentiation of more plasma cells and memory B cells during secondary responses. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 11.13 Image description.]

Active Versus Passive Immunity

Immunity to pathogens, and the ability to control pathogen growth so that damage to the tissues of the body is limited, can be acquired by:

1. The active development of an immune response in the infected individual.
   or
2. The passive transfer of immune components from an immune individual to a non-immune one.

The downside to this passive immunity is the lack of the development of immunological memory. Once the antibodies are transferred, they are effective for only a limited time before they degrade.

Table 11.2 Active Versus Passive Immunity. From Betts et al., 2013. Licensed under CC BY 4.0.

Immunity	Natural	Artificial
Active: resistance to pathogens acquired during an adaptive immune response	Result of memory cells formed during the adaptive immune response to a pathogen	**Vaccine** response. Through vaccination, one avoids the disease that results from the first exposure to the pathogen, yet reaps the benefits of protection from immunological memory. Vaccination was one of the major medical advances of the twentieth century and led to the eradication of smallpox and the control of many infectious diseases, including polio, measles, and whooping cough
Passive: transfer of antibodies from an immune person to a nonimmune person	Trans-placental antibodies from mother to fetus and maternal antibodies in breast milk protect newborn from infections	Immunoglobulin injections taken from animals previously exposed to a specific pathogen; a fast-acting method of temporarily protecting an individual who was possibly exposed to a pathogen

Evasion of the Immune System by Pathogens

The immune system and pathogens are in a slow, evolutionary race to see who stays on top. Early childhood is a time when the body develops much of its immunological memory that protects it from diseases in adulthood. Pathogens have shown the ability, however, to evade the body's immune responses, as described below.

- **Protective adaptations**: It is important to keep in mind that although the immune system has evolved to be able to control many pathogens, pathogens themselves have evolved ways to evade the immune response. An example is in *Mycobactrium tuberculosis*, which has evolved a complex cell wall that is resistant to the digestive enzymes of the macrophages that ingest them, and thus persists in the host, causing the chronic disease tuberculosis.
- **Multiple strains**: Bacteria sometimes evade immune responses because they exist in multiple strains, each having different surface antigens and requiring individual adaptive immune responses. One example is a small group of strains of **S. *aureus***, called methicillin-resistant *Staphylococcus aureus* (MRSA), which has become resistant to multiple antibiotics.
- **Antigen mutation:** Because viruses' surface molecules mutate continuously, viruses like influenza change enough each year that the flu vaccine for one year may not protect against the flu common to the next. New vaccine formulations must be derived for each flu season.
- **Genetic recombination:** An example is the influenza virus, which contains gene segments that can recombine when two different viruses infect the same cell. Recombination between human and pig influenza viruses led to the 2010 H1N1 swine flu outbreak.
- **Immunosuppression**: Pathogens, especially viruses, can produce immunosuppressive molecules that impair immune function.

Tissue Transplantation

With the use of **tissue typing** and anti-rejection drugs, transplantation of organs and the control of the anti-transplant immune response have made huge strides in the past 50 years.

Immunosuppressive drugs such as cyclosporine A have made transplants more successful, but tissue matching is still key. Family members, since they share a similar genetic background, are much more likely to share **MHC** molecules than unrelated individuals do.

One disease of transplantation occurs with bone marrow transplants, which are used to treat various diseases, including **SCID** and **leukemia**. Because the bone marrow cells being transplanted contain lymphocytes capable of mounting an immune response, and because the recipient's immune response has been destroyed before receiving the transplant, the donor cells may attack the recipient tissues, causing **graft-versus-host disease**. Symptoms of this disease, which usually include a rash and damage to the liver and mucosa, are variable, and attempts have been made to moderate the disease by first removing mature T cells from the donor bone marrow before transplanting it.

Immune Responses Against Cancer

It is clear that with some cancers, like Kaposi's sarcoma (see Figure 11.14), for example, that a healthy immune system does a good job at controlling them. This disease, which is caused by the human herpes virus, is almost never observed in individuals with strong immune systems. Other examples of cancers caused by viruses include liver cancer caused by the hepatitis B virus and cervical cancer caused by the human papilloma virus. As these last two viruses have vaccines available for them, getting vaccinated can help prevent these two types of cancer by stimulating the immune response.

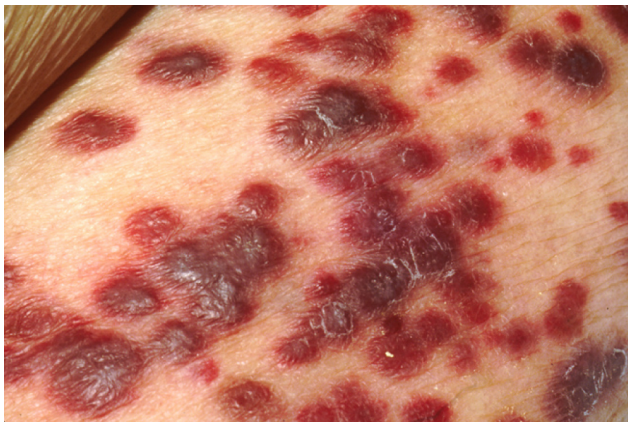


Figure 11.14 Karposi's Sarcoma Lesions. (credit: Image by National Cancer Institute, CC BY 3.0). From Betts et al., 2013.

On the other hand, as cancer cells are often able to divide and mutate rapidly, they may escape the immune response, just as certain pathogens, such as HIV, do.

There are three stages in the immune response to many cancers:

1. **Elimination** occurs when the immune response first develops toward tumor-specific antigens specific to the cancer and actively kills most cancer cells.
2. **Equilibrium** is the period that follows, during which the remaining cancer cells are held in check.
3. **Escape** of the immune response, and resulting disease, occurs because many cancers mutate and no longer express any specific antigens for the immune system to respond to.

This fact has led to extensive research in trying to develop ways to enhance the early immune response to

completely eliminate the early cancer and thus prevent a later escape. One method that has shown some success is the use of cancer vaccines. These differ from other vaccines in that they are directed against the cells of one's own body. Treated cancer cells are injected into cancer patients to enhance their anti-cancer immune response and thereby prolong survival. The immune system has the capability to detect these cancer cells and proliferate faster than the cancer cells do, thus overwhelming the cancer in a similar way as they do for viruses. Cancer vaccines are being developed for malignant melanoma and renal (kidney) cell carcinoma.

Immune Responses and Stress

In order to protect the entire body from infection, the immune system is required to interact with other organ systems, sometimes in complex ways. For example, hormones such as cortisol (naturally produced by the adrenal cortex) and prednisone (synthetic) are well known for their abilities to suppress T cell immune mechanisms, hence, their prominent use in medicine as long-term, anti-inflammatory drugs.

One well-established interaction of the immune, nervous, and endocrine systems is the effect of stress on immune health. In the human vertebrate evolutionary past, stress was associated with the fight-or-flight response, largely mediated by the central nervous system and the adrenal medulla. This stress was necessary for survival since fighting or fleeing usually resolved the problem in one way or another. It has been found that short-term stress diverts the body's resources towards enhancing innate immune responses. This has the ability to act fast and would seem to help the body prepare better for possible infections associated with the trauma that may result from a fight-or-flight exchange.

On the other hand, there are no physical actions to resolve most modern day stresses, including short-term stressors like taking examinations and long-term stressors such as being unemployed or losing a spouse. The effect of stress can be felt by nearly every organ system, and the immune system is no exception (see Table 11.3). Chronic stress, unlike short-term stress, may inhibit immune responses even in otherwise healthy adults. The suppression of both innate and adaptive immune responses is clearly associated with increases in some diseases.

Table 11.3 Effects of Stress on Body Systems. From Betts et al., 2013. Licensed under CC BY 4.0.

System	Stress-Related Illness
Integumentary system	Acne, skin rashes, irritation
Nervous system	Headaches, depression, anxiety, irritability, loss of appetite, lack of motivation, reduced mental performance
Muscular and skeletal systems	Muscle and joint pain, neck and shoulder pain
Circulatory system	Increased heart rate, hypertension, increased probability of heart attacks
Digestive system	Indigestion, heartburn, stomach pain, nausea, diarrhea, constipation, weight gain or loss
Immune system	Depressed ability to fight infections
Male reproductive system	Lowered sperm production, impotence, reduced sexual desire
Female reproductive system	Irregular menstrual cycle, reduced sexual desire

Immune System Medical Terms

Medical Terms Not Easily Broken into Word Parts

Lymphatic System Medical Terms Not Easily Broken Down (Text Version)
Practice the following lymphatic system words by breaking into word parts and pronouncing.

1. **allergen**
    - Substance capable of producing an allergic (hypersensitivity) reaction
2. **Allergist**
    - Specialist who studies and treats allergies
3. **allergy**
    - inflammatory response due to a hypersensitivity to a substance
4. **acute inflammation**
    - Inflammation occurring for a limited time period, rapidly developing
5. **afferent lymphatic vessels**
    - vessels that lead into a lymph node
6. **antibody**
    - antigen-specific protein secreted by plasma cells, immunoglobulin
7. **antigen**
    - molecule recognized by the receptors of b and t lymphocytes
8. **chronic inflammation**
    - Inflammation occurring for long periods of time
9. **chyle**
    - lipid-rich lymph inside the lymphatic capillaries of the small intestine
10. **efferent lymphatic vessels**
    - vessels that lead out of a lymph node

11. **erythroblastosis fetalis**
    - Also called HDN (hemolytic disease of newborn) disease of RH-positive newborns in RH-negative mothers with multiple RH-positive children. Resulting from the action of maternal antibodies against fetal blood.
12. **Graft-versus-host disease (GVHD)**
    - In bone marrow transplants, occurs when the transplanted cells mount an immune response against the recipient
13. **immunological memory**
    - ability of the adaptive immune response to mount a stronger and faster immune response upon re-exposure to a pathogen
14. **innate immune response**
    - rapid but relatively non-specific immune response
15. **lymph**
    - fluid contained within the lymphatic system
16. **lymph node**
    - one of the bean-shaped organs found associated with the lymphatic vessels
17. **Severe combined immunodeficiency disease (SCID)**
    - Genetic mutation that affects both t cell and b cell arms of the immune response
18. **Spleen**
    - Secondary lymphoid organ that filters pathogens from the blood and remove degenerating or damage blood cells
19. **Thymus**
    - Primary lymphoid organ, where t lymphocytes proliferate and mature
20. **Tonsils**
    - Lymphoid nodules associated with the nasopharynx
21. **vaccine**
    - An agent administered by injection, orally or nasal spray that provides active acquired immunity to a particular infectious disease.
22. **Apoptosis**

- Programmed Cell Death

23. **Bone Marrow**
    - tissue found inside bones, the site of all blood cell differentiation and maturation of b lymphocytes
24. **Immunity**
    - Post infection, memory cells remain in the body providing an immune response to the same pathogen. This protects us from getting sick by the same pathogen
25. **Histamine**
    - Vasoactive mediator in granules of mast cells
      Primary cause of allergies and anaphylactic shock
26. **Inflammation**
    - Immune response characterized by heat, redness, pain, and swelling
27. **Interstitial**
    - Between cells of the tissues
28. **Interstitial Space**
    - Spaces between individual cells in the tissues
29. **Passive Immunity**
    - Transfer of immunity (usually by injection of antibodies) to a pathogen by an individual who lacks immunity.

Lymphatic and Immune System Abbreviations

Lymphatic System Common Abbreviations

- **AIDS** (acquired immunodeficiency syndrome)
- **CBC and DIff** (complete blood count and differential)
- **GVHD** (Graft-versus-host Disease)
- **Hct** (hematocrit)
- **HDN** (hemolytic disease of the newborn)
- **Hgb** (hemoglobin)
- **HIV** (human immunodeficiency virus)
- **IV** (Intravenous)
- **SCID** (severe combined immunodeficiency)
- **SPECT** (single-photon emission computed tomography)
- **WBC** (White Blood Cell)

Activity source: Lymphatic System Common Abbreviations by Kimberlee 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 11.12 image description: This graph shows the antibody concentration as a function of time in primary and secondary response. Initial exposure indicates a low concentration of antibody, which then elevates over time during the primary immune response. It decreases a little during secondary exposure, but then spikes during the secondary immune response. [Return to Figure 11.12].

Figure 11.13 image description: This flow chart shows how the clonal selection of B cells takes place. The left panel shows the primary response and the right panel shows the secondary response. During a primary B cell immune response, both antibody-secreting plasma cells and memory B cells are produced. These memory cells lead to the differentiation of more plasma cells and memory B cells during secondary responses. [Return to Figure 11.13].

Attribution

11.4 - Lymphatic Diseases, Disorders and Diagnostic Testing

The immune response can be under-reactive or over-reactive, leading to a state of disease. The factors that maintain immunological homeostasis are complex and incompletely understood.

Underactive Immune System: Immunodeficiencies

Suppressed immunity can result from inherited genetic defects or by acquiring viruses (Betts et al., 2013).

Inherited Immunodeficiencies/SCID

While many inherited immunodeficiencies exist, the most serious is **severe combined immunodeficiency disease (SCID)**. This complex disease is caused by many different genetic defects which result in impaired B cell and T cell arms of the adaptive immune response. Children with this disease usually die of opportunistic infections within their first year of life unless they receive a bone marrow transplant. Such a procedure had not yet been perfected for David Vetter, the "boy in the bubble," who was treated for SCID by having to live in a sterile plastic cocoon for the 12 years before his death from infection in 1984. One of the features that make bone marrow transplants work as well as they do is the proliferative capability of hematopoietic stem cells of the bone marrow. Only a small amount of bone marrow from a healthy donor is given intravenously to the recipient. It finds its own way to the bone where it populates it, eventually reconstituting the patient's immune system, which is usually destroyed beforehand by treatment with radiation or chemotherapeutic drugs (Betts et al., 2013).

New treatments for SCID using gene therapy (inserting nondefective genes into cells taken from the patient and giving them back) have the advantage of not needing the tissue match required for standard transplants. Although not a standard treatment, this approach holds promise, especially for those in whom standard bone marrow transplantation has failed (Betts et al., 2013).

Acquired Immunodeficiency/HIV and AIDS

Although many viruses cause suppression of the immune system, only **HIV** wipes it out completely. HIV is transmitted through semen, vaginal fluids, and blood, and can be caught by risky sexual behaviors and the sharing of needles by intravenous drug users. There are sometimes, but not always, flu-like symptoms in the first 1 to 2 weeks after infection. The presence of anti-HIV antibodies indicates a positive HIV test. Because **seroconversion** takes different lengths of time in different individuals, multiple HIV tests are given months apart to confirm or eliminate the possibility of infection.

After seroconversion, the amount of virus circulating in the blood drops and stays at a low level for several years.

During this time, the levels of **CD4 T cells** decline steadily, until at some point, the immune response is so weak that opportunistic disease and eventually death result.

Treatment for the disease consists of drugs that target virally encoded proteins that are necessary for viral replication but are absent from normal human cells. By targeting the virus itself and sparing the cells, this approach has been successful in significantly prolonging the lives of HIV-positive individuals (Betts et al., 2013).

Overactive Immune System: Hypersensitivities and Autoimmune Diseases

Hypersensitivities

Over-reactive immune responses include the **hypersensitivities**: allergies and inflammatory responses to nonpathogenic environmental substances (Betts et al., 2013). The table below compares different hypersensitivities.

Table 11.4 Table Summarizing Types of Hypersensitivities. From Betts et al., 2013. Licensed under CC BY 4.0.

Type of Hypersensititivy	Details and Explanation
Type I	• Allergies and allergic asthma • Major symptoms of inhaled **allergens** are the nasal edema and runny nose caused by the increased vascular permeability and increased blood flow of nasal blood vessels • 'Immediate Hypersensitivity': usually rapid and occur within just a few minutes • Mild allergies are usually treated with antihistamines • Severe allergies that may cause **anaphylactic shock**, which can be fatal within 20 to 30 minutes if untreated; epinephrine raises blood pressure and relaxes bronchial smooth muscle and is routinely used to counteract the effects of anaphylactic shock
Type II	• Occurs during mismatched blood transfusions and blood compatibility diseases such as **erythroblastosis fetalis**
Type III	• Occurs with diseases such as **systemic lupus erythematosus**
Type IV	• 'Delayed hypersensitivity'-takes 24-72 hours to develop • A standard cellular immune response in which the first exposure to an antigen is called **sensitization**, such that on re-exposure, an immune response results • The classical test for delayed hypersensitivity is the tuberculin test for tuberculosis, where bacterial proteins from *M. tuberculosis* are injected into the skin. A couple of days later, a positive test, as indicated by an **induration**, means that the patient has been exposed to the bacteria and exhibits a cellular immune response to it • Another type of delayed hypersensitivity is contact sensitivity, where substances such as the metal nickel cause a red and swollen area upon contact with the skin in an individual who was previously sensitized to the metal.

Autoimmune Responses

The worst cases of the immune system over-reacting are autoimmune diseases in which the immune systems begin to attack cells of the patient's own body, causing chronic inflammation and significant damage. The trigger for these diseases is often unknown, although environmental and genetic factors are likely involved. Treatments are usually based on resolving the symptoms using immunosuppressive and anti-inflammatory drugs. Figure 11.15 below provides two examples of autoimmune diseases: rheumatoid arthritis (RA) and systemic lupus erythematosus (SLE)(Betts et al., 2013).

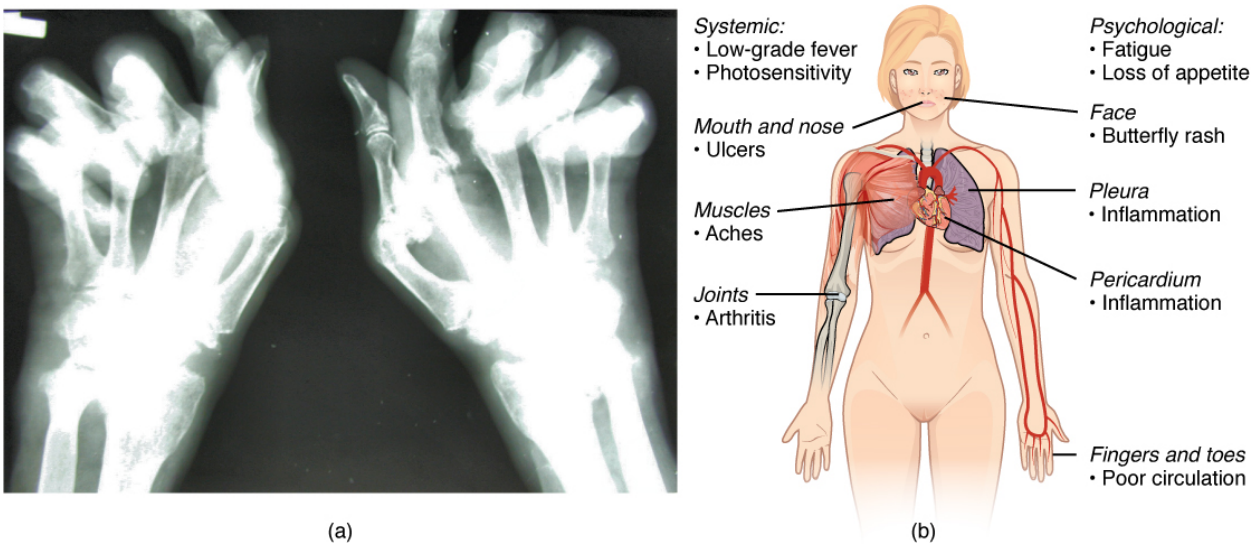


Figure 11.15 Autoimmune Disorders: Rheumatoid Arthritis and Lupus. (a) Extensive damage to the right hand of a rheumatoid arthritis sufferer is shown in the x-ray. (b) The diagram shows a variety of possible symptoms of systemic lupus erythematosus. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 11.15 Image description.]

Overall, there are more than 80 different autoimmune diseases, which are a significant health problem in the elderly. Table 11.5 below lists several of the most common autoimmune diseases, the antigens that are targeted (autoantigen or "self" antigen), and the resulting tissue damage (Betts et al., 2013).

Table 11.5 Autoimmune Diseases. From Betts et al., 2013. Licensed under CC BY 4.0.

Disease	Autoantigen	Symptoms
Celiac disease	Tissue transglutaminase	Damage to small intestine
Diabetes mellitus type I	Beta cells of pancreas	Low insulin production; inability to regulate serum glucose
Graves' disease	Thyroid-stimulating hormone receptor (antibody blocks receptor)	Hyperthyroidism
Hashimoto's thyroiditis	Thyroid-stimulating hormone receptor (antibody mimics hormone and stimulates receptor)	Hypothyroidism
Lupus erythematosus	Nuclear DNA and proteins	Damage of many body systems
Myasthenia gravis	Acetylcholine receptor in neuromuscular junctions	Debilitating muscle weakness
Rheumatoid arthritis	Joint capsule antigens	Chronic inflammation of joints

Lymphoma

Lymphoma was briefly discussed in the previous chapter.

Lymphatic Medical Terms in Use

Medical Terms in Context

Lymphatic System – Medical Report (Text version)

Fill in the following medical reporting using the words listed below:

- itchy
- runny
- allergies
- dander
- medications
- distress
- heart
- drainage
- Dyspnea
- rhinitis
- iron

PATIENT NAME: Sally WESSON

AGE: 43

SEX: Female

DOB: September 26

DATE OF ASSESSMENT: March 20

ATTENDING PHYSICIAN: Trevor Sharpe, MD

CHIEF COMPLAINT: Allergies.

HISTORY: A 43-year-old Asian female states being very tired and irritable. She had presented watery and _____[Blank 1] eyes, itchy throat, sneezing, _____[Blank 2] and stuffy nose. She has family history of _____[Blank 3]. She always struggled with many different allergies: dust, pollen, cat and dog _____[Blank 4]. She had tried different types of over-the-counter allergy _____[Blank 5], but they didn't help to alleviate the symptoms. She is currently taking Reactine 5 mg daily which does not relieve all of her symptoms.

PHYSICAL EXAMINATION: GENERAL: Patient is pale and in moderate _____[Blank 6]. VITAL SIGNS: Weight 160 pounds, B/P 120/80, _____[Blank 7] rate 90 beats per minute, respiratory rate 18 per minute, temperature 98.6 F. HEENT: EYES: Red, watery, itching, burning and swelling. EARS: Normal. NOSE: Mouth breathing, sneezing, runny and itchy nose, post-nasal _____[Blank 8], nasal congestion. THROAT: Itchy and swollen. CHEST: _____[Blank 9] and wheezing.

MEDICATIONS

1. Reactine 5 mg _____[Blank 10].
2. Escitalopram 20 mg q.d.
3. Lorazepam 0.5 mg p.r.n. nightly at bedtime.
4. Fenofibrate 145 mg q.h.s.

ASSESSMENT

1. Patient has severe seasonal allergic _____[Blank 11].
2. Possible anemia.

PLAN

1. Recommended Reactive 10 mg q.d.
2. Referred to an allergist to provide patient more options for allergy treatments.
3. Ordered a blood work to check her _____[Blank 12] and cholesterol levels.
4. Follow up in 4 days to review her blood work results.

_____
Trevor Sharpe, MD

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]

Lymphatic System – Medical Report

Lymphatic System – Medical Report (Text version)
Fill in the following medical report using the words listed below:

- stones
- fatigued
- fever
- tonsillitis
- temperature
- cervical
- dysphagia
- erythema
- crypts
- tonsillolith
- pseudomembranes
- tonsillectomy
- gargles

PATIENT NAME: Celine CAMERON

AGE: 16

SEX: Female

DOB: March 25

DATE OF ASSESSMENT: August 4

ATTENDING PHYSICIAN: Grant Talbot, MD, Pediatrics

HISTORY: This is a 16-year-old female today with complaints of throat pain. She has been struggling with inflamed tonsils for the last 2 weeks. The patient claims that tonsil _____[Blank 1] are forming and that a white film has appeared over their tonsils. She has been feeling very _____[Blank 2], has developed a mild _____[Blank 3] and occasionally feel nauseous.

The client has a family history of _____[Blank 4] resulting in tonsillectomy. She mentioned that her grandmother experienced recurrent tonsillitis around the same age. The condition of tonsillitis has occurred on 2 other occasions in the past 5 months.

PHYSICAL AND EXAMINATION: Ms. Cameron is in no acute distress. She appears fatigued. VITAL SIGNS: Blood Pressure 132/83, _____[Blank 5] is slightly elevated at 99.6, pulse 67. She is in generally in good condition. Throat palpation was performed. There is significant enlargement of the _____[Blank 6] lymph nodes. She appears to be experiencing _____[Blank 7]. Throat was examined and revealed swelling, _____[Blank 8] and tonsillar _____[Blank 9] visible. A _____[Blank 10] was seen to be forming within one of the crypts. Celine's claims of _____[Blank 11] were also confirmed. She denies any symptoms such as a nasal discharge, cough, or abdominal pain. Throat was swabbed.

ASSESSMENT: Ms. Cameron appears to be experiencing recurrent tonsillitis correlated to exaggerated tonsillar crypts. Possible _____[Blank 12] may be required.

PLAN

1. Patient was given a referral to an ENT specialist and may require tonsillectomy.
2. The patient was instructed to follow a diet of soft, smooth foods and soothing liquids.
3. It was suggested that the patient use saltwater _____[Blank 13] in the mornings and before bed.

4. A prescription of Amoxicillin 400 mg p.o. p.c.

_____
Grant Talbot, MD, Pediatrics

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]

Lymphatic System – Medical Report

Lymphatic System – Medical Report (Text version)

Fill in the following medical report using the words listed below:

- dysphagia
- prescribed
- lymph
- enlarged
- ibuprofen
- erythromycin
- tonsillectomy
- surgery

PATIENT NAME: Jason MACDONALD

AGE: 7

SEX: Male

DOB: August 19

DATE OF ASSESSMENT: November 15

ATTENDING PHYSICIAN: Grant Talbot, MD, Pediatrics

DIAGNOSIS: Tonsillitis

HISTORY: This 7-year-old white male has been seen by me on several occasions over the last two years. He has complained of pharyngitis, _____[Blank 1], and fever. I have _____[Blank 2] erythromycin in the past.

PHYSICAL EXAMINATION: When I examined Jason today, he once again had the same complaints as in

the past. I also noticed that the _____[Blank 3] nodes in his neck were _____[Blank 4] and tender. He had a temperature of 39 degrees.

TREATMENT: I gave Jason _____[Blank 5] for his fever and prescribed _____[Blank 6] again.

PLAN: It is my recommendation that Jason undergo a _____[Blank 7]. Jason's parents are in agreement. I will make the arrangements for Jason's _____[Blank 8].

_____
Grant Talbot, MD, Pediatrics

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 and Procedures Related to the Lymphatic and Immune Systems

Clinical Immunology/Allergy is a medical specialty that diagnoses and treats diseases of the immune system (Canadian Medical Association, 2019). For more information, please visit the Canadian Medical Association Specialty Profiles Clinical Immunology page [PDF].

Skin testing (for allergies) is done by a clinical immunologist/allergist to identify allergens in Type I hypersensitivity. In skin testing, allergen extracts are injected into the epidermis, and a positive result of the **wheal and flare response** usually occurs within 30 minutes. The soft center is due to fluid leaking from the blood vessels and the redness is caused by the increased blood flow to the area that results from the dilation of local blood vessels at the site (Betts et al., 2013).

Image Descriptions

Figure 11.15 image description: The left panel of this figure shows an x-ray image of a person's hand with rheumatoid arthritis, and the right panel of this figure shows a woman's body with labels showing the different responses in the body when the patient suffers from lupus. Labels (from top, clockwise) read: psychological:

fatigue, loss of appetite, face butterfly rash, pleura inflammation, pericardium inflammation, fingers and toes poor circulation, joints arthritis, muscles aches, mouth and nose ulcers, systemic: low-grade fever photosensitivity. [Return to Figure 11.15].

Attribution

Notes

1. 1. itchy, 2. runny, 3. allergies, 4. dander, 5. medication, 6. distress, 7. heart 8. drainage, 9.Dyspnea, 10. daily, 11.rhinitis, 12. iron
2. 1. stones, 2.fatigue, 3.fever 4. tonsillitis, 5. temperature, 6. cervical, 7. dysphagia, 8. erthema, 9. crypts, 10. tonsillolith, 11. pseudomembranes, 12. tonsillectomy, 13. gargles
3. 1. dysphagia, 2. prescribed, 3. lymph, 4. enlarged, 5. ibuprofen, 6. erythromycin, 7. tonsillectomy, 8. surgery

Vocabulary & Check Your Knowledge

Lymphatic System and Immune System Vocabulary

Active immunity

Immunity developed from an individual's own immune system.

Acute inflammation

Inflammation occurring for a limited time period; rapidly developing.

Adaptive immune response

Relatively slow but very specific and effective immune response controlled by lymphocytes.

Afferent lymphatic vessels

Lead into a lymph node.

Allergens

Antigens that evoke type 1 hypersensitivity (allergy) responses.

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.

Antibody

Antigen-specific protein secreted by plasma cells, immunoglobulin.

Antigen

Molecule recognized by the receptors of b and t lymphocytes.

Apoptosis

Programmed cell death.

B cells

Lymphocytes that act by differentiating into an antibody-secreting plasma cell.

Barrier defenses

Antipathogen defenses deriving from a barrier that physically prevents pathogens from entering the body to establish an infection.

Bone marrow

Tissue found inside bones, the site of all blood cell differentiation and maturation of b lymphocytes.

Bronchus-associated lymphoid tissue (balt)

Lymphoid nodule associated with the respiratory tract.

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.

Chemokine

Soluble, long-range, cell-to-cell communication molecule.

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.

Chronic inflammation

Inflammation occurring for long periods of time.

Chyle

Lipid-rich lymph inside the lymphatic capillaries of the small intestine.

Cisterna chyli

Bag-like vessel that forms the beginning of the thoracic duct.

Complement

Enzymatic cascade of constitutive blood proteins that have antipathogen effects, including the direct killing of bacteria.

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.

Cytokine

Soluble, short-range, cell-to-cell communication molecule.

Deep Lymphatic Vessels

Lymphatic vessels of the organs.

Efferent lymphatic vessels

Lead out of a lymph node.

Erythroblastosis fetalis

Disease of rh factor-positive newborns in rh-negative mothers with multiple rh-positive children; resulting from the action of maternal antibodies against fetal blood.

Genetic mutation that affects both t cell and b cell arms of the immune response.

Genetic Recombination

The combining of gene segments from two different pathogens.

Graft-versus-host disease

In bone marrow transplants, occurs when the transplanted cells mount an immune response against the recipient.

Histamine

Vasoactive mediator in granules of mast cells and is the primary cause of allergies and anaphylactic shock.

HIV

Human Immunodeficiency Virus. An infectious disease usually transmitted via blood or sexual fluids. It attacks the immune system and can lead to AIDS.

Hypersensitivities

Reacting to something that would not normally evoke a reaction.

Immune system

Series of barriers, cells, and soluble mediators that combine to response to infections of the body with pathogenic organisms.

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.

Immunological memory

Ability of the adaptive immune response to mount a stronger and faster immune response upon re-exposure to a pathogen.

Induration

A firm, raised reddened patch of skin.

Inflammation

Basic innate immune response characterized by heat, redness, pain, and swelling.

Innate immune response

Rapid but relatively nonspecific immune response.

Intercellular

Between cells.

Interferons

Early induced proteins made in virally infected cells that cause nearby cells to make antiviral proteins.

Interstitial Fluid

Fluid that has leaked out of blood capillaries into the tissue spaces.

Interstitial

Between cells of the tissues, often used interchangeably with 'intercellular'.

Interstitial Space

Spaces between individual cells in the tissues.

Intracellular

Inside the cell membrane or within the cell.

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.

Lymph

Fluid contained within the lymphatic system.

Lymph node

One of the bean-shaped organs found associated with the lymphatic vessels.

Lymphatic capillaries

Smallest of the lymphatic vessels and the origin of lymph flow.

Lymphatic system

Network of lymphatic vessels, lymph nodes, and ducts that carries lymph from the tissues and back to the bloodstream.

Lymphatic trunks

Large lymphatics that collect lymph from smaller lymphatic vessels and empties into the blood via lymphatic ducts.

Lymphocytes

White blood cells characterized by a large nucleus and small rim of cytoplasm.

Lymphoid nodules

Unencapsulated patches of lymphoid tissue found throughout the body.

Lymphoma

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.

Macrophage

Ameboid phagocyte found in several tissues throughout the body.

Mast cell

Cell found in the skin and the lining of body cells that contains cytoplasmic granules with vasoactive mediators such as histamine.

Memory t cells

Long-lived immune cell reserved for future exposure to an pathogen.

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.

Monocyte

Precursor to macrophages and dendritic cells seen in the blood.

Mucosa-associated lymphoid tissue (malt)

Lymphoid nodule associated with the mucosa.

Mucosal

Mucous membranes line body cavities that open to the outside world, including the respiratory tract, gastrointestinal tract, urinary tract and reproductive tracts.

Naïve lymphocyte

Mature b or t cell that has not yet encountered antigen for the first time.

Natural killer cell (nk)

Cytotoxic lymphocyte of innate immune response.

Neutrophil

Phagocytic white blood cell recruited from the bloodstream to the site of infection via the bloodstream.

Opsonization

An antibody or an antimicrobial protein binds to a pathogen, thereby marking it as a target for phagocytes.

Passive immunity

Transfer of immunity to a pathogen to an individual that lacks immunity to this pathogen usually by the injection of antibodies.

Pathogens

Disease causing agents.

Phagocytosis

Movement of material from the outside to the inside of the cells via vesicles made from invaginations of the plasma membrane.

Plasma cell

Differentiated b cell that is actively secreting antibody.

Primary adaptive response

Immune system's response to the first exposure to a pathogen.

Primary lymphoid organ

Site where lymphocytes mature and proliferate, red bone marrow and thymus gland.

Right lymphatic duct

Drains lymph fluid from the upper right side of body into the right subclavian vein.

S. aureus

Staphylococcus aureus is a bacterium that is commonly found in minor skin infections, as well as in the nose of some healthy people.

Secondary adaptive response

Immune response observed upon re-exposure to a pathogen, which is stronger and faster than a primary response.

Secondary lymphoid organs

Sites where lymphocytes mount adaptive immune responses, examples include lymph nodes and spleen.

Seroconversion

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).

Severe combined immunodeficiency disease (scid)

Genetic mutation that affects both t cell and b cell arms of the immune response.

Spleen

Secondary lymphoid organ that filters pathogens from the blood (white pulp) and removes degenerating or damaged blood cells (red pulp).

Superficial Lymphatics

Lymphatic vessels of the subcutaneous tissues of the skin.

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.

T cell

Lymphocyte that acts by secreting molecules that regulate the immune system or by causing the destruction of foreign cells, viruses, and cancer cells.

Thoracic duct

Large duct that drains lymph from the lower limbs, left thorax, left upper limb, and the left side of the head.

Thymocytes

Lymphocytes that develop into T-cells in the thymus gland.

Thymus

Primary lymphoid organ, where t lymphocytes proliferate and mature.

Tonsils

Lymphoid nodules associated with the nasopharynx.

Tissue typing

The determination of MHC molecules in the tissue to be transplanted to better match the donor to the recipient.

Vaccine

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.

Vasodilation

The smooth muscle layer in the wall of the blood vessel relaxes, allowing the vessel to widen. This decreases blood pressure in the vessel.

Wheal and flare response

A soft, pale swelling at the site surrounded by a red zone.

Lymphatic and Immune Systems Glossary Reinforcement Activity

Lymphatic and Immune Systems Glossary Reinforcement Activity (Text version)

1. Vasoactive mediator in granules of mast cells and is the primary cause of allergies and anaphylactic shock is called _____[Blank 1].

    a. Histamine
    b. Mast cell
    c. Cisterna chyli

2. Large duct that drains lymph from the lower limbs, left thorax, left upper limb, and the left side of the head is referred to as _____[Blank 2].

    a. Thoracic duct
    b. Lymph
    c. Plasma cell

3. _____[Blank 3] is the primary lymphoid organ; where t lymphocytes proliferate and mature.

    a. Lymphatic capillaries
    b. Thymus
    c. Antigen

4. Tissue found inside bones; the site of all blood cell differentiation and maturation of b lymphocytes are called _____[Blank 4].

    a. Neutrophil
    b. Interferons
    c. Bone marrow

5. Ability of the adaptive immune response to mount a stronger and faster immune response upon re-exposure to a pathogen is called _____[Blank 5].

    a. Immunological memory
    b. Chemokine
    c. Barrier defenses

Check your answers: [1]

Attribution

Notes

1. 1. Histamine 2. Thoracic duct, 3. Thymus, 4. Bone marrow, 5. Immunological memory.

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CHAPTER 12: DIGESTIVE SYSTEM (GASTROINTESTINAL)

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.

12.1 - Introduction to the Digestive System

Learning Objectives

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

Digestive System Word Parts

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

Prefix

- **hemi–** (half)
- **endo–** (within, in)
- **sub–** (under, below)
- **dys–** (painful, abnormal, difficult, laboured)

Combining Form

- **abdomin/o** (abdomen, abdominal)
- **an/o** (anus)
- **antr/o** (antrum)
- **append/o** (appendix)
- **appendic/o** (appendix)

- **cec/o** (cecum)
- **celi/o** (abdomen, abdominal cavity)
- **cheil/o** (lip)
- **cholangi/o** (bile duct)
- **chol/e** (gall, bile)
- **choledoch/o** (common bile duct)
- **col/o** (colon)
- **colon/o** (colon)
- **diverticul/o** (diverticulum)
- **duoden/o** (duodenum)
- **enter/o** (intestine)
- **esophag/o** (esophagus)
- **gastr/o** (stomach)
- **gingiv/o** (gum)
- **gloss/o** (tongue)
- **hepat/o** (liver)
- **herni/o** (hernia, protrusion of an organ through a membrane or cavity wall)
- **ile/o** (ileum)
- **jejun/o** (jejunum)
- **lapar/o** (abdomen, abdominal cavity)
- **lingu/o** (tongue)
- **or/o** (mouth)
- **palat/o** (palate)
- **pancreat/o** (pancreas)
- **peritone/o** (peritoneum)
- **polyp/o** (polyp, small growth)
- **proct/o** (rectum)
- **pylor/o** (pylorus, pyloric sphincter)
- **rect/o** (rectum)
- **sial/o** (saliva, salivary gland)
- **sigmoid/o** (sigmoid colon)
- **steat/o** (fat)
- **stomat/o** (mouth)
- **uvul/o** (uvula)

Suffix

- **-al** (pertaining to)
- **-cele** (hernia, protrusion)
- **-centesis** (surgical puncture to aspirate fluid)
- **-ectomy** (excision)
- **-gram** (the record, radiographic image)
- **-graph** (instrument used to record)

- **-graphy** (process of recording)
- **-ia** (condition of, diseased state, abnormal state)
- **-iasis** (condition)
- **-itis** (inflammation)
- **-logist** (specialist or physician who studies and treats)
- **-logy** (study of)
- **-malacia** (softening)
- **-oma** (tumour)
- **-sis** (abnormal condition)
- **-pathy** (disease)
- **-pepsia** (digestion)
- **-phagia** (eating or swallowing)
- **-plasty** (surgical repair)
- **-ptosis** (prolapse, drooping)
- **-rrhaphy** (suturing, repairing)
- **-rrhea** (flow, discharge)
- **-scope** (instrument used for visualization)
- **-scopy** (process of viewing, visualization)
- **-stomy** (creation of an artificial opening)
- **-tomy** (incision, cut into)

Introduction to the Digestive System

The digestive system is continually at work, yet people seldom appreciate the complex tasks it performs in a choreographed biologic symphony. Consider what happens when you eat an apple. Of course, you enjoy the apple's taste as you chew it, but in the hours that follow, unless something goes amiss and you get a stomachache, you don't notice that your digestive system is working. You may be taking a walk or studying or sleeping, having forgotten all about the apple, but your stomach and intestines are busy digesting it and absorbing its vitamins and other nutrients. By the time any waste material is excreted, the body has appropriated all it can use from the apple. In short, whether you pay attention or not, the organs of the digestive system perform their specific functions, allowing you to use the food you eat to keep you going.

This chapter examines the structure and functions of these organs, and explores the mechanics and chemistry of the digestive processes. The function of the digestive system is to break down the foods you eat, release their nutrients, and absorb those nutrients into the body. Although the small intestine is the workhorse of the system, where the majority of digestion occurs, and where most of the released nutrients are absorbed into the blood or lymph, each of the digestive system organs makes a vital contribution to this process (see Figure 12.1).

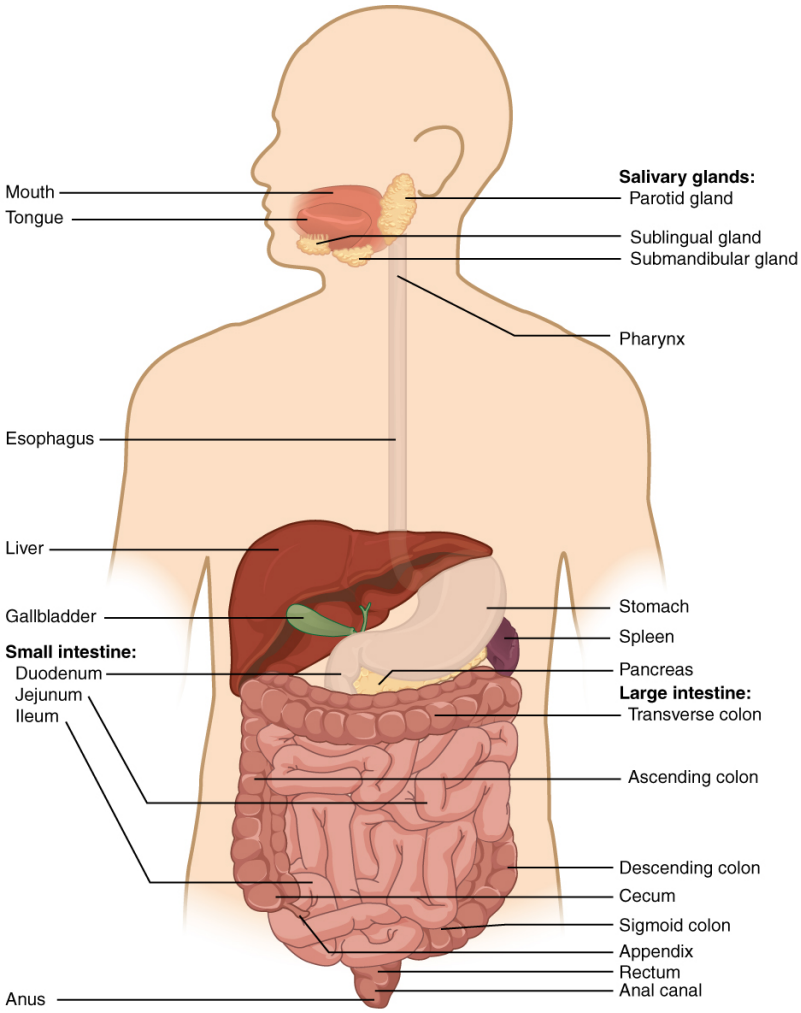


Figure 12.1 Components of the Digestive System. All digestive organs play integral roles in the life-sustaining process of digestion. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 12.1 Image description.]

Watch Digestive System, Part 1: Crash Course Anatomy & Physiology #33 (11 min)

Digestive System Medical Terms

Now that you have memorized the word parts, see if you can break down the following digestive terms and define them.

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

1. **gastroenterology (gastr/o/enter/o/logy)**
    - study of the stomach and intestines
2. **cholecystitis (chol/e/cyst/itis)**
    - inflammation of the gallbladder
3. **proctoscope (proct/o/scope)**
    - instrument used to view the rectum
4. **pyloroplasty (pylor/o/plasty)**
    - surgical repair of the pylorus
5. **hepatomegaly (hepat/o/megaly)**
    - enlarged liver
6. **gastric (gastr/ic)**
    - pertaining to the stomach
7. **cholangiography (cholangi/o/graphy)**
    - radiographic imaging of the bile duct
8. **gastroenterologist (gastr/o/enter/o/logist)**
    - specialist who studies and treats stomach and intestines
9. **cholangiogram (cholangi/o/gram)**
    - radiographic image of the bile duct
10. **hepatoma (hepat/oma)**
    - tumour of the liver

11. **pancreatitis (pancreat/itis)**
    - inflammation of the pancreas
12. **esophagogram (esophag/o/gram)**
    - radiographic image of the esophagus
13. **steatosis (steat/osis)**
    - abnormal condition of fat
14. **rectocele (rect/o/cele)**
    - protrusion of the rectum
15. **endoscope (endo/scope)**
    - instrument used to view within (hollow organs)
16. **abdominal (abdomin/al)**
    - pertaining to the abdomen
17. **proctoptosis (proct/o/ptosis)**
    - condition of prolapse of the rectum
18. **diverticulitis (diverticul/itis)**
    - inflammation of the diverticulum
19. **oral (or/al)**
    - pertaining to the mouth
20. **appendectomy (append/ectomy)**
    - excision of the appendix
21. **esophagoscopy (esophag/o/scopy)**
    - process of viewing the esophagus
22. **cheilorrhaphy (cheil/o/rrhaphy)**
    - suturing of the lip
23. **glossorrhaphy (gloss/o/rrhaphy)**
    - suturing of the tongue
24. **pyloromyotomy (pylor/o/my/o/tomy)**

- incision into the pyloric muscle

25. **gastroplasty (gastr/o/plasty)**
    - surgical repair of the stomach
26. **colectomy (col/ectomy)**
    - excision of the colon
27. **sigmoidoscopy (sigmoid/o/scopy)**
    - process of viewing the sigmoid colon
28. **palatitis (palat/itis)**
    - inflammation of the palate
29. **esophageal (esophag/eal)**
    - pertaining to the esophagus
30. **colitis (col/itis)**
    - inflammation of the colon
31. **ileocecal (ile/o/cec/al)**
    - pertaining to the ileum and cecum
32. **gastrectomy (gastr/ectomy)**
    - excision of the stomach
33. **anoplasty (an/o/plasty)**
    - surgical repair of the anus
34. **cholelithiasis (chole/lith/iasis)**
    - condition of gallstones
35. **gastroscopy (gastr/o/scopy)**
    - process of viewing the stomach
36. **colostomy(col/o/stomy)**
    - creation of an artificial opening in the colon
37. **polyposis (polyp/osis)**
    - abnormal condition of (multiple) polyps

38. **laparoscopy (lapar/o/scopy)**
    - process of viewing the abdominal cavity
39. **cholecystectomy (chole/cyst/ectomy)**
    - excision of the gallbladder to remove stones
40. **glossitis (gloss/itis)**
    - inflammation of the tongue
41. **cholangioma (cholangi/oma)**
    - tumour of the bile duct
42. **pancreatic (pancreat/ic)**
    - pertaining to the pancreas
43. **stomatitis (stomat/itis)**
    - inflammation of the mouth
44. **ileocecal (ile/o/cec/al)**
    - pertaining to the ileum and cecum
45. **nasogastric (nas/o/gastr/ic)**
    - pertaining to the nose and stomach
46. **proctoscopy (proct/o/scopy)**
    - process of viewing the rectum
47. **herniorrhaphy (herni/o/rrhaphy)**
    - suturing of a hernia
48. **appendicitis (appendic/itis)**
    - inflammation of the appendix
49. **gingivectomy (gingiv/ectomy)**
    - excision of the gums
50. **gastroenterocolitis (gastr/o/enter/o/col/itis)**
    - inflammation of the stomach, intestines, and colon
51. **choledocholithotomy (choledoch/o/lith/o/tomy)**

- incision into the common bile duct to remove stones

52. **gastroscope (gastr/o/scope)**
    - instrument used to view the stomach
53. **diverticulosis (diverticul/osis)**
    - abnormal condition of having diverticula
54. **uvulitis (uvul/itis)**
    - inflammation of the uvula
55. **dysphagia (dys/phagia)**
    - difficult swallowing
56. **gastrostomy (gastr/o/stomy)**
    - creation of an artificial opening in the stomach
57. **hemicolectomy (hemi/col/ectomy)**
    - excision of half of the colon
58. **choledocholithiasis (choledoch/o/lith/iasis)**
    - condition of stones in the common bile duct
59. **uvulectomy (uvul/ectomy)**
    - excision of the uvula
60. **peritoneal (periton/eal)**
    - pertaining to the peritoneum
61. **ileostomy (ile/o/stomy)**
    - creation of an artificial opening in the ileum
62. **steatorrhea (steat/o/rrhea)**
    - discharge of fat
63. **sialolith (sial/o/lith)**
    - stone in the salivary gland
64. **proctology (proct/o/logy)**
    - study of disease and disorders of the rectum

65. **gastrojejunostomy (gastr/o/jejun/o/stomy)**
    - creation of an artificial opening between the stomach and the jejunum
66. **rectal (rect/al)**
    - pertaining to the rectum
67. **gingivitis (gingiv/itis)**
    - inflammation of the gums
68. **colonoscopy (colon/o/scopy)**
    - process of viewing the colon
69. **colorectal (col/o/rect/al)**
    - pertaining to the colon and rectum
70. **anal (an/al)**
    - pertaining to the anus
71. **duodenal (duoden/al)**
    - pertaining to the duodenum
72. **abdominocentesis (abdomin/o/centesis)**
    - surgical puncture to aspirate fluid from the abdomen
73. **hepatitis (hepat/itis)**
    - inflammation of the liver
74. **laparoscope (lapar/o/scope)**
    - instrument used to view the abdominal cavity
75. **antrectomy (antr/ectomy)**
    - excision of the antrum (of the stomach)
76. **enterorrhaphy (enter/o/rrhaphy)**
    - suturing of the intestine
77. **esophagitis (esophag/itis)**
    - inflammation of the esophagus
78. **uvulopalatopharyngoplasty (UPPP)**

- uvul/o/palat/o/pharyng/o/plasty
- surgical repair of the uvula, palate, and pharynx

79. **peritonitis (periton/itis)**
    - inflammation of the peritoneum
80. **diverticulectomy (diverticul/ectomy)**
    - excision of the diverticula
81. **enteropathy (enter/o/pathy)**
    - disease of the intestines
82. **proctologist (proct/o/logist)**
    - Specialist who studies and treats diseases of the rectum
83. **gastritis (gastr/itis)**
    - inflammation of the stomach
84. **abdominoplasty (abdomin/o/plasty)**
    - surgical repair of the abdomen
85. **celiotomy (celi/o/tomy)**
    - incision into the abdominal cavity
86. **gastroenteritis (gastr/o/enter/itis)**
    - inflammation of the stomach and intestines
87. **endoscopy (endo/scopy)**
    - process of viewing within (hollow organs)
88. **palatoplasty (palat/o/plasty)**
    - surgical repair of the palate
89. **laparotomy (lapar/o/tomy)**
    - incision into the abdominal cavity
90. **colonoscope (colon/o/scope)**
    - instrument used to view the colon
91. **polypectomy (polyp/ectomy)**
    - excision of polyps

92. **gastrojejunostomy (gastr/o/jejun/o/stomy)**
    - creation of an artificial opening between the stomach and the jejunum
93. **CT colonography (CT colon/o/graphy)**
    - radiographic imaging of the colon using computed tomography
94. **esophagogastroduodenoscopy (EGD)**
    - esophag/o/gastr/o/duoden/o/scopy
    - process of viewing the esophagus, stomach and duodenum
95. **stomatogastric (stomat/o/gastr/ic)**
    - pertaining to the mouth and stomach
96. **celiac (celi/ac)**
    - pertaining to the abdomen
97. **gastromalacia (gastr/o/malacia)**
    - softening of the stomach
98. **dyspepsia (dys/pepsia)**
    - difficult digestion
99. **esophagogastroplasty (esophag/o/gastr/o/plasty)**
    - surgical repair of the esophagus and stomach
100. **sublingual (sub/lingu/al)**
    - pertaining to under the tongue
101. **steatohepatitis (steat/o/hepat/itis)**
    - inflammation of liver associated with fat

Digestive System

Practice with this activity:

Digestive System(Text version)

Fill in the blanks using the following list of words:

- polyp
- palpate
- obesity
- hemorrhoids
- emesis
- melena
- flatus
- ascites
- feces
- reflux
- nausea
- cirrhosis
- dysentery
- adhesion
- stoma

The Physician during an examination will _____[Blank 1] to feel for texture, size, consistency and location of body parts with hands.

A _____[Blank 2] is a small tumour-like growth that extend from the surface of a mucous membrane.

_____[Blank 3] is an abnormal increase in the proportion of fat cells resulting in excess body weight for height.

Distended and swollen veins in the rectum and anus are called _____[Blank 4].

The medical term for vomiting is _____[Blank 5].

_____[Blank 6] is black tarry stool that contains blood from the gastrointestinal tract.

_____[Blank 7] is the medical term for gas in the gastrointestinal tract.

Abnormal intraperitoneal accumulation of fluid with large amount of proteins and electrolytes is _____[Blank 8].

_____ is fecal matter.

Abnormal backward flow is called _____[Blank 10].

The urge to vomit is _____[Blank 11].

_____[Blank 12] is a chronic degenerative disease of the liver due to alcohol abuse.

_____[Blank 13] is an inflammation of the intestine presenting with abdominal pain and bloody diarrhea.

A band of scar tissue that binds anatomic surfaces to each other is called an _____[Blank 14].

The surgical opening between an organ and the surface of the body is called a _____[Blank 15].

Check your answers: [1]

Image Descriptions

Figure 12.1 image description: This diagram shows the digestive system of a human being, with the major organs labeled. Labels read (clockwise, from top): salivary glands: parotid gland, sublingual gland, submandibular gland; pharynx, stomach, spleen, pancreas, large intestine: transverse colon, ascending colon, descending colon, cecum, sigmoid colon, appendix, rectum, anal canal, anus; small intestine: duodenum, jejunum, ileum, gall bladder, liver, esophagus, tongue, mouth. [Return to Figure 12.1].

Attribution

Notes

1. 1. palpate, 2. polyp, 3. obesity, 4. hemorrhoids, 5. emesis, 6. melena, 7. flatus, 8.ascites, 9. feces, 10. reflux, 11. nausea, 12. cirrhosis, 13. dysentery, 14. adhesion, 15. stoma

12.2 - Anatomy (Structures) of the Digestive System

The Mouth

The cheeks, tongue, and palate frame the mouth, which is also called the **oral cavity** (or buccal cavity). The structures of the mouth are illustrated in Figure 12.2.

At the entrance to the mouth are the lips, or **labia** (singular = labium). Their outer covering is skin, which transitions to a mucous membrane in the mouth proper. Lips are very vascular with a thin layer of keratin, hence the reason they are red.

The pocket-like part of the mouth that is framed on the inside by the gums and teeth and on the outside by the cheeks and lips is called the **oral vestibule**. Moving farther into the mouth, the opening between the oral cavity and throat (oropharynx) is called the **fauces** (like the kitchen "faucet"). The main open area of the mouth, or oral cavity proper, runs from the gums and teeth to the fauces.

When you are chewing, you do not find it difficult to breathe simultaneously. The next time you have food in your mouth, notice how the arched shape of the roof of your mouth allows you to handle both digestion and respiration at the same time. This arch is called the palate. The anterior region of the palate serves as a wall (or septum) between the oral and nasal cavities as well as a rigid shelf against which the tongue can push food. It is created by the maxillary and palatine bones of the skull and, given its bony structure, is known as the hard palate. If you run your tongue along the roof of your mouth, you'll notice that the hard palate ends in the posterior oral cavity, and the tissue becomes fleshier. This part of the palate, known as the **soft palate**, is composed mainly of skeletal muscle. You can therefore manipulate, subconsciously, the soft palate—for instance, to yawn, swallow, or sing (see Figure 12.2).

Did You Know 1?

You can eat upside down. Food doesn't need gravity to reach your stomach. Peristalsis, a wave-like muscle movement, pushes food along.

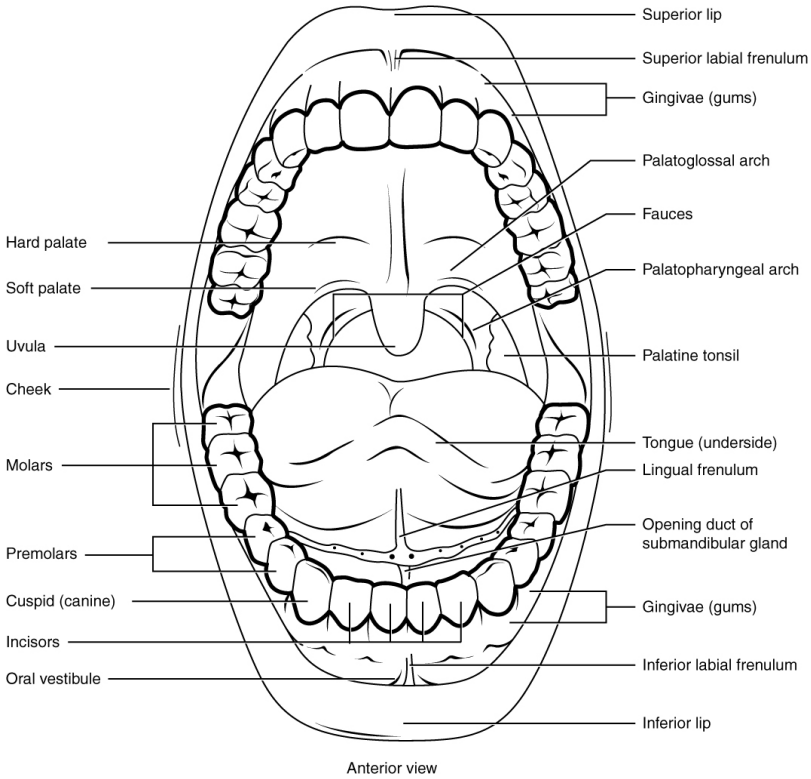


Figure 12.2 Mouth. The mouth includes the lips, tongue, palate, gums, and teeth. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 12.2 Image description.]

A fleshy bead of tissue called the **uvula** drops down from the center of the posterior edge of the soft palate. Although some have suggested that the uvula is a vestigial organ, it serves an important purpose. When you swallow, the soft palate and uvula move upward, helping to keep foods and liquid from entering the **nasal cavity**. Unfortunately, it can also contribute to the sound produced by snoring. Two muscular folds extend downward from the soft palate, on either side of the uvula. Toward the front, the **palatoglossal arch** lies next to the base of the tongue; behind it, the **palatopharyngeal arch** forms the superior and lateral margins of the fauces. Between these two arches are the **palatine tonsils**, clusters of lymphoid tissue that protect the pharynx. The **lingual tonsils** are located at the base of the tongue.

Tongue

Perhaps you have heard it said that the **tongue** is the strongest muscle in the body. Those who stake this claim cite its strength proportionate to its size. Although it is difficult to quantify the relative strength of different muscles, it remains indisputable that the tongue is a workhorse, facilitating **ingestion**, **mechanical digestion**, **chemical digestion** (lingual lipase), sensation (of taste, texture, and temperature of food), swallowing, and vocalization.

The tongue is attached to the mandible, the styloid processes of the temporal bones, and the hyoid bone. The hyoid is unique in that it only distantly/indirectly articulates with other bones. The tongue is positioned over

the floor of the oral cavity. A medial septum extends the entire length of the tongue, dividing it into symmetrical halves.

The top and sides of the tongue are studded with papillae, extensions of lamina propria of the mucosa, which are covered in **stratified squamous epithelium** (see Figure 12.3).

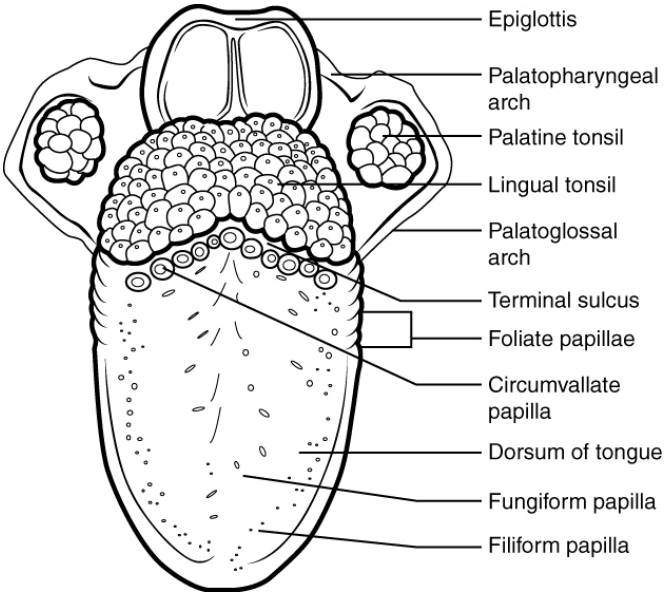


Figure 12.3 Tongue. This superior view of the tongue shows the locations and types of lingual papillae. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 12.3 Image description.]

Salivary Glands

Many small **salivary glands** are housed within the mucous membranes of the mouth and tongue. These minor **exocrine** glands are constantly secreting **saliva**, either directly into the oral cavity or indirectly through ducts, even while you sleep. In fact, an average of 1 to 1.5 liters of saliva is secreted each day. Usually, just enough saliva is present to moisten the mouth and teeth. Secretion increases when you eat, because saliva is essential to moisten food and initiate the chemical breakdown of **carbohydrates**. Small amounts of saliva are also secreted by the **labial glands** in the lips. In addition, the **buccal glands** in the cheeks, palatal glands in the palate, and lingual glands in the tongue help ensure that all areas of the mouth are supplied with adequate saliva.

Concept Check 1

- Describe how the **anatomy** of the **mouth** permits breathing and chewing at the same time
- Explain the role **saliva** performs in the digestive system

Pharynx

The pharynx (throat) is involved in both digestion and respiration. It receives food and air from the mouth, and air from the nasal cavities. When food enters the pharynx, involuntary muscle contractions close off the air passageways. A short tube of skeletal muscle lined with a **mucous membrane**, the pharynx runs from the posterior oral and nasal cavities to the opening of the esophagus and larynx. It has three subdivisions. The most superior, the nasopharynx, is involved only in breathing and speech. The other two subdivisions, the **oropharynx** and the **laryngopharynx**, are used for both breathing and digestion. The oropharynx begins inferior to the nasopharynx and is continuous below with the laryngopharynx. The inferior border of the laryngopharynx connects to the esophagus, whereas the anterior portion connects to the larynx, allowing air to flow into the bronchial tree.

Esophagus

The esophagus is a muscular tube that connects the pharynx to the stomach. It is approximately 25.4 cm (10 in) in length, located posterior to the trachea, and remains in a collapsed form when not engaged in swallowing. As you can see in Figure 12.4, the esophagus runs a mainly straight route through the mediastinum of the thorax. To enter the abdomen, the esophagus penetrates the diaphragm through an opening called the esophageal hiatus.

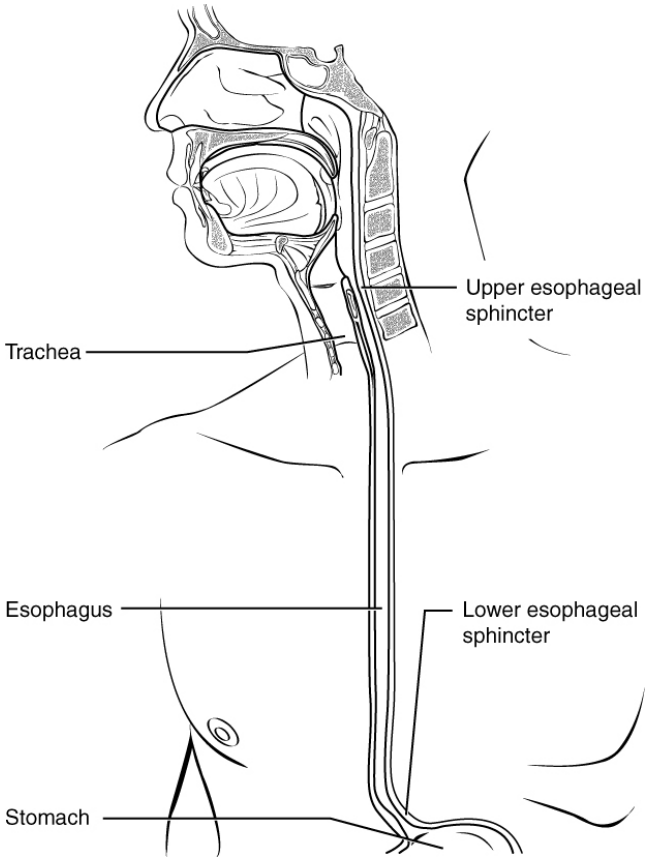


Figure 12.4 Esophagus. The upper esophageal sphincter controls the movement of food from the pharynx to the esophagus. The lower esophageal sphincter controls the movement of food from the esophagus to the stomach. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 12.4 Image description.]

Passage of Food Through the Esophagus

The upper **esophageal sphincter**, which is continuous with the inferior pharyngeal **constrictor,** controls the movement of food from the pharynx into the esophagus. The upper two-thirds of the esophagus consists of both smooth and skeletal muscle fibers, with the latter fading out in the bottom third of the esophagus. Rhythmic waves of **peristalsis**, which begin in the upper esophagus, propel the bolus of food toward the stomach. Meanwhile, secretions from the esophageal mucosa lubricate the esophagus and food. Food passes from the esophagus into the stomach at the lower esophageal sphincter (also called the gastroesophageal or cardiac sphincter). Recall that sphincters are muscles that surround tubes and serve as valves, closing the tube when the sphincters contract and opening it when they relax.

Stomach

There are four main regions in the **stomach**: the cardia, fundus, body, and pylorus (see Figure 12.5). The **cardia** (or

cardiac region) is the point where the esophagus connects to the stomach and through which food passes into the stomach. Located inferior to the diaphragm, above and to the left of the cardia is the dome-shaped **fundus**. Below the fundus is the **body**, the main part of the stomach. The funnel-shaped **pylorus** connects the stomach to the duodenum. The wider end of the funnel, the **pyloric antrum**, connects to the body of the stomach. The narrower end is called the **pyloric canal**, which connects to the duodenum. The smooth muscle **pyloric sphincter** is located at this latter point of connection and controls stomach emptying. In the absence of food, the stomach deflates inward, and its mucosa and submucosa fall into a large fold called a **ruga.**

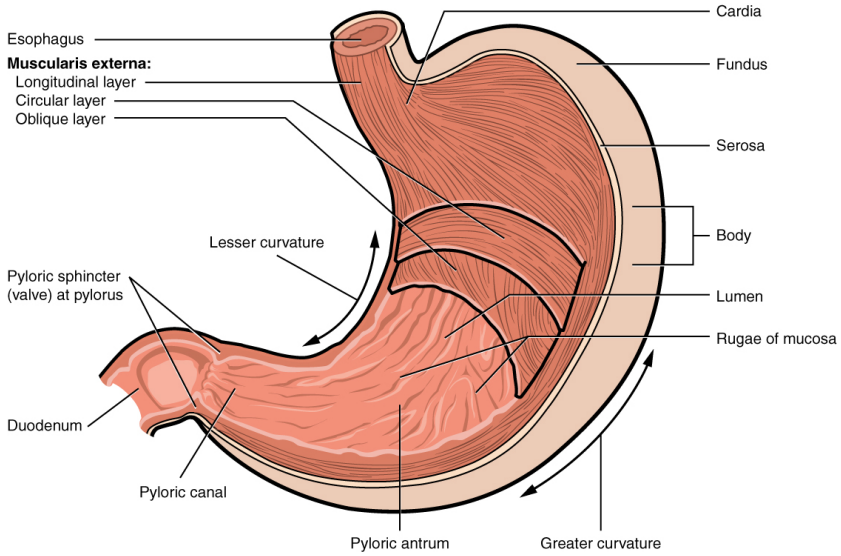


Figure 12.5 Stomach. The stomach has four major regions: the cardia, fundus, body, and pylorus. The addition of an inner oblique smooth muscle layer gives the muscularis the ability to vigorously churn and mix food. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 12.5 Image description.]

The **convex** lateral surface of the stomach is called the greater curvature; the **concave** medial border is the lesser curvature. The stomach is held in place by the lesser omentum, which extends from the liver to the lesser curvature, and the greater **omentum**, which runs from the greater curvature to the posterior abdominal wall. Partially digested food mixed with digestive juices of the stomach becomes known as chyme.

Small Intestines

Chyme released from the stomach enters the **small intestine**, which is the primary digestive organ in the body. Not only is this where most digestion occurs, it is also where practically all absorption occurs. The longest part of the **alimentary canal**, the small intestine is about 3.05 meters (10 feet) long in a living person (but about twice

as long in a cadaver due to the loss of muscle tone). Since this makes it about five times longer than the large intestine, you might wonder why it is called "small." In fact, its name derives from its relatively smaller diameter of only about 2.54 cm (1 in), compared with 7.62 cm (3 in) for the large intestine. As we'll see shortly, in addition to its length, the folds and projections of the lining of the small intestine work to give it an enormous surface area, which is approximately 200 m^2, more than 100 times the surface area of your skin. This large surface area is necessary for complex processes of digestion and absorption that occur within it.

Did You Know 2?

Your body absorbs 90 per cent of our nutrients through the **small intestine**, into your blood.

The coiled tube of the small intestine is subdivided into three regions. From **proximal** (at the stomach) to **distal**, these are the duodenum, jejunum, and ileum (see Figure 12.6).

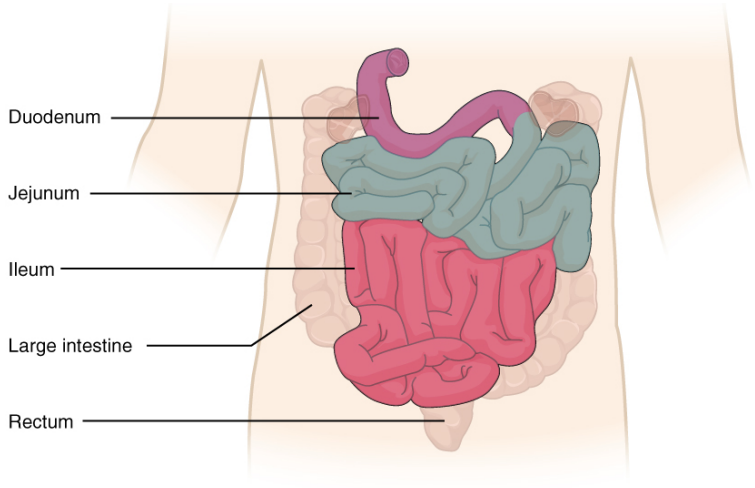


Figure 12.6 Small Intestine. The three regions of the small intestine are the duodenum, jejunum, and ileum. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 12.6 Image description.]

Large Intestines

The **large intestine** is the terminal part of the alimentary canal. The primary function of this organ is to finish the absorption of nutrients and water, synthesize certain vitamins, form feces, and eliminate feces from the body.

The large intestine runs from the appendix to the anus. It frames the small intestine on three sides. Despite being about one-half as long as the small intestine, it is called large because it is more than twice the diameter of the small intestine, about 3 inches.

The large intestine is subdivided into four main regions: the cecum, the colon, the rectum, and the anus. The ileocecal valve, located at the opening between the ileum and the large intestine, controls the flow of **chyme** from the small intestine to the large intestine.

Cecum

The first part of the large intestine is the **cecum**, a sac-like structure that is suspended inferior to the ileocecal valve. It is about 6 cm (2.4 in) long, receives the contents of the ileum, and continues the absorption of water and salts. The **appendix** (or vermiform appendix) is a winding tube that attaches to the cecum. Although the 7.6-cm (3-in) long appendix contains **lymphoid** tissue, suggesting an immunologic function, this organ is generally considered vestigial. However, at least one recent report assumes a survival advantage conferred by the appendix: in diarrheal illness, the appendix may serve as a bacterial reservoir to repopulate the enteric bacteria for those surviving the initial phases of the illness. Moreover, its twisted anatomy provides a haven for the accumulation and multiplication of enteric bacteria. The **mesoappendix**, the mesentery of the appendix, tethers it to the mesentery of the ileum.

Colon

The cecum blends seamlessly with the **colon**. Upon entering the colon, the food residue first travels up the **ascending colon** on the right side of the abdomen. At the inferior surface of the liver, the colon bends to form the **right colic flexure** (hepatic flexure) and becomes the **transverse colon**. The region defined as hindgut begins with the last third of the transverse colon and continues on. Food residue passing through the transverse colon travels across to the left side of the abdomen, where the colon angles sharply immediately inferior to the spleen, at the **left colic flexure** (splenic flexure). From there, food residue passes through the **descending colon**, which runs down the left side of the posterior abdominal wall. After entering the pelvis inferiorly, it becomes the s-shaped **sigmoid colon**, which extends medially to the midline (see Figure 12.7). The ascending and descending colon and the rectum (discussed next) are located in the retroperitoneum. The transverse and sigmoid colon are tethered to the posterior abdominal wall by the mesocolon.

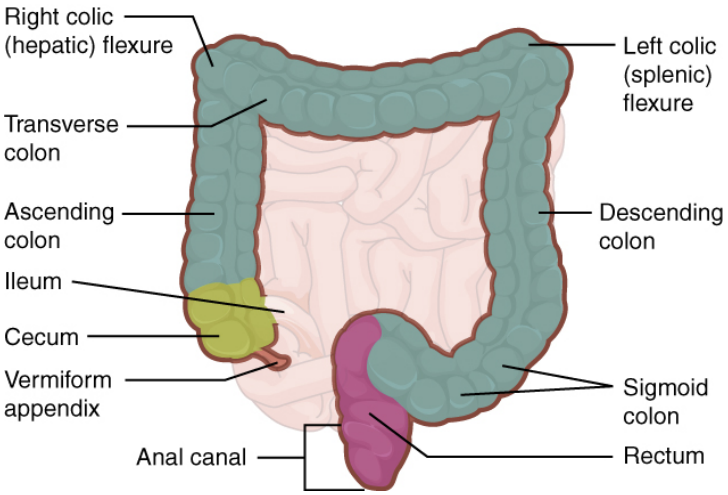


Figure 12.7 Large Intestine. The large intestine includes the cecum, colon, and rectum. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 12.7 Image description.]

Accessory Organs of Digestion

Chemical digestion in the small intestine relies on the activities of three accessory digestive organs: the liver, pancreas, and gallbladder (see Figure 12.8). The digestive role of the liver is to produce bile and export it to the duodenum. The gallbladder primarily stores, concentrates, and releases bile. The pancreas produces pancreatic juice, which contains digestive enzymes and **bicarbonate** ions, and delivers it to the duodenum.

Concept Check 2

On the Figure 6 diagram, locate the following **anatomical organs** and consider how these organs **support** the digestive process:

- Liver
- Pancreas
- Gallbladder

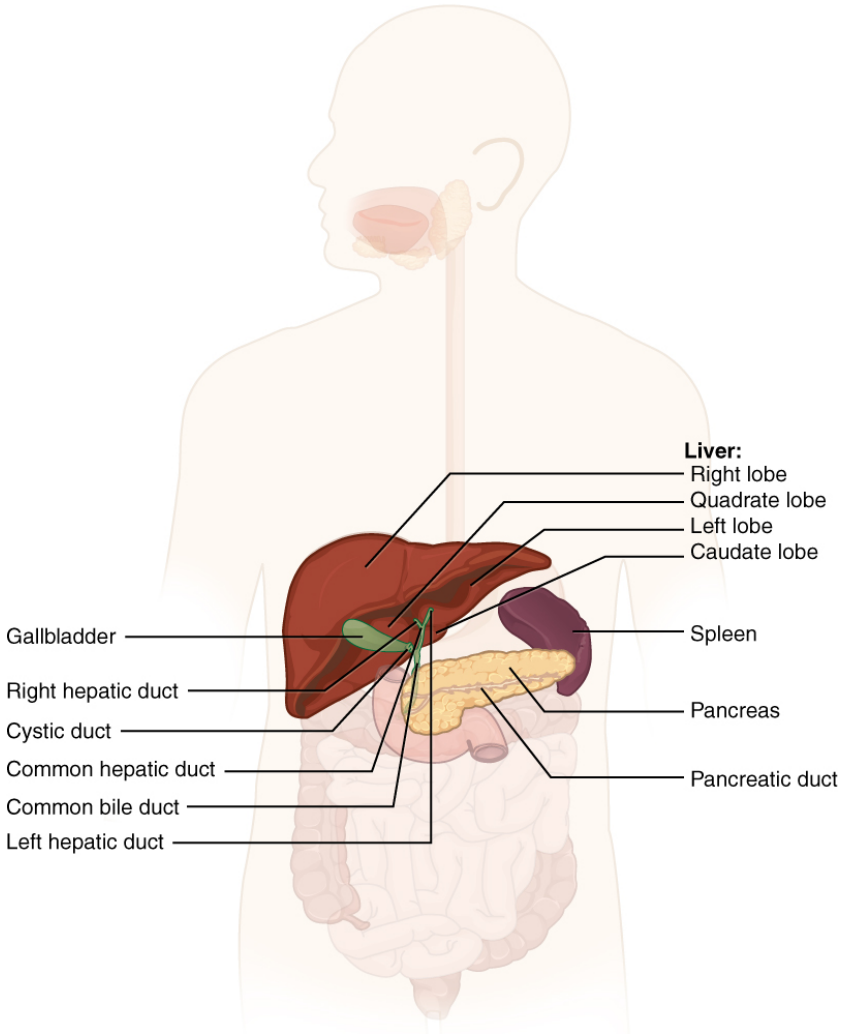


Figure 12.8 Accessory Organs. The liver, pancreas, and gallbladder are considered accessory digestive organs, but their roles in the digestive system are vital. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 12.8 Image description.]

Liver

The **liver** is the largest gland in the body, weighing about three pounds in an adult. It is also one of the most important organs. In addition to being an accessory digestive organ, it plays a number of roles in metabolism and regulation. The liver lies inferior to the diaphragm in the right upper quadrant of the abdominal cavity and receives protection from the surrounding ribs.

The liver is divided into two primary lobes: a large right lobe and a much smaller left lobe. In the right lobe, some anatomists also identify an inferior **quadrate** lobe and a posterior caudate lobe, which are defined by internal features. The liver is connected to the abdominal wall and diaphragm by five peritoneal folds referred to as ligaments.

The **porta hepatis** ("gate to the liver") is where the **hepatic artery** and **hepatic portal vein** enter the liver. These

two vessels, along with the common hepatic duct, run behind the lateral border of the lesser omentum on the way to their destinations. The hepatic portal vein delivers partially deoxygenated blood containing nutrients absorbed from the small intestine and actually supplies more oxygen to the liver than do the much smaller hepatic arteries. In addition to nutrients, drugs and toxins are also absorbed. After processing the bloodborne nutrients and toxins, the liver releases nutrients needed by other cells back into the blood, which drains into the central vein and then through the hepatic vein to the inferior vena cava. With this **hepatic** portal circulation, all blood from the alimentary canal passes through the liver. This largely explains why the liver is the most common site for the metastasis of cancers that originate in the alimentary canal.

Bile produced by the liver is a mixture secreted by the liver to accomplish the **emulsification** of lipids in the small intestine.

Bilirubin, the main bile pigment, is a waste product produced when the spleen removes old or damaged red blood cells from circulation. These breakdown products, including proteins, iron, and toxic bilirubin, are transported to the liver via the splenic vein of the hepatic portal system. In the liver, proteins and iron are recycled, whereas bilirubin is excreted in the bile. It accounts for the green color of bile. Bilirubin is eventually transformed by intestinal bacteria into stercobilin, a brown pigment that gives your stool its characteristic color! In some disease states, bile does not enter the intestine, resulting in white ('acholic') stool with a high fat content, since virtually no fats are broken down or absorbed.

Between meals, bile is produced but conserved. The valve-like hepatopancreatic ampulla closes, allowing **bile** to divert to the gallbladder, where it is concentrated and stored until the next meal.

Pancreas

The soft, oblong, glandular **pancreas** lies transversely in the retroperitoneum behind the stomach. Its head is nestled into the "c-shaped" curvature of the duodenum with the body extending to the left about 15.2 cm (6 in) and ending as a tapering tail in the **hilum** of the spleen. It is a curious mix of **exocrine** (secreting digestive enzymes) and endocrine (releasing hormones into the blood) functions (Figure 12.9).

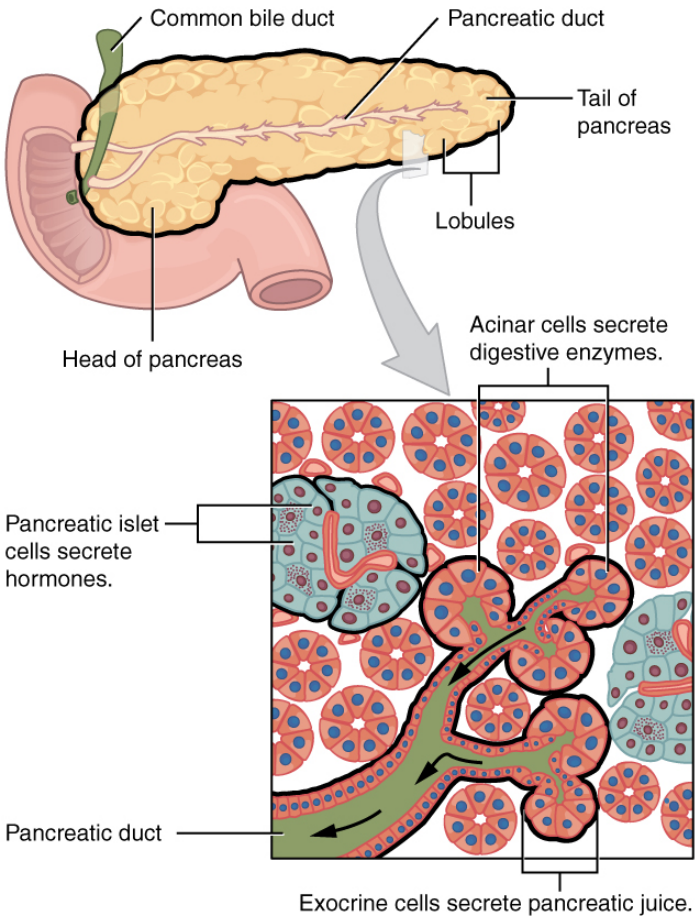


Figure 12.9 Exocrine and Endocrine Pancreas. The pancreas has a head, a body, and a tail. It delivers pancreatic juice to the duodenum through the pancreatic duct. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 12.9 Image description.]

The exocrine part of the pancreas arises as little grape-like cell clusters, each called an **acinus** (plural = acini), located at the terminal ends of pancreatic ducts. These acinar cells secrete enzyme-rich **pancreatic juice** into tiny merging ducts that form two dominant ducts. The larger duct fuses with the common bile duct (carrying bile from the liver and gallbladder) just before entering the duodenum via a common opening (the hepatopancreatic ampulla). The smooth muscle sphincter of the hepatopancreatic **ampulla** controls the release of pancreatic juice and bile into the small intestine. The second and smaller pancreatic duct, the **accessory duct** (duct of Santorini), runs from the pancreas directly into the duodenum, approximately 1 inch above the hepatopancreatic ampulla. When present, it is a persistent remnant of pancreatic development.

Scattered through the sea of exocrine acini are small islands of endocrine cells, the islets of Langerhans. These vital cells produce the hormones pancreatic polypeptide, insulin, glucagon, and somatostatin.

Gallbladder

The **gallbladder** is 8–10 cm (~3–4 in) long and is nested in a shallow area on the posterior aspect of the right lobe of the liver. This muscular sac stores, concentrates, and, when stimulated, propels the bile into the duodenum via the common bile duct. It is divided into three regions. The **fundus** is the widest portion and tapers medially into the body, which in turn narrows to become the neck. The neck angles slightly superiorly as it approaches the hepatic duct. The cystic duct is 1–2 cm (less than 1 in) long and turns inferiorly as it bridges the neck and hepatic duct.

The simple columnar epithelium of the gallbladder mucosa is organized in rugae, similar to those of the stomach. There is no submucosa in the gallbladder wall. The wall's middle, muscular coat is made of smooth muscle fibers. When these fibers contract, the gallbladder's contents are ejected through the **cystic duct** and into the bile duct (Figure 12.10). Visceral peritoneum reflected from the liver capsule holds the gallbladder against the liver and forms the outer coat of the gallbladder. The gallbladder's mucosa absorbs water and ions from bile, concentrating it by up to 10-fold (Betts et al., 2013).

Concept Check 3

- Locate the **cystic duct** on the diagram shown.
- Consider what **complications** could arise if this duct was blocked or obstructed.

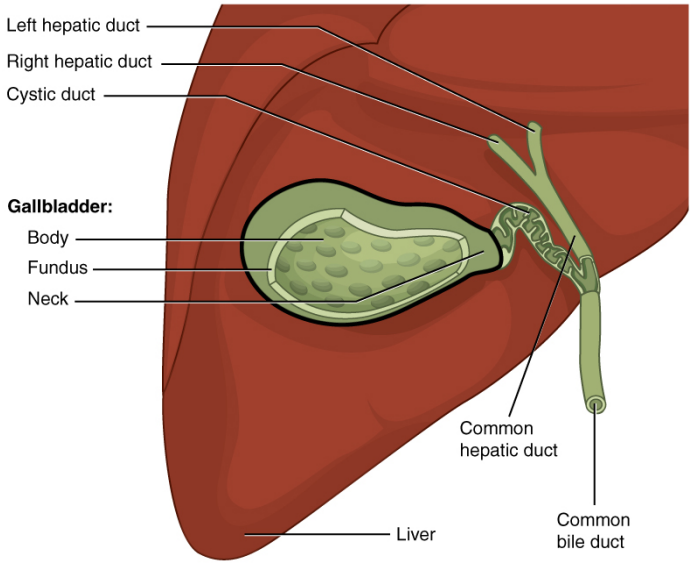


Figure 12.10 Gallbladder. The gallbladder stores and concentrates bile, and releases it into the two-way cystic duct when it is needed by the small intestine. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 12.10 Image description.]

Watch the following video to see the structure of the liver and how this structure supports the functions of the liver, including the processing of nutrients, toxins, and wastes. At rest, about 1500 mL of blood per minute flow through the liver. What percentage of this blood flow comes from the hepatic portal system? (Betts et al., 2013).

Watch How the Body Works: The Architecture of the Liver (1 min) on YouTube

Check Your Knowledge of the Digestive System

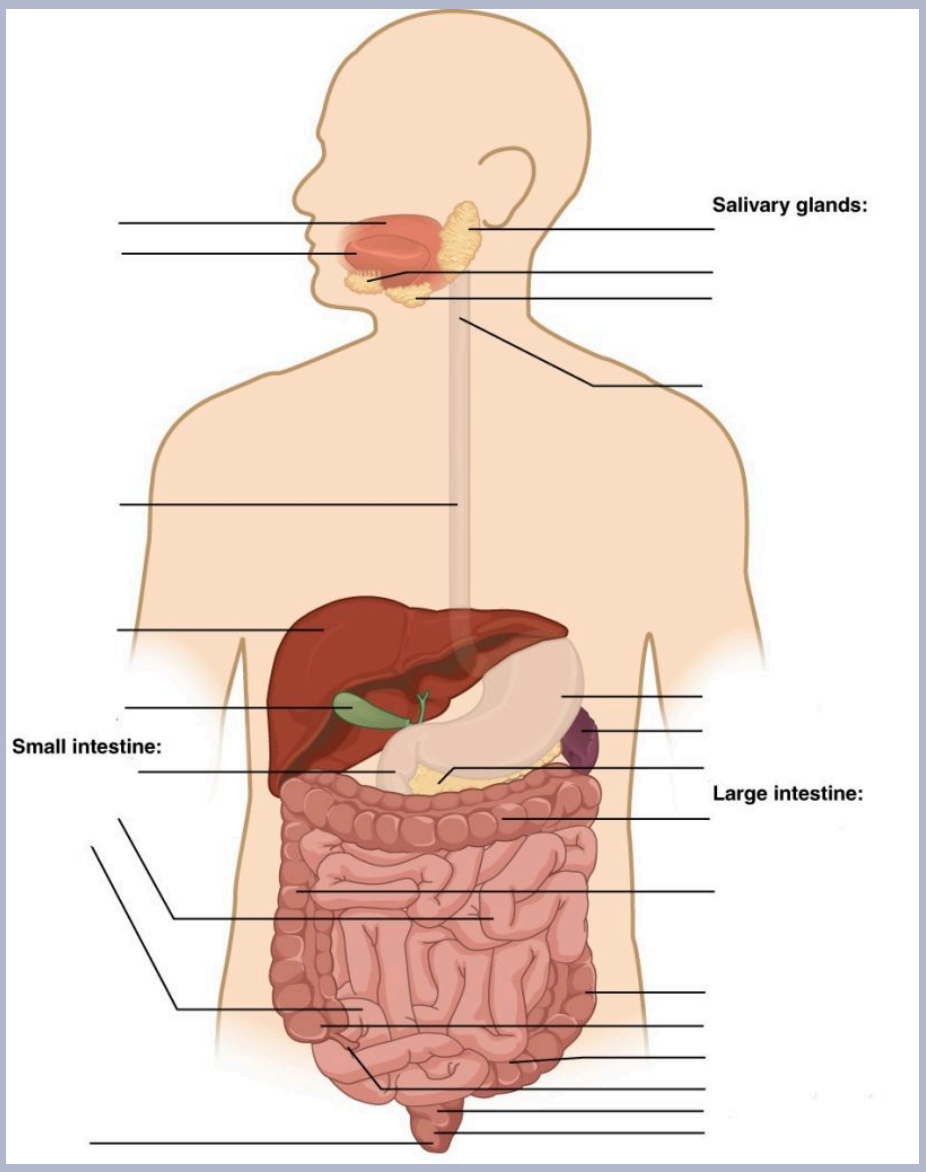
Anatomy Labeling Activity

Digestive System Anatomy (Text Version)

Label the diagram with correct words listed below:

1. Gallbladder
2. Mouth
3. Jejunum

4. Tongue
5. Ileum
6. Sigmoid colon
7. Liver
8. Submandibular gland
9. Anal canal
10. Parotid gland
11. Descending colon
12. Duodenum
13. Esophagus
14. Tranverse colon
15. Pharynx
16. Anus
17. Sublingual gland
18. Ascending colon
19. Cecum
20. Stomach
21. Spleen
22. Rectum
23. Appendix
24. Pancreas



Digestive System Anatomy Diagram (Text Version)

This diagram shows an anterior view of the head and torso of the human body with the anatomical organs and structures comprising the digestive system identified. From the top working clockwise. Located in the mouth or oral cavity are three glands which secrete saliva containing enzymes to aid in digestion these include: _____[Blank 1], _____[Blank 2], and the _____[Blank 3]. When the ingested food is ready to leave the mouth, it is transferred to the throat to swallow, the throat is also

known as the _____[Blank 4]. The _____[Blank 5] is a muscular hollow organ which aids in the digestive process by breaking down food for digestion. While the _____[Blank 6] located under the left portion of the diaphragm, helps to filter blood. The _____[Blank 7] is an accessory organ responsible for producing a hormone known as insulin and insulin is critical in the metabolism of sugars. The large intestines have many structural components _____[Blank 8],_____[Blank 9], _____[Blank 10], _____[Blank 11], and _____[Blank 12] with these structures responsible for the final stage of digestion known as elimination. A small finger-like projections hangs from the cecum known as the _____[Blank 13] and this structure has a role in the development of the immune system in early human development. As a continuation of the sigmoid colon a hollow structure known as the _____[Blank 14] is identified. Next, is the final segment of the digestive system and is a structure measuring about 3 to 4 cm long known as the _____[Blank 15]. Fecal matter is expelled through the terminal opening in the digestive system called the _____[Blank 16]. The small intestines divided into three distinct parts; the is the third part _____[Blank 17], the _____[Blank 18] is the second part, and the _____[Blank 19] is the first part. The _____[Blank 20] is an accessory organ of digestion and is responsible for storing bile for when it is needed to breakdown fats in the process of digestion. The _____[Blank 21] located in the upper right side of the abdomen is responsible for producing the bile to send to the gallbladder for storage until it the bile is released. The _____[Blank 22] connects the pharynx to the stomach it is responsible for gently moving the food from the pharynx to the stomach. The _____[Blank 23] located in the mouth is responsible for moving the food around in the mouth during the chewing or mastication process. The _____[Blank 24] also known as the oral cavity contains the saliva glands, the teeth and tongue and begins the process of digestion.

Check your answers [1]

Activity source: Digestive System 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.

Image Descriptions

Figure 12.2 image description: This diagram shows an anterior view of the structure of the mouth. The teeth, lips, tongue, gums and many other parts are labeled. Labels read (clockwise from top): superior lip, superior labial frenulum, gingivae, palatoglossal arch, fauces, palatopharyngeal arch, palatine tonsil, tongue, lingual frenulum, opening duct of submandibular gland, gingivae, inferior labial frenulum, inferior lip, oral vestibule, incisors, cuspid, premolars, molars, cheek, uvula, soft palate, hard palate. [Return to Figure 12.2].

Figure 12.3 image description: This diagram shows the structures of the tongue and lingual papillae. Labels read (from top): epiglottis, palatopharyngeal arch, palatine tonsil, lingual tonsil, palatoglossal arch, terminal sulcus, foliate papillae, circumvallate papilla, dorsum of tongue, fungiform papilla, filiform papilla. [Return to Figure 12.3].

Figure 12.4 image description: This diagram shows the esophagus, going from the mouth to the stomach. The

upper and the lower esophageal sphincter are labeled. Labels read (from top): upper esophageal sphincter, trachea, esophagus, lower esophageal sphincter, stomach. [Return to Figure 12.4].

Figure 12.5 image description: This image shows a cross-section of the stomach, and the major parts: the cardia, fundus, body and pylorus are labeled. Labels read (from top of stomach): esophagus, muscular externa (longitudinal layer, circular layer, oblique layer), cardia, fundus, serosa, lesser and greater curvatures, lumen, rugae of mucosa, pyloric antrum, pyloric canal, pyloric sphincter valve at pylorus, duodenum. [Return to Figure 12.5].

Figure 12.6 image description: This diagram shows the small intestine. The different parts of the small intestine are labeled. Labels read (from top of small intestine): duodenum, jejunum, ileum, large intestine, rectum. [Return to Figure 12.6].

Figure 12.7 image description: This image shows the large intestine; the major parts of the large intestine are labeled. Labels read (from start of large intestinal tract): vermiform complex, cecum, ileum, ascending colon, transverse colon, right colic hepatic flexure, left colic splenic flexure, descending colon, sigmoid colon, rectum, anal canal. [Return to Figure 12.7].

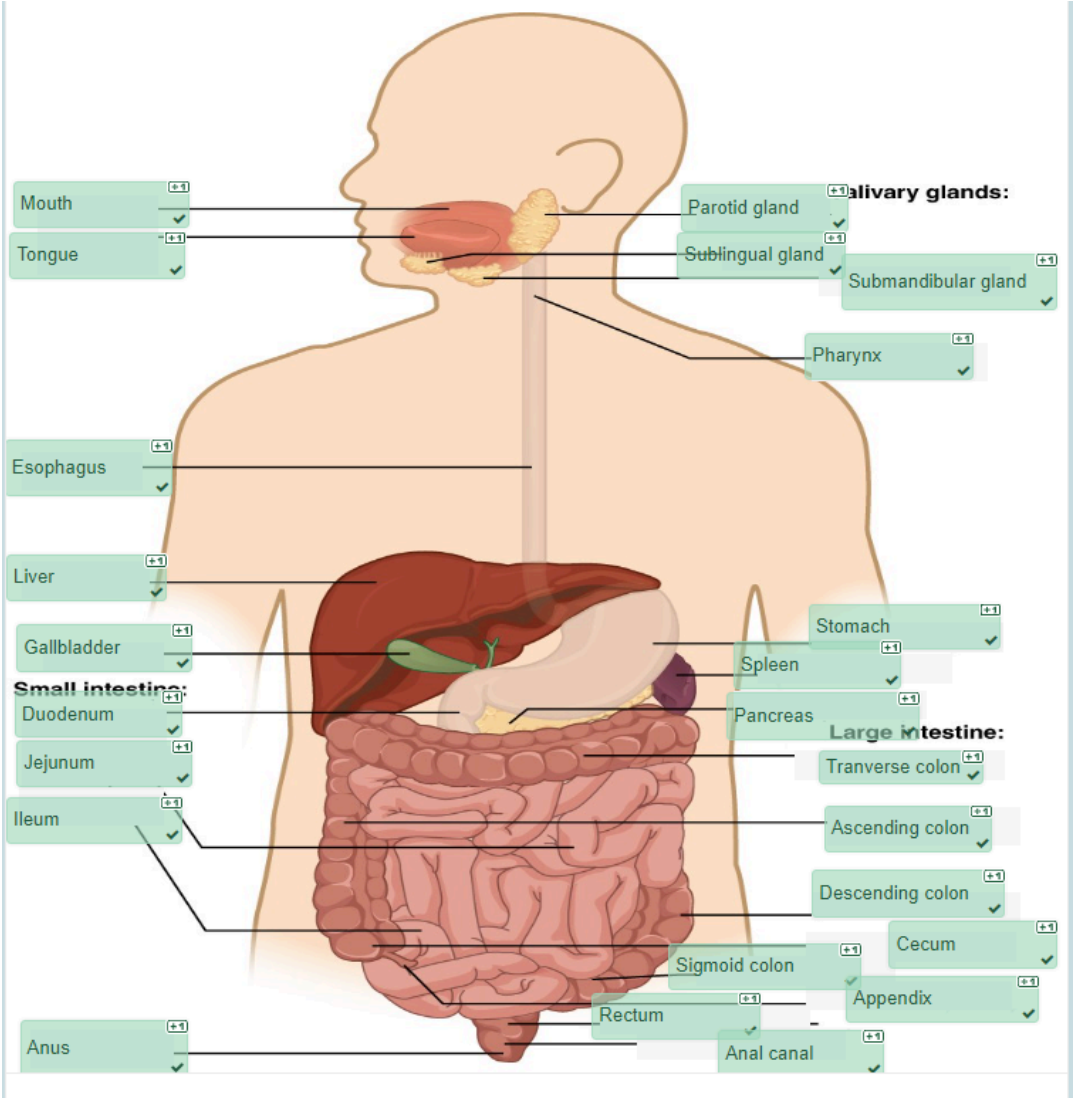
Figure 12.8 image description: This diagram shows the accessory organs of the digestive system. The liver, spleen, pancreas, gallbladder and their major parts are shown. Labels read: liver (right lobe, quadrate lobe, left lobe, caudate lobe), spleen, pancreas, pancreatic duct, gall bladder right hepatic duct, cystic duct, common hepatic duct, common bile duct, left hepatic duct. [Return to Figure 12.8].

Figure 12.9 image description: This figure shows the pancreas and its major parts Labels read (from left to right): common bile duct, head of pancreas, pancreatic duct, lobules, tail of pancreas. A magnified view of a small region of the pancreas shows the pancreatic islet cells, the acinar cells, exocrine cells, and the pancreatic duct. [Return to Figure 12.9].

Figure 12.10 image description: This figure shows the gallbladder and its major parts are labeled. Labels read (starting in gallbladder): body, fundus, neck, cystic duct, common hepatic duct, common bile duct, left and right hepatic ducts, liver. [Return to Figure 12.10].

Attribution

Notes

1. 

Check your answers: Digestive System Anatomy Diagram (Text Version) This diagram shows an anterior vies of the head and torso of the human body with the anatomical organs and structures comprising the digestive system identified. From the top working clockwise Located in the mouth or oral cavity are three glands which secrete saliva containing enzymes to aid in digestion these include: **parotid gland**, **sublingual gland**, and the **submandibular gland**. When the ingested food is ready to leave the mouth, it is transferred to the throat to swallow, the throat is also known as the **pharynx**. The **stomach** is a muscular hollow organ which aids in the digestive process by breaking down food for digestion. While the **spleen** located under the left portion of the diaphragm, helps to filter blood. The **pancreas** is an accessory organ responsible for producing a hormone known as insulin and insulin is critical in the metabolism of sugars. The large intestines have many structural components **transverse colon**, **ascending colon**, **descending colon**, **cecum**, and **sigmoid colon** with these structures responsible for the final stage of digestion known as elimination. A small finger-like projections hangs from the cecum known as the **appendix** and this structure has a role in the development of the immune system in early human development. As a continuation of the sigmoid colon a hollow structure known as the **rectum** is identified. Next, is the final segment of the digestive system and is a structure measuring about 3 to 4 cm long known as the **anal canal**. Fecal matter is expelled through the terminal opening in the digestive system called the **anus**. The small intestines divided into three distinct parts; the is the third part **ileum**, the **jejunum** is the second part, and the **duodenum** is the first part. The **gall bladder** is an accessory organ of digestion and is responsible for storing bile for when it is needed to breakdown fats in the process of digestion. The **liver** located in the upper right side of the abdomen is responsible for producing the bile to send to the gallbladder for storage until it the bile is released. The **esophagus** connects the pharynx to the stomach it is responsible for gently moving the food from the pharynx to the stomach. The **tongue** located in the mouth is responsible

for moving the food around in the mouth during the chewing or mastication process. The **mouth** also known as the oral cavity contains the saliva glands, the teeth and tongue and begins the process of digestion.

12.3 - Physiology (Function) of the Digestive System

The main functions of the digestive system are:

- Ingesting food
- Digesting food
- Absorbing nutrients
- Elimination of waste products

Digestive Processes

The processes of digestion include six activities: ingestion, **propulsion**, mechanical or physical digestion, chemical digestion, absorption, and **defecation**.

The first of these processes, **ingestion**, refers to the entry of food into the alimentary canal through the mouth. There, the food is chewed and mixed with saliva, which contains enzymes that begin breaking down the carbohydrates in the food plus some lipid digestion via lingual lipase. Chewing increases the surface area of the food and allows an appropriately sized bolus to be produced.

Food leaves the mouth when the tongue and pharyngeal muscles propel it into the esophagus. This act of swallowing, the last voluntary act until defecation, is an example of **propulsion**, which refers to the movement of food through the digestive tract. It includes both the voluntary process of swallowing and the involuntary process of peristalsis. **Peristalsis** consists of sequential, alternating waves of contraction and relaxation of alimentary wall smooth muscles, which act to propel food along (see Figure 12.11). These waves also play a role in mixing food with digestive juices. Peristalsis is so powerful that foods and liquids you swallow enter your stomach even if you are standing on your head.

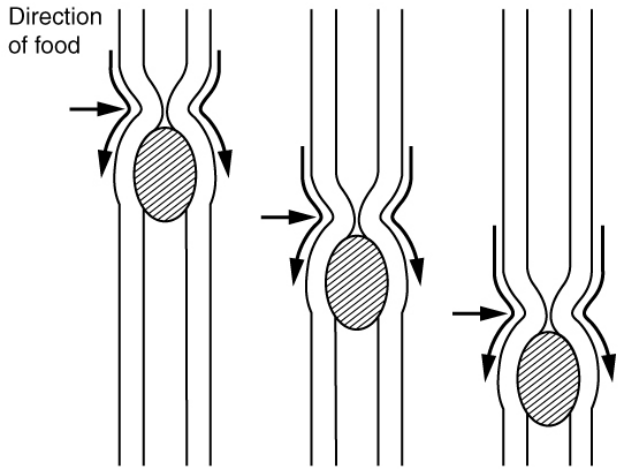


Figure 12.11. Peristalsis. Peristalsis moves food through the digestive tract with alternating waves of muscle contraction and relaxation. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 12.11 Image description.]

Digestion includes both mechanical and chemical processes. **Mechanical digestion** is a purely physical process that does not change the chemical nature of the food. Instead, it makes the food smaller to increase both surface area and mobility. It includes **mastication**, or chewing, as well as tongue movements that help break food into smaller bits and mix food with saliva. Although there may be a tendency to think that mechanical digestion is limited to the first steps of the digestive process, it occurs after the food leaves the mouth as well. The mechanical churning of food in the stomach serves to further break it apart and expose more of its surface area to digestive juices, creating an acidic "soup" called **chyme**. **Segmentation**, which occurs mainly in the small intestine, consists of localized contractions of circular muscle of the muscularis layer of the alimentary canal. These contractions isolate small sections of the intestine, moving their contents back and forth while continuously subdividing, breaking up, and mixing the contents. By moving food back and forth in the intestinal lumen, segmentation mixes food with digestive juices and facilitates absorption.

In **chemical digestion**, starting in the mouth, digestive secretions break down complex food molecules into their chemical building blocks (for example, proteins into separate amino acids). These secretions vary in composition but typically contain water, various enzymes, acids, and salts. The process is completed in the small intestine.

Food that has been broken down is of no value to the body unless it enters the bloodstream and its nutrients are put to work. This occurs through the process of **absorption**, which takes place primarily within the small intestine. There, most nutrients are absorbed from the lumen of the alimentary canal into the bloodstream through the epithelial cells that make up the mucosa. Lipids are absorbed into **lacteals** and are transported via the lymphatic vessels to the bloodstream.

In **defecation**, the final step in digestion, undigested materials are removed from the body as feces.

Digestive System: From Appetite Suppression to Constipation

Age-related changes in the digestive system begin in the mouth and can affect virtually every aspect of the digestive system. Taste buds become less sensitive, so food isn't as appetizing as it once was. A slice of pizza is a challenge, not a treat, when you have lost teeth, your gums are diseased, and your salivary glands aren't producing enough saliva. Swallowing can be difficult, and ingested food moves slowly through the alimentary canal because of reduced strength and tone of muscular tissue. **Neurosensory** feedback is also dampened, slowing the transmission of messages that stimulate the release of enzymes and hormones.

Pathologies that affect the digestive organs—such as **hiatal** hernia, **gastritis**, and **peptic ulcer** disease—can occur at greater frequencies as you age. Problems in the small intestine may include duodenal ulcers, **maldigestion**, and **malabsorption**. Problems in the large intestine include hemorrhoids, diverticular disease, and constipation. Conditions that affect the function of accessory organs—and their abilities to deliver pancreatic enzymes and bile to the small intestine—include jaundice, acute pancreatitis, cirrhosis, and gallstones.

In some cases, a single organ is in charge of a digestive process. For example, ingestion occurs only in the mouth and defecation only in the anus. However, most digestive processes involve the interaction of several organs and occur gradually as food moves through the alimentary canal (see Figure 12.12).

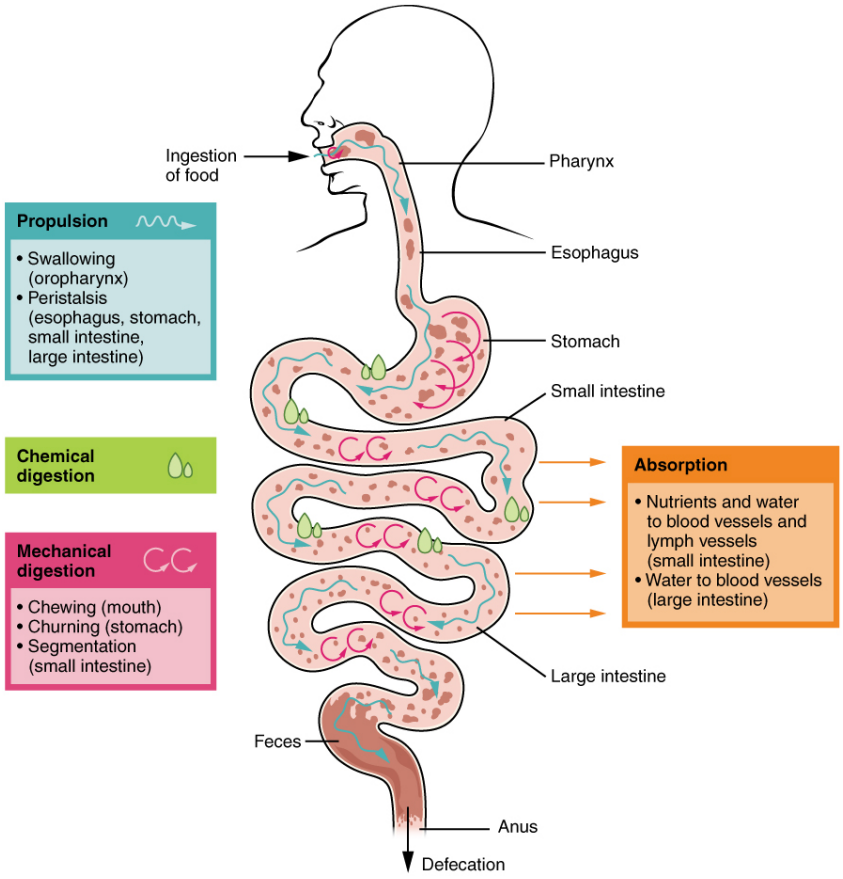


Figure 12.12. Digestive Processes. The digestive processes are ingestion, propulsion, mechanical digestion, chemical digestion, absorption, and defecation. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 12.12 Image description.]

Some chemical digestion occurs in the mouth. Some absorption can occur in the mouth and stomach, for example, alcohol and aspirin.

Regulatory Mechanisms

Neural and endocrine regulatory mechanisms work to maintain the optimal conditions in the lumen needed for digestion and absorption. These regulatory mechanisms, which stimulate digestive activity through mechanical and chemical activity, are controlled both extrinsically and intrinsically.

Watch Digestive System, Part 3: Crash Course Anatomy & Physiology #35 (11 min) on YouTube

Digestive System Medical Terms and Abbreviations

Medical Terms Not Easily Broken into Word Parts

Digestive System terms (Text Version)
Practice the following **digestive system** medical terms that are not easily broken into word parts.

1. **ascites**
    - abnormal intraperitoneal accumulation of fluid with large number of proteins and electrolytes
2. **hemorrhoids**
    - distended and swollen veins in the rectum and anus
3. **nausea**
    - urge to vomit
4. **stoma**
    - surgical opening between an organ and the surface of the body
5. **adhesion**

- band of scar tissue that binds anatomic surfaces to each other

6. **emesis**
    - vomiting
7. **cirrhosis**
    - chronic degenerative disease of the liver
8. **polyp**
    - small tumour-like growth that extends from the surface of a mucous membrane
9. **feces**
    - stool, fecal matter
10. **obesity**
    - abnormal increase in the proportion of fat cells resulting in excess body weight for height
11. **dysentery**
    - inflammation of the intestine presenting with abdominal pain and bloody diarrhea
12. **melena**
    - black tarry stool that contains blood from the GI tract
13. **flatus**
    - gas in the GI tract
14. **reflux**
    - abnormal backward flow
15. **palpate**
    - physical examination technique: The examiner feels for texture, size, consistency, and location of body parts with hands.

Common Digestive Abbreviations

Digestive System Abbreviations

- **APR** (abdominoperineal resection)
- **BE** (barium enema)
- **EGD** (esophagogastroduodenoscopy)
- **ERCP** (endoscopic retrograde cholangiopancreatography)
- **EUS** (endoscopic ultrasound)
- **FOBT** (fecal occult blood test)
- **GERD** (gastroesophageal reflux disease)
- **GI** (gastrointestinal)
- ***H.pylori*** (Helicobacter pylori)
- **IBS** (irritable bowel syndrome)
- **N&V** (nausea and vomiting)
- **PEG** (percutaneous endoscopic gastrostomy)
- **UC** (ulcerative colitis)
- **UGI** (upper gastrointestinal)
- **UPPP** (uvulopalatopharyngoplasty)

Image Descriptions

Figure 12.11 image description: This image shows the peristaltic movement of food. In the left image, the food bolus is towards the top of the esophagus and arrows pointing downward show the direction of movement of the peristaltic wave. In the center image, the food bolus and the wave movement are closer to the center of the esophagus and in the right image, the bolus and the wave are close to the bottom end of the esophagus. [Return to Figure 12.11].

Figure 12.12 image description: This image shows the different processes involved in digestion. The image shows how food travels from the mouth through the major organs. Associated textboxes list the various digestive processes: Absorption (nutrients and water to blood vessels and lymph vessels (small intestine), water to blood vessels (large intestine)), propulsion (swallowing (oropharynx), peristalsis (esophagus, stomach, small intestine, large intestine), chemical digestion, mechanical digestion (chewing (mouth), churning (stomach), segmentation

(small intestine)). Parts of the digestive tract are labelled: ingestion of food, pharynx, esophagus, stomach, small intestine, large intestine, feces, anus, defecation. [Return to Figure 12.12].

Attribution

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12.4 - Digestive Diseases, Disorders and Diagnostic Testing

Gastroesophageal Reflux Disease

This condition is largely caused by gastric acid flowing upwards from the stomach into the esophagus. Those suffering from the condition will often feel a burning sensation radiating near the top of the stomach (Mayo Clinic Staff, 2023). To learn more about GERD, visit the Mayo Clinic's Gastroesophageal Reflux Disease (GERD) page [New Tab].

Cholecystitis

This condition is known as inflammation of the gall bladder. Gallstone development can block the gall bladder's release of bile leading to an inflammatory response. Surgical removal (cholecystectomy) or laser stone crushing known as lithotripsy are often the treatment options ("Cholecystitis", 2023). To learn more about cholecystitis, visit the Radiology Info's cholecystitis web page [New Tab].

Cirrhosis

Cirrhosis is a condition whereby the liver scars. Advanced cirrhosis is life-threatening. It generally can not be reversed. It is caused by different forms of liver disease and chronic alcoholism (Mayo Clinic Staff, 2023).

Cirrhosis often has no signs or symptoms until liver damage is extensive and may include:

- Fatigue
- Easily bleeding or bruising
- Loss of appetite
- Nausea
- Edema
- Weight loss
- Itchy skin
- Jaundice
- Ascitis (Mayo Clinic Staff, 2023).

To learn more about cirrhosis, visit the Mayo Clinic's Cirrhosis web page [New Tab].

Esophageal Cancer

This is cancer of the esophagus. The cancer can occur anywhere along the esophageal tube, and can be caused by factors including tobacco use, alcohol, and chronic acid reflux (Canadian Digestive Health Foundation, 2020). To learn more about esophageal cancer, visit the CDHF's Esophageal Cancer web page [New Tab].

Hepatitis A, B and C

Inflammation of the liver is referred to as hepatitis. This condition can be caused by several factors such as viruses, alcohol consumption, toxins, and drug interactions. In some cases it can also be caused by an autoimmune response in the body. There are five types of viral hepatitis: A, B, C, D, and E (Booth, 2018). To learn more, visit Healthline's article on Hepatitis [New Tab].

Celiac Sprue (Celiac Disease)

Individuals with celiac disease have an immune sensitivity reaction occurring in the small intestines when they consume gluten. Typically, people with this condition are genetically predisposed to the condition. Damage to the small intestine will occur if continued consumption of gluten occurs. Once diagnosed, individuals eat a gluten-free diet as the best approach for the management of the condition (Celiac Disease Foundation, n.d.). To learn more, visit the Celiac Disease Foundation's *What is Celiac Disease?* article [New Tab].

Crohn's Disease and Ulcerative Colitis

Crohn's disease and ulcerative colitis are chronic inflammatory bowel diseases (IBD) whereby a section or segments of the digestive tract experience inflammation. Crohn's disease can occur anywhere along the digestive tract from the mouth to the anus, although it is most often found in the small intestines. This often leads to the malabsorption of nutrients from food. Ulcerative colitis is localized inflammation and ulcers in the colon (Crohn's and Colitis Canada, n.d.). To learn more, visit Crohn's and Colitis Canada's page about Crohn's and Colitis diseases [New Tab].

Colon Cancer

Colon cancer is a cancer formation in the colon portion of the digestive tract. It is typically found in older adults. Colon cancer is often diagnosed through a colonoscopy (Canadian Digestive Health Foundation, 2020). To learn more, visit the CDHF's page on colon cancer [New Tab].

Hernia

A hernia occurs when an organ or fatty tissue squeezes through a weak spot in a surrounding muscle or connective tissue. A hiatal hernia is found in the upper stomach region.

Irritable Bowel Syndrome

Irritable bowel syndrome (IBS) is a common disorder affecting the large intestines. IBS often involves abdominal pain as sensitive nerve tissue within the colon reacts to the movement of food and waste through the digestive tract. Along with the abdominal pain individuals often experience gas and bloating. Diet and lifestyle modifications often help in the management of the condition (Canadian Digestive Health Foundation, 2020). To learn more about irritable bowel syndrome, visit the CDHF's web page on IBS [New Tab].

Polyps

A polyp is a small growth of tissue protruding outward from the intestinal wall. Some cancers in the intestines start off as a polyp. Typically, they are found in people over the age of 50. Polyps start as a small collection of cells found within the colon. Most are harmless but can transition over time into cancerous growth (Mayo Clinic Staff, 2023). To learn more about polyps, review the Mayo Clinic's patient information page on polyps [New Tab].

Digestive System Medical Terms in Use

Digestive System – Consultation Report

Digestive System – Consultation Report (Text version)

Use the words below to fill in the consultation report:

1. diarrhea
2. treatment
3. electrolytes
4. Glucose
5. resists walking
6. session
7. vomiting
8. stools
9. eyes
10. gait

PATIENT NAME: Alex WEBB

AGE: 30

DOB: November 10

SEX: Male
CONSULTANT: Louis D. Wainwright, MD, Gastroenterology
REQUESTING PHYSICIAN: Trevor Sharpe, MD, Family Medicine

REASON FOR CONSULTATION: Please evaluate GI distress.

I was asked to see this 30-year old male in consultation because of unremitting nausea, _____[Blank 1], _____[Blank 2], abdominal pain, dizziness, and low-grade fever. The patient has a poor appetite but reports no weight loss. He has noted some postprandial cramping, midepigastric pain, and unremitting diarrhea but no blood in the _____[Blank 3]. He states he is "healthier," but he still has some dizziness.

Initial treatment consisted of IV fluids and control of _____[Blank 4]. Thereafter, the patient was progressed to clear fluids and soft diet. He has done well on this routine; however, his dizziness has persisted. Fever has resolved.

On admission, the patient's lab data revealed CBC with hematocrit of 142, hemoglobin 25 with differential of neutrophils 51%, bands 8%, lymphocytes 26%, monocytes 6%, basophils none. Serum electrolytes were normal. Potassium was low at 3.5, BUN: creatinine ratio was normal. _____[Blank 5] was within normal range. Stool studies were within normal.

On examination, I find the patient to be lethargic and uncomfortable with mild nausea and dizziness. He prefers to keep his eyes closed. On examination of the _____[Blank 6], I find no nystagmus. There is pallor to the skin, and he seems cool to the touch. Upon standing by the bedside, the patient is unsteady. Although he _____[Blank 7], when he attempts to walk, his _____[Blank 8] is halting, and he tends to fall to the left side. Abdomen is flat and nontender. Bowel sounds are WNL. Rectal exam deferred.

RECOMMENDATIONS: I think we should continue essential _____[Blank 9] of this gentleman. Because of the symptoms of dizziness on admission, we may want to consider a CT scan to rule out an intracerebral bleed or subdural hematoma. My opinion at this time is that we are dealing with a resolving _____[Blank 10] of gastritis.

Thank you for asking me to see this patient. I will be glad to follow him with you throughout his hospital stay.

_____
Louis D. Wainwright, MD, Gastroenterology

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]

Activity source: Digestive System – Consultation Report by Heather Scudder, from *Building a Medical*

Terminology Foundation by Kimberlee Carter and Marie Rutherford, licensed under CC BY- 4.0. / Text version added.

Digestive System – Operative Report

Digestive System – Operative Report (Text version)
Use the words listed below to fill in the operative report:

- esophagitis
- ulceration
- lateral
- stomach
- GE
- sporadic
- retroflexion
- bleeding
- antrum
- duodenum
- lidocaine
- duodenitis

PATIENT NAME: Bruce WEBSTER
AGE: 48
SEX: Male
DOB: September 23
DATE OF ADMISSION: July 2
DATE OF PROCEDURE: July 2
ADMITTING PHYSICIAN: Trevor Sharpe, MD, Family Medicine
SURGEON: Louis D. Wainwright, MD, Gastroenterology

PREOPERATIVE DIAGNOSIS: GI Bleed.
POSTOPERATIVE DIAGNOSES:

1. Severe _____[Blank 1].
2. Gastroesophageal _____[Blank 2].
3. No Significant bleeding seen in the stomach.

OPERATIVE PROCEDURE: Gastrointestinal endoscopy.
ANESTHESIA: _____[Blank 3] 1%.

PROCEDURE: The patient was placed into the left _____[Blank 4] position. A scope was introduced from the mouth, under visualization and advanced to the upper part of the _____[Blank 5], upper part of esophagus, middle of esophagus, _____[Blank 6] junction, and some _____[Blank 7] bleeding was seen at the GE junction. The scope was moved through the upper part of the stomach into the _____[Blank 8]. The _____[Blank 9] showed some inflammation and the scope was then brought out. _____[Blank 10] was not performed. The scope was then brought back slowly. Mild _____[Blank 11] was also seen and a little bit of ulceration noted at GE junction.

CONCLUSION: Severe esophagitis, may be some source of _____[Blank 12] from there, but no active bleeding at this time.

_____
Louis D. Wainwright, MD, Gastroenterology

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]

Activity source: Digestive System – Operative Report by Heather Scudder, from *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY- 4.0. /Text version added.

Medical Specialties and Procedures Related to the Digestive System

Gastroenterology

This specialty is focused on the diagnosis and treatment of conditions afflicting the digestive system. Gastroenterology is a branch of internal medicine. A physician who specializes in this area is known as a gastroenterologist (Canadian Medical Association, 2019). To learn more about gastroenterology, visit the Canadian Medical Association's Gastroenterology profile page [PDF].

Procedures

Upper and Lower Gastrointestinal Series

This is a diagnostic procedure involving the introduction of a contrast medium known as barium. Barium can be introduced by ingesting or by enema. After induction of the barium, x-rays can be taken of the upper and lower gastrointestinal system structures (Johns Hopkins Medicine, 2020). To learn more, visit Johns Hopkins Medicine's web page on barium x-rays [New Tab].

Fecal Occult Blood Test

This is a test for hidden blood in a fecal sample. A patient is provided with a card to place a small segment of fecal output. The sample is viewed under a microscope to look for blood. Blood detection can be an indicator of an abnormal growth occurring in the intestines (Johns Hopkins Medicine, 2020).

Stool Culture

This procedure involves the collection of a small sample of feces which is analyzed for abnormal bacterial growth through a culture check (Johns Hopkins Medicine, 2020).

Esophagogastroduodenoscopy

An EGD (upper endoscopy) is a procedure by which a physician examines the upper gastrointestinal tract (esophagus, stomach, duodenum) using a special instrument called an endoscope. The physician examines the tissues and is able to take a biopsy, if needed (Johns Hopkins Medicine, 2020).

Attribution

Notes

1. 1.diarrhea, 2.vomiting, 3.stools, 4. electrolytes, 5.Glucose, 6.eyes, 7.resists walking, 8.gail 9.treatment, 10.session
2. 1. esophagitis, 2.ulceration, 3. lidocaine, 4.lateral, 5.stomach, 6.GE, 7.sporadic, 8.antrum, 9.duodenum, 10.retroflexion, 11.duodenitis, 12.bleeding

Vocabulary & Check Your Knowledge

Digestive System Vocabulary

Ampulla

A sac-like enlargement of a canal or duct.

Bicarbonate

A by-product of the body's metabolism.

Carbohydrates

The sugars, starches and fibers found in fruits, grains, vegetables and milk products.

Convex

Curved outwards.

Distal

Away from the center of the body or from the point of attachment.

Emulsification

The process of breaking down the fat into smaller blood cells which makes it easy for enzymes to function and digest food.

Exocrine

To secrete externally, directly or through a duct.

Fundus

A part of a hollow organ.

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.

Labia

Lips of the mouth.

Lacteals

The lymphatic vessels of the small intestine which absorb digested fats.

Lingual Tonsils

A collection of lymphatic tissue located in the lamina propria of the root of the tongue.

Lymphoid

Resembling lymph or lymphatic tissues.

Malabsorption

A disorder that occurs when people are unable to absorb nutrients from their diets.

Maldigestion

Poor breakdown of food.

Nasal Cavity

The inside of your nose.

Neurosensory

Relating to afferent nerves.

Omentum

Fatty tissue that stretches over the abdomen, plays a role in immune response and the growth of certain cancers.

Palatine Tonsils

A pair of soft tissue masses located at the rear of the throat (pharynx).

Proximal

Situated nearer to the center of the body or the point of attachment.

Pyloric Sphincter

A band of smooth muscle at the junction between the pylorus of the stomach and the duodenum of the small intestine.

Quadrate

A square or rectangular shape.

Stratified Squamous Epithelium

Cells arranged in layers upon a basal membrane.

Digestive System Glossary Reinforcement Activity

Digestive System Glossary Reinforcement Activity (Text version)

1. _____ [Blank 1] is a band of smooth muscle at the junction between the pylorus of the stomach and the duodenum of the small intestine.

    a. Ampulla
    b. Quadrate
    c. Pyloric sphincter

2. Fatty tissue that stretches over the abdomen, plays a role in immune response and the growth of certain cancers is called _____[Blank 2].

    a. Fundus
    b. Convex
    c. Omentum

3. The process of breaking down the fat into smaller blood cells which makes it easy for enzymes to function and digest food is called _____[Blank 3].

    a. Bicarbonate
    b. Malabsorption
    c. Emulsification

4. _____[Blank 4] is the location where the diaphragm has a small opening through which the esophagus passes before connecting.

    a. Hiatal
    b. Lacteals
    c. Hilum

5. Situated nearer to the center of the body or the point of attachment is the _____ [Blank 5].

    a. Proximal
    b. Distal
    c. Quadrate

Check your answers: [1]

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Notes

1. 1. Pyloric sphincter, 2. Omentum, 3. Emulsification, 4. Hiatal, 5. Proximal,

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CHAPTER 13: SKELETAL 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.

13.1 - Introduction to the Skeletal System

Learning Objectives

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

Skeletal System Word Parts

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

Prefix

- **a-** (absence of, without)
- **ab-** (away from)
- **ad-** (towards)
- **brady-** (slow)
- **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

- **ankyl/o** (stiff, bent)
- **aponeur/o** (aponeurosis)
- **arthr/o** (joint)
- **burs/o** (bursa)
- **carp/o** (carpals, wrist)
- **chondr/o** (cartilage)
- **clavic/o** (clavicle, collarbone)
- **clavicul/o** (clavicle, collarbone)
- **cost/o** (ribs)
- **crani/o** (cranium)
- **disk/o** (intervertebral disk)
- **femor/o** (femur, upper leg bone)
- **fibul/o** (fibula, lower leg bone)
- **humer/o** (humerus, upper arm bone)
- **ili/o** (ilium)
- **ischi/o** (ischium)
- **kinesi/o** (movement, motion)
- **kyph/o** (increased convexity of the spine)
- **lord/o** (bent forward, increased concavity of the spine)
- **lumb/o** (loin, lumbar region of the spine)
- **mandibul/o** (mandible, lower jawbone)
- **maxill/o** (maxilla, upper jawbone)
- **menisc/o** (meniscus, crescent)
- **myel/o** (spinal cord)
- **oste/o** (bone)
- **patell/o** (patella, kneecap)
- **pelv/i** (pelvis, pelvic bone)
- **pelv/o** (pelvis, pelvic bone)
- **petr/o** (stone)
- **phalang/o** (phalanges, bones of finger and toes)
- **pub/o** (pubis)
- **rachi/o** (vertebral spine, vertebral column)
- **radi/o** (nerve root)
- **scapul/o** (scapula, shoulder blade)
- **scoli/o** (crooked, curved)
- **spondyl/o** (vertebra, spine, vertebral column)
- **stern/o** (sternum, breastbone)
- **tars/o** (tarsals, ankle bones)
- **ten/o** (tendon)

- **tendin/o** (tendon)
- **tend/o** (tendon)
- **tibi/o** (tibia, lower leg bone)
- **uln/o** (ulna, lower arm bone)
- **vertebr/o** (vertebra, spine, vertebral column)

Suffix

- **-al** (pertaining to)
- **-algia** (pain)
- **-ar** (pertaining to)
- **-asthenia** (weakness)
- **-centesis** (surgical puncture to aspirate fluid)
- **-clasia** (break)
- **-clasis** (break)
- **-clast** (break)
- **-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)
- **-malacia** (softening)
- **-oid** (resembling)
- **-oma** (tumour)
- **-sis** (abnormal condition)
- **-penia** (abnormal reduction)
- **-physis** (growth)
- **-plasty** (surgical repair)
- **-rrhaphy** (suturing, repairing)
- **-sarcoma** (malignant tumour)
- **-schisis** (split, fissure)
- **-scopy** (process of viewing, visual examination)
- **-tomy** (incision, cut into)
- **-trophy** (nourishment, development)

Introduction to the Skeletal System

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

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

Watch [The Skeletal System: Crash Course Anatomy & Physiology #19 (11 min) on YouTube]

Skeletal System Medical Terms

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

1. **ulnoradial**
    - uln/o/radi/al
    - pertaining to the ulna and radius
2. **tarsectomy**
    - tars/ectomy
    - excision of the tarsal
3. **osteocyte**
    - oste/o/cyte
    - bone cell
4. **cranioschisis**
    - crani/o/schisis
    - fissure of the cranium

5. **carpectomy**
    - carp/ectomy
    - excision of a carpal (wrist)
6. **chondroplasty**
    - chondr/o/plasty
    - surgical repair of cartilage
7. **cranioplasty**
    - crani/o/plasty
    - surgical repair of the cranium
8. **pelvisacral**
    - pelv/i/sacr/al
      pertaining to the pelvis and sacrum
9. **subscapular**
    - sub/scapul/ar
    - pertaining to below the scapula
10. **tenosynovitis**
    - ten/o/synov/itis
    - inflammation of the tendon and synovial membrane
11. **sarcopenia**
    - arc/o/penia
    - abnormal reduction of connective tissue presenting as skeletal muscle mass loss and loss of strength
12. **tibial**
    - tibi/al
    - pertaining to the tibia
13. **discitis**
    - disc/itis
    - Inflammation of the intervertebral disk
14. **phalangectomy**
    - phalang/ectomy
    - excision of the phalanges

15. **sternoclavicular**
    - stern/o/clavicul/ar
    - pertaining to sternum and clavicle
16. **humeral**
    - humer/al
    - pertaining to the humerus
17. **arthralgia**
    - arthr/algia
    - painful joint
18. **lumbosacral**
    - lumb/o/sacr/al
    - pertaining to the lumbar region of the spine and sacrum
19. **hyperkinesia**
    - hyper/kines/ia
    - condition of excessive movement
20. **radial**
    - radi/al
    - pertaining to radius
21. **vertebroplasty**
    - vertebr/o/plasty
    - surgical repair of the vertebral column
22. **arthrodesis**
    - arthr/o/desis
    - surgical fixation of a joint
23. **rachischisis**
    - rach/ischisis
    - fissure of vertebral column
24. **pubic**
    - pub/ic
    - pertaining to pubis
25. **intercostal**

- inter/cost/al
- pertaining to between the ribs

26. **osteopetrosis**

    - oste/o/petr/osis
    - abnormal condition of stone-like bones

27. **ankylosis**

    - ankyl/osis
    - abnormal condition of stiffness

28. **sternoid**

    - stern/oid
    - resembling the sternum

29. **chondrectomy**

    - chondr/ectomy
    - excision of cartilage

30. **osteonecrosis**

    - oste/o/necr/osis
    - abnormal condition of bone death (lack of blood supply)

31. **synovial sarcoma**

    - synovi/al sarcoma
    - malignant tumor pertaining to the synovial membrane

32. **dystrophy**

    - dys/trophy
    - abnormal development

33. **synovectomy**

    - synov/ectomy
    - excision of the synovial membrane

34. **osteopenia**

    - oste/o/penia
    - abnormal reduction of bone mass

35. **kyphosis**

    - kyph/osis

- abnormal condition of convexity of the spine

36. **osteitis**
    - oste/itis
    - inflammation of bone
37. **hypertrophy**
    - hyper/trophy
    - excessive development
38. **spondylosis**
    - spondyl/osis
      abnormal condition of the vertebrae
39. **spondylarthritis**
    - spondyl/arthr/itis
    - inflammation of the vertebra and joint
40. **cranial**
    - crani/al
    - pertaining to the cranium
41. **osteoclasis**
    - oste/o/clasis
      surgical breaking of a bone
42. **costochondral**
    - cost/o/chondr/al
    - pertaining to ribs and cartilage
43. **arthroscopy**
    - arthr/o/scopy
      process of viewing a joint
44. **pelvic**
    - pelv/ic
    - pertaining to pelvis, pevlic bone
45. **lumbar**
    - lumb/ar
    - pertaining to the lumbar region of the spine

46. **osteomyelitis**
    - oste/o/myel/itis
    - inflammation of bone and bone marrow
47. **osteoblast**
    - oste/o/blast
    - developing bone cell
48. **tenorrhaphy**
    - ten/o/rrhaphy
    - suturing of a tendon
49. **clavicular**
    - clavicul/ar
    - pertaining to the clavicle
50. **rachiotomy**
    - rachi/o/tomy
    - incision into the vertebral column
51. **intracranial**
    - intra/crani/al
    - pertaining to within the cranium
52. **tendinitis**
    - tendin/itis
    - inflammation of the tendon
53. **costectomy**
    - cost/ectomy
    - excision of rib(s)
54. **vertebrocostal**
    - vertebr/o/cost/al
    - pertaining to vertebrae and ribs
55. **bursectomy**
    - burs/ectomy
    - excision of bursa
56. **laminectomy**

- lamin/ectomy
- excision of the lamina

57. **craniotomy**

    - crani/o/tomy
    - incision into the cranium

58. **pubofemoral**

    - pub/o/femor/al
    - pertaining to pubic bone and femur

59. **submandibular**

    - sub/mandibul/ar
    - pertaining to under the mandible

60. **patellectomy**

    - patell/ectomy
    - excision of the kneecap

61. **lumbocostal**

    - lumb/o/cost/al
    - pertaining to the lumbar region of the spine and ribs

62. **intervertebral**

    - inter/vertebr/al
    - pertaining to between the vertebrae

63. **femoral**

    - femor/al
    - pertaining to the femur

64. **lordosis**

    - lord/osis
    - abnormal condition of increased concavity of the spine (bent forward)

65. **arthroplasty**

    - arthr/o/plasty
    - surgical repair of a joint

66. **iliofemoral**

    - ili/o/femor/al

- pertaining to the ilium and femur

67. **bursitis**

    - burs/itis
    - inflammation of the bursa

68. **arthrography**

    - arthr/o/graphy
    - process of recording a joint

69. **subcostal**

    - sub/cost/al
    - pertaining to below the ribs

70. **sternoclavicular**

    - stern/o/clavicul/ar
    - pertaining to the sternum and clavicle

71. **dyskinesia**

    - dys/kines/ia
    - condition of difficult movement

72. **bradykinesia**

    - brady/kines/ia
    - condition of slow movement

73. **sacral**

    - sacr/al
    - pertaining to the sacrum

74. **arthritis**

    - arthr/itis
    - inflammation of a joint

75. **diskectomy**

    - disk/ectomy
    - excision of the intervertebral disk

76. **maxillitis**

    - maxill/itis
    - inflammation of the maxilla

77. **suprapatellar**
    - supra/patell/ar
    - pertaining to above the knee cap
78. **ischiofibular**
    - ischi/o/fibul/ar
    - pertaining to the ischium and fibula
79. **tenomyoplasty**
    - ten/o/my/o/plasty
    - surgical repair of the tendon and muscle
80. **arthrocentesis**
    - arthr/o/centesis
    - surgical puncture to aspirate fluid from a joint
81. **osteosarcoma**
    - oste/o/sarcoma
    - malignant tumour of bone
82. **osteochondritis**
    - oste/o/chondr/itis
    - inflammation of bone and cartilage
83. **ostectomy**
    - ost/ectomy
    - excision of bone
84. **osteoarthritis**
    - oste/o/arthritis
    - inflammation of the bone and joint
85. **carpal**
    - carp/al
    - pertaining to carpal (wrist)
86. **chondromalacia**
    - chondr/o/malacia
    - softening of cartilage
87. **submaxillary**

- sub/maxill/ary
- pertaining to under the maxilla

88. **arthroclasia**
    - arthr/o/clasia
    - surgical breaking of a joint
89. **meniscitis**
    - menisc/itis
    - inflammation of the meniscus
90. **meniscectomy**
    - menisc/ectomy
    - excision of the meniscus
91. **maxillectomy**
    - maxill/ectomy
      excision of the maxilla
92. **substernal**
    - sub/stern/al
    - pertaining to below the sternum
93. **osteomalacia**
    - oste/o/malacia
    - softening of bone
94. **scoliosis**
    - scoli/osis
    - abnormal condition of (lateral) curved spine
95. **ulnoradial**
    - uln/o/radi/al
    - pertaining to the ulna and nerve root

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13.2 - Anatomy (Structures) of the Skeletal System

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

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

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

The Axial Skeleton

The **axial skeleton** forms the vertical, central axis of the body and includes all bones of the head, neck, chest, and back (see Figure 13.1). It serves to protect the brain, spinal cord, heart, and lungs. It also serves as the attachment site for muscles that move the head, neck, and back and for muscles that act across the shoulder and hip joints to move their corresponding limbs.

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

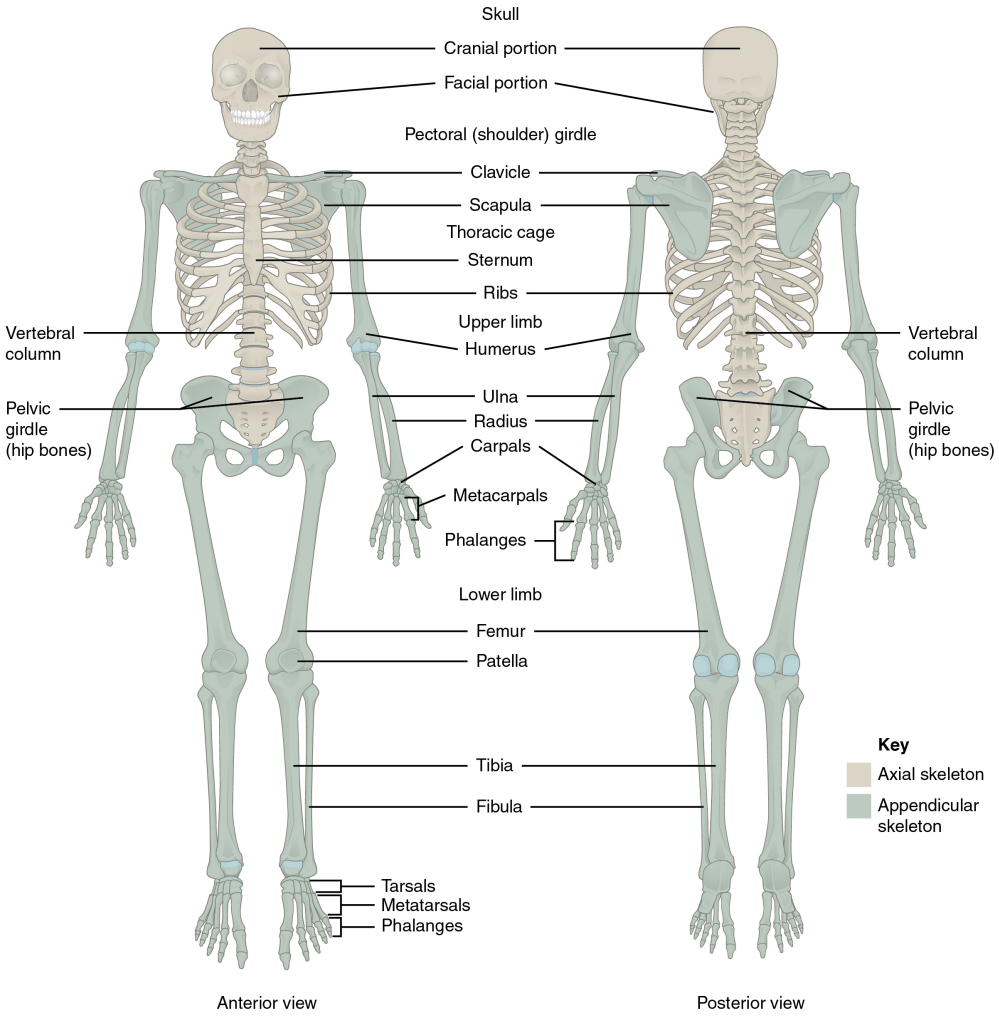


Figure 13.1 Axial and Appendicular Skeleton. The axial skeleton supports the head, neck, back, and chest and thus forms the vertical axis of the body. It consists of the skull, vertebral column (including the sacrum and coccyx), and the thoracic cage, formed by the ribs and sternum. The appendicular skeleton is made up of all bones of the upper and lower limbs. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 13.1 Image description.]

Did You Know 1?

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

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

Bones of the Skull

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

Bones of the Face

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

Bones of the Vertebral Column

The vertebral column is also known as the spinal column or spine (see Figure 13.2). It consists of a sequence of vertebrae (singular = vertebra), each of which is separated and united by an **intervertebral disc**. Together, the vertebrae and intervertebral discs form the vertebral column. It is a flexible column that supports the head, neck, and body and allows for their movements. It also protects the spinal cord, which passes down the back through openings in the vertebrae.

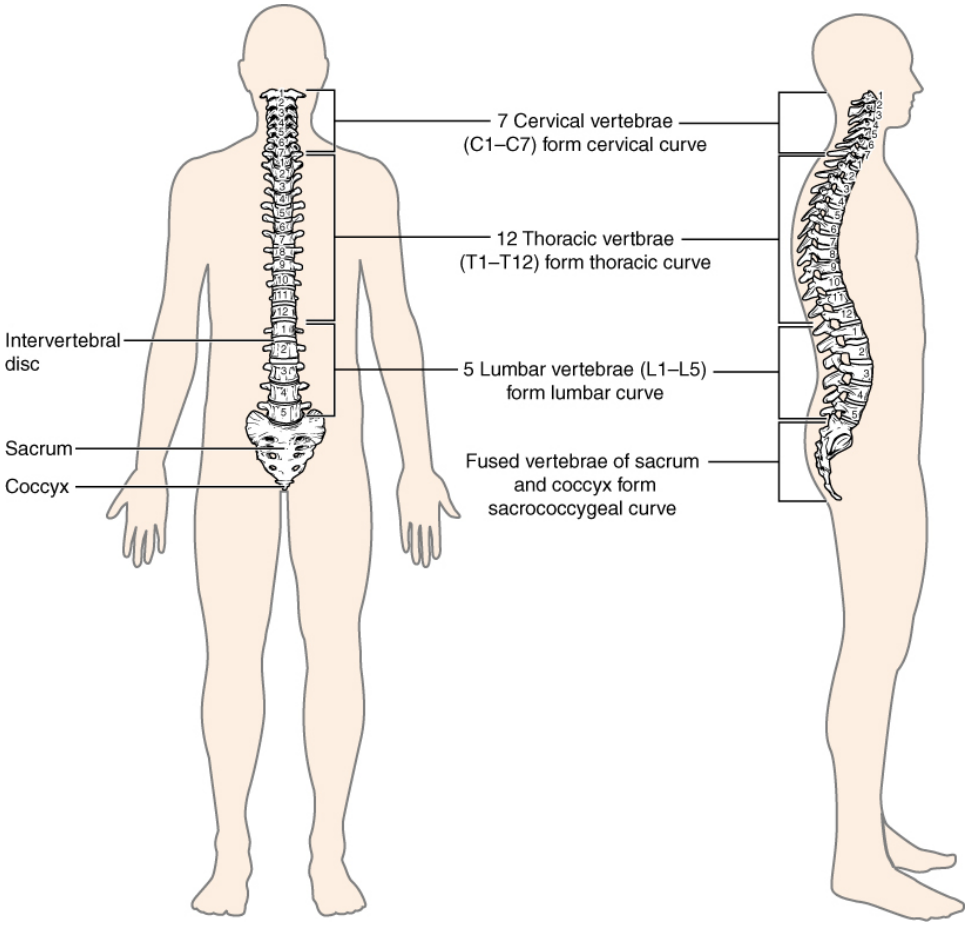


Figure 13.2 Vertebral Column. The adult vertebral column consists of 24 vertebrae, plus the sacrum and coccyx. The vertebrae are divided into three regions: cervical C1–C7 vertebrae, thoracic T1–T12 vertebrae, and lumbar L1–L5 vertebrae. The vertebral column is curved, with two primary curvatures (thoracic and sacrococcygeal curves) and two secondary curvatures (cervical and lumbar curves). From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 13.2 Image description.]

Types of Vertebrae

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

Bones of the Thoracic Cavity

The thoracic cage (rib cage) forms the thorax (chest) portion of the body. It consists of 12 pairs of ribs with their costal cartilages and the sternum (see Figure 13.3). The ribs are anchored posteriorly to the 12 thoracic vertebrae (T1–T12). The thoracic cage protects the heart and lungs.

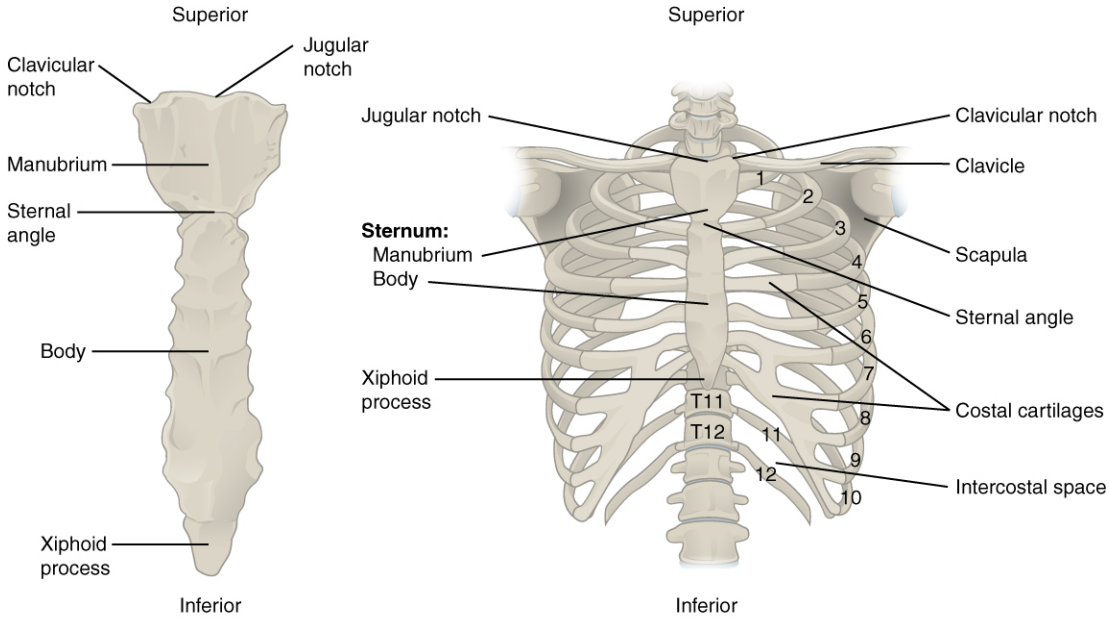


Figure 13.3 Thoracic Cage. The thoracic cage is formed by the (a) sternum and (b) 12 pairs of ribs with their costal cartilages. The ribs are anchored posteriorly to the 12 thoracic vertebrae. The sternum consists of the manubrium, body, and xiphoid process. The ribs are classified as true ribs (1–7) and false ribs (8–12). The last two pairs of false ribs are also known as floating ribs (11–12). From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 13.3 Image description.]

Ribs

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

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

Sternum

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

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

Concept Check 2

Answer the following questions:

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

The Appendicular Skeleton

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

Did You Know 2?

The appendicular skeleton has 126 bones. It is divided into the bones of the upper limbs and lower limb s that attach each limb to skeleton (Betts et al., 2013).

Bones of the Pectoral Girdle

- **Scapula**: the shoulder blades
- **Clavicle:** the collar bones. It connects the sternum to the scapula
- **Acromion:** the extension that forms the bony point of the shoulder

Bones of the Upper Limbs

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

Bones of the Arm

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

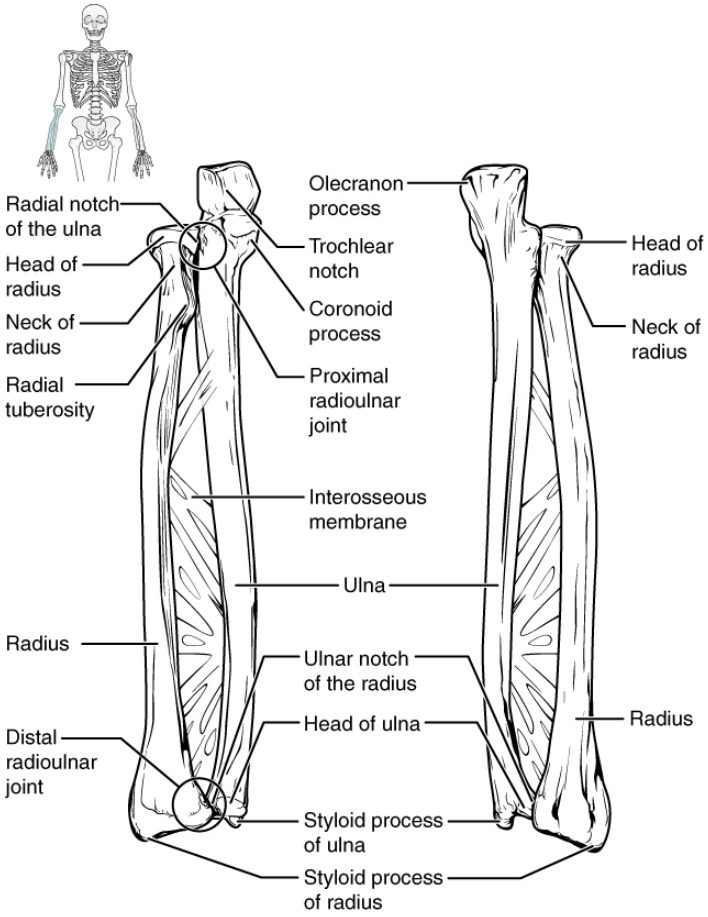


Figure 13.4 Ulna and Radius. The ulna is located on the medial side of the forearm, and the radius is on the lateral side. These bones are attached to each other by an interosseous membrane. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 13.4 Image description.]

Bones of the Wrist and Hand

- **Carpals** – the wrist bones
- **Metacarpals** – the bones in the palm of hand

- **Phalanges** – the finger and toe bones

Each phalanx has three bones: the distal, medial, and proximal. The exception is the thumb and big toe which has two bones: distal and proximal (see Fig 16.5 below). There are 30 bones in each upper limb. Can you count them on your limb?

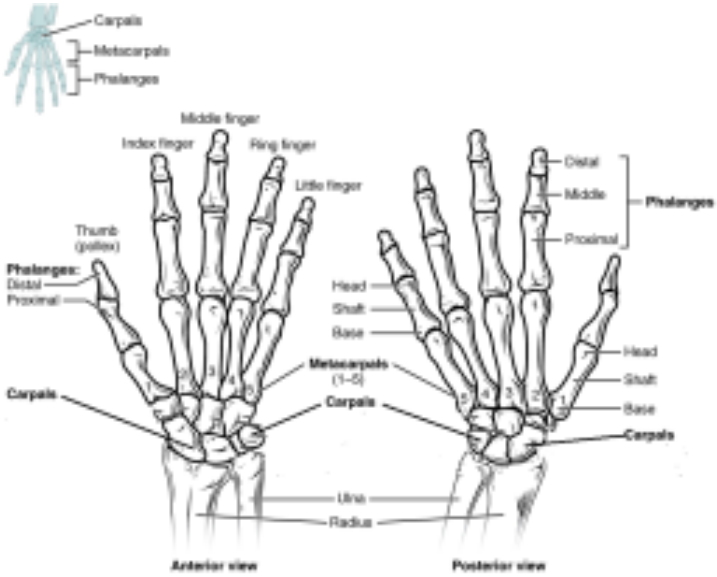


Figure 13.5 Bones of the Hands. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 13. 5 Image description.]

Bones of the Pelvic Region

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

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

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

Did You know 3?

The femur is the longest and strongest bone of the body, and accounts for approximately one-quarter of a person's total height (Betts et al., 2013).

Bones of the Lower Limbs

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

Bones of the Leg

- **Femur** – the thigh bone and is also referred to as the upper leg bone. It is the longest and strongest bone in the human body
- **Patella** – the kneecap
- **Tibia** – the shin bone. It is a medial bone and the main weight-bearing bone of the lower leg
- **Fibula** – the smaller of the lower leg bone (see Figure 13.6)

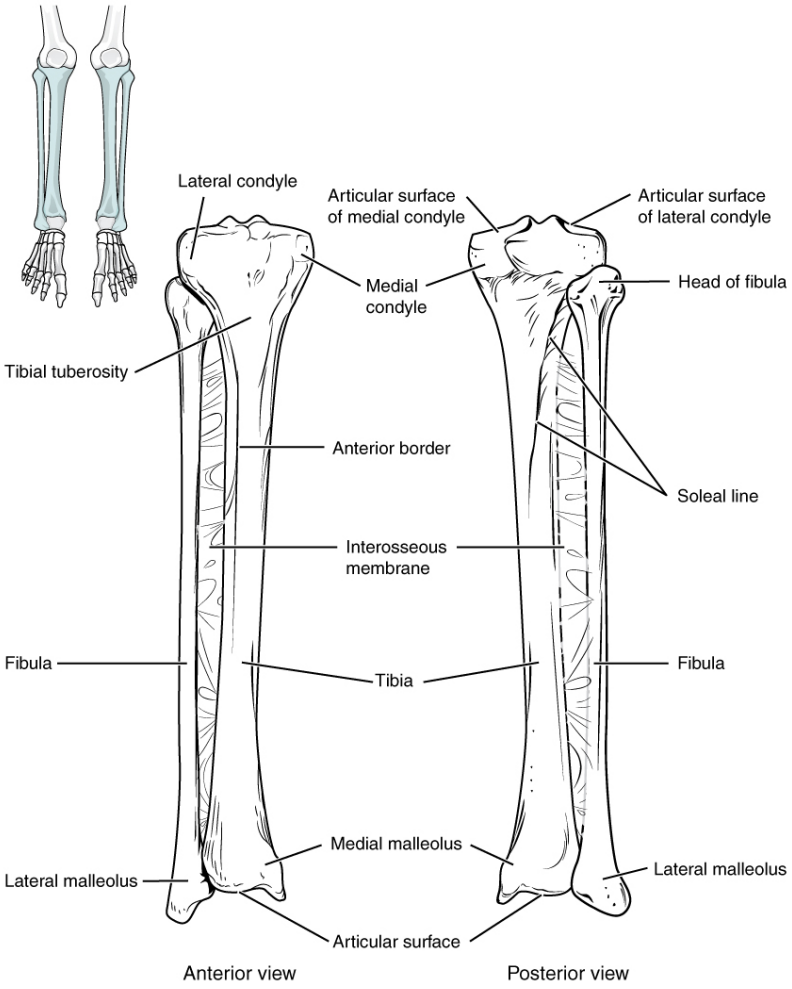


Figure 13.6 Tibia and Fibula. The tibia is the larger, weight-bearing bone located on the medial side of the leg. The fibula is the slender bone of the lateral side of the leg and does not bear weight. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 13.6 Image description.]

Bones of the Ankles and Feet

- **Tarsals** – the ankle bones (7 total)
- **Malleous** – the bony protrusions of the ankle bones
- **Talus** – the superior ankle bones
- **Calcaneous** – the heel bones
- **Metatarsals** – the foot bones
- **Phalanges** – the bones of the toes (see Figure 13.7)

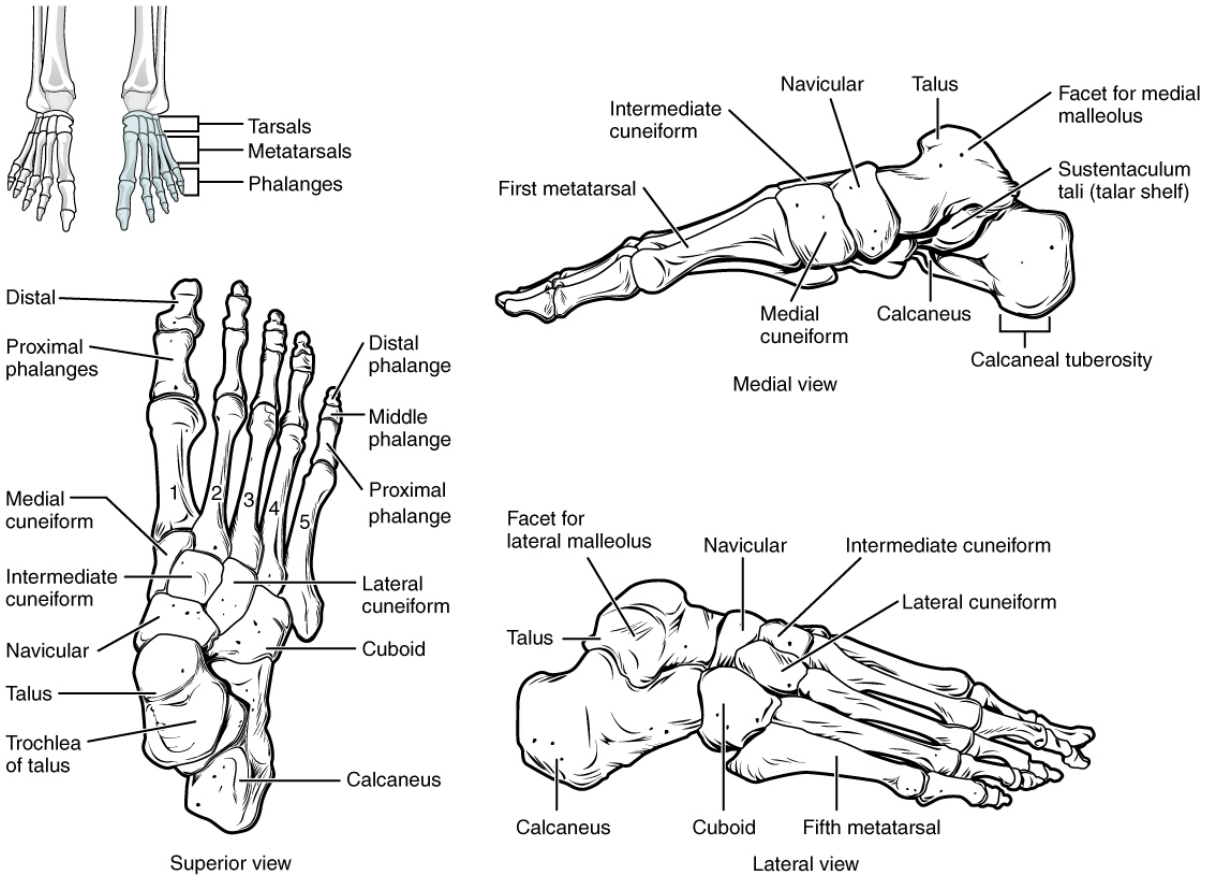


Figure 13.7 Bones of the Foot. The bones of the foot are divided into three groups. The posterior foot is formed by the seven tarsal bones. The mid-foot has the five metatarsal bones. The toes contain the phalanges. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 13.7 Image description.]

Check Your Knowledge of the Skeletal System

Concept Check 1

Answer the following questions:

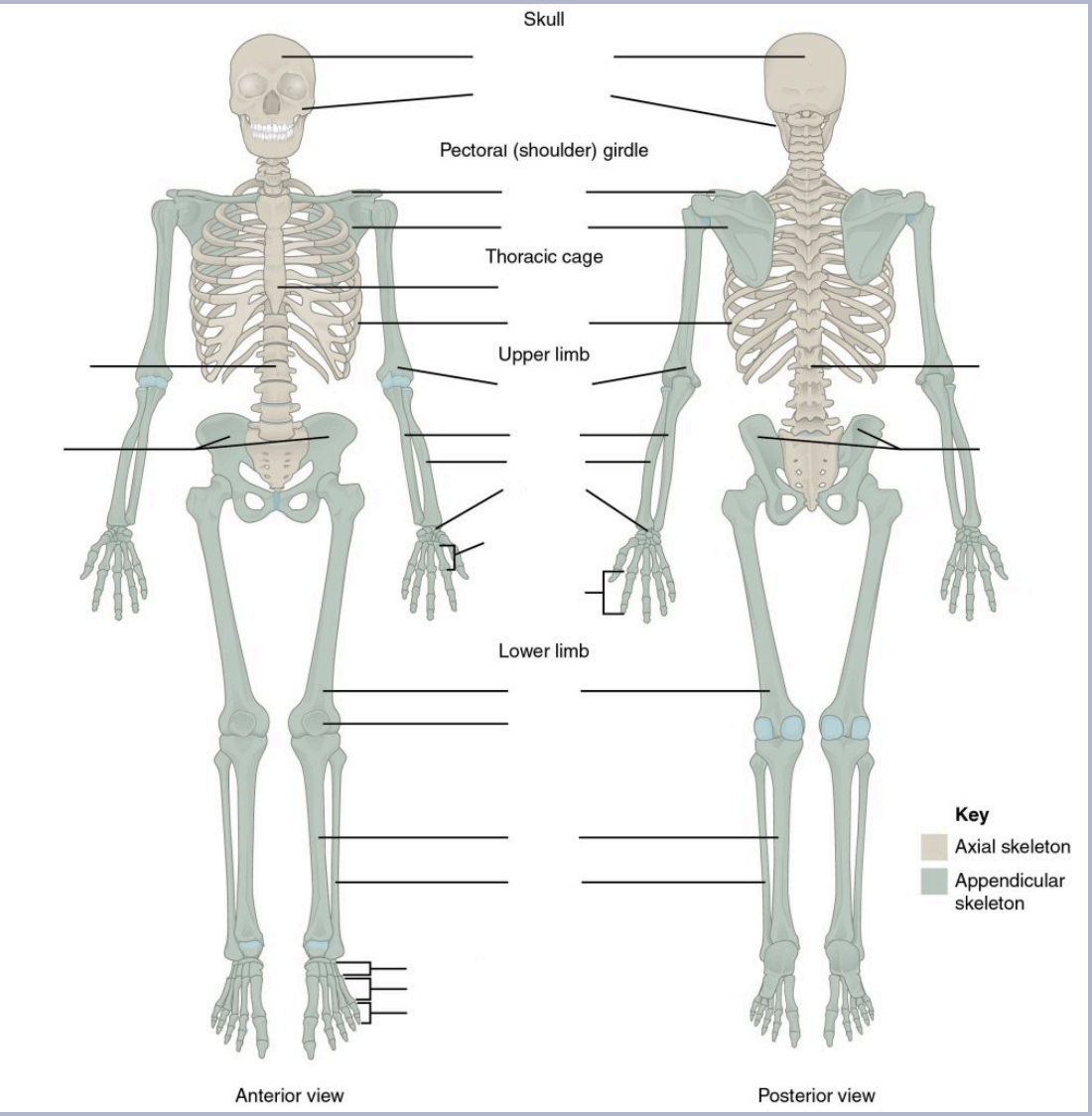
- Is the humerus the same as the funny bone?
- What is the medical term for the kneecap?

Musculoskeletal System-Skeleton Anatomy

Musculoskeletal System-Skeleton Anatomy (Text Version)

Label the diagram with the correct words listed below:

1. Fibula
2. Clavicle
3. Femur
4. Cranial portion
5. Radius
6. Facial portion
7. Vertebral column
8. Pelvic girdle
9. Vertebral column
10. Tibia
11. Ulna
12. Phalanges
13. Ribs
14. Tarsals
15. Phalanges
16. Pelvic girdle
17. Scapula
18. Metatarsals
19. Sternum
20. Metacarpals
21. Patella
22. Humerus
23. Carpals



Check your answers [1]

Activity source: Musculoskeletal System-Skeleton 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.

Image Descriptions

Figure 13.1 image description: This diagram shows the human skeleton and identifies the major bones. The left panel shows the anterior view (from the front) and the right panel shows the posterior view (from the back). Labels read (from the top of skull): skull (cranial portion, facial portion), pectoral shoulder girdle, clavicle, scapula, thoracic cage (sternum, ribs), upper limb (humerus, ulna, radius, carpals, metacarpals, phalanges), vertebral

column, pelvic girdle (hip bones), lower limb (femur, patella, tibia, fibula, tarsals, metatarsals, phalanges). [Return to Figure 13.1].

Figure 13.2 image description: This image shows the structure of the vertebral column. The left panel shows the front view of the vertebral column. Labels and the right panel shows the side view of the vertebral column. Labels read (from top): 7 cervical vertebrae (C1-C7) form cervical curve, 12 thoracic vertebrae (T1-T12) form thoracic curve, intervertebral disc, 5 lumbar vertebrae (L1-L5) form lumbar curve, Fused vertebrae of sacrum and coccyx form sacrococcygeal curve, sacrum, coccyx. [Return to Figure 13.2].

Figure 13.3 image description: This figure shows the skeletal structure of the rib cage. The left panel shows the anterior view of the sternum. Labels read (from top): clavicular notch, jugular notch, manubrium, sternal angle, body, xiphoid process. The right panel shows the anterior panel of the sternum including the entire rib cage. Labels read (from top): jugular notch, clavicular notch, clavicle, sternum (manubrium, body, xyphoid process), scapula, sternal angle, costal cartilages, intercostal space. Ribs are numbered 1-12 from the top. [Return to Figure 13.3].

Figure 13.4 image description: This diagram labels the bones of the lower arm (excluding the hands). Labels read (from top): olecranon process, head of radius, radial notch of the ulna, trochlear notch, coronoid process, radial tuberosity, proximal radioulnar joint, neck of radius, radius, interosseous membrane, ulna, ulnar notch of the radius, head of the ulna, distal radioulnar joint, styloid process of ulna, styloid process of radius. [Return to Figure 13.4].

Figure 13.5 image description: This diagram shows an anterior and posterior view of the hands with corresponding labels. Anterior view labels read (from top): middle finger, ring finger, index finger, little finger, thumb, phalanges (distal, proximal), metacarpals, carpals, ulna, radius. Posterior view labels read (from top): Phalanges (distal, middle, proximal), head shaft and base of proximal phalange, head shaft and base of metatarsal, metatarsals 1-5, carpals, ulna, radius. [Return to Figure 13.5].

Figure 13.6 image description: This image shows the structure of the tibia and the fibula. The left panel shows the anterior view. Labels read (from top): lateral condyle, medial condyle, tibial tuberosity, anterior border, interosseous membrane, fibula, tibia, medial malleolus, lateral malleolus, articular surface. The right panel shows the posterior view. Labels read (from top): articular surface of medial and lateral condyles, medial condyle, head of fibula, soleal line, interosseous membrane, tibia, fibula, medial malleolus, lateral malleolus, articular surface. [Return to Figure 13.6].

Figure 13.7 image description: This figure shows the bones of the foot. The left panel shows the superior view. Labels read (from toes): distal, proximal phalanges, distal phalange, middle phalange, proximal phalange, medial cuneiform, intermediate and lateral cuneiforms, navicular, cuboid, talus, trochlea of talus, calcaneus. The top right panel shows the medial view. Labels read (from left to right starting at toe): first metatarsal, medial cuneiform, intermediate cuneiform, navicular, talus, calcaneus, facet for medial malleolus, sustentaculum tali (talar shelf), calcaneal tuberosity. The bottom right panel shows the lateral view. Labels read (from left at the heel to right): calcaneus, talus, facet for lateral malleolus, cuboid, navicular, intermediate and lateral cuneiforms, fifth metatarsal. [Return to Figure 13.7].

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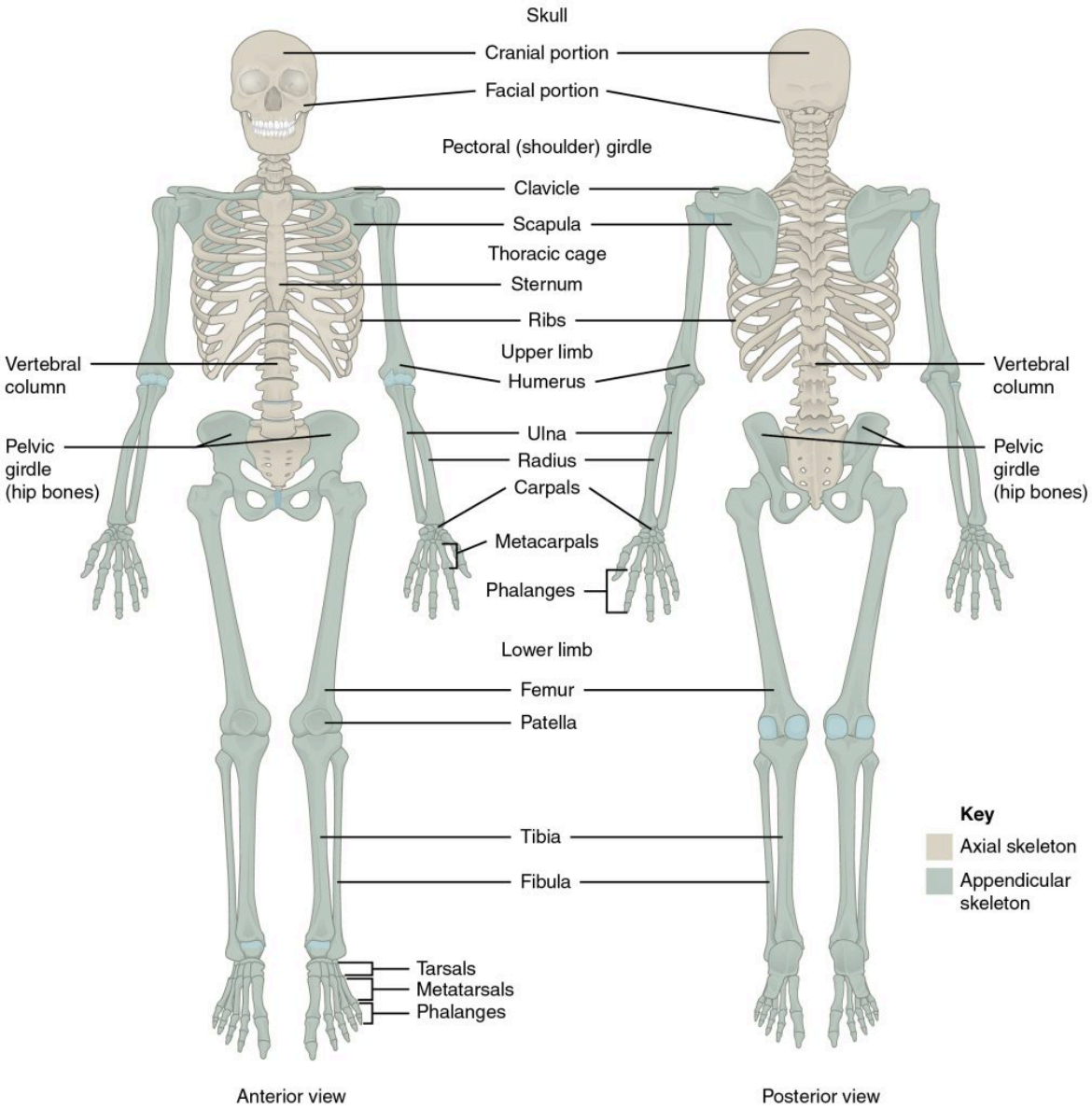
Notes



1.

13.3 - Physiology (Function) of the Skeletal System

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

Joints

Watch [Joints: Crash Course Anatomy & Physiology #20 (10 min) on YouTube]

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

Did You Know?

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

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

- **Synarthrosis** condition of joints which allow no movement
  - example: joints of the skull
- **Amphiarthrosis** condition of joints which allow some movement
  - example: joints of the pubic symphysis
- **Diarthrosis** condition of joints which allow for free movement

- example: joints of the knee

Structures associated with joints are:

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

Body Movements

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

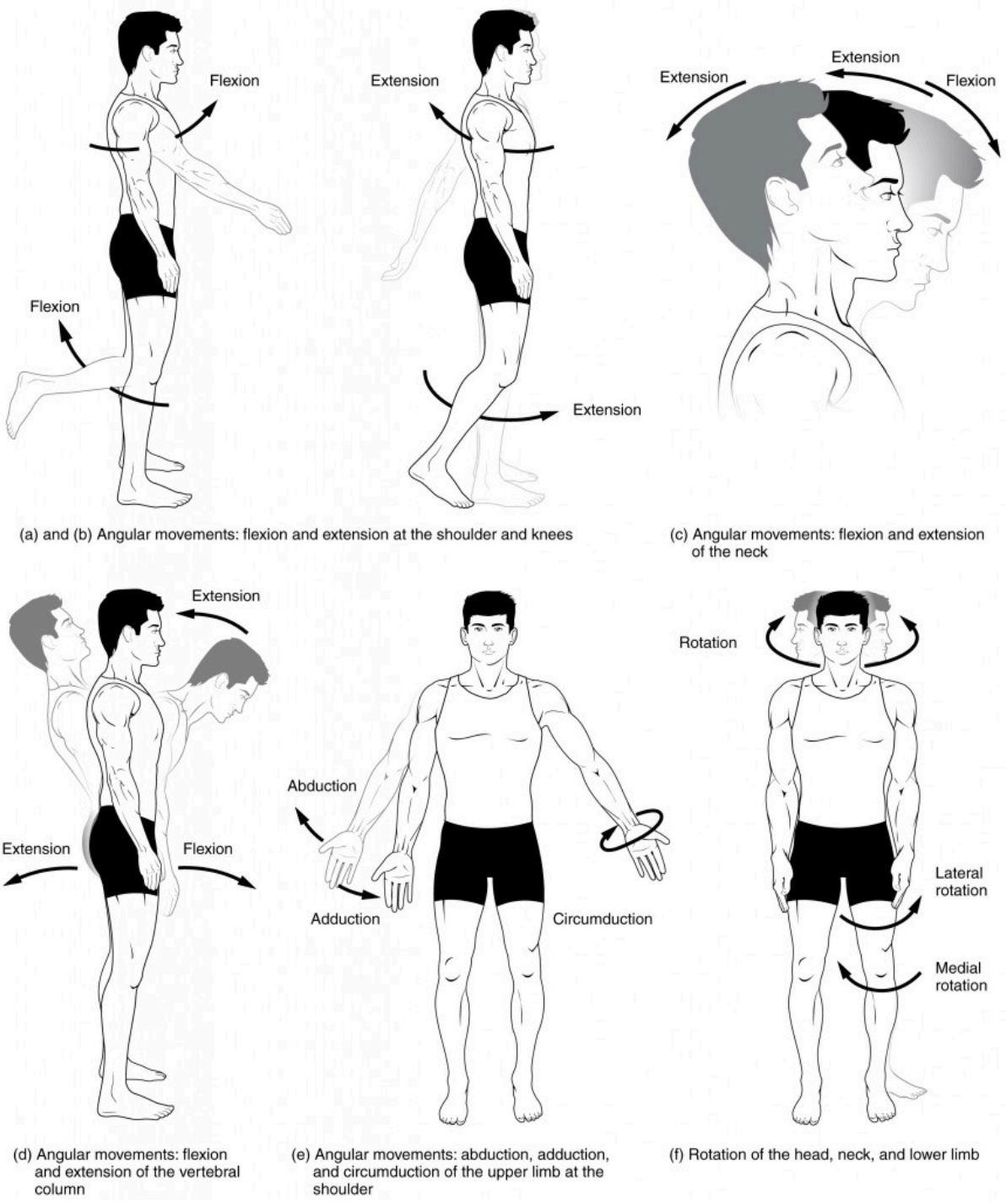


Figure 13.8 Movements of the Body, Part 1. Synovial joints give the body many ways in which to move. (a) and (b) Flexion and extension motions are in the sagittal (anterior and posterior) plane of motion. These movements take place at the shoulder, hip, elbow, knee, wrist, metacarpophalangeal, metatarsophalangeal, and interphalangeal joints. (c) and (d) Anterior bending of the head or vertebral column is flexion, while any posterior-going movement is extension. (e) Abduction and adduction are motions of the limbs, hand, fingers, or toes in the coronal (medial and lateral) plane of movement. Moving the limb or hand laterally away from the body, or spreading the fingers or toes, is abduction. Adduction brings the limb or hand toward or across the midline of the body, or brings the fingers or toes together. Circumduction is the movement of the limb, hand, or fingers in a circular pattern, using the sequential combination of flexion, adduction, extension, and abduction motions. Adduction/abduction and circumduction take place at the shoulder, hip, wrist, metacarpophalangeal, and metatarsophalangeal joints. (f) Turning of the head side to side or twisting of the body is rotation. Medial and lateral rotation of the upper limb at the shoulder or lower limb at the hip involves turning the anterior surface of the limb toward

the midline of the body (medial or internal rotation) or away from the midline (lateral or external rotation). From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 13.8 Image description.]

Flexion and Extension

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

In the limbs, flexion *decreases* the angle between the bones (bending of the joint), while extension *increases* the angle and straightens the joint (see Figure 13.8(a-d)). You will discover in the muscular system chapter that the associated muscles to these movements are the flexor and extensor.

Abduction and Adduction

Abduction and **adduction** motions occur within the coronal plane and involve medial-lateral motions of the limbs, fingers, toes, or thumb. For example, abduction is raising the arm at the shoulder joint, moving it laterally away from the body, while adduction brings the arm down to the side of the body (see Figure 13.8(e)). In the muscular system chapter you will discover that the associated muscles to these movements are the abductor and adductor.

Circumduction

Circumduction is the movement of a body region in a *circular* manner, in which one end of the body region being moved stays relatively stationary while the other end describes a circle. It involves the sequential combination of flexion, adduction, extension, and abduction at a joint (see Figure 13.8(e)).

Rotation

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

Rotation can also occur at the **ball-and-socket joints** of the shoulder and hip. Here, the humerus and femur rotate around their long axis, which moves the anterior surface of the arm or thigh either toward or away from the midline of the body (see Figure 13.8(f)).

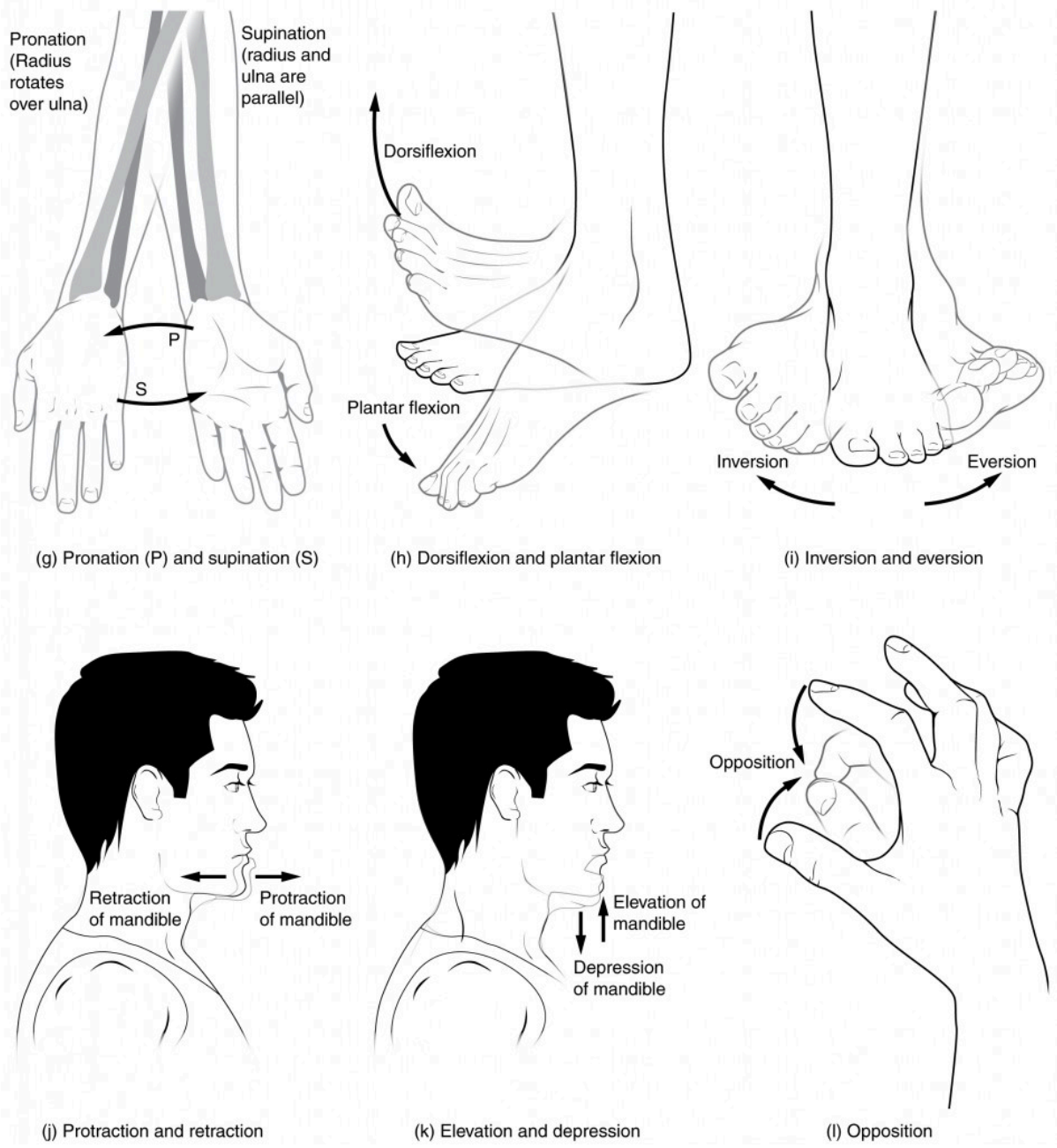


Figure 13.9 Movements of the Body, Part 2. (g) Supination of the forearm turns the hand to the palm forward position in which the radius and ulna are parallel, while forearm pronation turns the hand to the palm backward position in which the radius crosses over the ulna to form an "X." (h) Dorsiflexion of the foot at the ankle joint moves the top of the foot toward the leg, while plantar flexion lifts the heel and points the toes. (i) Eversion of the foot moves the bottom (sole) of the foot away from the midline of the body, while foot inversion faces the sole toward the midline. (j) Protraction of the mandible pushes the chin forward, and retraction pulls the chin back. (k) Depression of the mandible opens the mouth, while elevation closes it. (l) Opposition of the thumb brings the tip of the thumb into contact with the tip of the fingers of the same hand and reposition brings the thumb back next to the index finger. From Betts et al., 2013. Licensed under CC BY 4.0.

Supination and Pronation

Supination and pronation are movements of the forearm. In the anatomical position, the upper limb is held next to the body with the *palm facing forward*. This is the **supinated position** of the forearm. In this position, the radius and ulna are parallel to each other. When the *palm of the hand faces backwards*, the forearm is in the **pronated position**, and the radius and ulna form an X-shape.

Pronation is the movement that allows the palm of the hand to face *backwards*, while in *supination* the palm of the hand faces *forwards*. It helps to remember that supination is the motion you use when scooping up soup with a spoon (see Figure 13.9(g)).

Dorsiflexion and Plantar Flexion

Dorsiflexion and **plantar flexion** are movements at the ankle joint, which is a hinge joint. Lifting the front of the foot so that the top of the *foot moves (upward)* toward the anterior leg is dorsiflexion, while lifting the heel of the foot from the ground or pointing the *toes downward* is plantar flexion. These are the only movements available at the ankle joint (see Figure 13.9(h)).

Inversion and Eversion

Inversion and eversion are complex movements that involve the multiple plane joints among the tarsal bones of the posterior foot (intertarsal joints) and thus are not motions that take place at the ankle joint. **Inversion** is the turning of the foot to angle the bottom of the foot *toward the midline*, while **eversion** turns the bottom of the foot away from the midline. The foot has a greater range of inversion than eversion motion. These are important motions that help to stabilize the foot when walking or running on an uneven surface and aid in the quick side-to-side changes in direction used during active sports such as basketball, racquetball, or soccer (see Figure 13.9(i)).

Protraction and Retraction

Protraction and **retraction** are anterior-posterior movements of the scapula or mandible. Protraction of the scapula occurs when the *shoulder is moved forward*, as when pushing against something or throwing a ball. Retraction is the opposite motion, with the scapula being *pulled posteriorly* and medially toward the vertebral column. For the mandible, protraction occurs when the lower jaw is pushed forward to stick out the chin, while retraction pulls the lower jaw backwards (see Figure 13.9(j)).

Depression and Elevation

Depression and **elevation** are downward and upward movements of the scapula or mandible. The *upward movement of the scapula* and shoulder is elevation, while a *downward movement* is depression. These movements

are used to shrug your shoulders. Similarly, the elevation of the mandible is the upward movement of the lower jaw used to close the mouth or bite on something, and depression is the downward movement that produces an opening of the mouth (see Figure 13.9(k)).

Concept Check

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

Musculoskeletal System Body Movements

Musculoskeletal System Body Movements (Text Version)
Practice the following endocrine system words by breaking into word parts and pronouncing.

1. **adduction**
    - moving toward the midline
2. **rotation**
    - turn around on own axis
3. **extension**
    - increased angle between bone and joint by placing a limb in a straight position
4. **abduction**
    - moving away from the midline
5. **inversion**
    - turning inward
6. **supination**

- turn the palm up

7. **eversion**
    - turning outward
8. **pronation**
    - turn the palm down
9. **flexion**
    - decreasing the angle of a joint by bending a limb

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

Musculoskeletal System – Operative Report

Musculoskeletal System – OPERATIVE REPORT (Text version)
Using the words below fill in the operative report:

- chondromalacia
- x-rays
- arthritis
- Orthopedic
- arthroscopy
- total hip arthroplasty
- femoral
- tendinitis

PATIENT NAME: Mrs. Karen SMITH
AGE: 72 Sex: Female
DATE OF SURGERY: February 24
PREOPERATIVE DIAGNOSIS: Degenerative arthritis of both hips; more severe on the right side.
POSTOPERATIVE DIAGNOSIS: Severe degenerative arthritis and severe _____[Blank 1] of the right hip.

NAME OF PROCEDURE: Total hip arthroplasty.

HISTORY: Mrs. Karen Smith is a 72-year-old widow who has been living alone and independently since her husband's premature death 15 years ago. Mrs. Smith has worked for 30 years at the production line in a factory and is now retired.

Mrs. Smith has been experiencing discomfort in her hips, especially the right one, over the parts twenty

years or so. However, what started as a mild discomfort over time turned into severe pain. Now the pain is so bad that she is afraid that it might soon rob her of her independence. She first sought help for her hip pain many years ago. After physical examination, her family physician ordered _____[Blank 2] for both hip joints. Based on the results, it was concluded that the pain was due to severe _____[Blank 3] mainly due to wear and tear. She was advised to lose weight and to take over-the-counter painkillers as needed. She was also referred to a physiotherapist. However, despite the fact that she has lost 10% of her original body weight of 170 pounds and has been adhering to the exercise regimen recommended by her physiotherapist, the pain has grown worse over the years and now is almost unbearable. She was last visited by an orthopedic surgeon and subsequently was admitted to the General Hospital Outpatient _____[Blank 4] Clinic for _____[Blank 5] of both hips.

OPERATIVE REPORT: The patient was brought to the operating room by anesthesia personnel. She was placed on the operating table. A Foley catheter was inserted. The patient was then placed into the lateral decubitus position with her right side up. The right lower extremity was prepped and draped in standard fashion for a _____[Blank 6]. Dissection was carried sharply down through the soft tissue to the greater trochanter. The greater trochanter was used as a landmark to orient the remainder of the dissection which was continued posteriorly and proximally to expose the iliofemoral joint.

The acetabulum was reamed. A 50 mm acetabular shell was used. Femur was debrided using a _____[Blank 7] canal curette. The length of the femoral stem was then checked with the canal curette in place. Appropriate femoral stem and head were selected and implanted. Intraoperative radiographs were obtained to ensure proper component position.

The hip was then checked for range of motion. The patient reached 90 degrees of flexion and full extension with no instability. No abnormality was detected in the surrounding soft tissue. There was no indication of _____[Blank 8].

The area was then closed in a layered fashion. The subcutaneous tissues were closed using surgical Vicryl 5-0 sutures. An incisional VAC was placed over the wound as well. Sponge and needle counts were correct at the end of the operation. The patient tolerated the procedure well and was returned to the recovery room in good condition.

_____
Michael Porter, MD, Orthopedic Surgery

> **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]

Musculoskeletal System – Operative Report

Musculoskeletal System – Operative Report (Text version)

Use the words below to fill in the operative report:

- orthopedic
- supination
- colles
- carpal
- tenomyoplasty
- sterilized
- aligned
- fluoroscopy
- tenorrhaphy
- sutured
- splint
- arthralgia
- akinesia
- atrophy

PATIENT NAME: Liam PALMER

AGE: 22

SEX: Male

DOB: December 4

DATE OF ADMISSION: May 5

DATE OF PROCEDURE: May 5

ATTENDING PHYSICIAN: Michael Porter, MD, Orthopedic Surgery

PREOPERATIVE DIAGNOSIS: Fx of the distal end of radius.

POSTOPERATIVE DIAGNOSIS: Fx of the distal end of radius.

ANESTHESIA: General.

INDICATION: This 22-year-old male had been skating earlier today when he lost his balance and fell. Trying to break the fall with an outstretched arm, he landed on his right arm, breaking his wrist. Mr. Palmer was brought to the _____[Blank 1] clinic in Toronto General Hospital. The wrist has been kept in a neutral position since even a slight movement was painful. The injured area is edematous and any attempt for active or passive flexion, extension, _____[Blank 2], or pronation caused a sharp pain that shoots all the way to the right shoulder. Posterior-Anterior and lateral x-rays of the wrist and forearm confirmed _____[Blank 3] fracture of the distal end of radius with the broken piece displaced posteriorly. The _____[Blank 4] bones were intact. The patient required surgery to fix the broken bone. Although not certain at that point, there was a possibility that the patient also required _____[Blank 5].

PROCEDURE: The surgery was done under general anesthesia. The patient's arm was placed in a proper position to allow for an easy and unobstructed access to the surgical area. The surgical area was _____[Blank 6]. A longitudinal incision was made to access the fracture. The fractured bone was realigned, and a metal plate was used to secure the _____[Blank 7] bone and restore stability. Throughout the surgery _____[Blank 8] was used to ensure proper reduction of the bone. The surrounding muscles, tendons, and ligaments were examined to ensure their integrity. There was no need for tenomyoplasty or _____[Blank 9]. Once the surgery was completed, the surgical incision was _____[Blank 10], the wrist was bandaged, and the arm was placed in a long cast to immobilize the wrist and elbow joints. The patient left the operation room in good and stable condition.

The patient was discharged from the hospital on the following day. He was scheduled for his first follow

up visit in 3 weeks. At that time, the cast will be replaced with a removable wrist _____[Blank 11] and the patient will be referred to a physiotherapy clinic. Timely rehabilitation is extremely important in these types of fractures to reduce _____[Blank 12] and prevent from _____[Blank 13] and muscle _____[Blank 14].

_____
Michael Porter, MD, Orthopedic Surgery

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]

Activity source: MUSCULOSKELETAL SYSTEM – OPERATIVE REPORT by Saeedha Akram and Heather Scudder, from *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY- 4.0. /Text version added.

Image Descriptions

Figure 13.8 image description: This multi-part image shows different types of movements that are possible by different joints in the body. Labels read (from top, left): a and b angular movements: flexion and extension at the shoulders and knees, c) angular movements: flexion and extension of the neck (arrows pointing left and right to indicate movement). Labels (from bottom, left) read: d) angular movements: flexion and extension of the vertical column, e) angular movements abduction, adduction, and circumduction of the upper limb at the shoulder, f) rotation of the head, neck, and lower limb. [Return to Figure 13.8].

Attribution

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.chondromalacia, 2.x-rays, 3.arthritis, 4.Orthopedic, 5.arthroscopy, 6. total hip arthroplasty, 7.femoral, 8.tendinitis

2. 1.orthopedic, 2.supination, 3.Colles, 4.carpal, 5.tenomyoplasty, 5.sterilized, 6.aligned, 7.fluoroscopy, 8.tenorrhaphy, 9.sutured, 10.splint, 11.arthralgia, 12.akinesia, 13.atrophy

13.4 - Skeletal Diseases, Disorders and Diagnostic Testing

Common Diseases and Disorders

Osteoporosis

Health Canada (2018) describes **osteoporosis** as bone loss that causes bones to become weak and thin over time. This weakness can lead to fractures from simple movements and occurs often in the wrist, shoulder, spine, and hip. To learn more about osteoporosis, please visit the Osteoporosis Health Canada website [New Tab].

Arthritis

Arthritis often presents as **edema**, **arthralgia**, and **ankylosis** (Centers for Disease Control and Prevention, 2019). Common types of arthritis are **osteoarthritis** (OA), rheumatoid arthritis (RA), **fibromyalgia**, gout, and lupus. To learn more about arthritis, visit the CDC's Arthritis Basics webpage [New Tab].

Osteoarthritis

Osteoarthritis is the most common form of arthritis and, according to the Arthritis Society, affects Canadians more than the combination of all other types of arthritis. The breakdown of cartilage and bone occurs over time when joints are exposed to heavy workloads either through occupation, obesity, and/or prior injury to a joint. Common symptoms are pain, stiffness, and aching that worsens over time. While there is no cure, symptoms can be managed through exercise, medications and, in severe cases, joint replacements (Arthritis Society, 2020).

Rheumatoid arthritis

The CDC describes **rheumatoid arthritis (RA)** as an autoimmune and inflammatory disease. Autoimmune diseases are disorders in which the immune system overreacts and begins to attack itself. In the case of RA, inflammation of the joint tissues of the hands, wrists and knees is painful and debilitating. Treatments may include immunosuppressive drugs and anti-inflammatory drugs (Betts et al., 2013). RA can also affect other tissues throughout the body and cause problems in organs such as the lungs, heart, and eyes. RA can affect children, and in this case, it is referred to as **juvenile rheumatoid arthritis** (Centers for Disease Control and Prevention, 2022).