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**BOOK 4: HUMAN ANATOMY AS RELATED TO TUMOR FORMATION**

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SECTION A

OBJECTIVES AND CONTENT OF BOOK 4
SECTION A

OBJECTIVES AND CONTENT OF BOOK 4

The purpose of this book is to introduce you to human anatomy and to the neoplasms associated with the various anatomical structures. If you thoroughly studied Book 3, *The Composition of Medical Terms*, you will be prepared for the anatomical terms you will encounter in this book. If you acquire a good background in anatomy, your work in abstracting will become easier. However, these manuals can give you only a cursory glance at human anatomy. You will need to supplement your knowledge with independent study. A bibliography of suggested texts and references is provided at the end of this manual.

You will recall from the chapter on "Derivation of Cells and Tissues" (Section E of Book 2) that as the cells of the embryo divide, they change their shape, structure, and their relationship to each other to form three embryonic layers. From these three layers develop all the tissues, organs, and organ systems of the body, each of which is specialized for the performance of specific functions.

Our study of anatomy will begin with the integumentary system (skin and its derivatives) followed by the lymphatic, cardiovascular, respiratory, and digestive systems and continue with the urinary, reproductive, endocrine, skeletal, muscular, nervous systems, and the sensory organs. However, as an introduction to human anatomy, you will first study terms describing location and position within the body.
SECTION B

TERMS USED TO INDICATE BODY LOCATION AND POSITION
SECTION B

TERMS USED TO INDICATE BODY LOCATION AND POSITION

Superior (cranial or cephalic)

Anterior (ventral)

Posterior (dorsal)

Inferior (caudal)

Solid lines = sagittal, midsagittal (median)
Dotted lines = transverse (horizontal)
Dashed lines = frontal (coronal)

Figure 1A. PLANES OF REFERENCE AND DIRECTIONAL TERMS
SECTION B
TERMS USED TO INDICATE BODY LOCATION AND POSITION

Positional Terms

There are a number of words commonly used to describe body location such as, posterior (in back of), anterior (in front of), lateral (at the side of), and medial (near the middle of). There are also prefixes which are commonly used to describe location and position. As examples, the prefix bi means "both" or "double," therefore, the term bilateral means "affecting both (two) sides." The prefix para means "beside, near or adjacent," sub means "under," and supra means "above or over."

To understand the verbal descriptions contained within a medical record, it is necessary to know the meaning of words and prefixes which refer to location and position. This will enable you to abstract more accurately the reports contained in a medical record.

Some positional terms refer to the location of an anatomical part relative to another body part or location. The reference may be general; for example, cephal(o) is used as a prefix to denote "towards the head." Caudal is often used as a prefix to denote "towards the tail (feet)."

Sometimes the location reference may be quite specific. For example, the reference may denote a body organ or a specific structure such as the heart, cardi(o), or the rectum, proct(o).

There is no need for you to memorize long lists of these terms. As you encounter them, look them up in your medical dictionary or in a book on medical terminology. Before long, you will be familiar with most of them. It is recommended that every registry purchase at least one book on medical terminology.

Anatomical Position

By world-wide agreement, the position of body organs and structures is described as though the body were in anatomical position, that is, standing, looking straight ahead, arms at the side with palms of the hands facing frontward (see Figure 1A).

The following list gives the "directional planes" and some of the relative positional terms used to describe anatomical location. You are most apt to encounter these terms while reading an operative record (report of surgery). Also, these terms often are used in the physical examination (see Figure 1A).
### Directional Planes of the Body

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<td>Sagittal plane</td>
<td>Any vertical section of the body which divides it into right and left portions.</td>
</tr>
<tr>
<td>Midsagittal plane (Median)</td>
<td>A vertical section at the midline of the body such that the body is divided into equal right and left halves.</td>
</tr>
<tr>
<td>Frontal plane (Coronal)</td>
<td>A vertical section of the body dividing it into front (anterior) and back (posterior) portions.</td>
</tr>
<tr>
<td>Transverse plane (Horizontal)</td>
<td>Any horizontal section of the body dividing it into upper and lower portions.</td>
</tr>
</tbody>
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### Cavities of the Body

The spaces within the body which contain the internal organs are called the body cavities. There are two main body cavities: the dorsal cavity and the ventral cavity (see Figure 1B).

- **The dorsal cavity** is divided into:
  
  The **cranial cavity** containing the brain and the **vertebral cavity** containing the spinal cord. Protective membranes covering the brain and spinal cord are called meninges.

- **The ventral cavity** is divided by the diaphragm into:

  The **thoracic** and **abdominopelvic cavities**.

The **thoracic cavity** is subdivided into the right and left **pleural portions** and the **pericardial portion**. The pleural portions contain the lungs covered by serous membranes called pleurae. The pericardial portion encompasses the heart. In addition to the heart, the area between the lungs (called mediastinum) contains the trachea, esophagus, thymus, blood vessels, and lymphatic vessels and nodes.

The **abdominopelvic cavity** is subdivided into the **abdominal portion** containing the liver, gallbladder, stomach, spleen, pancreas, small and large intestines, kidneys, ureters; and the **pelvic portion** containing the bladder, rectum, sigmoid colon, and reproductive organs. Supportive and protective serous membranes covering these organs are classified, in general, as peritoneum.
Figure 1B. MAIN BODY CAVITIES
### Relative Positional and Directional Terms

**Anterior (ventral)**
Refers to the front (frontal plane) of or abdominal portion of the body. The trachea lies anterior (ventral) to the esophagus.

Note: In official anatomical nomenclature the terms anterior and ventral are used in reference to the ventral or belly surface of the body. When speaking about the trunk of the body, the term anterior or ventral can be used to mean "in front of." However, for parts of the head, the ventral structure is the underside or the side nearer to the belly. For instance, the ventral surface of the brain is the lower surface.

**Posterior (dorsal)**
Refers to the rear or back of the body. The kidneys are posterior (dorsal) to the stomach.

**Superior (cranial or cephalic)**
Refers to points nearer to or towards the head. The heart is superior to the stomach.

**Inferior (caudal)**
Refers to points nearer to or towards the tail or feet. The pancreas is inferior (caudal) to the heart.

**Medial**
Refers to a position nearer the middle (midsagittal plane) of the body. The heart is medial to the lungs.

**Lateral**
Refers to positions to the side of the body, to positions farther away from the midsagittal plane. The ascending colon is lateral to the small intestine; the lungs are lateral to the heart.

**Proximal**
Refers to positions nearer the origin, an attachment, or a reference point. The cecum is proximal to the ascending colon.

**Distal**
Refers to positions farther away from the origin, a reference point, source, or attachment. The rectum is located at the distal end of the digestive system.

**Superficial**
Refers to locations near the surface of the body or a specific organ. Most palpable lymph nodes are located superficially.

**Deep**
Refers to locations within the body or organ. Lymph nodes which drain organs and structures located in the abdominal cavity are deep nodes.
### External

Refers to locations which are toward the outside of a body or a specific organ, or outside a reference point. The ribs are external to the thoracic cavity.

### Internal

Refers to locations which are within the inner portion of the body, a specific organ, or a reference point. Internal may be synonymous with deep. The lungs are an internal reference point deep within the body.

### Central

Refers to the primary parts of the central nervous system (the brain and spinal cord) or to any axis of symmetry.

### Peripheral

Refers to that part of a system outside the central portion. The peripheral nervous system refers to the nerves connecting the central nervous system to all other parts of the body. A peripheral lesion is located away from (medially, laterally, superior or inferior to) the middle of the organ.

### Parietal

Refers to the walls of a cavity. The parietal pleura is that portion of the pleura closest to the chest wall.

### Visceral

Refers to the organs within the thoracic and abdominopelvic cavities. The visceral pleura is that portion of the pleura investing the lungs themselves.

### Quadrant (quarter)

One of the four corresponding parts, regions, or quarters into which the body or its parts may be divided for a more precise reference, such as the abdomen or each breast.

---

The abdominal quadrants are abbreviated as follows:

- **RUQ** - right upper quadrant
- **RLQ** - right lower quadrant
- **LUQ** - left upper quadrant
- **LLQ** - left lower quadrant

---

1. See Section I, The Reproductive System, for specific use of quadrant location for cancers of the breast.
Figure 3. ANATOMIC DIVISIONS OF THE ABDOMEN

1. Hypochondriac regions (upper lateral regions)
2. Epigastric region (upper mid-region medial to the hypochondriac regions)
3. Lumbar regions (midlateral regions)
4. Umbilical (navel) region
5. Inguinal or iliac regions (lower lateral regions)
6. Hypogastric or pelvic region (region inferior to the lower border of the iliac crest and medial to the inguinal regions)

On the following page is a practical exercise containing some commonly used terms. Use this test to identify those terms which you need to study.

As you study each body system, you will be asked questions which require you to use your knowledge about location terms. The questions might be something like this:

Q. Does the word suprarenal refer to a gland which is located above, below, distal to, or lateral to the kidney?
   Answer: above--the prefix supra means "above."

Q. Does the clavicle lie inferior to or superior to the maxilla (upper jaw)?
   Answer: inferior to--inferior means "situated below or directed downward."
Practical Exercise

Listed below on the left are terms used to denote anatomic position and location. Match the terms on the left with the definitions on the right. Caution: This is a somewhat difficult exercise because two or more definitions may define a term in whole or in part. So, for each term, select all the definitions which fit it at least in part.

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<th>Terms</th>
<th>Definitions</th>
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<td>1. towards the side, away from the middle</td>
</tr>
<tr>
<td>b. ____________ distal</td>
<td>2. within</td>
</tr>
<tr>
<td>c. ____________ endo-</td>
<td>3. towards the back, in back of</td>
</tr>
<tr>
<td>d. ____________ epi-</td>
<td>4. above, beyond, excessive</td>
</tr>
<tr>
<td>e. ____________ extra-</td>
<td>5. away from the beginning of a structure</td>
</tr>
<tr>
<td>f. ____________ hyper-</td>
<td>6. near the surface of the body or a specific organ</td>
</tr>
<tr>
<td>g. ____________ hypo-</td>
<td>7. towards the head, above</td>
</tr>
<tr>
<td>h. ____________ inferior (caudal)</td>
<td>8. outside of, in addition to</td>
</tr>
<tr>
<td>i. ____________ inter-</td>
<td>9. towards the middle vertical body plane</td>
</tr>
<tr>
<td>j. ____________ intra-</td>
<td>10. within the body cavities</td>
</tr>
<tr>
<td>k. ____________ juxta-</td>
<td>11. near to front, in front of</td>
</tr>
<tr>
<td>l. ____________ lateral</td>
<td>12. above, superior to</td>
</tr>
<tr>
<td>m. ____________ medial</td>
<td>13. near, beside</td>
</tr>
<tr>
<td>n. ____________ para-</td>
<td>14. before, in front of</td>
</tr>
<tr>
<td>o. ____________ peri-</td>
<td>15. nearer to the beginning of, closer to</td>
</tr>
<tr>
<td>p. ____________ posterior (dorsal)</td>
<td>16. behind, back of, backward</td>
</tr>
<tr>
<td>q. ____________ pre-</td>
<td>17. around, about</td>
</tr>
<tr>
<td>r. ____________ proximal</td>
<td>18. near, adjoining</td>
</tr>
<tr>
<td>s. ____________ retro-</td>
<td>19. between</td>
</tr>
<tr>
<td>t. ____________ sub-</td>
<td>20. under, below, beneath</td>
</tr>
<tr>
<td>u. ____________ superficial</td>
<td>21. on, upon, over</td>
</tr>
<tr>
<td>v. ____________ superior (cephalic)</td>
<td>22. below, under, deficient</td>
</tr>
<tr>
<td>w. ____________ supra-</td>
<td>23. inside, within</td>
</tr>
<tr>
<td>x. ____________ visceral</td>
<td>24. towards the tail (feet), below, away from the head</td>
</tr>
</tbody>
</table>
Answers to Practical Exercise

Note that the preferred definition is underlined when there is more than one possible answer.

<table>
<thead>
<tr>
<th>Terms</th>
<th>Definitions</th>
</tr>
</thead>
</table>
| a. anterior (ventral) | 11. near to front, in front of  
                          14. before, in front of |
| b. distal       | 15. away from the beginning of a structure       |
| c. endo-        | 2. within                                       
                          23. inside, within   |
| d. epi-         | 21. on, upon, over                              |
| e. extra-       | 4. above, beyond, excessive  
                          8. outside of, in addition to  
                          12. above, superior to |
| f. hyper-       | 4. above, beyond, excessive  
                          12. above, superior to |
| g. hypo-        | 20. under, below, beneath  
                          22. below, under, deficient |
| h. inferior (caudal) | 20. under, below, beneath  
                          22. below, under, deficient  
                          24. towards the tail (feet), below, away from the head |
| i. inter-       | 19. between                                      |
| j. intra-       | 2. within                                       
                          23. inside, within   |
| k. juxta-       | 13. near, beside                                
                          18. near, adjoining   |
| l. lateral      | 1. towards the side, away from the middle       |
| m. medial       | 9. towards the middle vertical body plane        |
Answers to Practical Exercise (continued)

<table>
<thead>
<tr>
<th>Terms</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>n. para-</td>
<td>13. near, beside</td>
</tr>
<tr>
<td></td>
<td>18. near, adjoining</td>
</tr>
<tr>
<td>o. peri-</td>
<td>13. near, beside</td>
</tr>
<tr>
<td></td>
<td>17. around, about</td>
</tr>
<tr>
<td>p. posterior (dorsal)</td>
<td>3. towards the back, in back of</td>
</tr>
<tr>
<td></td>
<td>16. behind, back of, backward</td>
</tr>
<tr>
<td>q. pre-</td>
<td>11. near to front, in front of</td>
</tr>
<tr>
<td></td>
<td>14. before, in front of</td>
</tr>
<tr>
<td>r. proximal</td>
<td>13. near, beside</td>
</tr>
<tr>
<td></td>
<td>15. nearer to the beginning of,</td>
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<tr>
<td></td>
<td>closer to</td>
</tr>
<tr>
<td></td>
<td>18. near, adjoining</td>
</tr>
<tr>
<td>s. retro-</td>
<td>3. towards the back, in back of</td>
</tr>
<tr>
<td></td>
<td>16. behind, back of, backward</td>
</tr>
<tr>
<td>t. sub-</td>
<td>20. under, below, beneath</td>
</tr>
<tr>
<td></td>
<td>22. below, under, deficient</td>
</tr>
<tr>
<td>u. superficial</td>
<td>6. near the surface of the body or</td>
</tr>
<tr>
<td></td>
<td>a specific organ</td>
</tr>
<tr>
<td>v. superior (cephalic)</td>
<td>4. above, beyond, excessive</td>
</tr>
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<td></td>
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<td></td>
<td>12. above, superior to</td>
</tr>
<tr>
<td>x. visceral</td>
<td>10. within the body cavities</td>
</tr>
</tbody>
</table>

17
SECTION C

THE INTEGUMENTARY SYSTEM
The skin (integument) covers the entire surface of the body. It consists of two layers (Figures 4A and 4B): a thin outer layer called the epidermis\(^1\) and an underlying thick layer, the dermis.\(^2\) The skin forms a pliable covering for the body and provides a barrier in preventing injury to underlying tissues. Unbroken skin keeps out ever-present bacteria and other microorganisms and essentially prevents body infections. It provides a nearly waterproof covering which enables the body to resist dehydration at normal temperatures. Pigmentation (melanin) in the skin gives the body protection against solar radiation.

Humans need to maintain a constant body temperature. Heat is continually produced in the body by the oxidation of fats and carbohydrates. The blood transfers the heat throughout the body. The skin’s complex vascular pattern plays an important role in the regulation of the body temperature. The surface evaporation of sweat is another mechanism for heat control. The skin has an excretory function because of the rich supply of sweat and sebaceous glands that are embedded in the dermis.

---

\(^1\) epidermis--The protective, outer layer of the skin.

\(^2\) dermis--The layer of skin under the epidermis consisting of dense vascular connective tissue; also known as the corium.
Epidermis

The epidermis (Figure 4A) is composed of stratified squamous epithelium. It has several layers. The cells of each of these layers change as they move from the basal layer up to the surface of the skin. The layers (from the surface inward) are:

- Cornified (horny) cell layer (stratum corneum): An outer layer of overlapping flattened scale-like (squamous) remnants of cells which have lost their nuclei and which are filled with keratin, a water-insoluble protein.

- Clear-cell layer (stratum lucidum): A thin transparent layer consisting of a substance called eleidin, a precursor of keratin. Since it is found only on the palms of the hands and the soles of the feet, this layer does not appear in Figure 4A below.

- Granular-cell layer (stratum granulosum): A layer of cells containing granules of keratohyalin, an earlier precursor of keratin.

- Prickle-cell layer (stratum spinosum)

- Basal-cell layer (stratum basale, formerly called stratum germinativum, also called Malpighian layer): A layer of actively dividing columnar cells attached to a basement membrane (basal lamina) which marks the junction of the dermis and epidermis.

Figure 4A. LAYERS OF THE EPIDERMIS

The keratinized surface-cell remnants are continually worn away or shed while new cells are being formed by the lower layers of the epidermis. As they are formed, they are pushed outward to the surface, gradually flattened, and become filled with keratin. Keratin is a term derived from the Greek word keras meaning "horny."
Melanocytes (pigment cells), located primarily in the basal layer of the epidermis, produce melanin (a dark pigment). The presence of melanin is one of the factors which determine skin color. All individuals except albinos have some melanin in their skins. It is vital for protection against the harmful effect of ultraviolet radiation.

**Dermis**

The *dermis* (corium) constitutes the greater part of total skin thickness and contributes strength and elasticity to the skin. The thickness of the dermis varies from 3 to 4 millimeters on the palms of the hands and the soles of the feet to less than 1/2 millimeter on the eyelids. It is composed of two layers of dense connective tissue:

- Papillary layer (stratum papillare): A thin layer which includes blood vessels, lymphatics, and nerve endings.
- Reticular layer (stratum reticulare): A thicker, deep layer consisting of connective tissue and containing sweat glands, sebaceous glands, and hair follicles. (The reticular layer of the dermis merges with the subcutaneous tissue.)

**Figure 4B. LAYERS OF THE SKIN: EPIDERMIS AND DERMIS**

1. *subcutaneous tissue*—The loose connective tissue under the dermis.
Q1

a. What are the two primary layers of the skin?
   
   1. __________________
   
   2. __________________

b. A lack of what component of the basal-cell layer of the epidermis causes persons with fair skin to sunburn more readily than those with darker skin?

   ____________________________________________________________

   c. Match the skin layer with the tissue type:

   _____ 1. epidermis      a. epithelium
   
   _____ 2. dermis          b. connective tissue
Answer: Q1

a. The two primary layers of the skin are:
   1. epidermis
   2. dermis or corium

b. Melanin. It causes the pigmentation of skin. It is produced by melanocytes. People with fair skin who have little melanin will sunburn easily.

c. The skin layers and tissue type match as follows:

   a  1. epidermis - epithelium
   b  2. dermis - connective tissue
Epidermis is epithelial tissue derived from ectoderm; it contains no blood vessels. Dermis is dense connective tissue which contains blood vessels, nerves, and glands.

**Accessory Organs**

The accessory organs or appendages of the skin are: sebaceous¹ glands, sweat or sudoriferous² glands, ceruminous³ glands, and the nails and hair. (The mammary glands are specialized accessory glands of the skin and will be discussed in The Reproductive System.)

---

¹sebaceous—Secreting an oily substance, sebum; glands are situated in the dermis.

²sudoriferous—Secreting sweat; glands are situated in the dermis and subcutaneous tissue.

³ceruminous—Secreting a waxlike substance, cerumen; glands are located in the skin of the external auditory canal.
Q2

Name the three glands of the skin:

1. _____________________
2. _____________________
3. _____________________
Answer: Q2

The three glands of the skin are:

1. Sebaceous glands
2. Sweat or sudoriferous glands
3. Ceruminous glands
• The sebaceous glands are widely distributed in the skin except in the palms of the hands and the soles of the feet. They develop from the follicular epithelium of the hair. Several of these glands grow out from each hair follicle with direct connection to the hair root by a short duct. Through these ducts is secreted sebum, an oil which coats the body hair at the surface of the skin.

• The sweat or sudoriferous glands are simple coiled tubular glands. The secreting portion of the gland is coiled into a ball and lies in the deep part of the dermis. Sweat, the product of this gland, passes upward through its duct into a pore which opens on the surface of the skin. Sweat glands are controlled by the central nervous system. Afferent\(^1\) nerves carry impulses from the skin to the brain informing it of environmental temperatures. The efferent\(^2\) nerves, in turn, carry impulses from the brain to the skin causing a reflex emergency mechanism to trigger the sweat glands to begin cooling the body temperature by evaporation. This reflex action is also responsible for an immediate withdrawal of your hand when you touch a hot surface.

• The ceruminous glands are thought to be modified sweat glands. The secretory portions of these glands open directly into the skin or into the ducts of the sebaceous glands. Their function is to lubricate the surfaces of the ear canals and the ear drum membranes ( tympanic membranes) by secreting ear wax.

• A hair is composed of keratinized cells compactly cemented together. Hair is distributed over almost the entire body. It consists of the root, or portion below the surface, and the shaft, or portion extending above the surface. The root is embedded in a pit-like depression called the hair follicle. It widens at its lower end to include small vascular papillae (small loops of blood vessels). These papillae provide nutrition for the growth of hair. Hair grows as a result of the division of the cells of the root. The hair follicle is placed obliquely in the skin, and a small smooth muscle called the arrector muscle, fastened to the side, causes the hair to stand up in cold or fright and gives the appearance of goose flesh to the skin.

• Nails are comparable to the horny-cell layer (stratum corneum). Nail beds underlying the nail consist of the deeper layers of the epidermis and the dermis. Blood in the dermal capillaries is responsible for the nails' pink color. The white halfmoons at the base of the fingernails are called lunulae.

\(^1\) afferent--Conveying towards a center.

\(^2\) efferent--Conveying away from a center.
Q3

Accessory skin organs are found mainly in the papillary/reticular layer of the dermis. (Circle one.)

Q4

a. Sebaceous glands secrete sweat/oil/wax. (Circle one.)

b. Sudoriferous glands secrete sweat/oil/wax. (Circle one.)

c. Ceruminous glands secrete sweat/oil/wax for the ear canals and the eardrum membranes. (Circle one.)
Answer: Q3

Accessory skin organs are found mainly in the reticular layer of the dermis.

Answer: Q4

a. Sebaceous glands secrete oil.

b. Sudoriferous glands secrete sweat.

c. Ceruminous glands secrete a wax for the ear canals and the eardrum membranes.
Benign Tumors

There is a large group of benign skin tumors appearing as moles or birthmarks which are designated by the term "nevus" or "nevi" (plural). These tumors are proliferations of melanocytes and are probably of neural crest origin. They may be 1) junctional (at the dermal-epidermal junction), 2) intradermal, or 3) compound (both). They may be pigmented or nonpigmented. The giant pigmented nevi which are present at birth may become malignant.

Connective tissue tumors, such as dermatofibroma, fibroxanthoma, hemangioma, and lymphangioma may arise in the dermis. Adenomas may arise in the glandular epithelium of the sebaceous, sweat, or ceruminous glands.

---

1nevus--A benign tumor composed of melanocytes.

2neural crest--A cellular band dorsolateral to the neural tube that gives rise to the cerebrospinal ganglia. (For further information, study the embryology of the nervous system.)
Malignant Tumors

A variety of malignant tumors also arise in the skin and may derive from epithelial and/or connective tissue of the skin and its appendages. Many of these are felt to be related to prolonged exposure to sun rays. Individuals with light skin/decreased melanin are more susceptible. The most common tumors are listed and described briefly below:

- Basal cell carcinoma: A malignant skin tumor composed of cells similar to those in the basal layer of the epidermis
- Squamous cell (epidermoid) carcinoma: A malignant tumor having characteristics of squamous cells
- Basosquamous cell carcinoma: A malignant skin tumor of mixed basal and squamous cells
- Bowen's disease: Intraepidermal (in-situ) squamous cell carcinoma
- Dermatofibrosarcoma (protuberans): A fibrosarcoma of the skin, a low grade malignant tumor of the fibrous tissue of the dermis
- Sweat gland adenocarcinoma: A malignant tumor of sudoriferous glandular epithelium
- Sebaceous gland adenocarcinoma: A malignant tumor of sebaceous glandular epithelium
- Kaposi's (multiple idiopathic hemorrhagic) sarcoma: A multifocal malignant vascular tumor characterized by bluish-red or brown plaques and nodules. Kaposi's sarcoma appears to be an opportunistic carcinoma in the presence of AIDS (acquired immune deficiency syndrome).
- Mycosis fungoides: A malignant lymphoma of the skin characterized by erythema, scaling, tumor formation, and ulceration
- Malignant melanoma: A malignant tumor of the melanin-producing cells (melanocytes), usually black-brown, although lesions may be nonpigmented (amelanotic)

Many cancer registries do not register basal and squamous cell carcinomas of the skin except for selected sites, such as skin of external genital organs: vulva, penis, and scrotum.
Q5 Match the malignant tumors of the skin on the left with the best description on the right.

___ 1. Bowen's disease  a. A malignant lymphoma of the skin
___ 2. Dermatofibrosarcoma  b. Intraepidermal squamous cell carcinoma
___ 3. Kaposi's sarcoma  c. A multifocal malignant tumor characterized by bluish red or brown plaques or nodules
___ 4. Mycosis fungoides  d. A malignant tumor of the fibrous tissue of the dermis
___ 5. Melanoma  e. A malignant tumor of the melanin-producing cells
Answer: Q5

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>1. Bowen’s disease</td>
<td>Intraepidermal squamous cell carcinoma</td>
</tr>
<tr>
<td>b</td>
<td>2. Dermatofibrosarcoma</td>
<td>A malignant tumor of the fibrous tissue of the dermis</td>
</tr>
<tr>
<td>c</td>
<td>3. Kaposi’s sarcoma</td>
<td>A multifocal malignant tumor characterized by bluish red or brown plaques or nodules</td>
</tr>
<tr>
<td>d</td>
<td>4. Mycosis fungoides</td>
<td>A malignant lymphoma of the skin</td>
</tr>
<tr>
<td>e</td>
<td>5. Melanoma</td>
<td>A malignant tumor of the melanin-producing cells</td>
</tr>
</tbody>
</table>
Malignant Melanoma

Malignant melanomas may arise directly from melanocytes at the dermal-epidermal junction or within the basal cell layer and not from pre-existing moles. There are, however, some pre-existing lesions in which melanomas are known to develop, namely:

- giant hairy (pigmented) nevus
- blue nevus
- junctional nevus
- intradermal nevus.

The B-K mole syndrome has recently been described by Clark and associates. Familial melanomas frequently arise from the large, irregular moles which have been called "B-K moles" after the first two families in which this syndrome was observed. Thus, if the diagnosis is made, all nevi should be removed in these individuals to prevent the lesions from becoming invasive.

Most melanomas occur in the skin; however, they may occur elsewhere in the body, often in the eye. Subungual melanoma, that is, melanoma beneath the nail, is not uncommon. When abstracting a case of melanoma, or any skin cancer for that matter, the primary site of the lesion should be carefully identified. Primary site classifications taken from the International Classification of Diseases for Oncology (ICD-O), Second Edition, are as follows:

**TOPOGRAPHY CODE FOR MELANOMAS (M-8720-8790)**

- C44.0 Skin of lip, NOS
- C44.1 Eyelid
- C44.2 External ear
- C44.3 Skin of other and unspecified parts of face
- C44.4 Skin of scalp and neck
- C44.5 Skin of trunk
- C44.6 Skin of upper limb and shoulder
- C44.7 Skin of lower limb and hip
- C44.8 Overlapping lesion of skin (overlaps the boundaries of two or more subcategories and whose point of origin cannot be determined)
- C44.9 Skin, NOS
- C51.0 - C51.2, C51.9 Skin of vulva
- C60.0 - C60.1, C60.9 Skin of penis
- C63.2 Skin of scrotum

Skin of the lip should not be confused with the lip itself which is considered to be part of the digestive system. The skin of the upper lip extends from the vermilion border to the anterior nares; the lateral borders are the nasolabial sulci. The skin of the lower lip extends from the lower vermilion border to the lateral semicircular groove where the chin begins.

---

1nasolabial sulcus--A groove which runs downwards and laterally from the side of the nose to the angle of the mouth.
The classification of cutaneous melanoma as to histologic type and depth of invasion has undergone considerable study in recent years, particularly in the United States and Australia with the evolution of similar classification schemes. The generally defined types of cutaneous melanoma are described as follows:

- **Lentigo maligna melanoma:** A melanoma arising in a Hutchinson's melanotic freckle. The atypical melanocytes are confined to the basal layer of the epidermis during the radial growth phase. The entity is known as lentigo maligna or Hutchinson’s melanotic freckle during the period of its intraepidermal growth. It is found primarily in elderly persons.

- **Superficial (radial) spreading type malignant melanoma:** A melanoma characterized by gradual radial enlargement over a period of several months or even years before the onset of its vertical growth phase.

- **Acral lentiginous melanoma:** A specific biologic form of melanoma occurring commonly on the palms of the hands and the soles of the feet. It may also occur in areas other than skin, i.e., in the mucous membranes and subungual areas.

- **Nodular melanoma:** A malignant tumor characterized by early and rapid dermal invasion with no radial growth phase as a developmental stage. These tumors are in vertical growth from onset.

- **Malignant melanoma, unclassified:** A malignant melanoma for which the radial growth phase has not been determined.

Breslow\(^1\) has emphasized the importance of measuring the thickness (vertical growth) of penetration of the melanotic lesion. The measurement represents the thickness of invasion in millimeters from the granular layer of the epidermis to the greatest depth of penetration of the tumor into the dermis.

The measurement categories for thickness are as follows:

- \(\leq 0.75 \text{ mm.}\)
- \(0.76 - 1.50 \text{ mm.}\)
- \(1.51 - 3.00 \text{ mm.}\)
- \(3.01 - 4.00 \text{ mm.}\)
- \(> 4.00 \text{ mm.}\)

Note: \(< = \text{less than, } > = \text{greater than, and the symbol } \leq = \text{less than or equal to}\)

\(^1\)Breslow, Alexander—He initiated the measurement of tumor thickness to evaluate the incidence of recurrent disease in relationship to depth of invasion of the melanoma into the dermis.
The description of the level\(^1\) of invasion of melanoma, sometimes called "Clark's\(^2\) Classification," describes five levels of invasion. The definitions of each level are as follows:

**Level I**  
Intraepidermal: Tumor confined to epidermis (in-situ) and does not penetrate the basement membrane (basal lamina)

**Level II**  
Papillary dermis: Tumor invades only the superficial or papillary zone of the dermis

**Level III**  
Papillary-reticular dermal interface: Tumor fills and expands the papillary dermis extending to the interface of the papillary and reticular layers without invading the reticular layer

**Level IV**  
Reticular dermis: Tumor invades the deep or reticular layer of the dermis

**Level V**  
Subcutaneous tissue: Tumor invades through the reticular dermis into the subcutaneous tissue

Figure 5. **CLARK'S CLASSIFICATION OF MALIGNANT MELANOMA**

---

\(^1\)For melanomas, it is recommended that the abstractor record both thickness (in mm.) and level of invasion.

\(^2\)Clark, Wallace H., Jr.--A pathologist identified with the classification of primary malignant melanoma by "level" of invasion.
Q6

In which of the following would you not expect to find a primary malignant melanoma?

(Check one.)

[ ] Skin of ear

[ ] Eye

[ ] Liver

[ ] Vulva

Q7

Subungual melanoma occurs under the tongue/beneath the nail. (Circle one.)

Q8

Match each histologic type of melanoma on the left with the appropriate description on the right.

1. Lentigo maligna melanoma
   a. Characterized by radial growth phase for months or years prior to onset of vertical growth phase

2. Superficial (radial) spreading malignant melanoma
   b. No radial growth phase

3. Acral lentiginous melanoma
   c. Confined to the basal layer of the epidermis during its radial growth phase

4. Nodular melanoma
   d. Occurring commonly on the palms of the hands and the soles of the feet
Q9

"Clark's Classification" of malignant melanoma describes five levels of invasion. Place the following terms in order from least invasive (I) to most invasive (V): papillary-reticular dermal interface, subcutaneous tissue, papillary dermis, intraepidermal, and reticular dermis.

I

II

III

IV

V
LIVER. Malignant melanomas may metastasize to the liver, but generally would not arise there.

"beneath the nail" should have been circled. The term for "under the tongue" is sublingual.

1. Lentigo maligna melanoma: Confined to the basal layer of the epidermis during its radial growth phase
2. Superficial (radial) spreading malignant melanoma: Characterized by radial growth phase for months or years prior to onset of vertical growth phase
3. Acral lentiginous melanoma: Occurring commonly on the palms of the hands and the soles of the feet
4. Nodular melanoma: No radial growth phase

Clark's Classification:

I Intraepidermal
II Papillary dermis
III Papillary- reticular dermal interface
IV Reticular dermis
V Subcutaneous tissue
Lymphatic Drainage of the Skin

The lymphatic drainage of the skin is to the superficial lymph nodes rather than to those situated deep within the body. If these superficial lymph nodes are involved with tumor, they frequently can be palpated.

The lymph nodes which receive direct (ipsilateral) lymphatic drainage from the skin are:

### REGIONAL LYMPH NODES OF SKIN BY PRIMARY SITE

<table>
<thead>
<tr>
<th>Head and Neck - cervical for all subsites</th>
<th>Thorax/chest wall/upper back</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lip: preauricular (parotid), facial, submental, submandibular</td>
<td>axillary</td>
</tr>
<tr>
<td>Eyelid/canthus: preauricular (parotid), facial, submandibular, infra-auricular</td>
<td>internal mammary</td>
</tr>
<tr>
<td>External ear/auditory canal: preauricular (parotid), postauricular (mastoid)</td>
<td>intercostal</td>
</tr>
<tr>
<td>Face, Other*: preauricular (parotid), facial, submental, submandibular</td>
<td>supraclavicular</td>
</tr>
<tr>
<td>Scalp/neck: preauricular (parotid), occipital, spinal accessory (posterior cervical) postauricular (mastoid) for scalp supraclavicular, axillary for neck</td>
<td>Abdomen/lower back</td>
</tr>
<tr>
<td></td>
<td>femoral (superficial inguinal)</td>
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<tr>
<td></td>
<td>Arm/shoulder</td>
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<tr>
<td></td>
<td>axillary</td>
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<tr>
<td></td>
<td>spinal accessory for shoulder</td>
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<tr>
<td></td>
<td>epitrochlear for hand, forearm</td>
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<tr>
<td></td>
<td>Leg/hip</td>
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<tr>
<td></td>
<td>femoral (superficial inguinal) except for heel</td>
</tr>
<tr>
<td></td>
<td>popliteal for heel and calf</td>
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<tr>
<td></td>
<td>Scrotum/perineum</td>
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<tr>
<td></td>
<td>femoral</td>
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<tr>
<td></td>
<td>inguinal</td>
</tr>
</tbody>
</table>

*Includes the skin of the cheek, chin, forehead, jaw, nose, temple
Figure 6. LYMPHATICS OF THE SKIN
Match the regions of the skin on the left with the lymph node drainage on the right.

___1. Head                       a. Supraclavicular and axillary lymph nodes
___2. Upper extremity           b. Submandibular and postauricular (parotid) lymph nodes
___3. Lower extremity           c. Axillary and epitrochlear lymph nodes
___4. Chest wall                d. Femoral (superficial inguinal) and popliteal lymph nodes
The skin locations on the left match the lymph nodes on the right as follows:

1. Head Submandibular and postauricular (parotid) lymph nodes
2. Upper extremity Axillary and epitrochlear lymph nodes
3. Lower extremity Femoral (superficial inguinal) and popliteal lymph nodes
4. Chest wall Supraclavicular and axillary lymph nodes
SECTION D

THE LYMPHATIC SYSTEM
SECTION D
THE LYMPHATIC SYSTEM

The lymphatic system and the cardiovascular system (Section E) together provide the internal environment of the body. The blood carries food and oxygen to, and waste products from, the cells of the body. The lymphatic system consists of a set of vessels and aggregations of lymphatic tissue which collect and carry lymph from the body tissues to the veins of the blood circulatory system.

Lymph vessels, like blood vessels, are distributed to nearly all parts of the body. The lymphatic system carries fluid away from, and not to the tissues; consequently, it is not a continuous closed circulation system as is the cardiovascular system. The lymph enters the system via the lymph capillaries and flows into larger and larger collecting vessels until it finally empties into the subclavian veins. Interposed along the lymphatics (lymph vessels) are many lymph nodes, structures which serve as filters to clear the lymph of particulate matter. Lymphatic organs and tissues include lymph nodes, the spleen, thymus, tonsils, and Peyer's patches of the small intestine. The lymph nodes, spleen, and thymus have roles as hematopoietic (lymphopoietic) centers mainly producing lymphocytes.

Figure 7. RELATIONSHIP BETWEEN THE BLOOD AND LYMPH CIRCULATORY SYSTEMS

---

1lymph--A clear watery fluid found in the lymph vessels (See page 63 for a more detailed discussion.

2hematopoiesis--(hemopoiesis)--Formation and development of blood cells.

3lymphopoiesis--Formation and development of lymphatic tissue or cells (lymphocytes).
T-Cells Versus B-Cells

The two principal classes of lymphocytes that can be recognized in an immune system are T and B lymphocytes. In recent years an attempt has been made to relate malignant lymphoma to the normal cells of the immune system and to understand which parts of the immune system are involved.

The T-cells mature in the thymus and are involved in cell-mediated immunity, that is, the cells themselves mediate the immune effect.

The B-cells derive from a bone-marrow precursor and mature in the chicken in an organ known as the bursa Fabricius. In humans and other mammals there is no bursa Fabricius, but B-cells mature in a bursa equivalent, which may be fetal liver. The B-cells, through their progeny, differentiate into plasma cells. These are cells which can secrete antibodies and are known to form the humoral component of the immune system, that is, they secrete products which mediate the effect; it is not the cell itself that is involved in the immune mechanism.
Q1

The lymphatic system collects ______________ from the tissues of the body via the lymphatic ______________. Lymph is filtered through the ______________, and finally it empties into the ______________ veins of the blood circulatory system.

Q2

Some specific lymphoid organs and tissues are:

1. ______________
2. ______________
3. ______________
4. ______________
5. ______________
Answer: Q1

The lymphatic system collects lymph from the tissues of the body via the lymphatic capillaries. Lymph is filtered through the lymph nodes, and finally it empties into the subclavian veins of the blood circulatory system.

Answer: Q2

Some specific lymphoid organs and tissues are:

1. Lymph nodes
2. Spleen
3. Thymus
4. Tonsils
5. Peyer's patches
Lymphatic Vessels

The function of the lymphatic vessels is to return lymph from the interstitial fluid\(^1\) to the blood circulatory system where it may be purified and recharged with nutrients and oxygen. In general, lymphatic vessels resemble veins in structure, but have thinner walls, many more valves, and lymph nodes located at intervals along their course. The valves are usually semilunar pairs with free edges in the direction of current flow. In case of blockage, the valves are often unable to withstand much increase in pressure and reverse (retrograde) flow may occur.

Lymphatics originating in the villi (finger-like projections) of the small intestine are called lacteals and the fluid found in them after digestion is called chyle.\(^2\) This fluid is milky in appearance from absorbed fats.

The lymphatic capillaries originate as microscopic blind-end vessels which are located in the intercellular spaces and are widely distributed throughout the body. Small lymphatics merge with larger ones and they, in turn, with still larger vessels until they join (much like the branches of a tree) to form the main lymphatic trunks: the right lymphatic duct and the thoracic duct. Lymph from the entire body, except the right upper quadrant, drains eventually into the thoracic duct which flows into the left subclavian vein at the point where it joins the left internal jugular vein. Lymph from the upper right quadrant of the body empties into the right subclavian vein by way of the right lymphatic duct.

Since most of the body lymph returns to the bloodstream via the thoracic duct, this vessel is much larger than the right lymphatic duct--but it is much smaller than the large veins which it resembles in structure. The thoracic duct varies in length from 35 to 48 cm. It originates as a dilated structure, the cisterna chyli, in the lumbar region of the abdominal cavity, and ascends by a winding course to the root of the neck where it joins the left subclavian vein. Diagrammatic representation of lymphatic drainage is shown for different parts of the body in Figures 8A and 8B.

\(^1\)interstitial fluid--The extra-cellular fluid which bathes the cells and is drained away as lymph.

\(^2\)chyle--The milky fluid taken up by the lacteals from the food in the small intestine during digestion. It passes into the thoracic duct at the cisterna chyli.
The shaded area is drained by the right lymphatic duct.
Q3

The lymphatic system collects lymph from body tissues in an ever-enlarging system of lymphatic vessels to form terminal lymphatic ducts which empty into ________________ that carry the lymph back to the blood circulatory system.

Q4

The main lymphatic trunks are the ________________ ________________ _______ and the ________________ _______.

Which of these ducts drains the greater part of the body?

_____________________________________________________________

Q5

The structure of the lymphatic vessels resembles veins with the major difference being that the lymphatics have ________________ ________________ along their course.
Answer: Q3

The lymphatic system collects lymph from body tissues in an ever-enlarging system of lymphatic vessels to form terminal lymphatic ducts which empty into veins that carry the lymph back to the blood circulatory system.

Answer: Q4

The main lymphatic trunks are the right lymphatic duct and the thoracic duct.

The thoracic duct drains the greater part of the body.

Answer: Q5

The structure of the lymphatic vessels resembles veins with the major difference being that the lymphatics have lymph nodes along their course.
Lymph Nodes

Lymph nodes are oval or bean-shaped masses of lymphoid tissue, densely packed with lymphocytes. They vary in size from a pinhead to a lima bean. They are each covered by a capsule of fibrous connective tissue. The lymph moves through the afferent (towards the node) lymphatic vessels into the node where it is filtered through sinus channels lined with reticuloendothelial cells\(^1\) (or histiocytes) and emerges by an efferent (away from the node) vessel (see Figure 9A for the internal structure of a lymph node, and Figure 9B for the external view).

Figures 9A and 9B. STRUCTURE OF A LYMPH NODE

---

\(^1\)reticuloendothelial cells (or histiocytes)--Special cells which ingest and destroy old erythrocytes and foreign substances; found mainly in the lymph nodes, liver, spleen, and bone marrow.
Lymph nodes accomplish two separate functions—defense and hematopoiesis.

- The defense functions are filtration and phagocytosis. The lymph slowly filters through the intricate structure of the sinus channels which remove the microorganisms and injurious particles—for example, cancer cells and soot. Blockage of lymph nodes with obstruction of the normal flow of lymph may cause edema, inflammation, and retrograde flow of lymph. Thus, metastasis may occur in adjacent lymph nodes as a result of direct flow, or may occur in lymph nodes accessible only by retrograde flow.

- The lymphoid tissue of the nodes produces nongranular white blood cells—lymphocytes. It also produces plasma cells (plasmacytes) which are the cells that create gamma globulins (antibodies). Production of these different blood cells is the hematopoietic (or lymphopoietic) function of the lymph nodes.

Lymph nodes tend to be grouped in certain areas of the body and are named according to their location. For example, axillary nodes are located in the axilla, cervical nodes in the neck, mesenteric nodes in the mesentery of the intestines, and so forth. It is essential that the cancer registrar be familiar with the location of lymph nodes and the organs and tissues each lymphatic basin drains.

---

1. **phagocytosis**—The engulfing of microorganisms, other cells, and foreign particles by certain cells (phagocytes).
Lymph and Tissue Fluid

Tissue fluid (interstitial fluid) is the clear watery fluid which surrounds all cells. It is sometimes referred to as "lymph," but technically lymph is derived from interstitial fluid. The word lymph should only be used in reference to that tissue fluid which has entered the vessels of the lymphatic system.

Both lymph and tissue fluid resemble blood plasma in composition since tissue fluid reaches the cells in the first place from the capillaries of the blood circulatory system. Tissue fluid fills the microscopic spaces between the cells and carries oxygen and nutrients from the blood to the cells. In returning with waste products from the cells, it enters the microscopic lymphatic capillaries as "lymph" and, as described on page 49, returns to the blood circulatory system via the subclavian veins. Thus, there is a continuous exchange of materials between the blood and the cells through the interstitial fluid.
Q6

The lymph nodes have two main functions:

1. ____________________________
2. ____________________________

Q7

Lymph nodes often have names specific to the area of the body in which they are located. See if you can match the named nodes in the left-hand column with the location described in the right-hand column. (Refer to Figures 6 and 8A and 8B, if necessary.)

<table>
<thead>
<tr>
<th>Lymph Nodes</th>
<th>Location Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>___________</td>
<td>1. Axillary a. Behind and slightly above the elbow</td>
</tr>
<tr>
<td>___________</td>
<td>2. Buccal b. In the mesentery of small intestine and colon</td>
</tr>
<tr>
<td>___________</td>
<td>3. Cervical c. Lateral portions of neck</td>
</tr>
<tr>
<td>___________</td>
<td>4. Epitrochlear d. In front of the sacrum</td>
</tr>
<tr>
<td>___________</td>
<td>5. Iliac e. Face, around the cheeks</td>
</tr>
<tr>
<td>___________</td>
<td>6. Inguinal f. Under the armpit</td>
</tr>
<tr>
<td>___________</td>
<td>7. Intercostal g. Between the ribs</td>
</tr>
<tr>
<td>___________</td>
<td>8. Mesenteric h. In the groin</td>
</tr>
<tr>
<td>___________</td>
<td>9. Sacral i. Under the chin</td>
</tr>
<tr>
<td>___________</td>
<td>10. Submental j. Around iliac blood vessels</td>
</tr>
</tbody>
</table>

Q8

The fluid located within the lymphatic system is called ____________; the fluid which surrounds the cells and which carries oxygen and nutrients from the ________________ to the cells is called ________________ ________________.
Answer: Q6

The lymph nodes have two main functions:

1. Defense
2. Hematopoiesis (or lymphopoiesis)

Answer: Q7

1. Axillary  Under the armpit (axilla)
2. Buccal  Face, around the cheeks
3. Cervical  Lateral portions of neck
4. Epitrochlear  Behind and slightly above the elbow
5. Iliac  Around iliac blood vessels
6. Inguinal  In the groin
7. Intercostal  Between the ribs
8. Mesenteric  In the mesentery of small intestine and colon
9. Sacral  In front of the sacrum
10. Submental  Under the chin

Answer: Q8

The fluid located within the lymphatic system is called lymph; the fluid which surrounds the cells and which carries oxygen and nutrients from the blood (or capillaries) to the cells is called interstitial fluid (tissue fluid).
Spleen

The spleen, the largest lymphoid organ in the body, is located beneath the diaphragm in the left upper quadrant directly posterior to the greater curvature of the stomach. It is designed to filter blood. It is also a reservoir for blood cells—lymphocytes, plasma cells, and monocytes. Its reticuloendothelial cells phagocytize old, worn-out red blood cells. The spleen produces antibodies for the defense of the body against microorganisms. Despite its many functions, the spleen can be removed without causing death since most of its functions can be assumed by lymphoid tissue and reticuloendothelial cells elsewhere. There is some evidence that spleen regeneration may occur when cells spill from the pulp of a damaged spleen, implant in the body, and grow. Sometimes several functional mini-spleens develop following splenectomy for trauma.

Figure 10. SPLEEN

Figure 11. THYMUS GLAND
Thymus

The thymus is situated in the anterior mediastinal portion of the thoracic cavity and may extend up to the lower edge of the thyroid gland. It is a two-lobed gland composed of lymphocytic and epithelial tissue. A ductless gland, it is assumed to have an endocrine function, but the mechanism of that endocrine function, if any, is really unknown at this time. The thymus is believed to play a vital part in hematopoiesis and in immunity against infection. It manufactures or activates specific lymphocytes called T-cells. The T-cells themselves mediate an immune effect. They seek out malignant cells that have on their surface particular antigens lacking in normal cells, attach to the surface antigen, and destroy the tumor cell.

Recent immunotherapy makes use of a complex interaction between macrophages\(^1\) and T-cells in protection against or treatment of specific cancers. Macrophages and T-cells are also largely responsible for the rejection of tissue transplants and for skin reactions to poison ivy and other allergens.

The thymus probably completes most of its work by infancy or in early childhood and is largest, relative to the rest of the body, when a child is about two years old. Its absolute size is largest at puberty after which the thymus gradually atrophies until in very old age it becomes largely replaced by fat. There is thought to be some association between thymic tumors and myasthenia gravis, a neuromuscular disease (see Figure 11 for a diagram of the thymus gland).

Tonsils

The tonsils are small rounded masses of lymphoid tissue located in or about the entrance to the pharynx. The palatine (faucial) tonsils are located in the lateral pharyngeal walls, the lingual tonsils are located at the base of the tongue, and the pharyngeal tonsils (adenoids) in the posterior wall of the nasopharynx. The circle of lymphoid tissue formed by these tonsillar areas is called Waldeyer's ring. This tissue is believed to act as a supply source of phagocytes to the mouth and pharynx for the purpose of destroying bacteria (see Figures 21A and 21B and Figure 23 for clarifying diagrams on the location of the tonsils).

Peyer's patches

Peyer's patches are small aggregates of lymphoid tissue found in the lamina propria of the small intestine, principally in the distal ileum.

---

\(^1\)macrophage--A phagocytic cell belonging to the reticuloendothelial system.
Q9

Match each lymphatic organ or tissue on the left with the appropriate description on the right.

_____ 1. Spleen  a. Waldeyer's ring
_____ 2. Peyer's patches  b. Located in the intestines
_____ 3. Thymus  c. Filters blood
_____ 4. Lymph nodes  d. Manufactures T-cells
_____ 5. Tonsils  e. Filters lymph

Q10

What lymphatic organ may also be an endocrine gland?
Answer: Q9

c 1. Spleen  Filters blood
b 2. Peyer’s patches  Located in the intestines
d 3. Thymus  Manufactures T-cells
e 4. Lymph nodes  Filters lymph
a 5. Tonsils  Waldeyer’s ring

Answer: Q10

The thymus is a lymphatic organ and may also be an endocrine gland.
Lymphatic Drainage

Lymph nodes, most of which occur in groups and/or chains, are arranged along the lymphatic vessels. The lymphatic drainage from the organs and tissues of the body is through these nodes—first to regional nodes, then to more distant nodes. The lymphatics tend to parallel major blood vessels (arteries and veins) and the groups of lymph nodes along these vessels are so named, e.g., the superior mesenteric nodes are located along the superior mesenteric artery; the internal (upper deep) jugular nodes follow the internal jugular veins.

The major groups of lymph nodes will be discussed briefly in this section. Within some of these major categories are more specific groups of nodes which you will learn when we discuss the lymphatic drainage of specific organs. All of the organs and tissues of the body have known drainage patterns which are important in the spread of cancer. There may be several names for a particular group of lymph nodes. Check with your medical consultant to avoid confusion over synonymous names. Also see Book 6, Comparative Staging Systems for Cancer.

While blood-borne metastasis is most common for sarcomas, carcinomas tend to spread by way of the lymphatics before entering the bloodstream. Primary tumors of the lymphatic system tend to involve multiple areas of lymphoid tissue before blood-borne metastasis occurs.

The diagnostic workup for most cancer patients will include an inspection or exploration of the most likely lymph-node drainage areas. Some lymph nodes are amenable to palpation by the examining physician while others are located deep within the body and can only be examined at the time of surgery or by lymphangiography,¹ CAT² scans, or MRI.³ Lymph nodes may therefore be termed "accessible" or "inaccessible" depending on whether or not they are palpable by the physician without surgical intervention.

---

¹lymphangiography—Radiographic visualization of lymphatic vessels and lymph nodes following injection of radiopaque material.

²CAT—Computerized axial tomography.

³MRI—Magnetic resonance imaging.
Q11
Lymphatics tend to parallel ________________ ________________ forming groups or chains of nodes which usually carry the same names as the blood vessels.

Q12
Sarcomas tend to spread by way of the ________________, while carcinomas first tend to spread by way of the ________________ __.

Q13
The diagnostic workup of a cancer patient should always include ________________ of accessible lymph nodes. Inaccessible lymph nodes may be visualized at exploratory surgery or by ________________, ________ ________, or ____________.
Answer: Q11

Lymphatics tend to parallel blood vessels forming groups or chains of nodes which usually carry the same names as the blood vessels.

Answer: Q12

Sarcomas tend to spread by way of the blood, while carcinomas first tend to spread by way of the lymph. Lymph node involvement is a frequent occurrence for carcinomas.

Answer: Q13

The diagnostic workup of a cancer patient should always include palpation of accessible lymph nodes. Inaccessible lymph nodes may be visualized at exploratory surgery, by lymphangiography, CAT scan, or MRI.

Figure 12A. LYMPH NODES OF THE HEAD AND NECK
Lymph Nodes of Head and Neck

The lymph node drainage for most sites within the head and neck will be to \textit{cervical} nodes. This is a general term for nodes located in the neck or draining into the nodes of the neck. More specifically, cervical nodes may be identified as:

- Occipital
- Mastoid (postauricular)
- Facial: infra-orbital, maxillary, buccinator, supramandibular
- Parotid: preauricular, subparotid, infra-auricular
- Sublingual (lingual)
- Retropharyngeal

- Submental
- Submandibular (submaxillary)
- Anterior cervical: prelaryngeal, pretracheal, paratracheal, laterotracheal (recurrent laryngeal nerve chain)
- Internal jugular: upper and lower deep cervical (jugulodigastric and jugulo-omohyoid)
- Spinal accessory (posterior cervical)
- Transverse cervical (supraclavicular)

The term "supraclavicular nodes" is commonly used to include the transverse cervical nodes and the lowest nodes of the internal jugular and spinal accessory chains.

The regional nodes for some of the anatomic sites in the head and neck area are, for example:

- Occipital and mastoid lymph nodes - skin of posterior scalp and neck
- Parotid lymph nodes - parotid gland, buccal mucosa, tympanic cavity, eyelids

- Retropharyngeal lymph nodes - pharynx, palate, nasal cavity

- Submental and submandibular lymph nodes - lip, anterior two-thirds of tongue, floor of mouth, submandibular gland

- Internal jugular (upper and lower deep cervical) lymph nodes, tongue, floor of mouth, palate, pharynx, larynx, thyroid gland

Refer to the Figures 6 and 28 if you need help in clarifying the locations of these lymph nodes.

\footnote{\textit{cervical}--Pertaining to the neck, or to the neck of any organ or structure.}
Q14

A general term for lymph nodes located in the neck is ____________.

Q15

A general term for lymph nodes of the transverse cervical chain and of the lowest nodes of the internal jugular (upper and lower deep cervical) and spinal accessory chains is ____________.

Q16

List five examples of specific cervical nodes:

1. ________________
2. ________________
3. ________________
4. ________________
5. ________________

Q17

What is another name commonly used for submandibular nodes?

____________________
Answer: Q14

A general term for lymph nodes located in the neck is cervical. You will learn more about the specific names of cervical nodes in Book 6, Comparative Staging Systems for Cancer.

Answer: Q15

A general term for lymph nodes of the transverse cervical chain and of the lowest nodes of the internal jugular (upper and lower deep cervical) and spinal accessory chains is supraclavicular.

Answer: Q16

Any of the neck nodes mentioned on page 74 are considered cervical lymph nodes.

Answer: Q17

The submandibular nodes and submaxillary nodes are the same.
Lymph Nodes of the Thorax

The lymph nodes of the thorax may be classified as parietal\(^1\) or visceral\(^2\) depending upon whether they are near the walls of the thoracic cavity or within the thorax, respectively. The primary regional lymph nodes and the sites which these nodes drain in each of the areas of the thorax are:

- **Parietal Area**
  - Internal mammary (parasternal) lymph nodes - breast and chest wall
  - Intercostal lymph nodes - chest wall and pleura
  - Diaphragmatic lymph nodes - diaphragm, pleura

- **Visceral Area**
  - Anterior mediastinal lymph nodes - lung, pleura, trachea, thyroid, thymus, pericardium
  - Posterior mediastinal lymph nodes - lung, pleura, esophagus, pericardium
  - Tracheobronchial (carinal, peritracheal, hilar) lymph nodes - trachea, bronchus, lung, upper esophagus

---

1. **parietal**—Of or pertaining to the walls of a cavity.

2. **visceral**—Contained within a body cavity; pertaining to the internal organs or viscera.
Q18

Lymph nodes of the thorax may be classified as _____________ if located in relation to (near) the chest wall or _______________ if located deeper within the thoracic cavity.

Q19

Indicate whether the following lymph nodes are parietal or visceral using the initial letters P and V:

_____ Intercostal
_____ Posterior mediastinal
_____ Diaphragmatic
_____ Tracheobronchial
_____ Internal mammary
Lymph nodes of the thorax may be classified as **parietal** if located in relation to (near) the chest wall or **visceral** if located deeper within the thoracic cavity.

The parietal and visceral lymph nodes are indicated by P or V as follows:

- **P** Intercostal
- **V** Posterior mediastinal
- **P** Diaphragmatic
- **V** Tracheobronchial
- **P** Internal mammary

**Figure 13. Lymph Nodes of the Abdomen and Pelvis**
Lymph Nodes of the Abdomen and Pelvis

The parietal nodes of the abdomen and pelvis are situated behind the peritoneum\(^1\) and are commonly called retroperitoneal nodes. These nodes lie parallel to the aorta and the iliac arteries (below the bifurcation\(^2\) of the aorta). The principal parietal nodes and some of the sites whose lymphatics drain directly into these nodes are:

- Aortic (para-aortic) lymph nodes: kidney, suprarenal (adrenal) gland, ovary, testis, corpus uteri
- Iliac (common, internal, external) lymph nodes: uterus, vagina, ovary
- Sacral lymph nodes: rectum, uterus, prostate gland

The visceral nodes of the abdomen are located along the branches of the celiac artery (left gastric, hepatic and splenic arteries) and the superior and inferior mesenteric arteries. These three major arteries branch off the aorta as it passes through the abdomen. The regional lymph nodes which drain the abdominal viscera and some of the sites which they drain are:

- Superior or left gastric lymph nodes: stomach, intrathoracic esophagus
- Inferior or right gastric lymph nodes: stomach, duodenum
- Splenic lymph nodes: stomach, spleen, body and tail of pancreas
- Superior mesenteric lymph nodes: jejunum, ileum, pancreas, ampulla of Vater
- Inferior mesenteric lymph nodes: descending colon, splenic flexure, sigmoid colon, rectosigmoid, rectum

Refer to Figure 13 for a diagram of abdominal and pelvic lymph nodes.

The lymphatics following the course of the above named arteries carry the lymph back to nodes located along the aorta; however, the aortic nodes are considered distant nodes for abdominal sites.

---

\(^1\)peritoneum--The serous membrane lining the interior abdominal cavity and investing (covering) the abdominal viscera.

\(^2\)bifurcation--Division into two branches; in this example, division of the aorta into the right and left common iliac arteries.
Q20

Lymph nodes of the abdomen may also be classified as visceral or parietal. The ______________ lymph nodes are located along branches of the celiac, superior, and inferior mesenteric arteries. Specific names for the lymph nodes located along branches of the celiac artery are:

1. __________________________
2. __________________________
3. __________________________

Q21

The __________________________ lymph nodes are located behind the peritoneum along the aorta and the iliac arteries. They are commonly called ______________ lymph nodes.

Specific names for these lymph nodes are:

1. __________________________
2. __________________________
3. __________________________
Lymph nodes of the abdomen may also be classified as visceral or parietal. The visceral lymph nodes are located along branches of the celiac and superior and inferior mesenteric arteries. Specific names for the lymph nodes located along branches of the celiac artery are:

1. Inferior or right gastric
2. Splenic
3. Superior or left gastric

The parietal lymph nodes are located behind the peritoneum along the aorta and the iliac arteries. They are commonly called retroperitoneal lymph nodes. Specific names for these lymph nodes are:

1. Aortic (periaortic)
2. Iliac
3. Sacral
Lymph Nodes of Upper and Lower Extremities

Located deep within the underarm and upper chest, the axillary nodes receive lymphatic drainage from the breast, skin, and other tissues of the arm, hand, shoulder, chest wall, and upper back. The lymphatics of the hand and forearm first drain through a few epitrochlear nodes situated just above the bend of the elbow, dorsally.

Analogous to the epitrochlear nodes are the popliteal nodes located behind the knee. These nodes drain the skin of the heel and posterior leg. The other lower extremity nodes are the femoral (superficial inguinal) nodes located in the groin (the area between the abdomen and upper thigh). The nodes associated with the upper and lower extremities and the sites which drain into these nodes are:

- Axillary lymph nodes: Arm, hand, shoulder, chest wall, upper back, breast
- Epitrochlear lymph nodes: Forearm, hand
- Femoral (superficial inguinal) lymph nodes: Vulva, penis, anus, scrotum, perineum,¹ anterior abdominal wall, lumbar region, lower back, lower extremities (excluding heel)
- Popliteal lymph nodes: Posterior leg, heel

See Figures 8A and 8B, for a diagram of lymph nodes of the upper and lower extremities.

¹perineum--The skin-covered muscular region between the vagina and the anus in the female and between the scrotum and the anus in the male.
Q22

Match the lymph nodes on the left with their most appropriate description of drainage on the right:

<table>
<thead>
<tr>
<th>Lymph Nodes</th>
<th>Description of Drainage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Popliteal</td>
<td>a. Arm</td>
</tr>
<tr>
<td>2. Axillary</td>
<td>b. Forearm</td>
</tr>
<tr>
<td>3. Epitrochlear</td>
<td>c. Heel</td>
</tr>
<tr>
<td>4. Superficial inguinal</td>
<td>d. Thigh</td>
</tr>
</tbody>
</table>
Answer: Q22

c 1. Popliteal  Heel
a 2. Axillary  Arm
b 3. Epitrochlear  Forearm
d 4. Superficial inguinal  Thigh
Malignant and Benign Tumors

Benign tumors of lymphoid tissue are rare. Those of the lymphatic vessels, as you have already learned, are known as lymphangiomas. Cancer registries may, or may not, elect to include these tumors.

Malignant Lymphomas

Lymphomas are malignancies of the lymph nodes and other lymphatic structures, such as the spleen, thymus, Waldeyer’s ring (tonsils), Peyer’s patches (ileum) of the small intestine, and lymphoid nodules of the appendix as well as extralymphatic/extranodal sites such as stomach and skin.

There are two principal kinds of lymphomas:

1) Hodgkin’s disease, which commonly arises in lymph nodes and other lymphatic structures, makes up 19% of all lymphomas. Of the Hodgkin’s disease cases reported, 99% are nodal.

2) Non-Hodgkin’s lymphoma (NHL), which frequently arises in extralymphatic/extranodal sites as well as in lymph nodes and other lymphatic structures, makes up 81% of all lymphomas. Of the non-Hodgkin’s lymphoma cases reported, 77% are nodal and 23% are extranodal.

The classification of NHL is discussed in detail in ICD-O-2 including a discussion of extranodal and nodal lymphomas.
Hodgkin's disease. The histologic classification of Hodgkin's disease has changed over the years. The original classification of Hodgkin's disease by Jackson and Parker in 1947 consisted of paragranuloma, granuloma, and Hodgkin's sarcoma. These all have specific code numbers in ICD-O, first edition, and ICD-O-2. However, such terms are rarely used any more. The Lukes-Butler classification came into existence in the early 1960’s and was modified at the Rye, NY Conference in 1966 and was then called the Rye classification or modification. It represents a spectrum based on the relative proportion of malignant cells seen, as follows:

- Lymphocytic predominance type (LP)
- Nodular sclerosis type (NS)
- Mixed cellularity type (MC)
- Lymphocytic depletion type (LD)
- Unclassified type (NOS)

Further additions or splits can be seen in ICD-O-2, such as splitting lymphocytic predominance by whether it is diffuse or nodular.

One of the requirements for a diagnosis of Hodgkin’s disease is the identification by the pathologist of Reed-Sternberg cells1 (malignant cells) in an appropriate cellular environment.

There is indirect evidence that Hodgkin’s disease involves the T-cell component of the immune system.

---

1Reed-Sternberg cell---Characteristic giant cell with large, inclusion-like nucleoli and double or multiple nuclei.
Q23

Benign tumors of lymphoid tissue are frequent/rare. (Circle one.)

Q24

Malignant tumors of the lymphoid tissue may be divided into two general categories:

1. ________
2. ________

Q25

Name the four major types of Hodgkin’s disease according to the histologic classification:

1. ________ _________
2. ________ _________
3. ________ _________
4. ________ _________

Q26

One requirement for a diagnosis of Hodgkin’s disease is identification by the pathologist of the presence of _______________ cells.
Answer: Q23

Benign tumors of lymphoid tissue are rare. Tumor registries may, or may not, elect to include these tumors.

Answer: Q24

The two general categories for lymphomas are:

1. Hodgkin’s disease
2. Non-Hodgkin’s lymphomas

Answer: Q25

The four major types of Hodgkin’s disease according to the current histologic classification are:

1. Lymphocytic predominance
2. Mixed cellularity
3. Lymphocytic depletion
4. Nodular sclerosis

Answer: Q26

One requirement for a diagnosis of Hodgkin’s disease is the presence of Reed-Sternberg cells.
Non-Hodgkin's Malignant Lymphoma. The classification of non-Hodgkin's lymphoma has undergone many changes. Most diagnostic schemes will describe it in terms of two parameters: pattern of growth and cell type. The most commonly used schemes describe the proliferative pattern of growth as:

- Nodular (follicular)
- Diffuse

There are six systems used throughout the world to classify non-Hodgkin's lymphoma:

- Rappaport classification
- BNLI—British National Lymphoma Investigation
- Dorfman Classification
- Kiel Classification
- Lukes-Collins
- World Health Organization

Several special conferences and meetings have been held to resolve the confusion that resulted from the various systems used and to reconcile the differences among them.

In 1979, the National Cancer Institute planned and sponsored a multi-institutional study of the six histopathologic systems used in the classification of non-Hodgkin's lymphoma to assess their clinical applicability and reproducibility. The results of the study, based on clinical correlations (survival curves, age, sex, presenting sites, and stage of disease), were published as a summary and description of a working formulation for clinical usage.\(^1\) The summary does not represent a new classification system, but rather, is "intended as a means of translation among all systems." It is discussed in detail in the ICD-O-2 on pages xxxii-xxxvi.

\(^1\)Cancer 49: 2112-2135, 1982.
**Extralymphatic/Extranodal Sites**

Lymphoid tumors may be described as "nodal" or "extralymphatic," sometimes called "extranodal," in reference to their sites of origin. Tumors classified as "nodal" include those arising in lymphatic tissue, such as in the spleen or Waldeyer's ring, as well as those originating in lymph nodes. Waldeyer's ring includes:

- Base of tongue (lingual tonsil)
- Oropharynx (palatine tonsil)
- Nasopharynx (pharyngeal tonsil)

"Extralymphatic" refers to tumors originating in sites which are not primarily composed of lymphoid tissue. The most common extralymphatic sites are:

- Stomach
- Skin (mycosis fungoides)
- Small intestine (ileum) and appendix

These extralymphatic sites may represent the primary site of lymphoma or may be involved as areas of metastatic spread from primary lymph node tumors. The cancer registrar must attempt to determine from all of the evidence in the medical record whether the lymphoid tumor has originated in or spread to these areas. This is not always readily determined. If in doubt, an opinion should be sought from the clinician or pathologist to determine how the case can most accurately be entered in the registry.

Rules for Determining Multiple Primaries for Lymphatic and Hematopoietic Diseases:

The tables entitled *Introduction and General Instructions* at the back of this manual are to be used to help determine multiple primaries of the lymphatic and hematopoietic diseases.

**RULES to follow are:**

1. No topography (site) is to be considered in determining multiple primaries of lymphatic and hematopoietic diseases. Multiple primaries are determined by histology (see the tables at the back of this manual).

2. The interval between diagnoses is NOT to enter into the decision.

Example: A lymphocytic lymphoma (M-9670/3) diagnosed in March, 1987 and an unspecified non-Hodgkin's lymphoma (M-9590/3) diagnosed in April, 1988 would be considered one primary, a lymphocytic lymphoma diagnosed in March, 1987 (the earlier diagnosis).
Q27

Non-Hodgkin's lymphomas may be described in terms of the predominant ____________
________ and the degree of _________________. The proliferative pattern may
also be described as ________________ or ___________________.

Q28

Lymphomas are primarily of ________________ ________________ origin, but two common
extralymphatic sites are __________ and _______________________________.

95
Non-Hodgkin's lymphomas may be described in terms of the predominant cell type and the degree of differentiation. The proliferative pattern may also be described as nodular or diffuse.

You might have said lymphomas are primarily of lymph node origin, but two common extralymphatic sites are the stomach and small intestine or any of the extralymphatic sites listed on page 94.
SECTION E

THE CARDIOVASCULAR SYSTEM
THE CARDIOVASCULAR SYSTEM

Figure 14A. BLOOD FLOW THROUGH THE BODY
(schematic approximation; not anatomic location of organs)
SECTION E

THE CARDIOVASCULAR SYSTEM

The cardiovascular (circulatory) system consists of the heart and a system of blood vessels (arteries, capillaries, veins) through which blood is transported from the heart to the tissues of the body and back again. Actually, the heart is a double pump, driving the blood through two circuits (Figures 14A-D):

• The pulmonary circuit conveys blood from the right side of the heart to the lungs and then returns it to the left side of the heart (see page 105).

• The systemic circuit carries blood from the left side of the heart to the rest of the body and returns it to the right side of the heart (see page 105).

If there were no mechanism for constantly changing or freshening the tissue fluid of the body, it would soon become depleted of food and oxygen and become saturated with waste products. In addition to its primary function of transporting various substances to and from body cells, the circulatory system contributes to cellular metabolism, balance (homeostasis) of fluid volume, balance of pH (hydrogen-ion concentration), homeostasis of body temperature, and defense against microorganisms.
CIRCULATORY SYSTEM

Figure 14D. BLOOD FLOW THROUGH HEART

Figure 14E. PORTAL CIRCULATION
Q1

The cardiovascular system consists of an organ called the _______ and a system of blood vessels:

________________, _____________, and ____________

Q2

The cardiovascular system is comprised of two separate circuits:

1. The ____________ circuit conveys blood to the lungs and then returns it to the ___________ side of the heart.

2. The ____________ circuit conveys blood to the rest of the body and then returns it to the ___________ side of the heart.

Q3

The primary function of the cardiovascular system is to ___________ blood to and from the body cells thus providing them with ______ and ___________ and carrying away ______________ and ______________.

Q4

The cardiovascular system also contributes to:

1. _______________________

2. _______________________

3. _______________________

4. _______________________

5. _______________________


The cardiovascular system consists of an organ called the heart and a system of blood vessels: arteries, capillaries, and veins.

1) The pulmonary circuit conveys blood to the lungs and then returns it to the left side of the heart.

2) The systemic circuit conveys blood to the rest of the body and then returns it to the right side of the heart.

The primary function of the cardiovascular system is to transport (carry) blood to and from the body cells thus providing them with food (nutrients) and oxygen, and carrying away waste products.

The cardiovascular system also contributes to:

1) Cellular metabolism

"Metabolism" is usually the term applied to the over-all series of chemical reactions taking place within the body cells in which oxygen and nutrients are consumed and carbon dioxide and other wastes are produced in the release of energy.

2) Balance (homeostasis) of fluid volume

3) Balance of pH (a measure of hydrogen-ion concentration: A pH of 7.0 is neutral; above 7.0 alkalinity increases and below 7.0 acidity increases.)

4) Homeostasis of body temperature

5) Defense against microorganisms
Heart and Pericardium

The heart is a hollow muscular organ about the size of a human fist lying within the mediastinum, between the lungs, with its apex on the diaphragm. It has four chambers (see Figure 14B).

- Right and left atria

The atria are small receiving chambers much like big veins. The right atrium, which receives blood from the systemic circulation, is larger than the left atrium, which receives blood from the lungs only. Both atria have thinner walls than do the ventricles since they have less pressure exerted on them than do the ventricles, just as veins have thinner walls than do arteries.

- Right and left ventricles

The ventricles are large, contracting chambers with thick walls. The walls of the left ventricle are thicker because the left ventricle must pump blood to the most distant parts of the body; the right ventricle pumps blood only to the lungs.

The openings between the atria and ventricles, the atrioventricular orifices, are controlled by cuspid valves:

- The tricuspid valve controls the opening between the right atrium and the right ventricle.
- The mitral (bicuspid) valve controls the opening between the left atrium and the left ventricle.

Semilunar valves control the opening from the right ventricle into the pulmonary artery and the opening from the left ventricle into the great aorta.

The heart muscle (myocardium) receives its blood supply from the branches of the right and left coronary arteries (Figure 14B). These vessels come off the ascending aorta just as this structure exits from the left ventricle.

A small mass of modified cardiac muscle called the sinoatrial node and an additional mass now termed the atrioventricular junction, along with an abundant nerve supply, contribute to the stimulation and regulation of heart action.
The heart lies in a loose-fitting sac called the *pericardium*. This sac is composed of an outer fibrous portion and an inner serous portion. The inner portion consists of two layers:

- The parietal layer lining the inside of the fibrous pericardium
- The visceral layer (epicardium) adhering to the exterior surface of the heart.

Between the parietal and visceral layers is a potential space, the pericardial space, which contains a few drops of pericardial fluid. This fluid reduces friction during movement of the heart.

The walls of the heart are composed of three layers:

- The *epicardium* or outer layer of the heart (the visceral layer of the serous pericardium described above)
- The *myocardium* or heart muscle
- The *endocardium* or inner lining of the four chambers of the heart.
The Heart As a Pump. You will recall that the heart receives blood from both systemic and pulmonary circuits.

- The DEOXYGENATED BLOOD RETURNS to the right atrium of the heart FROM THE SYSTEMIC CIRCUIT via the superior and inferior vena cavae. From the right atrium, the blood moves through the tricuspid valve into the right ventricle. When the right ventricle contracts, the tricuspid valve closes and the blood is forced through the pulmonary semilunar valve into the pulmonary trunk which divides into the right and left pulmonary arteries. The blood flows through the pulmonary arteries to the pulmonary capillaries where it absorbs oxygen and releases carbon dioxide.

- The OXYGENATED BLOOD RETURNS to the left atrium of the heart FROM THE PULMONARY CIRCUIT via the pulmonary veins. From the left atrium, the blood moves through the mitral (bicuspid) valve into the left ventricle. When the left ventricle contracts, the mitral valve closes, and the blood is forced through the aortic semilunar valve into the aorta and into the systemic circulation.

The pumping action of the heart creates pressure on the walls of the blood vessels which can be measured when your blood pressure is taken. Both the systolic\(^1\) and the diastolic\(^2\) values are measured.

\(^1\)systolic\) blood pressure--The force with which the blood is pushing against the artery walls when the ventricles are contracting.

\(^2\)diastolic\) blood pressure--The force with which the blood is pushing against the artery walls when the ventricles are relaxed.
Q5

The heart has four chambers called right and left __________ and right and left __________.

Q6

The heart lies within a loose-fitting sac called the __________ and is located in the __________ between the __________ with its apex on the ________.

Q7

The serous covering of the heart has two layers:

1) the __________ layer

2) the __________ layer

Q8

The heart walls are thickest in ventricles/atria because of the pumping action of these chambers.

(Circle one.)

Q9

Which veins contain oxygenated blood?

__________________________________________
Answer: Q5

The heart has four chambers called the right and left atria and the right and left ventricles.

Answer: Q6

The heart lies within a loose-fitting sac called the pericardium and is located in the mediastinum between the lungs with its apex on the diaphragm.

Answer: Q7

The serous covering of the heart has two layers:

1) The parietal layer

2) The visceral layer (epicardium)

Answer: Q8

The heart walls are thickest in the ventricles because of the pumping action of these chambers.

Answer: Q9

The right and left pulmonary veins contain oxygenated blood.
Deoxygenated blood from the body returns to the _________ (side) by way of two major veins: the _____________ ___________ ___________ and the _____________ ___________. The blood from these vessels enters into the _____________ ___________ (chamber). Blood is moved through the _____________ valve into the _____________ ___________ (chamber). When this chamber contracts, it forces blood through the _____________ ___________ valve into the _____________ ___________ (vessel), sending blood to the _____________ to be oxygenated.

The oxygenated blood returns to the _________ (side) of the heart by way of the _____________ ___________ (vessels) and enters into the _____________ ___________ (chamber). Blood is then moved through the _____________ ___________ valve into the _____________ ___________ (chamber). When this chamber contracts, it forces blood through the _____________ ___________ ___________ valve into the _____________, sending blood out into the _____________ circulatory system.
Deoxygenated blood from the body returns to the right (side) of the heart by way of two major veins: the superior vena cava and the inferior vena cava. The blood from these vessels enters into the right atrium (chamber). Blood is moved through the tricuspid valve into the right ventricle (chamber). When this chamber contracts, it forces blood through the pulmonary semilunar valve into the pulmonary artery (vessel), sending blood to the lungs to be oxygenated.

The oxygenated blood returns to the left (side) of the heart by way of the pulmonary veins (vessels) and enters into the left atrium (chamber). Blood then is moved through the mitral valve into the left ventricle (chamber). When this chamber contracts, it forces blood through the aortic semilunar valve into the aorta, sending blood out into the systemic circulatory system.
Blood Vessels

There are three kinds of blood vessels:

- **Arteries**—vessels that convey blood away from the heart. The pulmonary arteries carry deoxygenated blood from the heart to the lungs; all other arteries carry oxygenated blood from the heart to all other parts of the body.

- **Veins**—vessels that convey blood towards the heart. The pulmonary veins carry oxygenated blood from the lungs to the heart; all other veins carry deoxygenated blood from all the other parts of the body to the heart.

- **Capillaries**—microscopic vessels that carry blood from small arteries (arterioles) to small veins (venules). More importantly, they are the site of exchange of oxygen, nutrients, carbon dioxide, and waste products between the blood and the interstitial fluid.

The function of arteries¹ and arterioles² is to carry blood away from the heart to the capillaries. Capillary blood delivers oxygen and nutrients to the tissue fluid and collects carbon dioxide and other wastes from it. Finally, veins³ and venules⁴ return the blood from the capillaries to the heart. Arteries have thicker walls than do veins since the arteries have more pressure exerted on them.

---

¹ *artery*—A vessel which conveys blood away from the heart to the various parts of the body.

² *arteriole*—A minute arterial branch, especially one just proximal to a capillary.

³ *vein*—A vessel which conveys blood to or towards the heart from various parts of the body.

⁴ *venule*—A minute vein, especially one distal to a capillary.
**Portal System** (portal circulation)

Veins from the spleen, stomach, pancreas, and intestines converge to form the portal vein which carries blood and nutrients to the liver. The portal vein is formed by the joining of the splenic and the superior mesenteric veins. However, blood from the gastric, pancreatic, and inferior mesenteric veins drains into the splenic vein before it merges with the superior mesenteric vein.

In the liver the venous blood is processed in special structures called sinusoids. It mingles with the arterial blood in the capillaries, exchanges nutrient material with the liver cells, and is eventually drained from the liver by the hepatic veins that join the inferior vena cava.

If the portal circulation is interfered with (by certain types of liver disease, cancerous obstruction, or heart failure), venous drainage from most of the abdominal organs is decreased or shut off. This results in increased capillary pressure causing ascites (fluid in the abdominal cavity).

The liver is a frequent site of blood-borne metastasis because those tumors of the intestinal tract which drain into the portal system are filtered out in the liver.

Primary malignancies of the liver (including intrahepatic bile ducts) are relatively rare in the United States. They include:

- Hepatocellular carcinoma or hepatoma (arising from the liver cell)
- Intrahepatic bile duct carcinoma or cholangiocarcinoma (arising from the bile duct cell).
Q11

Name the three kinds of blood vessels and state their functions:

1. ________________: ______________________

2. ________________: ______________________

3. ________________: (a) ______________________

(b) ______________________

Q12

What is the relationship of the portal system and the venous system?

________________________________________

________________________________________

________________________________________

Q13

What happens if the portal circulation is interfered with or blocked?

________________________________________

________________________________________

________________________________________
The three kinds of blood vessels and their functions are as follows:

1. Arteries: Carry blood away from the heart
2. Veins: Carry blood towards the heart
3. Capillaries: a) Carry blood from small arteries (arterioles) to small veins (venules)
   b) Exchange nutrient material, oxygen, carbon dioxide, and waste products between blood and interstitial fluid.

The portal system is part of the venous system. It is comprised of veins from the spleen, stomach, pancreas, and intestines which converge to form the portal vein which carries blood to the liver and the hepatic veins which convey the blood from the liver to the inferior vena cava.

If portal circulation is interfered with, venous drainage from most abdominal organs is shut off. This results in increased capillary pressure causing ascites.
Blood

Blood is the fluid which circulates through the heart, arteries, veins, and capillaries carrying food and oxygen to all the cells in the body and returning waste products to points of separation from the blood, i.e., the kidneys, lungs, and sweat glands. The composition of the blood is as follows:

<table>
<thead>
<tr>
<th>Formed Elements (40-45%)</th>
<th>Plasma (55-60%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erythrocytes (RBC)</td>
<td>Leukocytes (WBC)</td>
</tr>
<tr>
<td>Thrombocytes (Platelets)</td>
<td></td>
</tr>
</tbody>
</table>

The blood cells, or formed elements of the blood, are suspended in the fluid medium called plasma which normally represents fifty-five to sixty percent of blood volume. The blood test which measures the percent of cells compared to the total volume is called the hematocrit.

The clear liquid that separates from the blood when it is allowed to clot completely is called "serum." Serum is essentially blood plasma from which fibrinogen has been removed in the process of clotting.

Erythrocytes or red blood cells transport oxygen picked up in the lungs to tissues throughout the body and return carbon dioxide to the lungs. The formation of red blood cells (erythropoiesis) takes place in the bone marrow. After an average life of about four months, the red blood cells (erythrocytes) are destroyed in the liver and spleen. The blood count (RBC) is normally 4.5-6.0 million cells per cu. mm. of blood for men and 4.5-5.5 million for women.

The hemoglobin or oxygen-carrying component of blood is measured in terms of grams percent (gm. %) or grams per 100 milliliters (gm./100 ml.) of blood. The hemoglobin content of the blood determines the amount of oxygen that it carries and is responsible for the red color of the erythrocyte and of the blood.

The red blood cell count may be lowered due to anemia or hemorrhage. It may be increased as a result of dehydration or of polycythemia\(^1\) vera.

\(^1\)polycythemia--Excess in the number of erythrocytes in the blood.
Q14

What are the three main types of blood cells?

1. ________________
2. ________________
3. ________________

Q15

The blood cells are suspended in a fluid called ________________.

Q16

The blood test which measures the percent of cells compared to total volume is called the ________________.

Q17

By way of hemoglobin, erythrocytes or __________ __________ __________ transport oxygen picked up in the lungs to tissues in the body and return carbon dioxide to the lungs.
The three main types of blood cells are:

1. Red blood cells or erythrocytes
2. White blood cells or leukocytes
3. Platelets or thrombocytes

The blood cells are suspended in a fluid called plasma.

The blood test which measures the percent of cells compared to total volume is called the hematocrit.

By way of hemoglobin, erythrocytes or red blood cells transport oxygen picked up in the lungs to tissues in the body and return carbon dioxide to the lungs.
Leukocytes, or white blood cells, function as a defense against invading microorganisms. The total white blood cell count (WBC) is normally 5,000-10,000 per cu. mm. of blood, but may increase to very high levels in cases of infection or as a reaction to treatment by radiation and/or chemotherapy. There are several types of white blood cells. The relative percentages of the various cells found in blood is called the white cell differential (see Book 5, Abstracting a Medical Record).

Leukocytes are produced in the bone marrow and in lymphoid tissue. Granulocytes (granular leukocytes), lymphocytes and monocytes (agranular leukocytes or mononuclear leukocytes) originate in the bone marrow, but multiply in the lymphoid tissue.

Platelets (thrombocytes) are formed in the bone marrow by fragmentation of large cells (megakaryocytes). Platelets normally number 200,000 to 500,000 per cu. mm. of blood. Upon disintegration they release a substance, thromboplastin, which combines with blood proteins and calcium to form prothrombin which initiates the production of fibrin to form blood clots (coagulation). Sometimes a blood clot will form within the heart or blood vessels partially or totally obstructing the vessel. Such a blood clot is called a thrombus. When a thrombus is dislodged and moves to another location, it is called an embolus (thromboembolus).
Q18

White blood cells which are known as _________________ function as a defense or protection against invading microorganisms (infection).

Q19

When a blood clot forms in and clogs a vessel, it is called a _________________.

121
Answer: Q18

White blood cells which are known as leukocytes function as a defense or protection against invading microorganisms (infection) or as a reaction to treatment by radiation and/or chemotherapy.

Answer: Q19

When a blood clot forms in and clogs a vessel, it is called a thrombus. When a blood clot breaks loose from an area in a vein and travels to another area and becomes lodged there, it is called an embolus.
Leukemia

Leukemia is a malignant disease of the blood-forming organs. As with other malignant diseases, leukemia is characterized by an uncontrolled proliferation of cells, in this case the white blood cells or leukocytes. However, an elevated leukocyte count usually represents a nonneoplastic reaction to infection or treatment by radiation and/or chemotherapy.

Leukemias are classified according to the type and number (percent) of abnormal cells and the rapidity of the clinical course. The predominant cell types are:

- Lymphocytic
- Myeloid/Granulocytic
- Monocytic

Leukemias are diagnosed by the microscopic detection of abnormal cells in the circulating (peripheral) blood and in the bone marrow. These abnormal cells may be described as atypical, immature, or "blast forms"—lymphoblasts, myeloblasts, or monoblasts. These are terms for immature cells which have not yet developed into the mature forms, namely, lymphocytes, granulocytes, or monocytes. The presence of myelocytes, metamyelocytes, or promyelocytes indicates granulocytic (myelocytic) leukemia; prolymphocytes indicate lymphatic (or lymphocytic) leukemia, and promonocytes indicate monocytic leukemia. In some cases the cells may be so undifferentiated or immature that they are impossible to identify and the disease may be classified as stem cell or blastic leukemia. You will recognize these terms in the outline (page 124) showing the development of white blood cells from stem cells. During the development of blood cells in the bone marrow, the primitive immature (unspecialized) stem cells change shape and structure several times in the course of becoming mature differentiated (specialized) blood cells.
LEUKEMIAS may also be categorized as acute, subacute, or chronic. In acute leukemia the white cell population will show a high proportion of blast forms, while in chronic leukemia the majority of cells will be more mature. The clinical progression of disease is extremely rapid in acute leukemia, but in chronic leukemia it may remain unchanged for a long period of time even without treatment.

The total white blood cell count (WBC) will be significantly elevated in most cases of leukemia (leukocytosis). However, particularly in chronic leukemia, the leukocyte count may be normal or actually below normal (leukopenia) in which case the disease may be classified as aleukemic (subleukemic) leukemia.

A decreased platelet count (thrombocytopenia) and a decreased hemoglobin level are characteristic of patients with a diagnosis of leukemia.

There are variants of the major types listed above. Consult your medical dictionary and other reference books for descriptions of unfamiliar terms. There are also diagnoses such as erythroleukemia (Di Guglielmo's disease) and plasma cell leukemia which, although termed leukemias, are actually neoplasms involving other blood cells and not leukocytes.

See Book 5, Abstracting A Medical Record for a review of definitions of hematologic terms and normal values.

Note: Other neoplasms arising in bone marrow (multiple myeloma, plasmacytoma, plasma cell myeloma) are closely related to the leukemias and will be discussed later in Section K, The Skeletal System.
Q20

Malignant diseases of the blood-forming organs are called ____________________.

Q21

Leukemias are characterized by uncontrolled __________________ of ____________
_____________ _____________ and/or especially the presence of ____________
or ________________ cells.

Q22

The classification of leukemias is determined by the:

1. ____________________
2. ____________________
3. ____________________

Q23

What are three predominant cell types?

1. ____________________
2. ____________________
3. ____________________

Q24

Leukemias may also be categorized as follows:

1. ____________________
2. ____________________
3. ____________________
Malignant diseases of the blood-forming organs are called leukemias.

Leukemias are characterized by uncontrolled proliferation of white blood cells and/or especially the presence of abnormal or immature cells.

The classification of leukemia is determined by the:

1. Type of abnormal white blood cells
2. Number of abnormal white blood cells
3. Rapidity of the clinical course

Three predominant cell types are:

1. Lymphocytic
2. Granulocytic
3. Monocytic

Leukemias may also be categorized as follows:

1. Acute
2. Subacute
3. Chronic
Q25

Match the disease on the left with the characteristic on the right.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Leukemia</td>
<td>a. An uncontrolled excess of red blood cells</td>
</tr>
<tr>
<td>2. Polycythemia vera</td>
<td>b. An uncontrolled excess of white blood cells</td>
</tr>
</tbody>
</table>
Answer: Q25

b 1. Leukemia  An uncontrolled excess of white blood cells

a 2. Polycythemia vera  An uncontrolled excess of red blood cells
SECTION F

THE RESPIRATORY SYSTEM
The respiratory system consists of those organs and parts of the body that make it possible to breathe. Respiration can be divided into two distinct phases: 1) external respiration and 2) internal respiration.

- External respiration involves both inspiration (inhaling) and expiration (exhaling) of air. Inspiration is the means by which oxygen is carried from the air into the lungs and then into the blood. Expiration is the means by which carbon dioxide is returned from the blood to the lungs and then expelled into the air.

- Internal respiration is concerned with the exchange of oxygen and carbon dioxide at the tissue level: the passage of oxygen from the blood to the tissues and the return of carbon dioxide from the tissues to the blood. First the oxygen is carried from the lungs by the red blood cells. Then carbon dioxide is carried by the red blood cells to the lungs. The utilization of oxygen and the elimination of carbon dioxide by the cells is called cellular respiration.

The respiratory system begins with the nose; at the other end of the system are the lungs. In between the nose and the lungs are the nasopharynx, oropharynx, larynx, trachea, and bronchi. The thorax, which houses most of the organs of the respiratory system, plays a major role in respiration. The elliptical shape of the ribs and the angle of their attachment to the spine allows the thorax to expand during inspiration. Thus, the lungs provide a place where large amounts of oxygen can be taken from the air and quickly absorbed into the bloodstream. Conversely, large amounts of carbon dioxide are discharged into the lungs where it is exhaled.

Figure 15. RESPIRATORY SYSTEM
Q1

Name the parts of the respiratory system between the nose and the lungs:

1. ___________________
2. ___________________
3. ___________________
4. ___________________
5. ___________________

Q2

The lungs are located in a body cavity called the ________________.

Q3

The primary purpose of the respiratory system is to make it possible for _____________ and _____________ to exchange gases, namely, _____________ ________________ and _____________ ________________.
Answer: Q1

The parts of the respiratory system between the nose and the lungs are:

1. Nasopharynx
2. Larynx
3. Trachea
4. Bronchi
5. Oropharynx

Answer: Q2

The lungs are located in a body cavity called the thorax.

Answer: Q3

The primary purpose of the respiratory system is to make it possible for blood and air to exchange gases, namely, carbon dioxide and oxygen.
Nose and Paranasal (Accessory) Sinuses

The nose consists of the two nasal cavities formed by the maxilla and palatine bones and the nasal, frontal, ethmoid, and sphenoid bones. On the lateral walls are three bony structures, one above the other, which are called conchae (superior, middle and inferior), so-called because they resemble shells. They may also be referred to as turbinates. The external orifices of the nose are the nostrils; the posterior orifice, or the opening into the nasopharynx, is called the choana. The nasal cavities are lined with mucous membrane.

The nose serves as a passageway for air going to and coming from the lungs. Air passes through the nose and, then, into the nasopharynx. The nose filters the air of certain impurities, warms it, and moistens it. In addition, the nose can detect the presence of certain types of chemicals which might be irritating to the mucous lining of the respiratory tract. The nose serves also as the organ for the sense of smell. Olfactory (odor) receptors are located in the nasal mucosa. The nose aids also in phonation (the making of vocal sounds).

The paranasal sinuses are air cavities lined with mucous membrane. The frontal sinuses are located in the bone of the forehead above the orbital cavities. The ethmoid sinuses are made up of small air cells located between the upper nasal cavities and the orbits. The sphenoid sinuses are wedge-shaped sinuses in the bone at the back of the orbital cavities. The maxillary sinuses (antrum of Highmore) are located in the upper jawbone.

The external and internal carotid arteries supply blood to the nose and the paranasal sinuses. The venous blood returns to the internal and external jugular veins.

The lymphatic vessels from the nose and the paranasal sinuses enter the retropharyngeal, submental, submandibular (submaxillary), and the internal jugular (upper and lower deep cervical) lymph nodes.

Malignant Tumors

While tumors of the nasal cavities are rare, the most common type is squamous cell (epidermoid) carcinoma. Other types which occur less frequently are adenocarcinoma, adenoid cystic carcinoma, melanoma, and lymphoma. A malignant tumor known as esthesioneuroblastoma or esthesioneuroepithelioma, which arises in the olfactory nerve, will be found occasionally in the nasal cavities.

Ninety percent of the neoplasms of the paranasal sinuses are located in the maxillary sinuses. Histologically, the tumors are similar to those found in the nasal cavities.
Q4

What are the purposes of the nose?

1. ___________________
2. ___________________
3. ___________________
4. ___________________
5. ___________________

Q5

Name the paranasal sinuses:

1. _________________
2. _________________
3. _________________
4. _________________

Q6

What is the most common histologic type of malignant tumor which you would expect to find in the nasal cavities and paranasal sinuses?

________________________________________________________________________________________
Answer: Q4

1. Serves as a passageway for air going to and from the lungs.
2. Filters the air of impurities, warms it, and moistens it.
3. Detects the presence of chemicals which might be irritating to the mucous lining of the respiratory tract.
4. Serves as the organ of smell.
5. Aids in phonation (the making of vocal sounds).

Answer: Q5

The paranasal sinuses are:

1. Frontal
2. Ethmoid
3. Sphenoid
4. Maxillary

Answer: Q6

The most common histologic type of malignant tumor which you would expect to find in the nasal cavities and paranasal sinuses is squamous cell carcinoma.
Nasopharynx

The pharynx is a muscular structure lined with mucous membrane. It is divided into three parts: the nasopharynx, located behind the nasal cavities; the oropharynx, located behind the oral cavity; and the hypopharynx (laryngopharynx), located behind and lateral to the larynx. The oropharynx and the hypopharynx are considered part of the digestive system and are discussed in Section G.

The nasopharynx is considered part of the respiratory system. Its subsites are:

- **Posterior superior wall (vault) extends from the choana**, or the opening of the nasal cavities into the nasopharynx, posteriorly to a level opposite the soft palate. The pharyngeal tonsils (adenoids) are located in this part of the nasopharynx.

- **Lateral wall** extends from the base of the skull on each side to the level of the soft palate. The auditory (eustachian) tube from the middle ear opens into the lateral wall just anterior to Rosenmuller's fossa (pharyngeal recess).

Lymphatics of the nasopharynx drain into submental, submandibular (submaxillary), and internal jugular (upper and lower deep cervical): jugulodigastric, jugulo-omohyoid, and retropharyngeal lymph nodes. The blood supply is via the external carotid arteries and internal jugular veins.

Malignant Tumors

Nasopharyngeal tumors are usually squamous cell carcinoma, lymphoepithelioma, salivary gland type tumors, and, occasionally, lymphoma.

**Figure 16. NASOPHARYNGEAL REGION AND PARANASAL SINUSES**
Q7

The pharynx can be divided into three parts called the:

1. __________________
2. __________________
3. __________________

Q8

The framework of the pharynx is composed of ____________ and lined with a ____________.

Q9

The lymphoid tissue found in the nasopharynx is located in the ____________ also known as the ____________.
Answer: Q7

The pharynx can be divided into three parts called the:

1. Nasopharynx
2. Oropharynx
3. Hypopharynx (laryngopharynx)

Answer: Q8

The framework of the pharynx is composed of muscle and lined with a mucous membrane.

Answer: Q9

The lymphoid tissue found in the nasopharynx is located in the pharyngeal tonsils also known as the adenoids.
Larynx

The larynx or voice box is a small but complex structure situated in front of the hypopharynx and contiguous with the upper end of the trachea. The larynx consists of nine pieces of cartilage. The three single and more prominent pieces are:

- **Thyroid cartilage** (Adam’s apple)
- **Epiglottis** which has a hinge-like action and forms a kind of lid over the opening of the larynx when swallowing takes place
- The **cricoid (signet-ring) cartilage**, so named because it resembles a signet ring in shape. The cricoid cartilage forms the inferior border of the larynx.

In addition there are three paired cartilages:

- Arytenoid cartilages (jar-like)
- Corniculate cartilages (horn-like)
- Cuneiform cartilages (wedge-like)

These cartilages are united by joints strengthened by various membranes and ligaments. The mucous membrane lining of the larynx forms two horizontal folds, the false vocal cords. Below these are the true vocal cords which are fibrous bands stretched across the hollow interior of the larynx. The space between the true vocal cords is called the glottis. Air forced through these cords produces sound.

**Figure 17A. LARYNX**

![Diagram of the larynx showing cartilages and vocal cords.](image-url)
The larynx can be divided into three anatomic subsites: the supraglottis, glottis, and subglottis.

- **The supraglottis** includes the posterior (laryngeal) surface of the epiglottis, the aryepiglottic folds, the arytenoids, and the ventricular bands (false cords). The epiglottis guards the superior opening of the larynx. The aryepiglottic folds are folds of tissue which border the epiglottis and make up the sides of the entrance to the larynx.

- **The glottis** consists of the true vocal cords including the anterior and posterior commissures. The vocal cords stretch across the cavity of the larynx from the thyroid cartilage to the anterior borders of the arytenoid cartilages.

- **The subglottis** lies below the true cords and extends to the inferior border of the cricoid cartilage.

The laryngeal branches of the thyroid arteries supply the blood for the larynx. The venous drainage is by way of the laryngeal tributaries of the thyroid veins into the internal jugular veins.

The principal lymph node drainage for the larynx is to the internal jugular and anterior cervical nodes. Anterior cervical nodes are the prelaryngeal, pretracheal, paratracheal, and lateral tracheal (recurrent laryngeal) nodes. Bilateral involvement is common, and spread to submandibular and submental nodes may sometimes occur.

**Figure 17B. THE ANATOMIC SUBSITES OF THE LARYNX**
Malignant Tumors

The glottic region is the area of the larynx most commonly involved with cancer; however, these tumors have the most favorable prognosis. The true vocal cords contain very few lymphatics, so the probability of metastasis to regional nodes of an early cancer is small. In contrast, the supraglottis has an abundant supply of lymphatics. Cancers of the supraglottis quickly spread to the cervical lymph nodes. The subdigastic nodes of the internal jugular chain are commonly involved as well as the prelaryngeal nodes. Thus, although supraglottic cancers rank second to glottic cancers in frequency, the prognosis is worse for patients with these cancers. The rarest form of laryngeal cancer arises in the subglottic region. Squamous cell carcinoma is the most common cell type of all laryngeal cancers.
Q10
The three single cartilages in the larynx are the ________, ________, and ________.

Q11
The three paired cartilages in the larynx are the ________, ________, and ________.

Q12
The ________ vocal cords are formed by folds of mucous membrane; the ________ vocal cords are fibrous bands stretched across the hollow interior of the larynx.

Q13
The three major anatomical subsites of the larynx are:

1. ________________

2. ________________

3. ________________
The three single cartilages in the larynx are the cricoid, thyroid, and epiglottis.

The three paired cartilages in the larynx are the arytenoid, corniculate, and cuneiform.

The false vocal cords are formed by folds of mucous membrane; the true vocal cords are fibrous bands stretched across the hollow interior of the larynx.

The three major anatomical subsites of the larynx are:

1. Supraglottis
2. Glottis
3. Subglottis
Trachea

The trachea or windpipe is a tube composed of smooth muscle lined with mucous membrane, and C-shaped rings of cartilage are embedded in the muscle. The trachea extends from below the cricoid cartilage of the larynx to the carina, and is about 2.5 cm in diameter and about 10 cm long. The trachea forms a major part of the passageway through which external air reaches the lungs, the simple but vital function of this structure. The trachea is a rare tumor site.

Bronchi

At its lower end, the trachea divides into the right main stem bronchus and left main stem bronchus (primary bronchi) at the carina. The walls of the bronchi are made of cartilage with a ciliated mucous lining. The extrapulmonary portion of each bronchus enters the lung on its own side and immediately divides into branches called lobar (secondary) bronchi. The secondary bronchi continue to branch, forming bronchioles which become smaller and smaller, forming microscopic branches which divide into alveolar ducts. At the terminal ducts are grape-like formations known as alveolar sacs which provide surfaces where the exchange of air and carbon dioxide takes place.

The intrapulmonary (lobar) bronchi are lined with ciliated columnar, mucin-producing epithelium. The walls are composed of a submucosa, smooth muscle, fibrous tissue and cartilage.
Q14
The windpipe or _____________ serves as a ________________ by which air can reach the _________________.

Q15
The trachea divides into the _____________ _____________ which in turn divide into smaller branches called _____________ _____________, _____________, _____________, and _____________ _____________.
Answer: Q14

The windpipe or trachea serves as a passageway by which air can reach the lungs.

Answer: Q15

The trachea divides into the right main stem bronchus and left main stem bronchus which in turn divide into smaller branches called lobar/secondary bronchi, bronchioles, alveolar ducts, and alveolar sacs.
**Lungs**

The lungs are cone-shaped organs of respiration which lie in the thoracic cavity, one on either side of the mediastinum.

The rounded upper portion of each lung is called the apex; the base is the concave lower portion resting on the diaphragm; and the hilus is the area on the medial surface through which the main bronchus, pulmonary artery, pulmonary vein, nerves, and lymph vessels enter and leave each lung. The left lung is partially divided by a fissure into an upper and lower lobe. Projecting from the lower portion of the left upper lobe is an area called the lingula (coded to left upper lobe). The right lung is divided by two fissures into three lobes (upper, middle, and lower).

Visceral pleura or mesothelium covers the outer surfaces of the lungs and adheres to them (See Figure 18). Parietal pleura or mesothelium lines the thorax. The potential space between the visceral and parietal pleura is called the (inter)pleural space or pleural cavity. The pleural space contains a lubricating pleural fluid which eliminates friction during the breathing process. This fluid drains to the mediastinal nodes. When the mediastinal nodes become inflamed or involved with a disease process such as a malignancy, a pleural effusion develops. Breathing then becomes labored and painful.

**Figure 18. LUNGS**
The lungs provide a place where large amounts of oxygen can be loaded quickly into the blood and large amounts of carbon dioxide can be removed from it. The PULMONARY ARTERY from the right side of the heart branches into two arteries which carry DEOXYGENATED blood to both lungs. Each artery continues dividing and subdividing within the lungs forming smaller and smaller vessels which end in capillaries which surround the alveolar sacs of the respiratory bronchioles. As the blood passes through the pulmonary capillaries, it absorbs oxygen and releases carbon dioxide. Then the newly OXYGENATED blood immediately returns through the venules (small veins) to the PULMONARY VEINS which return to the left side of the heart.

The lung itself gets its nutriment supply from the bronchial arteries which branch off the aorta.

All regional lymph nodes for the lung and the pleura are above the diaphragm. They include the intrathoracic, scalene, and supraclavicular. The intrathoracic lymph nodes can be divided into two main groups: intrapulmonic and mediastinal.

1. **Intrapulmonic:**
   - Intrapulmonary (incl. interlobar, lobar, segmental)
   - Hilar (proximal lobar, pulmonary roots)
   - Peribronchial

2. **Mediastinal:**
   - Carinal (subcarinal/precarinal)
   - Mediastinal (anterior, posterior)
   - Peri/paratracheal (incl. tracheobronchial, lower peritracheal, azygos)
   - Pretracheal and retrotracheal (incl. precarinal)
   - Peri/paraesophageal
   - Aortic (peri/para aortic, subaortic, aorticopulmonary window, ascending aorta or phrenic), above the diaphragm
   - Pulmonary ligament

If any of the above nodes are contralateral or bilateral, they are still considered regional, by the American Joint Committee on Cancer (AJCC), but are put in a separate category (N3) along with the supraclavicular and scalene nodes. Historically, these lymph nodes have been classified as "distant."

"Vocal cord paralysis," "superior vena cava syndrome," and "compression of the trachea or the esophagus" are classified as mediastinal lymph node involvement unless there is a statement of involvement by direct extension from the primary tumor.
Q16

The main bronchus, pulmonary artery and veins, nerves and lymph vessels enter and leave through the ____________ of the lung.

Q17

Describe the lobes of the lung:

a. Right lung:

b. Left lung:

Q18

__________ _______ covers the outer surface of the lung, while _________

__________ _______ lines the thorax.
Answer: Q16

The main bronchus, pulmonary artery and veins, nerves and lymph vessels enter and leave through the hilus of the lung.

Answer: Q17

The lobes of the lung may be described as follows:

a. Right lung: The right lung has three lobes--upper, middle, and lower.

b. Left lung: The left lung has two lobes--upper and lower.

Answer: Q18

Visceral pleura covers the outer surface of the lung, while parietal pleura lines the thorax.
Malignant Tumors

Carcinoma of the lung originates in the mucosal lining of the bronchi, bronchioles, and alveoli. The tumors may grow into the lumen of the bronchus or they may invade the wall of the bronchus into the lung parenchyma. Most bronchogenic carcinomas arise near the hilus of the lung and will extend along the main bronchus towards the carina into the mediastinum involving the organs and structures located in the mediastinum—the pericardium, major blood vessels and nerves, trachea, and esophagus—or they may extend peripherally to invade the pleura, chest wall, and ribs.

The histologic types of neoplasms which are commonly found in the lung are listed below:

- *Squamous cell carcinoma* is the most common type of bronchogenic carcinoma. It is believed to arise as a result of irritation of the bronchial mucosa causing squamous metaplasia progressing to squamous cell carcinoma. Cigarette smoking has been linked to the increasing incidence of squamous cell carcinoma of the lung.

- *Adenocarcinoma* may arise from the mucous glands embedded in the submucosa, or, since both adenocarcinoma and squamous cell carcinoma arise in the bronchus, it is thought that all bronchogenic carcinomas may arise from the multipotential reserve cells1 of the bronchial epithelium. Adenocarcinomas tend to occur more peripherally than do squamous cell carcinomas.

- *Adenosquamous carcinoma* (adenoacanthoma) is a tumor of mixed histologic type.

- *Undifferentiated carcinoma*, which is indistinguishable as either squamous cell carcinoma or adenocarcinoma, probably arises from the reserve cells. It may occur, for example, as large cell, small cell, or oat cell variants. These carcinomas have a worse prognosis than any of the above.

- *Bronchiolar (alveolar) carcinoma* arises in the terminal bronchioles or alveoli and is a rare tumor type.

- *Bronchial adenoma* is somewhat of a misnomer for a tumor that is frequently invasive. Variants are the carcinoid or cylindroid which are invariably malignant.

- *Mesothelioma* arises in the pleura or mesothelium that lines the pleural cavities and covers the lungs. It may be either benign or malignant.

- *Carcinoids* arise from enterochromaffin (EC) cells which occur primarily in the submucosa of the main bronchi.

The lung is one of the most common sites of metastatic disease since the body's blood flows directly into this organ and all lymphatic drainage, whether direct or retrograde, eventually flows into the lungs.

---

1*reserve cells*—Cells of the basal or germinal layer of the bronchial epithelium.
Clinical Manifestations

Clinical manifestations which are significant in the diagnosis of lung cancer are:

- Atelectasis (incomplete expansion--airless/functionless)
- Obstructive pneumonitis (inflammation)
- Superior vena cava syndrome (edema of the face, neck, and upper arms) caused by compression of the superior vena cava (most often by enlarged mediastinal lymph nodes)
- Vocal cord paralysis caused by involvement of the recurrent laryngeal nerve
- Paralysis of the diaphragm as a result of phrenic nerve involvement
- Pleural effusion (accumulation of fluid in the interpleural space (pleural cavity))

These findings are used in the clinical assessment of lung cancer.
Q19

What is the interpleural space (pleural cavity)?

Q20

Name the two groups of intrathoracic lymph nodes which drain the lung and pleura:

1. 

2. 

Q21

The most common type of bronchogenic carcinoma is 

Q22

The type of cancer which may arise from mucous glands embedded in the submucosa is 

Q23

is the most virulent type of bronchogenic carcinoma.
The interpleural space may be described as the space between the visceral pleura and parietal pleura.

The two groups of intrathoracic nodes which drain the lung and pleura that you might have mentioned are:

1. Intrapulmonary
2. Mediastinal

The most common type of bronchogenic carcinoma is squamous cell carcinoma.

Adenocarcinoma may arise from mucous glands embedded in the submucosa.

You might have said oat cell carcinoma or undifferentiated carcinoma is the most virulent type of bronchogenic carcinoma.
Match the description on the left with one of the terms on the right:

____ 1. Exchange of oxygen and carbon dioxide at the tissue level  
   a. thorax
   b. paranasal sinuses
   c. external respiration
   d. hypopharynx
   e. trachea
   f. right lung

____ 2. Smallest branches of bronchi
   g. internal respiration
   h. nose
   i. left lung

____ 3. Houses most organs of the respiratory system
   j. glottis
   k. visceral pleura

____ 4. The beginning part of the respiratory system
   l. undifferentiated carcinoma
   m. supraglottis
   n. parietal pleura

____ 5. A gaseous waste produced by body cells when oxygen and food combine
   o. oat cell carcinoma
   p. epiglottis
   q. mediastinum
   r. respiratory bronchioles
   s. adenoids
   t. carbon dioxide
   u. interpleural space
   v. main bronchi
   w. cilia

____ 6. The part of the pharynx located behind and lateral to the larynx
   x. epiglottis

____ 7. The region of the larynx which houses the true vocal cords
   y. mediastinum

____ 8. Thin hair-like structures which are attached to the mucous membrane epithelium lining the respiratory tract

____ 9. A passageway extending from the larynx to the bronchi

____ 10. Cartilage which acts as a lid for the larynx

____ 11. Lung having three lobes

____ 12. Exchange of gases between air and blood in the lungs

____ 13. Covering of the outer surface of the lung

____ 14. Region between the lungs in chest cavity which contains heart, aorta, esophagus, and trachea
   s. adenoids
   t. carbon dioxide
   u. interpleural space

____ 15. Collection of lymphoid tissue in nasopharynx called pharyngeal tonsils

____ 16. Branches from the trachea which act as passageways into the air spaces of the lung

____ 17. The potential space between the visceral and parietal pleura

161
Answer: Q24

1. Exchange of oxygen and carbon dioxide at the tissue level  
   internal respiration

2. Smallest branches of bronchi  
   respiratory bronchioles

3. Houses most organs of the respiratory system  
   thorax

4. The beginning part of the respiratory system  
   nose

5. A gaseous waste produced by body cells when oxygen and food combine  
   carbon dioxide

6. The part of the pharynx located behind and lateral to the larynx  
   hypopharynx

7. The region of the larynx which houses the true vocal cords  
   glottis

8. Thin hair-like structures attached to the mucous membrane epithelium lining the respiratory tract  
   cilia

9. A passageway extending from the larynx to the bronchi  
   trachea

10. Cartilage which acts as a lid for the larynx  
    epiglottis

11. Lung having three lobes  
    right lung

12. Exchange of gases between the air and the blood in the lungs  
    external respiration

13. Covering of the outer surface of the lung  
    visceral pleura

14. Region between the lungs in chest cavity which contains heart, aorta, esophagus, and trachea  
    mediastinum

15. Collection of lymphoid tissue in nasopharynx called pharyngeal tonsils  
    adenoids

16. Branches from the trachea which act as passageways into the air spaces of the lung  
    main bronchi

17. The potential space between the visceral and parietal pleura  
    interpleural space
SECTION G

DIGESTIVE SYSTEM
## DIGESTIVE SYSTEM: Esophagus-Rectum

<table>
<thead>
<tr>
<th>PRIMARY SITE</th>
<th>MUCOSA</th>
<th>SUB-MUCOSA</th>
<th>MUSCULARIS PROPRIA</th>
<th>SEROSA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Epithelium</td>
<td>Lamina Propria</td>
<td>Muscularis Mucosae</td>
<td></td>
</tr>
<tr>
<td>Esophagus (C15._)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Stomach (C16._)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Sm. Intestine (C17._)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Colon (C18._)</td>
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<td>Yes</td>
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<tr>
<td>Rectosigmoid (C19.9)</td>
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<td>Yes</td>
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<td>Yes</td>
</tr>
<tr>
<td>Rectum (C20.9)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Table: 164
SECTION G

DIGESTIVE SYSTEM

The main organs of the digestive system form a muscular tube extending from the lips to the anus. This tube is open at both ends and is referred to as the alimentary canal or the gastrointestinal (GI) tract.

Organs which compose the GI tract are the mouth, pharynx, esophagus, stomach, small intestine, colon, rectum and anus. There are other accessory organs and structures derived from the primitive gut and located in either the main digestive tract or opening into it. These include the tongue, teeth, gums, salivary glands, pancreas, gallbladder, bile ducts, liver, and appendix. The principal parts of the digestive system are shown in Figure 19 below.

Figure 19. PRINCIPAL PARTS OF THE DIGESTIVE SYSTEM
The organs of the digestive system perform the vital function of altering the food so that it can be used as nourishment by the body cells. The process of changing the chemical and physical composition of food so that it can be utilized by the body is called digestion. The digestive system provides the source of energy required for growth, maintenance, and function of the body. This energy is derived from the assimilation of food by the cells of the body through a series of chemical reactions called metabolism.

The walls of most of the organs of the gastrointestinal tract are made up of three main layers of tissue:

- A mucous lining called the *mucosa*. It consists of a surface epithelium, a lamina propria, and, in most of the length of the GI tract (lower esophagus, stomach, small intestine, colon, and rectum), a muscularis mucosae.

- A *submucosa* of connective tissue in which are embedded blood and lymph vessels

- A *muscularis propria* or muscular layer

Most of the organs have a *serosa* or covering layer of visceral peritoneum which invests the organ to a varying extent depending on the particular segment of the organ and its mesenteric attachments. The cecum, transverse colon and sigmoid are almost completely invested with peritoneum, while the ascending colon and descending colon are covered only on their anterior surfaces. The posterior portions of these two segments of the colon are covered by loose areolar tissue.

Study the diagram below carefully so that you will recognize the names of the various tissue layers of the organ wall. The depth of invasion of a neoplasm into the various layers of the wall is an important measure of the spread of the tumor. You will utilize this information in Book 6 when you study extent of disease and the staging of malignant tumors.

**Figure 20. STRUCTURE OF INTESTINAL WALL**
Q1

The main organs of the digestive system form a tube extending from the lips to the anus called the __________________________ canal or __________________________ tract.

Q2

The main structures which compose the digestive/alimentary tract are the:

1. ________________
2. ________________
3. ________________
4. ________________
5. ________________
6. ________________
7. ________________
8. ________________

Q3

The three main tissue layers of the walls of the organs which make up the gastrointestinal tract and their peritoneal covering (if present) are called:

1. ________________
2. ________________
3. ________________
4. ________________

Q4

The mucosa may be made up of three layers which are:

1. ________________
2. ________________
3. ________________
Answer: Q1

The main organs of the digestive system form a tube extending from the lips to the anus called the alimentary canal or digestive tract.

Answer: Q2

The main structures of the digestive/alimentary tract are:

1. Mouth
2. Pharynx
3. Esophagus
4. Stomach
5. Small intestine
6. Colon
7. Rectum
8. Anus

Answer: Q3

The three main tissue layers of the walls of the organs which make up the gastrointestinal tract and their peritoneal covering (if present) are called:

1. Mucosa
2. Submucosa
3. Muscularis propria
4. Serosa

Answer: Q4

The three layers of the mucosa are:

1. Surface epithelium
2. Lamina propria
3. Muscularis mucosae
Mouth

The gastrointestinal tract begins with the mouth (oral cavity). The lips form the anterior wall of the oral cavity; the cheeks (buccal mucosa) form the lateral walls; the hard and soft palates form the roof; the floor of the mouth forms the base of the cavity. Structures within the mouth are the tongue, gums (gingiva), and teeth. The entire cavity is lined with mucous membrane, but the muscularis mucosae found in other parts of the gastrointestinal tract is not present in the mouth or pharynx. The lamina propria and submucosa are, therefore, generally indistinguishable.

Food enters through the lips and is broken up and crushed by the action of the tongue and the teeth. At the same time, it is mixed with the saliva produced by the salivary glands. Mastication thus begins the first step in the digestive process.

The blood supply to structures of the oral cavity is from various branches of the external carotid artery. The venous blood drains into the superficial or deep jugular veins.

Ninety percent of the malignant tumors arising in the oral cavity are squamous cell carcinoma.

Figure 21. ORAL CAVITY

A. ABOVE THE TONGUE

B. BELOW THE TONGUE
Lips. The lips form the upper and lower anterior walls of the oral cavity. Each lip consists of an exposed surface of modified epidermis known as the **vermilion border** and a **labial mucosa** (mucous membrane) which lines the inner surface of the lip. Striated muscle and fibroelastic connective tissue lie beneath the surface.

"Lip" should not be confused with "skin of lip" which is not part of the digestive system.

The **commissure** is the point of union of the upper lip and the lower lip (corner of the mouth).

**Malignant Tumors**

The lower lip is the most common site of malignancy in the oral cavity. Malignant tumors of the upper lip are relatively rare. The most common type of malignant tumor of the lip is squamous cell (epidermoid) carcinoma.

Figure 22. LIPS

*Note: The latest revisions of the American Joint Committee define the lip as the vermilion surface only. The mucosa of the lip is included with the buccal mucosa. The ICD-O provides separate code numbers for labial mucosa (C00.3, C00.4) and vermilion surface (C00.0, C00.1) of the lip. You can combine or separate as you wish. Historically, the mucosa of the lip has been defined as part of the lip.
Q5

The lip consists of an exposed surface of modified epithelium called the ____________
______________ and an inner mucosal surface called the ____________ ____________.

Q6

The point of union of the upper and lower lips is called the _________________________.

Q7

Lip lesions occur most frequently on the ________________________ lip.
Answer: Q5

The lip consists of an exposed surface of modified epithelium called the **vermilion border** and an inner mucosal surface called the **labial mucosa**.

Answer: Q6

The point of union of the upper and lower lips is called the **commissure**.

Answer: Q7

Lip lesions occur most frequently on the **lower** lip.
• **Tongue.** The tongue is a mobile mass of striated muscle covered by mucous membrane. It attaches to the floor of the mouth and practically fills the oral cavity. The membrane on the undersurface of the tongue is thin and forms a fold at the midline called the frenulum which extends from near the tip of the tongue to the floor of the mouth. The mucous membrane on the dorsum of the tongue is thick; and, over the anterior two-thirds, it is studded with papillae.¹ Functions of the tongue are mastication, deglutition (swallowing) and articulation (in reference to speech). It also has the faculty for producing the sense of taste.

The anterior two-thirds of the tongue is the freely movable portion which extends anteriorly from the line of circumvallate papillae to the tip of the tongue and then posteriorly along the undersurface to its junction with the floor of the mouth. Its topographical subdivisions are:

1. Lateral borders and tip (apex)
2. Dorsal (upper) surface
3. Ventral (under) surface

The base of the tongue (posterior one-third) is less mobile and extends posteriorly from the line of circumvallate papillae to the base of the epiglottis. The hollow formed at the junction of the base of the tongue with the epiglottis is called the vallecula. The lingual tonsils are aggregates of lymphoid tissue located in the base of the tongue (see page 68 for a detailed discussion).

**Figure 23. DORSAL SURFACE OF TONGUE**

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¹ *papilla* (plural - papillae)—Small nipple-shaped projection or elevation on which are located numerous taste buds.
Malignant Tumors

Malignant lesions are more common on the anterior two-thirds than on the posterior one-third of the tongue. Along with the lower lip, carcinoma of the anterior tongue is one of the most common sites of malignant tumors of the oral cavity.

Squamous cell carcinomas constitute 90 percent of all malignant tumors of the tongue. The other 10 percent are made up primarily of lymphoepitheliomas and lymphosarcomas. Lymphosarcomas will arise in the lymphoid tissue (lingual tonsil) found in the base of the tongue.
Q8

The tongue is composed of _____________________________ covered by ____________
________________________.

Q9

What marks the division of the anterior two-thirds of the tongue and the base of the tongue?

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________

Q10

Which part of the tongue has the most malignant tumors?

_________________________________________________________________
Answer: Q8

The tongue is composed of muscle covered by mucous membrane.

Answer: Q9

The division of the anterior two-thirds of the tongue and the base of the tongue is the (circum)vallate papillae.

Answer: Q10

The anterior two-thirds of the tongue has more malignant tumors than does the base of the tongue.
- **Floor of mouth.** The floor of the mouth consists of a semilunar shaped area of loose, movable mucosa, an underlying subserosa and the mylohyoid and hypoglossus muscles. It extends from the inner surface of the lower alveolar ridge to the undersurface of the tongue. Its posterior boundary on each side is the base of the anterior pillar of the tonsil. It is divided anteriorly into two sides by the frenulum of the tongue and contains the ostia\(^1\) of the submandibular (submaxillary) and sublingual salivary glands.

- **Retromolar area.** The retromolar area (retromolar trigone) is the attached mucosa overlying the ascending ramus of the mandible from the level of the posterior surface of the last molar tooth to the apex superiorly (see Figure 24).

**Malignant Tumors**

The floor of the mouth is a relatively common site for intra-oral malignancies. Most of the floor of the mouth lesions are squamous cell carcinomas. The remaining five percent are adenocarcinomas arising in the minor salivary glands.

**Figure 24. FLOOR OF MOUTH**

\(^1\)ostium (plural - ostia)--An opening into a tubular organ, in this case, an opening through which the secretions of the salivary glands flow into the mouth.
• **Gums (gingiva).** The gums are folds of mucosa which surround the base of the teeth. The lamina propria is firmly attached to the underlying bone thus forming a fusion of mucous membrane and periosteum called "mucoperiosteum."

The **lower gum** is the mucosa covering the alveolar process of the mandible. It extends from the line of attachment of mucosa in the buccal gutter (sulcus) on the outer margin to the line of free mucosa of the floor of the mouth on the inner side. Posteriorly it extends to the ascending ramus of the mandible (retromolar trigone).

The **upper gum** is the mucosa covering the alveolar process of the maxilla. It extends from the line of attachment of mucosa in the gingival buccal sulcus to the junction with the mucosa of the hard palate. Its posterior margin is the upper end of the palatoglossal (pterygopalatine) arch.

**Malignant Tumors**

Cancer occurs more frequently on the lower than on the upper gingiva. It will sometimes invade underlying bone, but can be distinguished from tumors originating in bone on the basis of the histology. Malignant tumors of the gingival mucosa are almost always squamous cell carcinoma. A rare odontogenic tumor (ameloblastoma, adamantinoma) originating in the tissues which form the teeth may arise in the bone underlying the gingival mucosa.

**Figure 25. GINGIVA**
Q11

Match the structures on the left with their descriptions on the right:

_____ 1. Gum  a. A muscular organ covered with papillae attached to the floor of the mouth

_____ 2. Floor of mouth  b. Mucosal covering of alveolar process (ridge)

_____ 3. Tongue  c. Area of loose, movable mucosa extending from the undersurface of the tongue to the alveolar ridge

_____ 4. Lip  d. Anterior wall of the oral cavity
<table>
<thead>
<tr>
<th>Answer: Q11</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>b</strong> 1. Gum</td>
<td>Mucosal covering of the alveolar process (ridge)</td>
<td></td>
</tr>
<tr>
<td><strong>c</strong> 2. Floor of mouth</td>
<td>Area of loose, movable mucosa extending from the tongue to undersurface of the alveolar ridge</td>
<td></td>
</tr>
<tr>
<td><strong>a</strong> 3. Tongue</td>
<td>A muscular organ covered with papillae attached to the floor of the mouth</td>
<td></td>
</tr>
<tr>
<td><strong>d</strong> 4. Lip</td>
<td>Anterior wall of the oral cavity</td>
<td></td>
</tr>
</tbody>
</table>
- **Palate.** The palate is the roof of the mouth separating the oral cavity from the nasal cavity and nasopharynx.

  The *hard palate* consists of a mucosa and periosteum (mucoperiosteum). It covers the palatine processes of the maxillary palatine bones. The submucosa and muscularis are absent from the hard palate. It is a semilunar area which extends from the inner surface of the upper (superior) alveolar ridge to the posterior edge of the palatine bone.

  The *soft palate* consists of mucosa, submucosa, and the underlying palatine muscles. It extends posteriorly from the edge of the hard palate to its free border. A soft tissue projection, located medially on its free border, is the uvula.

- **Buccal mucosa.** The buccal mucosa lines the inner surface of the cheeks, the structure of which is formed by the buccinator muscles. The anatomic limits of the buccal mucosa are the upper and lower gingival buccal sulci, the labial (lip) mucosa anteriorly, and the anterior tonsillar pillars posteriorly. Again, squamous cell carcinoma is the predominant cell type of the malignant tumors arising in this area. (See the note on page 170 for grouping of mucosa of lip in the various staging and coding systems.)

**Figure 26. HARD AND SOFT PALATES**
Q12

What is the palate? ________________________________

Q13

In what way is the mucosa of the oral cavity different from that of the remainder of the digestive tract? ________________________________

Q14

What is the most common type of malignancy found in the oral cavity? ________________________________

Q15

Match the structure on the left with the description on the right:

____ 1. Buccal mucosa a. Covers the palatine muscles
____ 2. Gum b. Lines the inner surface of the cheeks
____ 3. Soft palate c. Covers the palatine processes of the maxillary bones
____ 4. Hard palate d. Surrounds the base of the teeth

Q16

The ostia of the submandibular and sublingual glands are located in the ______________ of the ______________.

Q17

What are the main structures which form the oral cavity?

1. ____________________ 2. ____________________
3. ____________________ 4. ____________________
5. ____________________ 6. ____________________
7. ____________________ 8. ____________________
Answer: Q12

The palate is the **roof of the mouth** separating the oral cavity from the nasal cavity and nasopharynx.

Answer: Q13

You might have said that the mucosa of the oral cavity is different from the remainder of the digestive tract because it has no **muscularis mucosae**.

Answer: Q14

The most common type of malignancy found in the oral cavity is **squamous cell carcinoma**.

Answer: Q15

b 1. Buccal mucosa  Lines the inner surface of the cheeks
d 2. Gum  Surounds the base of the teeth
a 3. Soft palate  Covers the palatine muscles
e 4. Hard palate  Covers the palatine processes of the maxillary bones

Answer: Q16

The ostia of the submaxillary and sublingual glands are located in the **floor of the mouth**.

Answer: Q17

The main structures forming the oral cavity are:

1. Lips
2. Cheeks (buccal mucosa)
3. Tongue
4. Hard palate
5. Soft palate
6. Floor of mouth
7. Gingiva
8. Retromolar area (trigone)
Salivary Glands

There are three pairs of major salivary glands: the parotid, submandibular (submaxillary), and sublingual glands.

- The *parotid* glands, the largest of the major salivary glands, lie below and in front of the ears. They secrete primarily serous substances into the mouth by way of the parotid duct (Stensen's duct).

- The *submandibular* glands lie in contact with the inner surface of the mandible. They secrete primarily serous substances into the mouth by way of the submandibular duct (Wharton's duct).

- The *sublingual* glands lie beneath the mucosa of the floor of the mouth. They pour mucous secretions into the mouth.

In addition, there are minor salivary glands scattered throughout the mucous membrane covering of the lips, cheeks, palate, and tongue. The salivary secretions may be thin and watery (produced by serous cells) or thick and viscid (produced by mucous cells).

The salivary glands moisten and lubricate the mouth with continuous secretions of saliva.

Malignant and Benign Tumors

Neoplasms arising in salivary gland tissue are predominantly mixed tumors (pleomorphic adenomas). Since approximately 75 percent of these tumors are benign, they will not be reported by most registries. Malignant tumors which you are likely to find are: mucoepidermoid carcinoma, squamous cell carcinoma, adenoid cystic carcinoma, and adenocarcinoma. These tumors arise most frequently in the parotid.

**Figure 27. SALIVARY GLANDS**

![Diagram of salivary glands]
Q18

Identify the major salivary glands below:

1. ________________
2. ________________
3. ________________

Q19

Most tumors arising in salivary gland tissue are ____________ (type) tumors which are benign 75 percent of the time.

Q20

In which of the major salivary glands do most of the malignant tumors arise?
The major salivary glands are as follows:

1. Parotid
2. Submandibular (submaxillary)
3. Sublingual

Most tumors arising in salivary gland tissue are mixed tumors which are benign 75 percent of the time.

Most of the malignant tumors which arise in the major salivary glands occur in the parotid gland.
Lymph Node Drainage

The regional lymph nodes for the various parts of the oral cavity and salivary glands are the upper cervical nodes which may be identified more specifically in relation to their areas of drainage.

Facial Lymph Nodes

| Lip |
| Gum |
| Buccal mucosa |

Parotid Lymph Nodes

| Upper lip and commissure |
| Parotid gland |
| Buccal mucosa |

Submental Lymph Nodes

| Lip |
| Tongue |
| Gum |
| Floor of mouth |
| Submandibular (submaxillary) gland |
| Palate |
| Buccal Mucosa |

Submandibular (submaxillary) Lymph Nodes

| Lip |
| Buccal mucosa |
| Floor of mouth |
| Gum |
| Tongue, all parts |
| Palate |
| Submandibular (submaxillary) gland |

| Anterior 2/3 of tongue |
| Floor of mouth |

Retropharyngeal Lymph Nodes

| Upper gum |
| Palate (hard and soft) |

| Lip |
| Tongue, all parts |
| Floor of mouth |
| Gum |
| Buccal mucosa |
| Palate |
| Submandibular (submaxillary) gland |

The supraclavicular (transverse cervical) lymph nodes are distant nodes for most sites, including the head and neck, except for skin of the lower neck and chest wall (see Figure 27 and Figure 28 for locations of lymph nodes).
Q21

Match the sites on the left with the lymph nodes on the right:

_____ 1. Gum a. Facial
_____ 2. Buccal mucosa b. Internal jugular
_____ 3. Lip c. Retropharyngeal
_____ 4. Tongue d. Submandibular

Q22

Except for skin of the lower neck and chest wall, the__________________ lymph nodes are always considered distant nodes.
Answer: Q21

c. 1. Gum
   Retropharyngeal

a,b,d 2. Buccal mucosa
   Facial, internal jugular, and submandibular

a,b,d 3. Lip
   Facial, internal jugular, and submandibular

b,d 4. Tongue
   Internal jugular (upper deep) and submandibular

Answer: Q22

Except for skin of the lower neck and chest wall, the supraclavicular (transverse cervical) lymph nodes are considered distant nodes for all sites.

Figure 28. ORAL CAVITY LYMPH NODE REGIONS
Pharynx

The pharynx is divided into three regions: the nasopharynx, the oropharynx, and the hypopharynx (laryngopharynx).

The nasopharynx lies behind the nasal cavities, above the soft palate, and below the base of the skull. The oropharynx lies behind the buccal cavity, below the soft palate, and above the opening to the larynx. The hypopharynx (laryngopharynx) is located behind, lateral and inferior to the larynx. The nasopharynx has been discussed in detail in Section F, The Respiratory System.

The pharynx (throat) serves as a passageway for the respiratory and digestive tracts, since air must pass through this structure before reaching the lungs, and food must pass through it to get to the stomach. The pharynx is also important for phonation because by changing its shape the different vowel sounds are formed. The pharynx is made of muscle which is lined with mucous membrane. Embedded within this muscle are the palatine and pharyngeal tonsils. The tonsils are composed of lymphoid tissue and may be considered part of the lymphatic system. However, they are located within the respiratory and digestive systems. The adenoids or pharyngeal tonsils are located in the nasopharynx. The faucial or palatine tonsils are located in the oropharynx. (The lingual tonsils, as we have learned, are in the base of the tongue. It is the palatine tonsils that are commonly removed by a tonsillectomy.)

The lymphatics for the pharynx drain into the cervical lymph nodes, namely, the internal jugular (upper and lower deep cervical), and retropharyngeal lymph nodes. The blood supply is via the external carotid arteries and internal jugular veins.

Figure 29. OROPHARYNX AND HYPOPHARYNX
Oropharynx. The air and food passageways cross in the oropharynx. The oropharynx extends from the level of the free borders of the soft palate to the tip of the epiglottis.

The anatomical limits are as follows:

- The *posterior oropharyngeal wall* is that part of the posterior pharyngeal wall that extends from a level opposite the free borders of the soft palate to the tip of the epiglottis.

- The *lateral walls* include the tonsillar pillars, tonsillar fossae, and the palatine (faucial) tonsils. On each side, the anterior pillar (glossopalatine fold) extends from the base of the tongue to the soft palate lying in front of the tonsillar fossa. The posterior tonsillar pillar (pharyngopalatine fold) lies in back of the tonsillar fossa. The area between the two pillars, the tonsillar fossa, houses the palatine tonsil, sometimes called the faucial tonsil.

- The *anterior wall* consists of the lingual (anterior) surface of the epiglottis and the pharyngoepiglottic and glossoepiglottic folds which bound the vallecula (the hollow formed at the junction of the base of the tongue and the epiglottis—see base of tongue).

Note: The latest revisions of the American Joint Committee include base of tongue and soft palate in the oral pharynx rather than in the oral cavity. ICD-O provides separate code numbers in the oral grouping: base of tongue (C01.9), soft palate (C05.1), and uvula (C05.2). Thus, these sites can be grouped with the oral cavity (as they have been historically) or they can be included in the oral pharynx.
Hypopharynx (laryngopharynx). The function of the hypopharynx is purely alimentary providing a passage behind the larynx. The sites within the hypopharynx are the pyriform sinus, the postcricoid area, and the posterior pharyngeal wall. The anatomical limits are as follows:

- The **pyriform sinus** extends from the pharyngoepiglottic fold to the upper edge of the esophagus between the inner surface of the thyroid cartilage and the posterior lateral surface of the thyroid and cricoid cartilages.

- The **postcricoid area** extends from the posterior surface of the arytenoid cartilages and the aryepiglottic folds to the inferior surface of the cricoid cartilage. The lateral margin is the anterior part of the pyriform sinus.

- The **posterior hypopharyngeal wall** is that part of the posterior pharyngeal wall that extends from the level of the tip of the epiglottis to the inferior margin of the cricoid cartilage and laterally to the posterior margins of the pyriform sinus.

**Malignant Tumors**

Malignant tumors of the pharynx are usually squamous cell carcinoma. Although tumors of lymphoid tissue do arise in these areas, the frequency is relatively low compared to tumors of this histologic type occurring elsewhere in the body.
Q23

What is another name for the hypopharynx?

__________________________

Q24

What histologic type of malignant tumor do you usually expect to find in the pharynx?

__________________________
Answer: Q23

Another name for the hypopharynx is the laryngopharynx.

Answer: Q24

You usually expect to find squamous cell carcinoma in the pharynx.
Q25

Match each structure on the left with its function on the right:

____ 1. Hypopharynx a. Serves as a passageway for food only

____ 2. Oropharynx b. Serves as a passageway for air only

____ 3. Nasopharynx c. Serves as a passageway for both food and air (crossover)

Q26

Match each structure on the left with its location on the right:

____ 1. Nasopharynx a. Behind the nasal cavities and above the soft palate

____ 2. Oropharynx b. Behind the buccal cavity and below the soft palate

____ 3. Hypopharynx c. Behind and lateral to the larynx

Q27

The pharynx is composed of ______________________ and is lined with

________________ _______ _____________.

199
Answer: Q25

a  1. Hypopharynx  Serves as a passageway for food only

c  2. Oropharynx  Serves as a passageway for both food and air (crossover)

b  3. Nasopharynx  Serves as a passageway for air only

Answer: Q26

a  1. Nasopharynx  Behind the nasal cavities and above the soft palate

b  2. Oropharynx  Behind the buccal cavity and below the soft palate

c  3. Hypopharynx  Behind and lateral to the larynx

Answer: Q27

The pharynx is composed of muscle and is lined with mucous membrane.
Q28

To which segment of the pharynx would you code a malignancy of each of the following?

a. Tonsillar pillar
b. Postcricoid region
c. Pyriform sinus
d. Anterior surface of the epiglottis
e. Pharyngeal tonsil
f. Laryngopharynx
g. Glossopalatine fold
h. Aryepiglottic fold

Q29

Match the tonsil on the left with its location on the right:

_____ 1. Adenoids  a. Oropharynx
_____ 2. Palatine   b. Base of the tongue
_____ 3. Lingual   c. Nasopharynx
Answer: Q28

a. Tonsillar pillar - Oropharynx
b. Posterior region - Hypopharynx
c. Pyriform sinus - Hypopharynx
d. Anterior surface of the epiglottis - Oropharynx
e. Pharyngeal tonsil - Nasopharynx
f. Laryngopharynx - Hypopharynx
g. Glossopalatine fold - Oropharynx
h. Aryepiglottic fold - Hypopharynx

Answer: Q29

c. 1. Adenoids Nasopharynx

a. 2. Palatine Oropharynx

b. 3. Lingual Base of the tongue
**Esophagus**

The esophagus is a muscular tube about ten inches (25 cm.) long extending from the hypopharynx to the stomach. The *peristaltic*\(^1\) motion of the esophagus moves food along to the stomach. The esophagus lies posterior to the trachea and the heart, and passes through the mediastinum and the hiatus, an opening in the diaphragm, in its descent from the thoracic to the abdominal cavity. The esophagus can be divided into three segments or regions: 1) cervical, 2) thoracic, and 3) abdominal. The location of esophageal lesions is frequently measured from the incisors (front teeth) and may be approximated as follows:

- **The cervical esophagus** begins at the lower border of the cricoid cartilage and ends at the thoracic inlet (suprasternal notch) approximately 18 cm measuring from the upper incisors.

- **The upper thoracic esophagus** extends from the thoracic inlet to the level of the tracheal bifurcation, approximately 24 cm from the upper incisors.

- **The mid-thoracic portion** is the proximal half of the esophagus between the tracheal bifurcation and the esophago-gastric junction. The lower level is approximately 32 cm from the upper incisor teeth.

- **The lower thoracic portion**, 8 cm in length (includes the abdominal esophagus), is the distal half of the esophagus between the tracheal bifurcation and the esophago-gastric junction, approximately 40 cm from the upper incisor teeth.

The esophagus may also be described in terms of upper, mid, and lower thirds. This measurement is *not* equivalent to the one just described as you can see from Figure 31. It may be approximated as follows:

- **The upper (proximal) third** extends from the sixth cervical vertebra to the sixth thoracic vertebra.

- **The mid third** extends from the sixth thoracic vertebra to the ninth thoracic vertebra.

- **The lower (distal) third** extends from the ninth thoracic vertebra to the cardioesophageal junction.

![Figure 30. DIVISIONS OF THE ESOPHAGUS](image)

\(^1\)peristalsis (n); *peristaltic* (adj)—Wavelike, involuntary contractions provided by the combination of longitudinal and circular muscles which propel the contents of the gastrointestinal tract.
Figure 31. MEASUREMENTS OF THE ESOPHAGUS (FROM THE INCISORS TO THE STOMACH)
The inner wall of the esophagus is lined with *mucosa*. The *mucosa* can be subdivided into surface epithelium, lamina propria, and muscularis mucosae. Beneath the mucosa lies the *submucosa* which contains mucous glands, blood vessels, lymphatics, and nerves. The *muscularis propria* lies beneath the submucosa. It consists of two layers of muscle, an inner circular and outer longitudinal layer. This muscular layer is composed of striated muscle in the upper third, mixed striated and smooth muscle in the middle third, and smooth muscle only in the lower third. There is no serosa on the esophagus, but rather an external adventitia of fibrous connective tissue. The lack of a serosa facilitates the spread of cancer beyond the primary site into adjacent tissues and lymph nodes.

Branches of the aorta and celiac artery supply blood to the esophagus. The venous drainage is to the azygos, thyroid, and left gastric veins. The lymphatic vessels drain into the cervical, mediastinal, and gastric lymph nodes depending on the segment of the esophagus from which they originate.

**Malignant Tumors**

The neoplasms arising in the esophagus are primarily squamous cell (epidermoid) carcinomas. Leiomyosarcomas of the muscle layers arise less frequently. The esophagus, despite its length, is an uncommon tumor site.

*Figure 32. ESOPHAGEAL LYMPH NODES  Figure 33. CROSS-SECTION OF ESOPHAGUS*
Q30

The esophagus is a muscular tube about ten inches long extending from the ________________ to the ________________ and is divided into four anatomic segments:

1. ________________
2. ________________
3. ________________
4. ________________

Q31

The esophagus passes through the ________________ in its descent from the ________________ cavity to the ________________ cavity.

Q32

The three main tissue layers of the wall of the esophagus are:

1. ________________
2. ________________
3. ________________
Answer: Q30

The esophagus extends from the pharynx to the stomach and can be divided into four anatomic segments:

1. Cervical
2. Upper thoracic portion
3. Mid-thoracic
4. Lower thoracic portion, including abdominal

Answer: Q31

The esophagus passes through the diaphragm (or hiatus in the diaphragm) in its descent from the thoracic cavity to the abdominal cavity.

Answer: Q32

The three main tissue layers of the wall of the esophagus are:

1. Mucosa
2. Submucosa
3. Musculature (muscularis propria)

Remember there is no serosa on the esophagus, only an adventitia of loose connective tissue.
Stomach

The stomach lies just below the diaphragm in the upper part of the abdominal cavity primarily to the left of the midline under a portion of the liver. Factors which influence the precise location are food ingestion and respiration (inspiration and expiration). Food leaves the esophagus and enters into this elongated pouch-like structure by way of the cardiac orifice. The role of the stomach is the mixing of food with gastric secretions by way of peristalsis to form chyme⁴ and the ejection of the chyme into the small intestine.

The main divisions of the stomach (Figure 34, below) are the cardia, the fundus (fornix), the body (corpus), and the antrum:

- The *cardia* is the portion of the stomach surrounding the cardioesophageal junction, or cardiac orifice (the opening of the esophagus into the stomach).
- The *fundus* is the enlarged portion to the left and above the cardiac orifice.
- The *body*, or corpus, is the central part of the stomach.
- The *pyloric antrum* is the lower or distal portion above the duodenum. The opening between the stomach and the small intestine is the *pylorus*, and the very powerful sphincter which regulates the passage of chyme into the duodenum is called the pyloric sphincter.

**Figure 34. STOMACH AND ADJOINING STRUCTURES**

---

¹Chyme--The fluid content of the stomach after food has undergone gastric digestion.
The medial border of the stomach is called the lesser curvature, and the lateral border is called the greater curvature. These designations are important in pinpointing the location of neoplasms.

A large fold of peritoneum called the greater omentum, or gastrocolic omentum, extends down from the anterior surface of the stomach connecting the abdominal viscera. It contains fat cells, blood and lymphatic vessels, and nerves. A similar fold called the lesser omentum, or gastrohepatic omentum, extends between the liver and the lesser curvature of the stomach.

The mucosa (described earlier) is composed of three layers: the surface epithelium, the lamina propria, and the muscularis mucosae. This middle layer (lamina propria) is thick and filled with glands which secrete both mucous and enzymes. When the stomach is empty, the mucosa forms folds called rugae. The submucosa is composed of dense connective tissue with large blood and lymph vessels. The muscularis propria is composed of three muscular layers as compared to two in the esophagus. These are called the longitudinal, circular, and oblique layers. This muscular wall serves as a churn to help break up and mix food with the gastric juices. A serosa of visceral peritoneum invests the outer surface of the stomach.

The blood supply to the stomach is derived from branches of the celiac artery. The venous drainage is into the portal vein, either directly or by way of the splenic and superior mesenteric veins.

The regional lymph nodes are as follows:

<table>
<thead>
<tr>
<th>Inferior (right) gastric:</th>
<th>Splenic:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater curvature</td>
<td>Gastroepiploic, left</td>
</tr>
<tr>
<td>Greater omental</td>
<td>Pancreaticocolenal</td>
</tr>
<tr>
<td>Gastrooduodenal</td>
<td>Peripancreatic</td>
</tr>
<tr>
<td>Gastrocolic</td>
<td>Splenic hilar</td>
</tr>
<tr>
<td>Gastroepiploic, right</td>
<td></td>
</tr>
<tr>
<td>Gastrohepatic</td>
<td></td>
</tr>
<tr>
<td>Pyloric, incl. sub-/infrapyloric</td>
<td></td>
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<tr>
<td>Pancreaticoduodenal (Anteriorly along first part</td>
<td></td>
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<tr>
<td>of the duodenal)</td>
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</table>

<table>
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<tr>
<th>Superior (left) gastric:</th>
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<tr>
<td>Lesser curvature</td>
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</tr>
<tr>
<td>Cardioesophageal</td>
<td></td>
</tr>
<tr>
<td>Celiac</td>
<td></td>
</tr>
<tr>
<td>Hepatic (excl. gastrohepatic)</td>
<td></td>
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</tbody>
</table>

\(^1\text{rugae--ridges, wrinkles, or folds, as of mucous membrane.}\)
The functions of the stomach are to:

1. Absorb water and glucose into the blood stream.

2. Secrete gastric enzymes. For example, rennin to clot milk; lipase to initiate the splitting of fats; pepsinogen, which in the presence of hydrochloric acid forms pepsin, to begin protein breakdown.

3. Secrete hydrochloric acid (HCl) which kills bacteria, changes some minerals to salts which are suitable for absorption in the intestine, and adjusts the pH of the chyme to permit the opening of the pyloric sphincter.

4. Produce, in the gastric mucosa, the intrinsic factor which is necessary for the absorption of Vitamin B12.

5. Secrete, in the pyloric glands, an alkaline mucous to neutralize the HCl.

6. Churn the food into a semi-liquid substance (chyme) and force it through the pyloric sphincter into the duodenum.

Malignant and Benign Tumors

- Adenocarcinoma is the most frequent malignant lesion of the stomach. The spread of the tumor is usually to regional lymph nodes and the liver. Later metastasis frequently occurs in the lungs, brain, bone, and ovaries. A tumor known as Krukenberg tumor is found in the ovary which represents a metastasis of adenocarcinoma of the gastrointestinal tract, usually of the stomach, to the ovary.

- Lymphomas arise more frequently in the stomach than in any other extranodal site. Any histologic type of lymphoma, including Hodgkin's disease, may occur.

- Leiomyosarcoma arises in the smooth muscles of the stomach wall.

- Squamous cell carcinoma occurs at the cardioesophageal junction.

- Linitis plastica is an advanced form of cancer which is characterized by a thickening of the stomach wall causing it to lose its elasticity and become rigid like a leather bottle. It has, therefore, been referred to as leather-bottle stomach.

- Leiomyomas and adenomas are the two most common benign tumors of the stomach.
Q33

The stomach lies just below the _____________ in the upper part of the abdominal cavity. The main divisions of the stomach are the:

1. _______________
2. _______________
3. _______________
4. _______________

Q34

The three tissue layers of the stomach wall and its peritoneal covering are:

1. _______________
2. _______________
3. _______________
4. _______________

Q35

The three major regional lymph node chains are:

1. _______________ _______________
2. _______________ _______________
3. _________________
Q36

Name three general functions the stomach performs:

1. 

2. 

3. 

Q37

The most frequent malignant neoplasm of the stomach is ________________________.
Answer: Q33

The stomach lies just below the diaphragm. Its main divisions are the:

1. Cardia
2. Fundus
3. Body or corpus
4. Pyloric antrum

Answer: Q34

The three tissue layers of the stomach wall and its peritoneal covering are:

1. Mucosa
2. Submucosa
3. Muscularis propria
4. Serosa

Answer: Q35

The three major regional lymph node chains are:

1. Superior (left) gastric
2. Inferior (right) gastric
3. Splenic

Answer: Q36

Some functions of the stomach are:

1. It churns or mixes food into a semi-liquid and forces it into the duodenum.
2. It secretes gastric juices (enzymes, hydrochloric acid, mucous, intrinsic factor).
3. It absorbs water and glucose.

Answer: Q37

The most frequent malignant neoplasm of the stomach is adenocarcinoma.
Small Intestine

The small intestine is a tube measuring about 2.5 cm. in diameter and over 20 feet (600 cm.) in length coiled in loops which fill most of the abdominal cavity. It has three divisions--duodenum, jejunum, and ileum:

- The duodenum is just below the pyloric portion of the stomach and is about 25 cm. long and shaped somewhat like the letter C. It receives chyme from the stomach, bile from the gallbladder, and pancreatic secretions from the pancreas. The common bile duct and pancreatic duct join the duodenum at the ampulla of Vater. The duodenum becomes the jejunum where the tube turns forward and downward.

- The jejunum continues for over 200 cm. and then becomes the ileum, although there is no demarcation between the two divisions.

- The ileum is over 300 cm. long and joins the large intestine at the ileocecal valve.

The wall of the small intestine is composed of the same three main layers of tissue as the rest of the gastrointestinal tract and is covered with serosa. Small aggregates of lymphoid tissue called Peyer’s patches are found in the lamina propria of the small intestine, principally in the distal ileum.

The small intestine completes the digestion of the material received from the stomach and moves it along in peristaltic waves to the colon. Increased epithelial surface needed for absorption is provided by circular folds and villi. The absorbed material which reaches the bloodstream via the intestinal capillaries and lymphatics includes 1) water, 2) carbohydrates, 3) fat, and 4) protein.

The lymphatic drainage of the small intestine is to lymph nodes along the branches of the superior mesenteric and hepatic arteries. Duodenal nodes, in particular, may be described in terms of their location in relation to adjacent organs, such as, the stomach (pyloric), gallbladder (cystic), bile ducts (percholedochal), pancreas (pancreaticoduodenal) and ampulla of Vater. The terminal ileum drains to posterior cecal and ileocecal nodes of the superior mesenteric group.

Malignant and Benign Tumors

In spite of the relatively long length of the small intestine, tumors are rare. Thirty-five percent of all tumors of the small intestine are benign. Only one-fourth of all tumors in this site are adenocarcinomas, most frequently found in the duodenum. Lymphoma is the next most frequently diagnosed tumor of the small intestine with carcinoid tumors (argentaffinomas) and leiomyosarcomas accounting for the remainder.

---

1. villus--(plural - villi)--A small vascular process or protrusion, usually covered by epithelium, especially such a protrusion from the free surface of a membrane.
Q38

The small intestine is about ____________ __________ in length and is composed of three parts which are:

1. ______________
2. ______________
3. ______________

Q39

Name two functions of the small intestine:

1. ______________
2. ______________

Q40

What are some of the most common types of tumors found in the small intestine?

1. ________________________________
2. ________________________________
3. ________________________________
4. ________________________________
The small intestine is about twenty feet (600 cm.) long. It is composed of three parts which are:

1. Duodenum
2. Jejunum
3. Ileum

Two functions of the small intestine are:

1. Digestion
2. Absorption

Some of the most common types of tumors found in the small intestine are:

1. Adenocarcinoma
2. Lymphoma
3. Leiomyosarcoma
4. Carcinoid tumor
Large Intestine

The large intestine (the colon, rectum, and anus) is approximately five feet (150 cm.) long with a diameter of about 6 cm., decreasing towards the lower end. The by-products of digestion pass from the small intestine through the ileocecal valve to the large intestine. The ileocecal valve projects into the large intestine preventing the contents of the colon from regurgitating into the small intestine.

The large intestine is divided into the following segments:

• The cecum is a large cul-de-sac at the lower end of the ascending colon (proximal to the entrance of the ileum into the colon). It comprises the first 5 to 7 cm. of the large intestine. The appendix is a blind sac opening into the cecum just below the ileocecal orifice.

• The ascending colon extends upward from the cecum on the right side of the abdomen to the under surface of the right lobe of the liver where it turns to the left forming the hepatic flexure.

• The transverse colon begins at the hepatic flexure passing horizontally across the abdomen, below the liver and stomach and above the small intestine. On the left side of the abdomen near the spleen, the colon turns downward at the junction of the transverse and descending colon forming the splenic flexure.

• The descending colon starts at the splenic flexure and passes downward until it turns towards the midline at the rim of the pelvis and continues downward to become the sigmoid colon.

• The sigmoid colon, sometimes called the pelvic colon, is curved like the letter S. The lower part of the curve joins the rectum at the rectosigmoid junction.

• The rectum extends down to the anal canal. The upper part of the rectum, generally that part above the peritoneal reflection, is often called the rectosigmoid. It extends from approximately 10 cm. up to 15 cm (measuring from the anal verge). The lower rectum is devoid of a peritoneal covering and, therefore, has no serosa. It extends to approximately 10 cm. (measuring from the anal verge).

• The anal canal constitutes the final 2.5 cm of the digestive tract. It begins at the anorectal junction (dentate or pectinate line) and ends at the anal verge where the anal tube turns outward to blend with the perianal skin. In contrast to the rest of the large intestine, the anal canal is lined with squamous epithelium.

The main functions of the large intestine are reabsorption of water, minerals, and salts into the blood stream and movement of unabsorbed solid material along until it is eventually eliminated from the body as feces. Absorption takes place principally in the right colon; storage in and expulsion of fecal material from the left colon.
The large intestine receives the fluid by-products of digestion from the small intestine. The water is absorbed into the blood stream. However, the unabsorbed solid material is merely stored in the colon and moved along by peristaltic action for elimination. Therefore, there are no villi present as there are in the small intestine. The tissue layers are similar to those in the stomach: a mucosa of surface epithelium, lamina propria and muscularis mucosae, a submucosal layer, and a muscularis propria. The muscularis propria differs from other parts of the gastrointestinal tract in that the longitudinal muscle layer is arranged in three flat bands called taenia coli. These bands are not as long as the intestine; consequently, it gives the wall a gathered (shirred) effect and creates sacs (haustra). Little pouches of fat called appendices epiploica hang from the wall of the intraperitoneal colon distending the serosa.

The colon is attached to the posterior abdominal wall by folds of peritoneum called mesenteries. The cecum, transverse colon, and sigmoid are almost completely invested by peritoneum, but the ascending and descending colon which lie along the posterior body wall (retroperitoneum) are covered on the anterior surfaces only. This covering is called the serosa. The lower rectum is called the extraperitoneal portion of the large intestine, lying as it does below the peritoneal reflection, i.e., outside of the peritoneal cavity.

Figure 35. STRUCTURE OF COLONIC WALL

![Structure of Colonic Wall](image)

Figure 36. RELATIONSHIP OF BOWEL WALL AND SEROSA TO PERICOLIC/MESENTERIC FAT

![Relationship of Bowel Wall and Serosa to Pericolic/Mesenteric Fat](image)
The blood supply to the wall of the large intestine is derived from branches of the superior and the inferior mesenteric arteries. The superior mesenteric artery and its branches supply the right side of the colon, hepatic flexure and just beyond the midline of the transverse. The inferior mesenteric artery and its branches supply the left side of the colon and a portion of the left transverse. The veins enter the inferior mesenteric vein and eventually the portal vein.

The lymphatics of the large intestine drain primarily into the superior and inferior mesenteric lymph nodes before eventually reaching the cisterna chyli and thoracic duct. To refresh your memory, turn to page 58 of the lymphatic system.

Epicolic lymph nodules lying beneath the serosa and paracolic lymph nodes in the adjacent mesentery are found along the length of the colon. Lymph collected in the paracolic nodes drains through the lymphatic vessels and intercalating lymph nodes in the mesentery toward the branching of the superior and inferior mesenteric arteries from the aorta.

Perirectal lymph nodes drain, in addition, to nodes along branches of the internal iliac artery and to sacral promontory nodes.

The branches of the major arteries and lymphatics are:

<table>
<thead>
<tr>
<th>Superior Mesenteric</th>
<th>Inferior Mesenteric</th>
</tr>
</thead>
<tbody>
<tr>
<td>ileocolic</td>
<td>left colic</td>
</tr>
<tr>
<td>right colic</td>
<td>hemorrhoidal, superior</td>
</tr>
<tr>
<td>mid-colic</td>
<td>sigmoidal (sigmoid mesenteric)</td>
</tr>
<tr>
<td>cecal, anterior/posterior</td>
<td></td>
</tr>
</tbody>
</table>

**Internal Iliac (Hypogastric)**

- sacral (lateral sacral)
- hemorrhoidal, middle

Often lymph nodes whose configurations have been obliterated by tumor are described by the pathologist as tumor nodules in pericolic fat. These are not to be confused with Peyer's patches which are areas of lymphoid tissue in the mucosa.
Malignant and Benign Tumors

The usual histologic type of intestinal malignancy is adenocarcinoma. Squamous cell carcinoma arises in the anus; cloacogenic transitional cell carcinoma arises at the anorectal junction. Tumors arising on the right side of the colon tend to be cauliflower-type lesions; those on the left encircling or "napkin-ring" type.

Carcinoids are the most common appendicial tumors. They rarely metastasize. There is a difference of opinion among pathologists as to the criteria for determining their malignancy.

There are some premalignant conditions of which you should be aware. Adenomatous polyps are small reddish lesions, frequently on a stalk, which are important because of the possibility of their becoming malignant. Villous adenomas are soft, spongy, sessile lesions which arise from the bowel wall and have an even higher likelihood of becoming malignant. Familial polyposis, a hereditary polyoid disease, has a marked tendency to undergo malignant change. Ulcerative colitis may also be a precursor of malignancy. You may be required to include some of these diagnoses in your registry, or, at least, record these conditions if they are mentioned in the history of a patient with malignant disease of the colon.

Figure 37. LYMPHATIC DRAINAGE OF THE COLON AND RECTUM
The distribution of malignant tumors in the large intestine is as follows:

<table>
<thead>
<tr>
<th>Subsite</th>
<th>Percent of all Colorectal Cancers*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appendix</td>
<td>1</td>
</tr>
<tr>
<td>Cecum</td>
<td>16</td>
</tr>
<tr>
<td>Ascending colon</td>
<td>9</td>
</tr>
<tr>
<td>Transverse colon incl. flexures</td>
<td>13</td>
</tr>
<tr>
<td>Descending colon</td>
<td>5</td>
</tr>
<tr>
<td>Sigmoid</td>
<td>25</td>
</tr>
<tr>
<td>Rectosigmoid</td>
<td>10</td>
</tr>
<tr>
<td>Rectum</td>
<td>18</td>
</tr>
<tr>
<td>Colon, NOS</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>100</td>
</tr>
</tbody>
</table>

Q41

The large intestine is about ________ feet long and is composed of three major parts:

1. _________________
2. _________________
3. _________________

Q42

The colon is usually subdivided into five major segments:

1. _________________
2. _________________
3. _________________
4. _________________
5. _________________
Answer: Q41

The large intestine is about five feet long and is composed of the following parts:

1. Colon
2. Rectum
3. Anus

Answer: Q42

The five major segments of the colon are:

1. Cecum
2. Ascending colon
3. Transverse colon
4. Descending colon
5. Sigmoid colon
Q43

The ileocolic nodes are regional nodes for which one of the following sites?

[ ] 1) Transverse colon
[ ] 2) Splenic flexure
[ ] 3) Ascending colon
[ ] 4) Rectum

Q44

Match the site on the left with the appropriate regional nodes on the right:

_____ 1) Ascending colon a. Right colic
_____ 2) Descending colon b. Inferior hemorrhoidal
_____ 3) Sigmoid colon c. Left colic
_____ 4) Rectum d. Inferior mesenteric
Answer: Q43

3. The ileocolic lymph nodes are regional for the **ascending colon**.

Answer: Q44

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a</strong></td>
<td>1) <strong>Ascending colon</strong></td>
<td>- <strong>Right colic</strong></td>
<td></td>
</tr>
<tr>
<td><strong>c,d</strong></td>
<td>2) <strong>Descending colon</strong></td>
<td>- <strong>Left colic, inferior mesenteric</strong></td>
<td></td>
</tr>
<tr>
<td><strong>d</strong></td>
<td>3) <strong>Sigmoid colon</strong></td>
<td>- <strong>Inferior mesenteric</strong></td>
<td></td>
</tr>
<tr>
<td><strong>b,d</strong></td>
<td>4) <strong>Rectum</strong></td>
<td>- <strong>Inferior hemorrhoidal, inferior mesenteric</strong></td>
<td></td>
</tr>
</tbody>
</table>
Liver

The liver is the largest internal organ of the body, weighing three to four pounds (1.4-1.8 kg.). It lies immediately under the diaphragm in the right upper abdomen. Its visceral surface is molded over the stomach, duodenum, gallbladder, hepatic flexure of the colon, right kidney, and right suprarenal gland. It is divided into right and left lobes. The right lobe has three parts called the right lobe proper, the caudate lobe, and the quadrate lobe. The small bile ducts within the liver (intrahepatic ducts) join to form two larger ducts which emerge from the under surface of the liver at the porta hepatis as the right and left hepatic ducts.

The liver is one of the most vital organs in the body and plays a crucial role in the digestion and absorption of food. It breaks down protein, stores glycogen, iron, and vitamins, maintains the composition of the blood, and secretes products of detoxification. It continuously produces bile which is important in the digestion of fat and protein. The liver assists in keeping the amount of glucose (sugar) in the blood at a normal level. The liver manufactures plasma proteins. It destroys worn-out erythrocytes and foreign materials (phagocytosis). It produces heparin, an anticoagulant. It removes nitrogen from amino acids and converts it into urea. The urea then enters the blood stream and is carried to the kidneys where it is concentrated in urine and eliminated from the body.

The liver secretes certain bile salts which aid in digestion. These substances pass through the bile ducts and may be stored in the gallbladder. With the stimulation of eating, these chemicals then pass through the cystic duct and the common bile duct to enter the duodenum at the ampulla of Vater. All of these ducts and the gallbladder are referred to as the "extra-hepatic biliary system."

The lymphatic drainage from the liver is to hilar nodes, hepatic and periportal nodes below the diaphragm, and to cardiac, pericardial, posterior mediastinal, and aortic nodes above the diaphragm. Lymphatic vessels reach all parts of the organ.

Malignant and Benign Tumors

Malignant tumors of the liver are of glandular origin, i.e., adenocarcinomas. Benign liver tumors are of current interest because of a suggested association with oral contraceptive use. Primary liver tumors are rare, but may be classified as follows:

- **Hepatocellular carcinoma** (hepatoma, liver cell carcinoma) arises in the parenchymal cells of the liver. It is the predominant type of primary malignant liver tumor and is associated with pre-existing cirrhosis of the liver.

- **Cholangiocarcinoma** (bile duct carcinoma) arises in the intrahepatic bile ducts. Consequently, you may find cholangiocarcinomas of the liver as well as of the extrahepatic bile ducts.

- **Hemangioma** is a benign tumor which arises in the blood vessels of the liver; it is the most common benign liver tumor.

- **Adenomas** may arise in either the liver cells or the bile ducts of the liver.
Metastatic tumors involving the liver are much more common than primary liver tumors. Both venous and arterial blood may transport tumor cells to the liver. Section E, The Cardiovascular System, describes the transport of blood to the liver more fully.

**Extrahepatic bile ducts.** The right and left hepatic ducts emerging from the liver immediately join to form one common hepatic duct. The common hepatic duct merges with the cystic duct from the gallbladder to form the common bile duct. At a point seven to ten cm. below the pylorus the common bile duct enters the duodenum at the ampulla of Vater.

**Figure 38. BILIARY SYSTEM**
Q45

The most common primary tumor of the liver is _____________ or ______________. The most common malignancy found in the liver is usually a _____________ tumor.
Answer: Q45

The most common primary tumor of the liver is hepatocarcinoma or hepatoma. The most common malignancy found in the liver is usually a metastatic tumor.
Gallbladder

The gallbladder is a pear-shaped sac 7 to 10 cm. long and about 2.5 cm. wide. It lies on the undersurface of the right lobe of the liver. The wall of the gallbladder is composed of three layers: a mucosa, a muscular layer, and an outer covering of peritoneum called the serosa which coats the gallbladder except where it is in immediate contact with the liver. The mucous lining is arranged in folds called rugae which are similar in structure and function to those of the stomach. The gallbladder stores and regulates the flow of bile manufactured by the liver. The bile enters the gallbladder via the hepatic and cystic ducts. The cystic duct from the gallbladder unites with the hepatic duct to form the common bile duct. During the digestive process the gallbladder ejects concentrated bile into the duodenum by way of the common bile duct. The duodenum receives a mixture of bile and pancreatic juice.

Lymph nodes for the gallbladder and extrahepatic bile ducts accompany the cystic and hepatic arteries to the celiac axis region. Nodes are located in relation to the common bile duct (pericholedochal), hilus of liver (hilal), the duodenum (periduodenal), liver (periportal), pancreas (peripancreatic), and cystic duct. A node of the anterior border of the foramen of Winslow\(^1\) may be identified specifically.

Adenocarcinoma is the most common tumor of gallbladder or bile duct origin. Those arising in bile ducts may be called cholangiocarcinomas.

---

\(^1\)foramen of Winslow--an epiploic (omential) foramen, an opening in the omentum.
Q46
The function of the gallbladder is to __________ and ___________ ____________.

Q47
The histologic type of the malignant tumors of bile duct origin, whether intrahepatic or extrahepatic, is called _________________.

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Answer: Q46

The function of the gallbladder is to store and regulate bile.

Answer: Q47

The histologic type of malignant tumors of bile duct origin, whether intrahepatic or extrahepatic, is called cholangiocarcinoma.
Pancreas

The pancreas is a gland shaped somewhat like a fish. It is located behind the stomach with its head situated in the C-shaped curve of the duodenum, its body extending horizontally across the posterior abdominal wall and its tail touching the spleen. The pancreas is both an exocrine and endocrine gland. Its exocrine functions are in manufacturing and secreting pancreatic juice which empties into the duodenum via the main pancreatic duct (duct of Wirsung). This juice helps to break down all types of food. For example, it contains lipase which helps in the digestion of fats, and it makes amylase which helps in the digestion of sugars and starches. Its endocrine functions involve certain cells (beta) of the islets of Langerhans scattered all over the gland, which secrete insulin, a hormone that plays a major role in carbohydrate metabolism. When these cells begin to lose their ability to produce insulin, the disease known as diabetes mellitus results. Other cells (alpha) of the pancreas secrete glucagon, another hormone involved in carbohydrate metabolism.

The blood supply is derived from the splenic, superior mesenteric, and hepatic arteries. The veins accompany the arteries and drain into the portal vein by way of the splenic and superior mesenteric tributaries.

Peripancreatic lymph nodes may be located superior, inferior, anterior or posterior to the organ, and the drainage will differ depending on whether it is from the head or body and tail of the pancreas. The lymph nodes for the pancreas are the:

- Splenic: pancreaticocolienal (body and tail)
- Hepatic: infrapyloric/subpyloric (head)
- Superior mesenteric
- Celiac axis (head)
- Lateral aortic/retroperitoneal

Malignant and Benign Tumors

Adenocarcinomas make up the majority of all malignant tumors of the pancreas. Two-thirds are located in the head of the pancreas. Usually these tumors spread to adjacent organs or have metastasized by the time the diagnosis is made. Islet cell tumors may arise from the cells of the islets of Langerhans, and may be further subdivided as insulinomas, glucagonomas, or gastrinomas on the basis of their hormonal activity. These tumors may be malignant.
Q48

The pancreas plays an important role in ________________ because it secretes ____________ ____________ found in pancreatic juices.

Q49

The three anatomic subdivisions of the pancreas are the ____________, ________________, and ____________.

Q50

The ____________ duct and the ____________ duct carry digestive juices to the intestine emptying into the ________________ by way of the ____________ ____________ ____________.
Answer: Q48

The pancreas plays an important role in digestion because it secretes digestive enzymes found in pancreatic juices. Beta cells produce insulin (hormone), and alpha cells produce glucagon (hormone) into the blood stream. Both are involved in carbohydrate metabolism and assist in controlling glucose levels. Diabetes occurs when beta cells malfunction.

Answer: Q49

The three anatomic subdivisions of the pancreas are the head, body, and tail.

Answer: Q50

The hepatic duct and the cystic duct carry digestive juices to the intestine emptying into the duodenum by way of the common bile duct.
SECTION H

THE URINARY SYSTEM
Figure 39. PRINCIPAL PARTS OF THE URINARY SYSTEM
SECTION II

THE URINARY SYSTEM

The urinary system in both males and females consists of two kidneys, two ureters, a urinary bladder, and a urethra. It is part of the excretory system of the body which also includes the respiratory, integumentary, and digestive systems.

Kidney

Each kidney is located lateral to the spinal column in the lumbar region behind the abdominal cavity. Each is, therefore, retroperitoneal, or in back of the peritoneal cavity. Each is embedded in a mass of fatty tissue which is surrounded by a fibrous covering called the renal fascia or Gerota's fascia. The renal pelvis represents extensions of the ureter and the kidney parenchyma at the hilus which is located on the inner, or medial side of each kidney. The structures of the kidney parenchyma and kidney pelvis are quite different:

- The **kidney parenchyma** is the glandular part of the organ where the filtration of blood takes place and urine is produced. The outer connective tissue layer is called the cortex; the inner structure is called the medulla. The medulla consists of renal (medullary) pyramids which are separated from one another by extensions of the cortex into the medulla called renal columns.

- The **renal pelvis** and **calyces** collect the urine which is then transported by the ureters from the kidney to the urinary bladder for storage.

Figure 40. KIDNEY

---

1 parenchyma--the functional working elements of an organ.

2 calyces--(plural of calyx--cuplike organs or cavities.)
The microscopic structure of the renal pelvis is similar to that found in parts of the gastrointestinal tract as well as the bladder and ureter and is as follows:

- **MUCOSA**
  
  The EPITHELIAL LAYER contains no blood vessels or lymphatics.
  
  The BASEMENT MEMBRANE is a sheet of extracellular material that functions as a filtration barrier and a boundary which helps to generate and maintain tissue structure.

- **LAMINA PROPRIA**, composed of areolar connective tissue, contains blood vessels, nerves, and, in some regions, glands. Once tumor has broken through the basement membrane into the lamina propria, it can spread by way of the lymphatics and blood vessels to the other parts of the body.

The urinary sites have NO MUSCULARIS MUCOSAE, and therefore, the lamina propria and the submucosa tend to merge; these terms will be used interchangeably.

- The SUBMUCOSA is a thick layer of either dense or areolar connective tissue. It contains blood vessels, lymphatic vessels, nerves, and, in some regions, glands.

- The MUSCULARIS PROPRIA is composed of two layers of smooth muscle tissue; it constitutes the wall of the organ.

- The SEROSA, the outermost layer covering, is a serous membrane, part of the visceral peritoneum. There is no serosa on the renal pelvis or ureters. Where there is no serosa, the connective tissue of surrounding structures merges with the connective tissue of the organ and is called ADVENTITIA.
Q1

The urinary system consists of two ____________, two ____________, a urinary ____________, and a ____________.

Q2

The kidneys are located in back of the peritoneal cavity or retroperitoneally, specifically, lateral to the ____________ ____________ in the ____________ region behind the abdominal cavity.

Q3

The glandular (working) part of the kidney is called the ____________, while the part of the kidney that collects the urine which is then transported by way of the ureter to the urinary bladder is called the ____________ ____________.
Answer: Q1

The urinary system consists of two kidneys, two ureters, urinary bladder, and a urethra.

Answer: Q2

The kidneys are located in back of the peritoneal cavity or retroperitoneally, specifically, lateral to the spinal column in the lumbar region behind the abdominal cavity.

Answer: Q3

The glandular (working) part of the kidney is called the parenchyma, while the part of the kidney that collects the urine which is then transported by way of the ureter to the urinary bladder is called the renal pelvis.
The Structural and Functional Unit of the Kidney

The structural and functional unit of the kidney is called a nephron. Each kidney has hundreds of thousands of nephrons, each of which is composed of a glomerulus (a knot of coiled capillaries arising from the renal artery) and a renal tubule:

• The glomerulus and a surrounding Bowman's capsule are called the renal corpuscle. The renal corpuscles are located in the cortex of the kidney.

• The renal tubule begins in the glomerular capsule and has three different designations along its course: the proximal convoluted tubule, the descending loop of Henle, and the distal convoluted tubule (the end of the nephron). The proximal and the distal convoluted tubules are located in the cortex of the kidney; the loop of Henle is located in the medulla. The proximal tubules form the double-walled cup known as Bowman's capsule. The distal tubules of several nephrons empty into a common collecting tubule that transports urine back into the renal pyramids of the medulla and then into a minor calyx of the renal pelvis.

1capillary—a minute blood vessel.
Figure 41. A NEPHRON

Diagram showing:
- Glomerulus
- Bowman's capsule
- Capillary from interlobular arteriole
- Collecting tubules
- Loop of Henle
- Proximal convoluted tubule
- Distal convoluted tubule

Renal corpuscle

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The function of the kidney is to remove metabolic waste products from the blood and to maintain the electrolyte\(^1\) balance. This is accomplished by the production of urine.

The formation of urine and the regulation of the internal environment of the body by the kidneys are a composite of four processes:

- **Filtration** of the blood through the capillaries of the glomerulus into Bowman's capsule
- Selective **reabsorption** by the renal tubules of materials required to maintain the internal environment of the body, i.e., the fluid and electrolyte balance
- **Secretion** of certain substances produced in the distal and collecting tubules causing potassium, hydrogen ions, and other substances to be taken from the blood and added to the tubular filtrate
- **Maintenance** of acid-base balance (\(pH\)\(^2\) 7.4) by regulating the amount of acid or base which the kidneys eliminate in the urine.

**The Production of Urine**

The aorta brings waste-filled blood from the heart to the kidneys by way of the renal arteries. Here in the kidneys the waste products of metabolism and toxic substances are eliminated. Blood enters the glomerulus through the afferent arteriole which divides into capillaries. These will later unite to form the efferent arteriole that drains blood from the glomerulus. As the blood passes through the glomerulus, water, glucose, salts, and nitrogenous wastes are filtered into Bowman's capsule which is the beginning of the renal tubule. The contents of the distal portion of the tubule pass to branches of the collecting tubule which empties into the calyces of the renal pelvis. These contents are then transported through the ureters from the renal pelvis to the bladder. Certain substances required to maintain fluid and electrolyte balance are reabsorbed by the peritubular capillaries\(^3\) (e.g., sodium, glucose, water) and returned to the blood. Secretions produced in the distal and collecting tubules cause other substances to be added to the tubular filtrate from the blood (e.g., potassium, hydrogen ions, and ammonia).

Some abnormal constituents found in the urine are albumin, blood, calculi, melanin, and malignant cells.

Through the capillaries of the glomeruli, approximately 120 milliliters (ml) of water and salts are filtered from the blood each minute. Most of the water is reabsorbed as are other essential substances unless their concentration in the body happens to be too high. The urine passes out through the collecting tubules at a rate of approximately 1.0 milliliter per minute, so that a healthy person will excrete about 1 to 1 and 1/2 liters per day.

---

1. electrolytes—mainly, ions such as sodium, potassium, ammonium chloride, bicarbonate, phosphate, and sulfate. Levels vary with diet and other factors.

2. pH—refers to the hydrogen ion concentration expressing both acidity and alkalinity on a scale whose values run from 0 to 14 with 7 representing neutrality, numbers less than 7 increasing acidity, and numbers greater than 7 increasing alkalinity.

3. peritubular capillaries—capillary beds that surround the renal tubules.
Q4

Why is blood circulated through the kidneys?

a. ____________________________

b. ____________________________

Q5

What is the structural and functional unit of the kidney?

______________________________

Q6

Through which parts of the kidney are water and salts filtered?

______________________________

Q7

Give the names of the major structures involved in the urinary process from the point at which blood enters the capillaries in the cortex of the kidney until it enters the calyces of the renal pelvis.

1. ____________________________ 2. ____________________________
3. ____________________________ 4. ____________________________
The blood is circulated through the kidneys:

a. To excrete waste products of metabolism and toxic substances from the body.
b. To help maintain the fluid and electrolyte balance.

The nephron is the structural and functional unit of the kidney.

Water and salts are filtered through the capillaries of the glomeruli.

The major structures involved in the urinary process from the point at which blood enters the capillaries in the cortex of the kidney until it enters the calyces of the renal pelvis are:

1. Glomerulus
2. Bowman’s capsule
3. Renal tubule
4. Collecting tubule
Regional Lymph Nodes

The lymphatics of the kidney and renal pelvis drain to retroperitoneal nodes along the abdominal aorta and vena cava (paracaval), primarily to those near the origin of the renal arteries. Perirenal nodes are those at the renal hilus.

Malignant Tumors

Tumors which arise in the kidney parenchyma or the renal pelvis usually can be distinguished by the histologic type:

Malignant tumors of the kidney parenchyma:

- *Adenocarcinoma* makes up 80 per cent of renal tumors. It may also be called hypernephroma, renal cell carcinoma, and Grawitz's tumor.

- *Wilms' tumor* or nephroblastoma is the most common abdominal malignancy in children. It is almost exclusively a disease of children under six years of age. It is a mixed tumor histologically made up of embryonal tissue, probably of nephrogenic origin. It is highly malignant but often is successfully treated.

Malignant tumors of the renal pelvis:

- *Transitional cell carcinoma* is the most common tumor of the renal pelvis.

- *Squamous cell carcinoma* is rare.

Tumors of the renal pelvis comprise 15-18 percent of the renal malignancies.
Q8

The regional lymph node drainage for the kidney parenchyma is to:

1. ______________________

2. ______________________

3. ______________________

The regional lymph node drainage for the renal pelvis is to:

1. ______________________

2. ______________________

3. ______________________

Q9

Indicate whether the following tumors would most likely arise in the kidney parenchyma (use symbol k) or in the renal pelvis (use symbol r):

_____ 1. Transitional cell carcinoma

_____ 2. Wilms’ tumor

_____ 3. Adenocarcinoma

_____ 4. Squamous cell carcinoma

Q10

What is the major kidney tumor occurring in childhood?

________________________________________

Q11

What is the most common type of kidney cancer?

________________________________________
The regional lymph node drainage for the kidney parenchyma is to:
1. Renal hilar lymph nodes
2. Paracaval lymph nodes
3. Para-aortic or retroperitoneal lymph nodes

The regional lymph node drainage for the renal pelvis is to:
1. Renal hilar lymph nodes
2. Paracaval lymph nodes
3. Para-aortic or retroperitoneal lymph nodes

The following tumors would most likely arise in the kidney parenchyma (indicated by k) or the renal pelvis (indicated by r):

r  1. Transitional cell carcinoma
k  2. Wilms’ tumor
k  3. Adenocarcinoma
r  4. Squamous cell carcinoma

The major kidney tumor occurring in childhood is Wilms’ tumor.

The most common type of kidney cancer is adenocarcinoma. It may also be called a renal cell carcinoma, hypernephroma, or Grawitz’s tumor.
Ureters

Each kidney is connected to the urinary bladder by a ureter. These muscular tubes are about 26 to 28 cm in length, beginning at the renal pelvis. They transport urine from the kidney to the bladder.

The microscopic structure of the ureter is similar to that of the renal pelvis consisting of a mucosa of epithelium and lamina propria, a submucosa, a muscularis propria, and an outer adventitia of fibroelastic connective tissue.

Regional Lymph Nodes

The regional lymph node drainage for the ureters is to the:

- Periureteral
- Renal hilar
- Common iliac
- Internal iliac (hypogastric)
- External iliac
- Paracaval

Malignant Tumors

Primary cancer of the ureter is rare. When cancer does occur, it is usually transitional cell carcinoma, resembling cancer of the renal pelvis; it often presents as an ureteral obstruction.
Q12

What is the tube which carries urine from the kidney to the bladder?

Q13

What are the tissue layers of the renal pelvis excluding the basement membrane?
1. __________________________  }  Mucosa
2. __________________________  }
3. __________________________
4. __________________________
5. __________________________
Answer: Q12

The tube which carries urine from the kidney to the bladder is the ureter.

Answer: Q13

The tissue layers of the renal pelvis are:

1. Epithelium } Mucosa

2. Lamina propria }

3. Submucosa

4. Muscularis propria (or two layers of smooth muscle)

5. Adventitia
Urinary Bladder

The urinary bladder is a hollow muscular organ which serves as a reservoir for urine. It lies in the pelvis behind the pubic bone. The adult urinary bladder has a capacity of 300-350 milliliters.

Three openings mark off a triangular area called the **trigone** at the base of the bladder. These are the orifices of the two ureters and the urethra. The trigone is smooth even when the bladder is empty; the remainder of the bladder wall is in folds allowing for expansion when the bladder is full. The superior surface of the bladder may be referred to as the dome; other subsites are the lateral, anterior, and posterior walls. The trigone may also be referred to as the floor or base.

In the female, the bladder is located in front of and below the uterus being separated from the anterior part of the uterus by a fold of peritoneum called the uterovesical pouch. Posteriorly, it is connected to the cervix and upper vagina by a thick layer of connective tissue.

In the male, the inferior surface of the bladder which is not covered by peritoneum is in proximity to the upper rectum and is separated from it by the rectovesical fascia which contains the seminal vesicles and vas deferens. The prostate lies just below the bladder and surrounds the proximal part of the urethra as it emerges from the urinary bladder.

**Figure 42. URINARY BLADDER**
URINARY BLADDER, RENAL PELVIS AND URETERS

<table>
<thead>
<tr>
<th>PRIMARY SITE</th>
<th>MUCOSA</th>
<th>MUSCULARIS PROPIA</th>
<th>SEROSA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urinary Bladder</td>
<td>Epithelium Yes</td>
<td>Lamina Propria/Yes</td>
<td>Yes, on superior surface</td>
</tr>
<tr>
<td>(C67.9)</td>
<td></td>
<td>Submucosa Yes</td>
<td></td>
</tr>
<tr>
<td>Renal pelvis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(C65.9)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ureter(s)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(C66.9)</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>

The bladder wall has the same three tissue layers as the renal pelvis and ureter:

- **EPITHELIAL LAYER** (mucosa) contains no blood vessels or lymphatics.

- **BASEMENT MEMBRANE** is a sheet of extracellular material that functions as a filtration barrier and a boundary which helps to generate and maintain tissue structure.

  - **LAMINA PROPRIA**, composed of areolar connective tissue, contains blood vessels, nerves, and, in some regions, glands. Once tumor has broken through the basement membrane into the lamina propria, it can spread by way of the lymphatics and blood vessels to the other parts of the body.

The urinary sites have **NO MUSCULARIS MUCOSAE**, and therefore, the lamina propria and the submucosa tend to merge; these terms will be used interchangeably.

- **SUBMUCOSA** is a thick layer of connective tissue. It contains blood vessels, lymphatic vessels, nerves, and in some regions, glands.

- **MUSCULARIS PROPRIA** consists of three layers of smooth muscle which provide the ability to expand and contract.

- The superior and posterior aspects of the bladder have a *serosal covering* (peritoneum) which is not found interiorly.
Regional Lymph Nodes

The regional lymph nodes draining the bladder are:

Perivesical
Internal iliac (hypogastric) including obturator
External iliac
Sacral (lateral, presacral, promontory (Gerota's))

Figure 43. LYMPHATIC DRAINAGE OF THE BLADDER
Malignant Tumors

Bladder cancer is the most frequent malignancy of the urinary tract, and it is more common in men than in women. Most bladder tumors are papillary in appearance and will often occur and recur in multiple sites within the bladder. The lateral and posterior walls are involved with tumor more frequently than is the trigone. There is a high frequency of bladder cancer in heavy smokers.

- *Transitional cell carcinoma* is the most common bladder cancer accounting for 90-95 percent of bladder tumors. The grading, as well as the staging, of these tumors is of particular significance in prognosis, there being a high level of correlation between grade (differentiation) and stage (invasiveness).

There are different grading systems. Using Broders'\(^1\) Classification, bladder tumors may be diagnosed as carcinoma Grades I - IV. In other classifications, Broders' Grade I tumor is called a papilloma, with further subdivision into carcinoma Grades I - III.

Foci of squamous cell carcinoma and adenocarcinoma may be found in association with transitional cell carcinoma, especially in high-grade tumors.

- *Squamous cell carcinoma* occurring in a pure form is rare, less than 10 percent of all bladder carcinomas.

- *Adenocarcinoma* of the bladder is rarely found in pure form and is almost impossible to distinguish from prostatic carcinoma with extension to the bladder.

- *Leiomyosarcoma* is a rare tumor arising in the smooth muscle of the bladder.

\(^1\)Broders, Albert C.—a pathologist who formulated a four-grade classification of malignancy based on the degree of cellular dedifferentiation.
Q14

What is the term for the muscular sac which serves as a reservoir for urine?

__________________________________________________________

Q15

What is the trigone area of the organ referred to in Q14 above?

__________________________________________________________

Q16

Which of the following lymph nodes are regional for the bladder?

☐ a. SuprACLAVICULAR
☐ b. External iliac
☐ c. Inguinal
☐ d. Obturator
☐ e. Aortic (para-, peri-, lateral) (retroperitoneal)

Q17

What are the layers of the bladder wall (interior to exterior)?

1. __________ of (a) _________ and (b) ___________

2. ___________________________________________

3. ___________________________________________

4. ___________________________________________
The urinary bladder is a reservoir for urine.

You might have said: The trigone area of the bladder is a triangular area at the base of the bladder marked off by orifices of the two ureters and urethra.

Regional nodes for the bladder are:

b. External iliac
d. Obturator

The layers of the bladder wall (interior to exterior) are:

1. Mucosa of (a) epithelium and (b) lamina propria
2. Submucosa
3. Muscularis propria or musculature (three layers of smooth muscle)
4. Serosa (superior surface only)
Urethra

The urethra is a membranous tube which conveys urine from the urinary bladder to the exterior of the body.

At the proximal end is a circular smooth muscle which surrounds the bladder neck and is known as the *internal sphincter*. It is controlled by the autonomic nervous system. The *external sphincter* of the urethra is a circular striated muscle which is under voluntary control. In the female, the external sphincter is located in the vulva; in the male it is in the glans penis.

The urethra differs in men and women:

The female urethra is a part of only the excretory system and is approximately 2.5 - 3.0 cm long.

The male urethra is a part of both the excretory system and the reproductive system. It has three regions:

- The *prostatic urethra* which passes through the prostate gland is approximately 2.5 cm long.
- The *membranous urethra* which comprises the external muscular section is approximately 1.3 cm long.
- The *penile* (spongy or cavernous) *urethra* which passes through the penis is approximately 9.0 - 15.0 cm long.

**Regional Lymph Nodes**

The regional lymph nodes for the urethra are:

- Common iliac
- Internal iliac (hypogastric) including obturator
- External iliac
- Inguinal (superficial or deep)
- Presacral

*Malignant tumors* are rare and are almost always transitional cell carcinomas.
Q18

The _______________________ is a membranous tube which conveys urine from the urinary bladder to the exterior of the body.

Q19

Match the terms on the left with the descriptions on the right.

___  1.  Bowman’s a.  Tubules leading from Bowman’s capsule to the
capsule collecting tubules

___  2.  Renal tubules b.  Tube carrying urine from the bladder to the
outside of the body

___  3.  Glomerulus c.  Muscular sac which serves as a reservoir for
urine

___  4.  Urethra d.  Tubes carrying urine from the kidney to the
urinary bladder

___  5.  Ureters e.  Collection of capillaries through which blood is
filtered

___  6.  Bladder f.  Structure in the kidney which receives the
filtered materials directly from the glomerulus

___  7.  Nephron g.  The structural and functional unit of the kidney
Q20

The renal pelvis is:

- a. a muscular sac which serves as a reservoir for urine.
- b. the central urine-collecting structure of the kidney from which urine is delivered to the bladder via the ureters
- c. a structure which receives the filtered materials directly from the glomerulus.
- d. the outer layer of the kidney.
Answer: Q18

The urethra is a membranous tube which conveys urine from the urinary bladder to the exterior of the body.

Answer: Q19

1. Bowman’s capsule  Structure in the kidney which receives the filtered materials directly from the glomerulus
2. Renal tubules  Tubules leading from Bowman’s capsule to the collecting tubules
3. Glomerulus  Collection of capillaries through which blood is filtered
4. Urethra  Tube carrying urine from the bladder to the outside of the body
5. Ureters  Tubes carrying urine from the kidney to the urinary bladder
6. Bladder  Muscular sac which serves as a reservoir for urine
7. Nephron  The structural and functional unit of the kidney

Answer: Q20

The renal pelvis is:

b. The central urineCollecting structure of the kidney from which urine is delivered to the bladder via the ureters.
SECTION I

THE REPRODUCTIVE SYSTEM
Figure 44. FEMALE PELVIS (frontal view)
SECTION I

THE REPRODUCTIVE SYSTEM

Female Reproductive System

The female reproductive system is made up of the uterus and two ovaries, two fallopian tubes (uterine tubes or oviducts), a vagina, and a vulva (pudendum or external genitalia). Two breasts (or mammary glands) are considered to be accessory organs of the female reproductive system and will be discussed in this section.

Uterus

The uterus is a hollow, pear-shaped, muscular organ located in the pelvic cavity between the bladder and the rectum. The uterus plays a role in three important functions: menstruation, pregnancy, and parturition. It is composed of two parts, an upper portion called the corpus (or body), and a lower, narrow part called the cervix. The fundus is that portion of the corpus which rounds into a bulging prominence at about the level at which the fallopian tubes enter the corpus.

Midway between the uterus and the rectum is a region in the abdominal cavity known as the cul de sac. It is important that you remember this term because it will be examined for the presence of cancer.

Figure 45. FEMALE PELVIS (sagittal view)
The wall of the uterine corpus is composed of the following microscopic layers:

- **The EPITHELIAL LAYER** contains no blood vessels or lymphatics.

  The BASEMENT MEMBRANE is a sheet of extracellular material that functions as a filtration barrier and boundary which helps to generate and maintain tissue structure.

  The LAMINA PROPRIA, composed of areolar connective tissue, contains blood vessels, nerves, and, in some regions, glands. Once tumor has broken through the basement membrane into the lamina propria, it can spread by way of the lymphatics and blood vessels to other parts of the body.

- **There is NO MUSCULARIS MUCOSAE OR SUBMUCOSA** in the endometrium.

- **The MYOMETRIUM**, the thick middle layer, is composed of three layers of smooth muscle fibers: longitudinal, transverse, and oblique, that extend in all directions and give great strength to the uterus. It contains an abundance of blood vessels, lymphatics, and nerves.

The uterine cervix is composed of:

- **A MUCOSA** of columnar glandular epithelium in the upper portion of the cervical canal (endocervix) which is continuous with that of the corpus. It becomes stratified squamous epithelium at the lower end of the canal extending onto the lip of the cervix (ectocervix or exocervix).

- **A LAMINA PROPRIA** (stroma) of dense connective tissue which contains a few smooth muscle fibers and the cervical glands.
Q1

The female reproductive organs are:

1. 

2. 

3. 

4. 

5. 

Q2

The uterus is located in the ___________ cavity between the ___________ and the ___________.

Q3

The uterus is composed of two parts, an upper portion called the ___________ and a lower, narrow portion called the ___________.

Q4

The portion of the body of the uterus which rounds into a bulging prominence at about the level at which the fallopian tubes enter is called the ___________.

Q5

The three tissue layers of the body of the uterus are:

1. 

2. 

3. 

275
The female reproductive organs are:

1. The uterus
2. Two ovaries
3. Two fallopian tubes (uterine tubes or oviducts)
4. A vagina
5. A vulva

The uterus is located in the pelvic cavity between the bladder and the rectum.

The uterus is composed of two parts, an upper portion called the body (or corpus) and a lower, narrow portion called the cervix.

The portion of the body of the uterus which rounds into a bulging prominence at about the level at which the fallopian tubes enter is called the fundus.

The three tissue layers of the body of the uterus are:

1. Endometrium (mucosa)
2. Myometrium
3. Serosa (Perimetrium)
The uterus has thick walls and a small, flat, triangular-shaped cavity. Its apex is directed downward and forms the *internal os* which opens into the cervical canal. The cervical canal narrows at its lower end and forms the *external os* opening into the vagina. The mucosa of the vaginal wall is contiguous with the mucosa of the cervix. A circular recess around the cervix at its junction with the vagina is called the fornix. It is divided into four fornices or parts: anterior, posterior, and two lateral. The fallopian tubes join the uterine cavity at the upper, outer angles. A generous blood supply is received by the uterus from the uterine arteries which are branches of the internal iliac arteries. Eight ligaments which hold the uterus in place but allow considerable movement are two broad ligaments, two uterosacral ligaments, the posterior ligament, the anterior ligament, and two round ligaments.

Parametrium, connective tissue which surrounds the uterus, separates the cervix from the bladder and extends between the two serosal layers of the broad ligaments as well as to and over the pelvic walls.

**Regional Lymph Nodes**

The regional lymph nodes for both the corpus and the cervix uteri are:

- **Pelvic Nodes:**
  - Paracervical
  - Parametrial
  - Common iliac
  - Internal iliac (hypogastric, including obturator)
  - External iliac
  - Sacral (lateral, presacral, promontory (Gerota’s), uterosacral)
  - Aortic (para-, peri-, lateral)—regional for corpus uteri only

The major lymphatic trunk is the utero-ovarian (infundibulo-pelvic), which drains into the iliac and sacral nodes.

**Malignant Tumors**

The histologic types of cancer arising in the uterus are:

- Adenocarcinoma arising in the glandular epithelium of the endometrium and of the upper two-thirds of the cervical canal
- Leiomyosarcoma arising in the smooth muscle of the myometrium
- Adenosquamous carcinoma arising at the squamous columnar junction
- Squamous cell carcinoma arising in the lower one-third of the cervical canal and the lip of the cervix, and often extending into the vagina. The majority of the neoplasms arising in the cervix will arise in the lower one-third. These will be chiefly in situ, i.e., there will be no stromal invasion. Lesions with stromal invasion of 3 mm or less may be described as micro-invasive.
- Endometrial stromal sarcoma
- Choriocarcinoma, a highly malignant tumor composed of chorionic (placental) type tissue

- Muellerian mixed tumor (mixed mesenchymal or mesodermal sarcoma), a relatively large group of sarcomas with no single histologic pattern

- Carcinosarcoma, a tumor of the endometrium which is composed of carcinomatous elements as well as stroma with characteristics of sarcoma.
Q6

For each of the sites below, list four lymph node groups that drain these sites.

Corpus:

____________________
____________________
____________________
____________________

Cervix

____________________
____________________
____________________
____________________
Answer: Q6

For corpus uteri you might have said:

- Common iliac
- Internal iliac or hypogastric or obturator
- External iliac
- Parametrial
- Paracervical
- Aortic (para-, peri-, lateral)
- Sacral

For cervix uteri you might have said:

- Common iliac
- Internal iliac or hypogastric or obturator
- External iliac
- Sacral
- Paracervical
- Parametrial
Ovaries

The ovaries, female gonads\(^1\), are the shape and size of large almonds and are located one on either side of the uterus, below and behind the fallopian tubes. Each ovary lies between the folds of the broad ligament and is attached to its posterior surface by the mesovarian ligament. The ovarian ligament anchors it to the uterus. The distal portion of the fallopian tube curves about the ovary so that a fimbriated cup hangs over each ovary but is not actually attached to it. The ovary is an example of a gland whose duct is detached from it.

Microscopically, the ovary consists of a layer of germinal epithelial cells and a layer of connective tissue in which structures known as graafian follicles are embedded. When a graafian follicle matures (usually one per month alternating between right and left ovaries), it expels an ovum. This process is called ovulation. After ovulation, the wall of the follicle is transformed into an endocrine gland, the corpus luteum, which secretes progesterone and some estradiol. The corpus luteum lasts only about 12-14 days if the ovum is not fertilized; it then deteriorates into a small fibrous cicatrix.\(^2\) When the ovum has been fertilized, it travels to the uterus and becomes embedded in endometrial tissue. The developing trophoblast\(^3\) produces hormones (chorionic gonadotrophins) which stimulate the corpus luteum to increase in size and to prolong its production of progesterone which furthers the developing of the endometrium and the anchoring and nurturing of the embryo. Near the end of pregnancy, the corpus luteum shrinks and over a period of months undergoes the same degenerative changes as when the ovum is not fertilized.

The development and activities of the graafian follicle and of the corpus luteum are triggered by hormones secreted by the pituitary gland. However, as indicated above, the ovary itself has a hormonal function. During the maturation of the graafian follicle, certain cells (thecal and granulosal) surrounding or sheathing the developing ovum produce estrogentic hormones, mainly estradiol and estrone. These cells are replaced by the luteal cells after ovulation. The normal cyclical process of menstruation, with development and degeneration of endometrial cells, is governed by these hormonal activities of the pituitary and the ovaries.

Regional Lymph Nodes

Regional lymph node metastasis from the ovary is infrequent, but when it occurs it is primarily to the para-aortic nodes. However, any of the following may be considered regional lymph nodes draining the ovaries:

Pelvic lymph nodes:
- Common iliac
- Internal iliac (hypogastric, including obturator)
- External iliac
- Lateral sacral
- Aortic (para-, peri-, lateral)
- Inguinal (rare)

\(^1\)gonads--organs which produce sex cells--ovaries and testes.

\(^2\)cicatrix--scar resulting from formation and contraction of fibrous tissue.

\(^3\)trophoblast--the ectodermal layer covering and attaching the embryo to the uterine wall and supplying nutrition for it.
Fallopian tubes

The fallopian tubes, also called oviducts and uterine tubes, are attached to the uterus at its upper, outer angles. They lie between the folds of the broad ligaments and extend upward and outward toward the pelvic sidewalls and then curve downward and backward.

The walls of the tubes are composed of the same three tissue layers as the uterine corpus.

- A ciliated mucous lining of epithelial tissue. (The cilia propel the ovum from the ovary to the uterus.)
- Smooth muscle
- Serosa (or external peritoneal covering)

At the distal end, each tube expands into a funnel-like portion (the infundibulum) which resembles a fringe or is "fimbriated." Here the mucous lining of the tubes is directly continuous with the peritoneum. The fallopian tubes serve as ducts for the ova produced by the ovaries. Fertilization (union of a spermatozoon and an ovum) normally occurs in the fallopian tubes. Tumors of the fallopian tubes are extremely rare.

Regional Lymph Nodes

The regional lymph nodes for the fallopian tubes are:

Pelvic lymph nodes
- Common iliac
- Internal iliac (hypogastric, including obturator)
- External iliac
- Lateral sacral
- Aortic (para-, peri-, lateral)
- Inguinal
Q7

Match the sites on the left with the descriptions on the right.

1. Uterus  a. Ducts through which ova travel into the uterus
2. Fallopian tubes  b. Pear-shaped muscular organ in the pelvic cavity in which the embryo develops after fertilization
3. Ovaries  c. Organs which produce ova and hormones associated with female reproduction and secondary sex characteristics
**Answer: Q7**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>b</td>
<td>1. Uterus</td>
<td>Pear-shaped muscular organ in the pelvic cavity in which the embryo develops after fertilization</td>
</tr>
<tr>
<td>a</td>
<td>2. Fallopian tubes</td>
<td>Ducts through which ova travel into the uterus</td>
</tr>
<tr>
<td>c</td>
<td>3. Ovaries</td>
<td>Organs which produce ova and hormones associated with female reproduction and secondary sex characteristics</td>
</tr>
</tbody>
</table>
Common histologic types of ovarian tumors are as follow:

- **Cystadenocarcinoma** is a malignant tumor growing within a cyst, the walls of which are lined with columnar epithelial cells. This glandular epithelium may be serous-secreting or mucinous-secreting giving rise to:

  1. **Serous cystadenocarcinoma**, a cystic cavity which is lined with ciliated epithelial cells and contains serous fluid. It is the most common malignant tumor of the ovary.

  2. **Mucinous cystadenocarcinoma**, a cystic cavity which is lined with ciliated epithelial cells and contains mucin. These mucinous cystadenocarcinomas sometimes rupture and spill their contents into the peritoneal cavity. This spillage can cause a clinical condition called **pseudomyxoma peritonei** in which tumor is implanted on all serosal surfaces and the abdominal contents are matted together.

- **Endometrioid carcinoma** is an ovarian tumor of epithelial origin that microscopically resembles a tumor originating in the endometrium.

- **Dysgerminoma** is a relatively uncommon tumor of germ cell origin, the counterpart of seminoma of the testis.

- **Teratocarcinoma or malignant teratoma** is a tumor of germ cell origin composed of embryonic tissue which is differentiated into bone, hair, teeth, cartilage, and skin. All these types of tissues may be found in the tumor. A benign tumor with these characteristics is called a dermoid.

- **Granulosa cell and theca cell tumors** arise from cells of the early ovarian mesenchyme in the ovarian stroma which surrounds the developing ovum. They are sometimes called feminizing or estrogen-producing tumors.

- **Krukenberg tumor** is a metastatic tumor of the ovary, usually from a primary in the stomach or other gastrointestinal site, with a marked ovarian tissue proliferation.

Less common tumors of the ovary are: Brenner tumors, arrhenoblastoma (masculinizing tumor), fibrosarcoma, and mesonephric tumors.

Ovarian tumors are frequently bilateral. They spread by implantation to the peritoneum, omentum, and serosal surfaces. They may also arise as independent primaries with no evidence of intraperitoneal spread.
Q8

Name the three openings of the uterus:

1. 
2. 
3. 

Q9

The walls of the fallopian tubes are composed of the same three tissue layers as the uterus except that the mucosa is ________________ to propel the ovum.

Q10

What is the purpose of the fallopian tubes? ________________________________

Q11

The regional lymph nodes which drain the fallopian tubes and the ovaries are:

1. 
2. 
3. 
4. 
5. 

Q12

In relation to the uterus, the ovaries are located ________________.
Q13

The fimбриae of the fallopian tubes cup over the ovaries but are not actually attached to them.

This is an example of a gland whose ____________ is detached.
Answer: Q8

In naming the three openings of the uterus, you might have said the openings of two fallopian tubes (oviducts or uterine tubes) and the opening into the vagina (or the external os).

Answer: Q9

The walls of the fallopian tubes are composed of the same three tissue layers as the uterus except that the mucosa is ciliated to propel the ovum.

Answer: Q10

You might have said the fallopian tubes serve as ducts to carry the ova produced by the ovaries to the uterus.

Answer: Q11

The regional lymph nodes draining the fallopian tubes and the ovaries are:

- Common iliac
- Internal iliac or hypogastric or obturator
- External iliac
- Lateral sacral
- Aortic (para-, peri-, lateral)
- Inguinal (rare)

Answer: Q12

The ovaries are located on either side of the uterus below and behind the fallopian tubes.

Answer: Q13

The fimbriae of the fallopian tubes cup over the ovaries but are not actually attached to them. This is an example of a gland whose duct is detached.
**Vagina**

The vagina is situated posterior to the bladder and anterior to the rectum. It extends upward and backward from the vaginal orifice to the uterus. The vagina is a collapsible tube, capable of great distension, composed mostly of smooth muscle lined with a mucous membrane of stratified squamous epithelium and connective tissue (stroma) arranged in rugae. It is about 3 inches (7.5 cm) in length. A fold of mucous membrane, the hymen, forms a border around its external opening in the virginal state. The functions of the vagina include: 1) receiving semen from the male; 2) serving as the lower part of the birth canal; and 3) acting as the excretory duct for uterine secretions and the menstrual flow.

The region between the vaginal orifice and the anus is called the perineum.

**Vulva**

The external female genitalia (or vulva) consist of the following structures:

- **The mons pubis** (mons veneris) is a skin-covered pad of fat over the symphysis pubis (pubic bone).
- **Labia majora** (large lips) are covered with pigmented skin and hair on the outer surface, smooth and free from hair on the inner surface, and composed mainly of fat and glands.
- **Labia minora** (small lips) are located within the labia majora and are covered with a modified skin. (These labia come together anteriorly in the midline, and the area between them is called the vestibule of the vagina.)
- The clitoris, a small organ composed of erectile tissue located just behind the upper junction of the labia minora, corresponds in structure to the corpora cavernosa and glans of the penis in the male. The prepuce or foreskin covers the clitoris as it does the glans penis in the male.
- The urinary (urethral) meatus, the small opening of the urethra located between the clitoris and the vaginal orifice.
- The vaginal orifice, the opening into the vagina, located posterior to the urinary meatus.
- Bartholin’s glands (greater vestibular glands), two bean-shaped glands, one on either side of the vaginal orifice. Each gland opens by means of a single, long duct into the space between the hymen and the labia minora and corresponds to the bulbourethral glands in the male. They secrete a lubricating fluid.
- Skene’s glands (lesser vestibular glands) open into the vestibule of the vagina near the urinary meatus through two small ducts. They are a group of tiny mucous glands.

---

1 *rugae*—ridges, wrinkles, or folds of mucous membrane.
Regional Lymph Nodes

The regional lymph nodes draining the vagina are:

Upper two-thirds of vagina:

Pelvic lymph nodes:
- Common iliac
- Internal iliac (hypogastric, including obturator)
- External iliac
- Sacral promontory

Lower one-third of vagina and vulva:

- Superficial Inguinal or Femoral (unilateral or bilateral)
- Deep inguinal: Rosenmuller’s or Cloquet’s node (vulva only)

Malignant Tumors

The most common histologic type of malignant neoplasm found in the vulva and vagina is squamous cell carcinoma. The usual spread of disease from the vagina is to the cervix, vulva, rectum, and bladder. For tumors arising in the vulva, the usual spread of disease is to the vagina, urethral orifice, and perineum.
Q14

The vagina is situated between the ____________, which is posterior to it, and the ____________, which is anterior to it.

Q15

The vagina is a collapsible tube, the walls of which are composed of ________________ ________________ lined with ________________ ________________.

Q16

The female external genitalia are called the ________________. Match each of its parts (on the left) with the descriptions on the right.

_____ 1. Mons pubis (mons veneris) a. A small organ composed of erectile tissue

_____ 2. Labia majora b. The external opening of the vagina

_____ 3. Labia minora c. A skin-covered pad of fat over the pubic bone

_____ 4. Clitoris d. Tiny mucous glands opening into the vestibule near the urinary meatus

_____ 5. Urinary meatus e. Covered with pigmented skin on outer surface and composed mainly of fat and glands

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6. Vaginal orifice  
f. Glands that secrete a lubricating fluid into the space between the hymen and the labia minora

7. Bartholin's glands  
g. The small opening of the urethra located between the clitoris and the vaginal orifice

8. Skene's glands  
h. Located within the labia majora and covered with modified skin.

Q17

Match the neoplasms on the left with the descriptions on the right:

1. Cystadenocarcinoma  
a. A metastatic ovarian tumor, usually a primary of the gastrointestinal tract, especially of the stomach

2. Dysgerminoma  
b. Malignant tumor derived from more than one type of germ cell and containing several tissue types

3. Krukenberg tumor  
c. An epithelial tumor that microscopically resembles a tumor of endometrial origin

4. Teratocarcinoma  
d. A tumor derived from the germ cells of the ovary comparable to seminoma of the testis in the male
5. Endometrioid carcinoma  e. An adenocarcinoma growing within a cyst, serous or mucinous

Q18

The most common histologic type of malignant tumor found in the vulva and vagina is

__________________.

For both sites, lymph node drainage is to the _____________ and ______________

_______ nodes.
The vagina is situated between the rectum which is posterior to it, and the bladder which is anterior to it.

The vagina is a collapsible tube, the walls of which are composed of smooth muscle lined with mucous membrane.

The female external genitalia are called the vulva. Match each of its parts (on the left) with the descriptions on the right.

- **c** 1. Mons pubis (mons veneris) A skin-covered pad of fat over the pubic bone
- **e** 2. Labia majora Covered with pigmented skin on the outer surface and composed mainly of fat and glands
- **h** 3. Labia minora Located within the labia majora and covered with modified skin.
- **a** 4. Clitoris A small organ composed of erectile tissue
- **g** 5. Urinary meatus The small opening of the urethra located between the clitoris and the vaginal orifice
- **b** 6. Vaginal orifice The external opening of the vagina
- **f** 7. Bartholin's glands Glands that secrete a lubricating fluid into the space between the hymen and the labia minora
- **d** 8. Skene's glands Tiny mucous glands opening into the vestibule near the urinary meatus

Match the neoplasms on the left with the descriptions on the right:

- **e** 1. Cystadenocarcinoma An adenocarcinoma growing within a cyst, serous or mucinous.
- **d** 2. Dysgerminoma A tumor derived from the germ cells of the ovary comparable to seminoma of the testis in the male
3. Krukenberg tumor  
A metastatic ovarian tumor, usually a primary of the gastrointestinal tract, especially of the stomach.

4. Teratocarcinoma  
Malignant tumor derived from more than one type of germ cell and containing several tissue types

5. Endometrioid carcinoma  
An epithelial tumor that microscopically resembles a tumor of endometrial origin

Answer: Q18

The most common histologic type of malignant tumor found in the vulva and vagina is squamous cell carcinoma.

For both sites, lymph node drainage is to the external and internal iliac nodes.
Breast

The breasts, or mammary glands, are modified sweat glands and, in some of the earlier classification systems, were grouped with the integumentary system. The breasts lie on top of the chest wall immediately over the pectoral muscles, pectoralis major and pectoralis minor, and are attached to the pectoralis major by a layer of connective tissue, the pectoral fascia. On the lower lateral aspect of the chest wall, the breasts are in contact with the serratus anterior muscles.

Each breast consists of many separate glands that are connected by individual ducts (lactiferous ducts) to the nipple. These glands constitute the lobes of the breast, 15 to 20 lobes (glands) for each breast. Each lobe is composed of many lobules which are formed from minute ducts and contain secreting cells (alveoli). The lobes are separated from each other by dense connective tissue and are surrounded by quantities of adipose tissue (fat). Suspensory ligaments (Cooper's ligaments) run from the corium of the skin through the breast to the fascia overlying the chest wall.

Located in the center of each breast is a nipple bordered by a circular pigmented area of skin called the areola. The lactiferous ducts from the lobes of the breast converge in the nipple. During pregnancy, hormonal changes in the body stimulate the production of milk in the lobes (mammary glands); the ducts transport the milk to the nipple.

Figure 46. BREAST (sagittal view)

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1. **pectoral muscles**--The function of the pectoralis major muscle is to adduct, flex, and rotate the humerus inward. The pectoralis minor lies between the pectoralis major and serves to depress the tip of the shoulder and help rotate the scapula downward and forward.

2. **serratus anterior muscles**--These muscles draw the scapula forward and rotate it to raise the tip of the shoulder.
Q19

The breasts overlie the ______________________ muscles.

Q20

Each breast consists of multiple glandular ___________ which are further subdivided into ______________________ formed from minute ducts surrounded by alveoli.

Q21

The circular area bordering each nipple is called the ______________________.
Answer: Q19

The breasts overlie the pectoral muscles.

Answer: Q20

Each breast consists of multiple glandular lobes which are further subdivided into lobules formed from minute ducts surrounded by alveoli.

Answer: Q21

The circular area bordering each nipple is called the areola.
The female breast is classified according to the following subsites in ICD-O:

- Nipple/areola C50.0
- Central portion (subareolar, retroareolar) C50.1
- Upper-inner quadrant (UIQ) C50.2
- Lower-inner quadrant (LIQ) C50.3
- Upper-outer quadrant (UOQ) C50.4
- Lower-outer quadrant (LOQ) C50.5
- Axillary tail C50.6
- Inner/outer/upper/lower breast, midline C50.8

You will sometimes find the location described in terms of hours on the clock; it is important to note that this designation will be different for the inner and outer quadrants of the right and left breast.

**Figure 47. Quadrants of the Breast**

One shortcoming of our present classification system is that midline tumors, tumors at 3, 6, 9, and 12 o'clock, are grouped in a single category (C50.8) in ICD-0, and thus lose their identification. Since a substantial number of tumors arise in these locations, we may be obscuring useful information by including all of them in code C50.8. Medial lesions, for instance, have a poorer prognosis because of their potential for metastasis to the internal mammary nodes.
A tumor specified as "subareolar" is coded to the central portion of the breast (C50.1) indicating that the tumor is located directly under the nipple.

Extending outward from the nipple and areola and covering the entire surface of the breast is a layer of skin. Skin changes are significant in the clinical evaluation of breast cancer and indicate involvement of parenchymal tissue as well as invasion of the skin itself. Changes such as dimpling, tethering, and nipple retraction are presumed to be due to tension on Cooper's ligaments and not to actual skin involvement; adherence, attachment, fixation, induration, and thickening are usually due to extension of tumor to the skin or subcutaneous tissue. Edema, peau d'orange,\(^1\) en cuirasse\(^2\), and ulceration clinically indicate extensive skin involvement.

The blood supply to the breast is from both the internal thoracic (subclavian) and the lateral thoracic (axillary) arteries. The veins form both superficial and deep plexuses and correspond in general to the arterial pattern.

**Regional Lymph Nodes**

The lymph nodes of the breast may be divided into the following categories:

- **Axillary lymph nodes (ipsilateral)**
  - Low axillary (Level I): area adjacent to the tail of the breast
  - Mid axillary (Level II): central, interpectoral (Rotter's node)
  - High axillary (Level III): apex of the axilla including those designated as subclavicular, infraclavicular, and apical nodes

- **Internal mammary (parasternal) lymph nodes (ipsilateral)**: in the intercostal spaces along the edge of the sternum in the endothoracic fascia

Nodules of cancer cells found in the axillary fat which are not specifically identified as lymph nodes are considered to be nodes which have lost their architectural configuration or to be intransit metastases in the lymphatics.

Contralateral or bilateral involvement of any of the above lymph nodes is considered distant lymph node metastasis.

All other lymph node metastases are coded as distant metastases, including any supraclavicular, scalene, and cervical lymph nodes.

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\(^1\)peau d'orange—a dimpled skin condition resembling the skin of an orange.

\(^2\)en cuirasse—an inflammatory process in which skin involvement resembles armor plate.
Q22

One of the first and most frequent areas of nodal metastasis in breast cancer patients is the ________ lymph nodes.

Q23

Match the axillary lymph node levels on the left with the descriptions on the right.

_  1. Low a. Area next to the tail of the breast
_  2. Mid b. Apex of the axilla
_  3. High c. Area under the pectoralis minor muscles

Q24

What are the most frequently involved distant lymph nodes for breast cancer?
One of the first and most frequent areas of nodal metastasis in breast cancer patients is the axillary lymph nodes.

Answer: Q23

a. 1. Low Area adjacent to the tail of the breast  
c. 2. Mid Area under the pectoralis minor muscles  
b. 3. High Apex of the axilla

The most frequently involved distant lymph nodes for breast cancer are the supraclavicular (transverse cervical) lymph nodes.
Malignant Tumors

Ninety percent of all breast cancers arise from the glandular epithelial lining of the ducts. Thus, most tumors are intraductal in origin. The epithelium is supported by a basement membrane and an incomplete layer of myoepithelial cells. Invasion takes place when the tumor penetrates the basement membrane of the duct and grows into the supporting stroma. The histologic types of tumors generally described are:

- **Intraductal (adenocarcinoma)**, is a noninfiltrating or in situ lesion.
- **Ductal (duct cell) (adenocarcinoma)** is a general term denoting an infiltrating tumor of ductal origin.
- **Medullary (adenocarcinoma)** is a well-differentiated tumor of epithelial origin which will often have evidence of lymphoid infiltration in the stroma.
- **Mucinous (adenocarcinoma)** is a mucin-producing tumor which may have a gelatinous or colloid (glue-like) appearance when sufficient amounts of mucin are present.
- **Lobular (adenocarcinoma)** arises in the lobules of the breast as the name implies. It is most often diagnosed in situ but will eventually invade the parenchyma. Multiple foci are frequently found including foci in both breasts.
- **Inflammatory carcinoma** is a clinical term used to describe a condition in which there is diffuse involvement of the breast, particularly of the skin, causing widespread erythema, edema, and discoloration. It is generally inoperable and has a poor prognosis.
- **Scirrhous (adenocarcinoma)** is a tumor of ductal epithelial origin in which fibrous connective tissue has formed giving it a hard consistency.
- **Paget's disease** presents as a weeping eczematoid lesion of the nipple and areola. It occurs as the result of nipple invasion from an underlying ductal carcinoma. The presence of Paget's disease does not alter the staging of the original tumor.
- **Cystosarcoma phylloides**, also known as cellular intracanalicular fibroma, is usually a benign disease contrary to the inclusion of "sarcoma" in the name of this tumor. It is one of the rare stromal tumors of the breast and, although it may become very large, cystic, and hemorrhagic, it only infrequently becomes invasive.
REVIEW TEST

Match the descriptions on the left with the organs on the right:

___ 1. Gonads in the female  a. Perineum
___ 2. Muscular layer of the uterus  b. Cul de sac
___ 3. Fringe bordering opening of the fallopian tube  c. Myometrium
___ 4. Area between the vagina and anus  d. Ovaries
___ 5. External genitalia of female  e. Fallopian tubes
___ 6. Ducts through which the ova travel into the uterus  f. Female genitalia
___ 7. Region of abdominal cavity midway between the rectum and uterus  g. Vulva
          h. Fimbria
<table>
<thead>
<tr>
<th></th>
<th>1. Gonads in the female</th>
<th>Ovaries</th>
</tr>
</thead>
<tbody>
<tr>
<td>d</td>
<td>2. Muscular layer of the uterus</td>
<td>Myometrium</td>
</tr>
<tr>
<td></td>
<td>3. Fringe bordering opening of the fallopian tube</td>
<td>Fimbria</td>
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<tr>
<td>h</td>
<td>4. Area between the vagina and anus</td>
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</tr>
<tr>
<td>a</td>
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<td>Vulva</td>
</tr>
<tr>
<td>g</td>
<td>6. Ducts through which the ova travel into the uterus</td>
<td>Fallopian tubes</td>
</tr>
<tr>
<td>e</td>
<td>7. Region of abdominal cavity midway between the rectum and uterus</td>
<td>Cul de sac</td>
</tr>
</tbody>
</table>
Male Reproductive System

The male reproductive system, like that of the female, consists of those organs whose function is to produce a new individual, i.e., to accomplish reproduction. This system consists of a pair of testes and a network of excretory ducts (epididymis, ductus deferens (vas deferens), and ejaculatory ducts), seminal vesicles, the prostate, the bulbourethral glands, and the penis.

Scrotum

The scrotum is a skin-covered pouch of muscle and fascia suspended on the outside of the body. It is one of the supporting structures of the male reproductive system. The scrotum is divided internally into two (left and right) sacs by a septum (partition) so that each sac contains a testis, epididymis, and the lower part of the spermatic cord.

Testes

The testes are two small ovoid glands, male gonads, which lie in the scrotum. These glands are not developed within the scrotal sac, but descend from the abdominal cavity during fetal development. A thick fibrous capsule (tunica albuginea) encases each testis, extensions of which (septa) partition the interior into lobules. Each lobule contains tiny coiled seminiferous tubules and many interstitial (Leydig) cells which lie between the seminiferous cells. The interstitial cells are glandular cells that produce the hormone testosterone.

The primary functions of the testes are:

- Production of male reproductive cells by the seminiferous tubes (spermatozoa or sperm)
- Secretion of hormones, mainly testosterone, by the interstitial cells of Leydig.

Testosterone is an androgen secreted by the Leydig cells of the testicle. Testosterone is responsible for the development of male secondary sex characteristics and genital growth; it also influences the retention of nitrogen, potassium, phosphorous, and calcium, required for building protoplasm. Androgens also have important growth-regulating functions.

Regional nodes for the testis are found on page 322.
Q25

The male gonads consist of a pair of _____________ enclosed in a sac called the _____________ lying outside of the body cavity.

Q26

A major hormone secreted by the interstitial cells of the testes is _________________. It is responsible for the development of the male sex characteristics.
Answer: Q25

The male gonads consist of a pair of testes enclosed in a sac called the scrotum lying outside of the body cavity.

Answer: Q26

A major hormone secreted by the interstitial cells of the testes is testosterone. It is responsible for the development of the male sex characteristics.

Figure 48. MALE PELVIS (sagittal view)
The internal structure of the testis is composed of seminiferous tubules. The seminiferous tubules are narrow, coiled tubules located within the lobules of the testis and composed of parenchymal tissue. Thus, these tubules perform the essential, active work of the organ, that is, production of the sperm cells by two types of cells: 1) the spermatogenic cells and 2) the Sertoli cells which support and protect the developing sperm cells and may even contribute to their nourishment. The Sertoli cells are resistant to heat, radiation, and other agents that prove toxic to germ cells.

Epididymis. Each epididymis consists of a single coiled tube or duct encased in a fibrous covering. It is about 20 feet long with a very small diameter and lies along the top and side of the testis. The sperm cells are temporarily stored in the epididymis after leaving the testis.

Vas deferens. The vas deferens (seminal duct or ductus deferens) is really an extension of the epididymis. It carries sperm from the epididymis to the urethra. The vas deferens passes from the scrotal sac through the opening of the pelvic body wall called the inguinal canal and into the pelvic cavity. There it extends over the top and down the posterior surface of the bladder where it joins the duct from the seminal vesicle on each side to form the ejaculatory ducts. These short tubes, the ejaculatory ducts, pass through the prostate gland and terminate in the prostatic portion of the urethra.

The aggregate of vas deferens and associated blood vessels, lymphatics, and nerves is bound within a connective tissue sheath called the spermatic cord.

Figure 49. TESTIS (sagittal view)
Q29

Match the structures on the left with its function on the right.

____ 1. Epididymis a. Narrow tubes which carry sperm from the epididymis to the urethra

____ 2. Vas deferens b. Narrow, coiled tubules in the testes which produce sperm

____ 3. Seminiferous tubules c. Tube located on top of each testis which carries and stores sperm before they enter the vas deferens

Q28

The ___________________________ _____________ are the parenchymal (essential) tissue of the testes because they produce the sperm.
Answer: Q27

1. Epididymis - Tube located on top of each testis which carries and stores sperm before they enter the vas deferens
2. Vas deferens - Narrow tubes which carry sperm from the epididymis to the urethra
3. Seminiferous tubules - Narrow, coiled tubules in the testes which produce sperm

Answer: Q28

The *seminiferous tubules* are the parenchymal (essential) tissue of the testes because they produce the sperm.
Seminal Vesicles

The seminal vesicles are two glands located on the posterior surface of the urinary bladder between the bladder and the rectum. They secrete a substance that nourishes the sperm cells. Approximately 30 percent of the semen is composed of the secretion produced by the seminal vesicles.

Prostate Gland

The prostate gland is located on the inferior surface of the urinary bladder encompassing the prostatic portion of the urethra. It lies behind the symphysis pubis (to which it is connected by the puboprostatic ligament), above the urogenital diaphragm (pelvic floor), and in front of the rectum. It is separated from the rectum by Denonvilliers' fascia. The adult prostate weighs about 20 grams and is typically divided into three lobes: the right and left lateral lobes and the middle lobe. These lobes consist of alveoli lined with columnar epithelium encased in a thin capsule of connective tissue and embedded in a thick fibromuscular stroma. The prostate secretes an alkaline substance which constitutes the largest part (60 percent) of the seminal fluid. This establishes a suitable pH environment for sperm reaching the vagina and protects the ejaculated semen from mechanical damage. The seminal fluid is drained from the navel by a system of branching ducts which open into the prostatic portion of the urethra.

Acid phosphatase is present in the prostatic secretions. Patients with prostatic carcinoma which is still confined within the prostatic capsule usually have a normal serum acid phosphatase level. However, elevated serum levels are seen in patients with carcinoma of the prostate that has extended beyond the prostatic capsule. Acid phosphatase determination is used diagnostically to help determine the spread of the disease. See page 116 of Book 5 for normal values.

Figure 50. PROSTATE GLAND (sagittal view)

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1Denonvilliers' fascia—a portion of the rectovesical fascia between the rectum and prostate gland.
Figure 51. PROSTATE GLAND (frontal view)

Relationship of Prostatic Hypertrophy, Hyperplasia, and Prostatic Cancer

Hypertrophy means an increase in size of the prostate due to the increase in the size of the individual cells. In contrast, hyperplasia means an increase in the size of the prostate due to an increase in the number of its cells.

Benign prostatic hypertrophy (enlargement of the prostate) is very common in elderly men. Its exact etiology is not known, although there is some evidence to show that part of it is hormonally mandated. Benign prostatic hypertrophy increases with age as does prostatic cancer; and both require testosterone to grow and divide. In general, prostatic cancer originates in the periphery of the prostate where benign prostatic hypertrophy occurs. That is why it is possible for the physician to palpate these tumors via the rectum. A clinical diagnosis of benign prostatic hypertrophy may be made when a man has symptoms of prostatic disease. Then a TUR is done, and only then may a diagnosis of cancer be made based on the increase in the number of cells, hyperplasia.

Bulbourethral (Cowper's) Glands

The Cowper's glands are located below the prostate on either side of the membranous urethra. They resemble peas in both size and shape. A duct about 2.5 cm long connects each of them with the urethra. Cowper's glands, like the prostate, secrete an alkaline, mucous fluid which makes up about 5 percent of the semen. These glands are also supplied with muscular tissue which aids in expulsion of sperm during ejaculation.
Match the structures on the left with the descriptions on the right

___ 1. Prostate   a. Glands which nourish sperm cells by their secretions

___ 2. Bulbourethral  b. Gland which secretes an alkaline substance (60 percent of seminal fluid) providing protective environment for sperm

___ 3. Seminal vesicles  c. Glands which aid in ejaculation because of their muscular tissue
1. Prostate  - Gland which secretes an alkaline substance (60 percent of seminal fluid) providing protective environment for sperm
2. Bulbourethral  - Glands which aid in ejaculation because of their muscular tissue
3. Seminal vesicles  - Glands which nourish sperm cells by their secretions
Penis

The penis consists of erectile and connective tissue sheathed in skin. There are three distinct bands of the erectile tissue within the penis: The two *corpora cavernosa* and the single *corpus spongiosum*. At the distal end is the *glans penis* over which there is a double fold of skin called the prepuce or foreskin. The penis contains the penile (spongy or cavernous) segment of the urethra which is the terminal duct for both the urinary and the reproductive tracts in the male.

The penile blood supply is from the internal iliac and femoral arteries by way of the pudendal arteries. Blood drains to the internal iliac veins. During erection, the blood vessels of the penis undergo a change; the arteries become dilated and the veins constricted.

The penis serves two purposes:

- An excretory organ for liquid wastes
- The male copulatory organ
Regional Lymph Nodes

The regional lymph node drainage for the prostate is:
- Periprostatic
- Internal iliac: (hypogastric, including obturator)
- External iliac
- Sacral (lateral, presacral, promontory (Gerota's))

The regional lymph node drainage for the testis is:
- Paracaval
- Aortic (para-, peri-, lateral)
- External iliac (intrapelvic)

The regional lymph node drainage for the penis is:
- External iliac
- Internal iliac (hypogastric)
- Superficial inguinal (femoral)
- Deep inguinal: Rosenmuller's or Cloquet's node

Figure 52. LYMPHATIC DRAINAGE OF THE PROSTATE AND TESTES
Malignant Tumors

The most common malignant neoplasms which occur in the male reproductive systems are as follows:

- Adenocarcinoma of the prostate gland, diagnosed primarily in men over 65 years of age.

- Testicular tumors occurring primarily in young men. The classification of testicular tumors is highly controversial and complicated by the frequent occurrence of tumors of mixed cell types. Tumors arising in the germinal epithelium (germ cell types) account for 97 percent of testicular tumors. The most frequent histologic types are as follows:

  Seminoma is the most common testicular tumor. It also has the best prognosis as it is slow to spread. Foci of the more malignant types of germ cell tumors, embryonal carcinoma and choriocarcinoma, may be found in the seminoma. Then the prognosis is similar to the more malignant tumor rather than to the pure seminoma. Variants of seminoma are the anaplastic type of seminoma and the spermatocytic seminoma, both of which are rare.

  Teratocarcinoma or malignant teratoma is the second most common testicular tumor. Teratomas are tumors of germ cell origin composed of embryonic tissue which is differentiated into bone, hair, teeth, cartilage, and skin. All these types of tissues may be found in the tumor.

  Embryonal carcinoma is a more infiltrative type of testicular tumor and consequently has a poorer prognosis. It arises from the primitive or multipotential cells of the germinal epithelium and occurs in a variety of cellular patterns.

  Choriocarcinoma (chorioepithelioma) is a rare tumor in its pure form although foci of choriocarcinoma may be found in any of the other germinal tumors. It is highly malignant and metastasizes rapidly. It is derived from primitive cells differentiating as trophoblastic cells\(^1\). High levels of gonadotropin hormone may be found in the urine with the tumor.

Nongerminal tumors of the testes are extremely rare. Tumors arising in the gonadal stroma include: interstitial cell (Leydig cell) tumors and Sertoli cell tumors. These tumors are seldom malignant.

---

\(^1\) trophoblastic cells—pertaining to the layer of extraembryonic ectodermal tissue which covers the embryo.
Q30

Male hormones are produced primarily in the ________________.

Q31

Which of the following are regional nodes for the prostate? (Check as appropriate.)

____ 1. Aortic (para-, peri-, lateral)

____ 2. Internal iliac (hypogastric)

____ 3. Sacral

____ 4. External iliac

____ 5. Periprostatic

Q32

Which of the following are regional nodes for the testes?

____ 1. Portal

____ 2. Aortic (para-, peri-, lateral)

____ 3. External iliac

____ 4. Inguinal

____ 5. Internal iliac (hypogastric)
Answer: Q30

Male hormones are produced primarily in the testes (or in the interstitial cells of Leydig of the testes).

Answer: Q31

The regional nodes for the prostate are:

2 Internal iliac (hypogastric)
3 Sacral
4 External iliac
5 Periprostatic

Answer: Q31

The regional nodes for the testes are:

2 Aortic (para-, peri-, lateral)
3 External iliac
SECTION J

THE ENDOCRINE SYSTEM
Figure 53. ENDOCRINE GLANDS
SECTION J

THE ENDOCRINE SYSTEM

The endocrine system is comprised of ductless glands which manufacture and release specific organic secretions called hormones directly into the bloodstream to be carried to various parts of the body where they perform their particular functions. The individual glands are located in widely separated parts of the body and form a system only from a functional point of view. In contrast, the exocrine glands, such as the tear, digestive, and sweat glands release their secretions into ducts leading to the body cavities or outside the body as appropriate. (You may wish to review the pancreas, ovary, and testis which are also part of the endocrine system.)

The islets of Langerhans of the pancreas are part of the endocrine system and have already been described under the digestive system. The endocrine functions of the ovaries and testes were described under the reproductive system. The remaining endocrine glands and their distinct functions as well as their interesting relationships with each other are described below.

Pituitary Gland (Hypophysis)

The pituitary gland (hypophysis) is controlled by the hypothalamus of the brain and links the nervous system to the endocrine system. Located at the base of the brain behind the eyes in the sella turcica of the sphenoid bone, the pituitary is only the size of a pea. It is referred to as the master gland since it controls all secretions of hormones within the body. The pituitary gland has two lobes, the anterior lobe (the adenohypophysis) and the posterior lobe of the neurohypophysis. Each lobe has definite functions.

The anterior lobe is responsible for producing at least the following hormones:

- **Adrenocorticotropic hormone**: ACTH controls the development and secretory activity of the adrenal cortex for secretion of the glucocorticoids (primarily cortisol).

- **Thyrotrophic (thyroid-stimulating) hormone**: TSH stimulates the growth and development of the thyroid gland and stimulates it to secrete thyroxin and tri-iodothyronine (together called thyroid hormone).

- **Follicle-stimulating hormone**: FSH stimulates the development of ovarian follicles which secrete estrogen in the female. In the male, FSH stimulates the development of the seminiferous tubules and promotes spermatogenesis.

- **Male gonadotrophic hormone (interstitial cell-stimulating hormone)**: ICSH stimulates the development of the interstitial cells (cells of Leydig) of the testes and the secretion of testosterone.

- **Female luteinizing hormone**: LH stimulates the secretion of progesterone by the corpus luteum in the ovaries.

- **Growth or somatotrophic hormone**: GH or STH accelerates growth of bone, muscle, kidney, liver, and adipose tissues.
• Prolactin (luteotrophic hormone): LTH is concerned with initialization and maintenance of lactation in the mammary glands. LH stimulates the ovary to release the developed ovum and prepares the uterus for implantation of a fertilized ovum. It also stimulates formation of the corpus luteum in the ovary, which secretes progesterone and readies the mammary glands for milk secretion.

• Melanocyte-stimulating hormones: MSH and ACTH are thought to produce increased pigmentation of the skin.

The function of the posterior lobe of the pituitary is to produce the following:

• Oxytocin (pitocin) which stimulates the uterine muscles to contract during childbirth and causes the secretion of milk in lactating breasts.

• Antidiuretic hormone (vasopressin) (ADH) which has several effects on the body:

  It has an antidiuretic effect stimulating the reabsorption of water by the kidney tubules.

  It is thought to have a pressor effect increasing blood pressure by constriction of the arterioles.

  It also is believed to have an effect on the smooth muscle of the intestinal tract.

Tumors

Tumors of the pituitary are almost always benign; malignant tumors are rare. These benign tumors may produce hormonal changes in the body or may simulate the symptoms of a brain tumor.

• Adenomas, representing about three-fourths of the pituitary tumors, are of three main types: acidophilic (eosinophilic), basophilic, and chromophobe.

• Craniopharyngioma (Rathke’s pouch tumor) arises along the craniopharyngeal duct and is benign.
Thyroid Gland

The thyroid gland consists of two lateral lobes united by a strip of glandular tissue called the isthmus. It is covered by two capsules: an inner capsule of fibroelastic tissue and an outer capsule continuous with and part of the deep cervical fascia. The thyroid is located on either side of the trachea just below the thyroid cartilage. The unit structure of the thyroid gland is the follicle. A thin, continuous basal membrane surrounds each follicle. Between the follicles are capillaries, fibroblasts, and small bundles of collagenous fibers. This gland produces the hormones thyroxin and tri-iodothyronine which are necessary to maintain a normal level of metabolism in all body cells. These hormones are synthesized in the thyroid gland from iodine. Another hormone produced by the thyroid gland is thyrocalcitonin which aids in maintaining the proper level of calcium in the blood. In summary, the main physiological actions of this gland are to assist in regulating the metabolic rate in concert with growth and tissue regulation.

Lymphatic drainage is to cervical and mediastinal nodes:

- Delphian node
- Anterior cervical: prelaryngeal, pretracheal, laterotracheal (recurrent laryngeal nerve chain)
- Internal jugular: jugulodigastric and jugulo-omohyoid
- Tracheoesophageal
- Mediastinal, upper anterior and posterior (tracheoesophageal)
- Retropharyngeal

Tumors

Malignant tumors of the thyroid are primarily of two main types:

- **Papillary adenocarcinoma** is the most common thyroid cancer. It is generally well differentiated and characterized by well-defined papillary fronds. Spread is usually via the lymphatics to the cervical lymph nodes. Prognosis is good following excision of the involved lobe(s). Lymph node dissection may be deferred until there is clinical evidence of nodal involvement.

- **Follicular adenocarcinoma** is the second most common type of thyroid malignancy. It has well-developed follicles resembling normal thyroid tissue. Dissemination is usually via the blood stream to distant sites.

Mixed papillary and follicular carcinoma is common. It behaves like papillary carcinoma.

- **Medullary carcinoma** with amyloid stroma is a rare tumor.
- **Anaplastic carcinoma** is also rare; it occurs predominantly in older patients.

The most common benign tumor of the thyroid is the adenoma of which there are several types, such as: papillary, follicular, colloid, fetal, and Hurthle cell. These benign tumors are not generally included in the cancer registry unless they are of special interest to the medical staff.
Parathyroid Gland

There are four parathyroid glands located immediately behind the thyroid gland beneath its outer capsule. There is, however, little correlation between the functions of the thyroid and the parathyroids. Although each parathyroid is only about the size of a grain of rice, its function is essential to life.

The chief cells of the parathyroid secrete a hormone, parathormone, which maintains the normal phosphorous and calcium levels in the body. Parathormone controls the excretion of phosphorus in the kidney and also mobilizes calcium and phosphorus in bone. It also increases the absorption of calcium from the intestinal tract when necessary.

An excess of parathormone may cause Recklinghausen's disease of the bone (osteitis fibrosa cystica). Excessive parathormone draws calcium from the bone and raises this level in the blood. Pathological fractures may result.

Tumors of the parathyroid are extremely rare; most are benign adenomas.

Pineal Gland

The pineal gland (epiphysis) is located in the brain attached to the roof of the third ventricle (epithalamus). It secretes the hormone melatonin, which contributes to the process of skin pigmentation, and is thought to secrete serotonin and adrenoglomerulotropin. Although its true functions remain a mystery, it is also believed to serve as a "biological clock."

Tumors of the pineal gland are called pinealomas and are usually benign. Since these tumors are located in the brain, you may be requested to include them in the registry together with benign brain tumors.

Figure 54. THYROID AND PARATHYROID GLANDS

Figure 55. PINEAL GLAND
Adrenal (Suprarenal) Glands

There are two adrenal (suprarenal) glands, about the size of the last digit of the little finger, each paired with and located on top of a kidney and behind the peritoneum. Each adrenal gland consists of two parts, an inner medulla and an outer cortex.

- The adrenal medulla secretes hormones called catecholamines, i.e., epinephrine and norepinephrine. These are hormones produced by stress and were once referred to only as adrenalin.

  Epinephrine (adrenalin) increases heart rate and cardiac activity, dilates the bronchial tubes, and stimulates the production of glucose from glycogen.

  Norepinephrine (acetylcholine) constricts blood vessels and raises blood pressure.

- The adrenal cortex secretes hormones called steroids. Some of the more important ones are:

  Aldosterone, a mineralocorticoid, promotes sodium retention and potassium loss in the urine and vice versa as needed to balance the body fluids.

  Cortisol increases the ability of the cells to make new sugars out of fats and proteins. (Cortisone is a hormone similar to cortisol but is produced synthetically.)

  Androgens, estrogens, and progestin (male and female hormones) are secreted by the adrenal cortex in small amounts. They promote normal development of bones and reproductive organs.

Tumors

Adrenal tumors may be divided into those arising from the cortical cells and those from the medullary cells of the glands.

- Neuroblastoma, which arises in the medulla, is the most common malignant tumor of the adrenal gland. It is found most frequently in children and young adults and is, in fact, one of the most common childhood tumors. Neuroblastomas can also arise from neural tissue elsewhere in the body.

- Pheochromocytoma and ganglioneuroma are benign, rarely malignant, tumors of the adrenal medulla.

- Adrenal cortical adenocarcinoma arises in the adrenal cortex. Its benign counterpart is the cortical adenoma.
Thymus Gland

The thymus gland is located behind the sternum in the mediastinum. It is large in childhood, but shrinks in adults. Its structure is lymphoepithelial. It is a source of lymphocytes. T lymphocytes mature in the thymus and are involved in cell-mediated immunity, that is, the cells themselves mediate the immune effect. The thymus is also included in the section on the Lymphatic System.

Tumors of the thymus, thymomas, are rare and most often benign. As a lymphoid organ, the thymus may be primarily or secondarily involved in lymphomas of the mediastinum.

The condition of myasthenia gravis, which is characterized by muscular weakness and fatigue, may be associated with tumors of the thymus.

Other Hormone Producers

The stomach wall secretes a hormone called gastrin which stimulates the blood vessels and secretions of the stomach glands.

The upper part of the small intestine secretes a hormone called secretin which stimulates the pancreas and causes the gallbladder to contract.

The placenta produces chorionic gonadotropic hormones which help to maintain pregnancy.

Figure 56. ADRENAL GLAND

Figure 57. THYMUS GLAND
Q1

Match the terms on the left with the descriptions on the right.

___ 1. Hormones  a. An endocrine gland which lies at the base of the brain; the pituitary

___ 2. Hypophysis  b. Ductless glands which secrete substances into the bloodstream

___ 3. Exocrine glands  c. A narrow strip of tissue connecting two parts

___ 4. Isthmus  d. Organic secretions originating in a ductless gland and conveyed to another part of the body by the bloodstream

___ 5. Endocrine glands  e. Glands which secrete substances through ducts in the body surfaces or into body cavities

___ 6. Steroids  f. Hormones produced by the adrenal cortex, such as aldosterone, cortisol, and androgens
Q2

Match the hormone on the left with the appropriate endocrine gland on the right. The same gland may be selected more than once.

__ 1. FSH (follicle-stimulating hormone) a. Pancreas

__ 2. Androgens b. Pituitary

__ 3. Cortisol c. Ovaries

__ 4. Insulin d. Adrenals (medulla)

__ 5. Thyroxin e. Testes

__ 6. Parathormone f. Adrenals (cortex)

__ 7. Epinephrine g. Thyroid

__ 8. Estrogen h. Parathyroid

__ 9. Steroids

Q3

The endocrine system consists of glandular tissue which secretes ________________ directly into the blood stream from its ________________ (type) glands.
Q4

Match the endocrine glands on the left with their locations in the body on the right:

1. Ovaries (paired)  
   a. In the mediastinum

2. Testes (paired)  
   b. On top of each kidney

3. Adrenals (paired)  
   c. In the middle brain

4. Parathyroids  
   d. At the base of the brain

5. Thyroid  
   e. Behind the stomach

6. Pancreas  
   f. On the dorsal aspect of the thyroid

7. Pineal  
   g. In the lower abdominal region of the female

8. Thymus  
   h. On either side of the trachea just below the thyroid cartilage

9. Pituitary  
   i. Suspended by the spermatic cord and surrounded by the scrotal sac

Q5

Match the tumor on the left with the typical gland of origin on the right. The same gland may be selected more than once.

1. Neuroblastoma  
   a. Pituitary gland

2. Papillary adenocarcinoma  
   b. Thyroid gland

3. Craniopharyngioma  
   c. Adrenal gland

4. Follicular adenocarcinoma
1. Hormones: Organic secretions originating in a ductless gland and conveyed to another part of the body by the bloodstream

2. Hypophysis: An endocrine gland which lies at the base of the brain; the pituitary

3. Exocrine glands: Glands which secrete substances through ducts to the body surface or into body cavities

4. Isthmus: A narrow strip of tissue connecting two parts

5. Endocrine glands: Ductless glands which secrete substances into the bloodstream

6. Steroids: Hormones produced by the adrenal cortex, such as aldosterone, cortisol, and androgens

---

1. FSH (follicle-stimulating hormone): Pituitary
2. Androgens: Testes, adrenals (cortex)
3. Cortisol: Adrenals (cortex)
4. Insulin: Pancreas
5. Thyroxin: Thyroid
6. Parathormone: Parathyroid
7. Epinephrine (adrenalin): Adrenals (medulla)
8. Estrogen: Ovaries, adrenals (cortex)
9. Steroids: Adrenals (cortex), testes
The endocrine system consists of glandular tissue which secretes hormones directly into the blood stream from its ductless glands.

Answer: Q3

1. Ovaries (paired) In the lower abdominal region of the female
2. Testes (paired) Suspended by the spermatic cord and surrounded by the scrotal sac
3. Adrenals (paired) On top of each kidney
4. Parathyroids On the dorsal aspect of the thyroid
5. Thyroid On either side of the trachea just below the thyroid cartilage
6. Pancreas Behind the stomach
7. Pineal In the middle brain
8. Thymus In the mediastinum
9. Pituitary At the base of the brain

Answer: Q5
1. Neuroblastoma Adrenal gland
2. Papillary adenocarcinoma Thyroid gland
3. Craniopharyngioma Pituitary gland
4. Follicular adenocarcinoma Thyroid gland
SECTION K
THE SKELETAL SYSTEM
Figure 58. AXIAL SKELETON

- Skull
- Cervical vertebrae
- Thoracic vertebrae
- Spinal column
- Sacrum
- Lumbar vertebrae
- Sternum
- Ribs
- Coccyx
SECTION K

THE SKELETAL SYSTEM

The skeletal system is composed of bones and cartilage. Most of the bones and much of the cartilage form joints which are held together by ligaments of tough, fibrous connective tissue. Joints can be classified as immovable (synarthrosis), slightly movable (amphiarthrosis), and freely movable (diarthrosis).

There are a total of 206 bones in the adult human body. Eighty of these bones form the upright axis of the body, the axial skeleton, which is the basic framework of the body. It includes the skull, vertebral column, and the bones (ribs) which encase the thorax. The other 126 bones comprise the appendicular skeleton which is made up of bones that are attached or appended to the axial skeleton: the upper and lower extremities (arms and legs) including the shoulder and pelvic girdles (clavicle, scapula, and hip bones). The main bones that compose the skeletal system can be located in Figures 58 and 67.

This complex skeletal system has a variety of functions.

- It provides a supporting framework for the body.
- It affords protection for the vital organs: heart, lungs, brain, spinal cord, as well as sensory organs, and soft tissues.
- It provides a leverage system for muscle action with the bones providing attachments for the muscles, ligaments,\(^1\) tendons,\(^2\) and fascia.\(^3\)
- It serves as a storehouse (within the bone) for minerals, and supplies calcium and phosphorus to the blood.
- It contains bone marrow which produces millions of red blood cells and thousands of white cells (hemopoiesis).

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\(^{1}\text{ligament}^\text{--a fibrous band of connective tissue that connects bones to bones serving to support and strengthen joints.}\)

\(^{2}\text{tendon}^\text{--a fibrous cord of connective tissue by which a muscle is attached to bone.}\)

\(^{3}\text{fascia}^\text{--a fibrous sheet of connective tissue covering and separating muscles.}\)
Q1

The skeletal system is composed of _______________ and _______________
which may be held together by _______________ at their joints.

Q2

Five functions of the skeletal system are:

1. _______________
2. _______________
3. _______________
4. _______________
5. _______________

Q3

The 206 bones of the skeleton may be grouped into two skeletal divisions:

1. _______________ _______________ (the basic framework of the body).
2. _______________ _______________ (the appendage of this framework).
Answer: Q1

The skeletal system is composed of bones and cartilage which may be held together by ligaments at their joints.

Answer: Q2

You might have said:

1. It provides a supporting framework for the body.
2. It protects the vital organs.
3. It provides leverage for muscle action.
4. It serves as a storehouse for minerals and supplies calcium and phosphorus to the blood.
5. The bone marrow produces blood cells.

Answer: Q3

The 206 bones of the skeleton may be grouped into two skeletal divisions:

1. **Axial skeleton** (the basic framework of the body).
2. **Appendicular skeleton** (the appendage of this framework).
Bone/Cartilaginous Tissue

Bone, or osseous tissue, is a form of dense connective tissue in which the intercellular substance, or matrix, is infiltrated with calcium salts. It differs from cartilage in that bone is a vascular tissue permeated with canaliculi. The canaliculi are tiny canals that connect the lacunae (in which bone cells lie) with each other and serve as a transport system (Haversian system) between the blood capillaries and the bone cells. Tissue fluid in the canaliculi diffuses oxygen and nutrient material from the blood to the bone cells and carries their waste material back to the circulatory system. Thus the bone cells (osteocytes) may remain alive although surrounded by calcified intercellular substance (bone matrix). No bone cell is more than 0.1 mm from a blood capillary.

In contrast, cartilage is nonvascular connective tissue. Its cells (chondrocytes) are nourished by means of blood vessels in the outer layer of perichondrium which covers the surface of the cartilage. There are three types of cartilage:

- **Hyaline cartilage**, the most abundant, may become calcified and replaced by bone. However, much of it remains uncalcified as part of the ears, nose, larynx, trachea, and larger bronchi, and as a covering of the articulating\(^1\) bones in freely moving joints where it has a cushioning effect.

- **Elastic cartilage** is rare; it occurs primarily in the external ear and in the epiglottis.

- **Fibrocartilage** (fibrous cartilage) is found in the areas where tendons insert into bone.

**Figure 59. OSSEOUS TISSUE**

**Figure 60. HYALINE CARTILAGE**

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\(^1\)articulation—the place of union or junction between two or more bones.
Q4

One characteristic which distinguishes bone from cartilage is that bone is _________ while cartilage is _________________.

Q5

Bone cells are called _________________.

Q6

Cartilage cells are called _____________________.

Q7

Match the types of cartilage on the left with the descriptions on the right:

___ 1. Hyaline  a. Rare, occurring only in external ear and epiglottis

___ 2. Elastic  b. Occurs in areas of insertion of tendons into bone

___ 3. Fibrous  c. Most abundant, may become calcified and be replaced by bone or remain uncalcified as a covering of articulating bones.
Answer: Q4

One characteristic which distinguishes bone from cartilage is that bone is **vascular** while cartilage is **nonvascular**.

Answer: Q5

Bone cells are called **osteocytes**.

Answer: Q6

Cartilage cells are called **chondrocytes**.

Answer: Q7

- **c** 1. Hyaline  
  Most abundant, may become calcified and be replaced by bone or remain uncalcified as a covering of articulating bones.

- **a** 2. Elastic  
  Rare, occurring only in external ear and epiglottis.

- **b** 3. Fibrous  
  Occurs in areas of insertion of tendons into bone
Classification of Bones

Bones may be classified by shape as follows:

- **Long bones** are found in the arms and legs. Examples: humerus, radius, ulna, phalanges, femur, tibia and fibula.

- **Short bones** are short and cuboid or irregular in shape. The three dimensions (length, width, and depth) are all about the same. Examples: wrist and ankle bones (carpal and tarsal).

- **Flat bones** are protection for the soft body parts. Examples: ribs, sternum, scapulae, and bones of the pelvis and skull (e.g., temporal, frontal).

- **Irregular bones** are similar in structure to flat bones, but because of their peculiar shape they are included in their own classification. Examples: vertebrae, sacrum, ethmoid, sphenoid, and ear bones of the skull.

- **Round bones** are small, flat round sesamoid bones, so named because of their resemblance to sesame seeds. Because the number of these bones varies greatly with the individual, only a few are reflected in the total bone count. The function of round bones is to eliminate or reduce friction. Example: The patella or kneecap is the largest sesamoid bone of the body and is embedded in the tendon of the quadriceps femoris muscle at each knee.

Figure 61. CLASSIFICATION OF BONES
Q8

The purpose of the sesamoid bones is to ____________________________.

Q9

Match the following bones with the appropriate descriptions of their shapes.

___ 1. Femur  a. Short
___ 2. Temporal  b. Flat
___ 3. Sacrum  c. Irregular
___ 4. Carpal  d. Round (sesamoid)
___ 5. Patella  e. Long

Q10

The ___________ consists of both flat and irregular bones.
Answer: Q8

The purpose of the sesamoid bones is to eliminate (or reduce) friction.

Answer: Q9

1. Femur Long  
2. Temporal Flat  
3. Sacrum Irregular  
4. Carpal Short  
5. Patella Round (sesamoid)

Answer: Q10

The skull consists of both flat and irregular bones.
Figure 62. Haversian System of the Bone
Adult Femur

1. Diaphysis (main shaft)
2. Metaphysis (shaft end)
3. Epiphysis (has separate center of bone growth)
4. Compact bone
5. Medullary cavity (with trabecular, cancellous spongy bone, and marrow)
6. Blood vessel (from marrow)
7. Inter-Haversian lamellae
8. Osteocyte within lacunae (enlarged to show canaliculi)
9. Central canal of Haversian system
10. Periosteum
Structure of Bone

Each long bone of the body is made up of several parts (Figure 62). The main shaft is called the diaphysis. It provides strong support without undue weight, and consists mainly of compact bone, although the innermost portion is composed of cancellous, or spongy, bone. At the ends of a bone are structures known as epipyses which are bulbous in shape, allowing ample space for muscle attachments near joints.

- Short bones consist of a core of cancellous bone encased in a thin layer of compact bone.
- Flat bones are made up of a layer of cancellous bone containing red marrow between two plates of compact bone.
- Irregular bones are similar in structure to short bones in that they are composed of a thin layer of compact bone forming a casing over cancellous bone.
- Round (or sesamoid) bones are made of dense fibrous tissue, cartilage, and bone in varying proportions. They are found embedded in tendons in close relation to articulating surfaces where they modify pressure and reduce friction.

The outside of the bone is covered by a fibrous membrane, the periosteum. Blood vessels, lymphatic vessels, and nerves are present in the periosteum and enter the Haversian canals of the compact bone to become vessels of the Haversian system permeating the entire bone.

The Haversian system is a series of small canals containing blood vessels which bring oxygen and nutrients to the bone and remove waste products such as carbon dioxide.

Bone Marrow

In the adult there are two types of bone marrow: yellow and red. In the center of the diaphysis there is a large space called the medullary cavity which is filled with yellow or fatty bone marrow. Red marrow fills the cancellous spaces in the upper (proximal) epipyses of the humerus and femur, the iliac crest, body of the vertebra, bones of the skull (diploe), ribs, sternum, clavicle, and scapula. Red bone marrow is the source of red cells and granular leukocytes as well as platelets and monocytes. Marrow is changed from red to yellow by the replacement of myeloid cells by fat cells, a process which begins soon after birth.

Special lymphocytes, B cells, are formed in the bone marrow. Mature B cells are responsible for the manufacture of antibodies which circulate in blood or other body fluids and respond to antigens found on the surface of viruses and bacteria, thus preventing the spread of infection.

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1 compact bone—continuous dense, hard structure in which spaces can only be distinguished with the aid of a microscope
2 cancellous bone—spongy or lattice-like structure surrounding intercommunicating spaces filled with bone marrow.
3 Haversian—the canal or system named after Clopton Havers (1650-1702) an English anatomist, who first described the structure of osseous tissue.
Q11

Name each of the five numbered parts of the gross structure of the long bone in Figure 62:

1. ____________
2. ____________
3. ____________
4. ____________
5. ____________

Q12

The outer covering of the bone is known as the ________________.

Q13

Periosteum contains _______ vessels, _______ vessels, and _______ which enter the compact bone to become vessels of the ________________ system.

Q14

Bone marrow is found in the ________________ _______ of long bones and in spaces of _______ bones.
The numbered parts of the gross structure of the long bone listed in Figure 62 are:

1. Diaphysis
2. Metaphysis
3. Epiphysis
4. Compact bone
5. Medullary cavity
6. Cancellous (spongy) bone

The outer covering of the bone is known as the periosteum.

Periosteum contains blood vessels, lymph vessels, and nerves which enter the compact bone to become vessels of the Haversian system.

Bone marrow is found in the medullary cavity of long bones and in spaces of cancellous bones.
AXIAL SKELETON

There are a total of eighty bones in the axial skeleton. It is composed of the skull (29 bones), the thorax (25 bones) and the vertebral column (26 bones).

Bones of the Skull. The skull is the skeleton of the face and head. These bones protect the brain and related structures. The skull is composed of 29 bones, 8 forming the cranium, 14 forming the bones of the face, 6 forming the small bones in the middle ear, and 1 hyoid bone.

Cranial bones. The cranial bones are the frontal, occipital, sphenoid, ethmoid, 2 temporal, and 2 parietal bones. They are joined together by suturae\(^1\) and are immovable.

- The frontal bone is located at the front of the skull. It contains the frontal sinuses and forms the upper rim of the orbit.
- The occipital bone makes up the framework of the lower, posterior part of the skull.
- The sphenoid bone houses the pituitary gland in a depression in its upper surface, the sella turcica, and forms a part of the roof of the nose with its undersurface. It contains the sphenoidal sinuses.
- The ethmoid bone is a light, spongy bone located at the base of the cranium, between the orbits, and at the roof of the nose. It contains the ethmoid air cells (sinuses).
- The temporal bones (2 bones) form part of the sides and part of the base of the skull.
- The parietal bones (2 bones) form the roof and upper part of the sides of the cranium.

Figure 63. CRANIAL BONES

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\(^1\)suturae--fibrous joints in which the apposed bony surfaces are so closely united by a very thin layer of fibrous connective tissue that no movement can occur.
Facial bones. The facial bones are the paired zygomatic, lacrimal, nasal, maxillae, palatine, conchae, and the unpaired vomer and mandible. All the facial bones except the mandible are joined together by suturae so that they are immovable.

- The zygomatic/malar bones form the cheek bones and part of the orbit.
- The lacrimal bones are the smallest and most fragile bones of the face. The tear ducts pass through them in the lacrimal canal.
- The nasal bones support the bridge of the nose.
- The maxillae compose the massive upper jaw bones. Joined by a sutura in the median plane, they contain the maxillary sinuses. A condition known as cleft palate results when the two bones do not grow together normally before birth.
- The vomer is a thin, flat bone which forms the lower portion of the nasal septum.
- The mandible is the lower jaw bone. It is movable for chewing and speaking purposes.
- The palatine bone forms part of the wall and floor of the nasal cavity and part of the roof of the mouth.
- The conchae (turbinates) are thin bony plates with curved margins which form the lower part of the lateral wall of the nasal cavity.

Bones of the ear. A chain of three small bones extend across the middle ear on each side: the malleus, the incus, and the stapes. These bones transmit sound waves from the eardrum membrane to the fluid of the inner ear.

Figure 64. FACIAL BONES
Bones of the Thorax. There are 25 bones in the thorax: the sternum, and 12 pairs of ribs.

- **Sternum** (breast bone) is a flat bone extending down the middle of the chest. It articulates on the sides with the clavicle and ribs.

- **Ribs.** There are 12 pairs of ribs.

  The first 7 pairs of ribs articulate with the sternum by cartilaginous attachments. These are called the true ribs.

  The last 5 pairs of ribs are called false ribs because they do not join the sternum directly. Instead, the first 3 (the 8th, 9th, and 10th) have cartilage which converges before the sternum is reached. The last two are floating ribs which end in the midchest; they are not attached to the sternum at all.

  All the ribs are attached to the vertebral column dorsally and form a cage-like structure enclosing and protecting the heart, lungs, and other thoracic structures.

Vertebral column. The vertebral column is made up of 26 bones.

- **Cervical vertebrae** (7 bones) constitute the skeleton of the neck.

- **Thoracic vertebrae** (12 bones) are situated between the cervical and lumbar vertebrae. They are attached to the 12 pair of ribs and form part of the posterior wall of the thorax.

- **Lumbar vertebrae** (5 bones) are situated between the thoracic vertebrae and the sacrum.

- The *sacrum* is formed by 5 vertebrae fused into a triangular-shaped bone in the adult.

- The *coccyx* (tailbone) is formed by four fused vertebrae.
Figure 65. BONES OF THE THORAX
(frontal view)

Figure 66. VERTEBRAL COLUMN
(sagittal view)
Q15

Name the cranial bones:

1. __________________
2. __________________
3. __________________
4. __________________
5. __________________
6. __________________

Q16

Name six facial bones:

1. __________________
2. __________________
3. __________________
4. __________________
5. __________________
6. __________________
Match the bones on the left with the descriptions on the right.

___ 1. Occipital  a. Bones which form part of the sides and part of the base of the skull

___ 2. Hyoid  b. Houses the pituitary gland and sphenoid sinuses

___ 3. Lacrimal  c. Framework of lower, posterior part of the skull

___ 4. Temporal  d. The tear ducts pass through them

___ 5. Sphenoid  e. Bone of attachment for muscles which move the tongue
The cranial bones are:

1. Frontal
2. Occipital
3. Sphenoid
4. Ethmoid
5. Temporal (2 bones)
6. Parietal (2 bones)

You might have mentioned any 6 of the following facial bones:

1. Zygomatic
2. Lacrimal
3. Maxillae
4. Nasal
5. Palatine
6. Vomer
7. Mandible
8. Conchae

Framework of lower, posterior part of the skull
Bone of attachment for muscles which move the tongue
The tear ducts pass through them
Bones which form part of the sides and part of the base of the skull
Houses the pituitary gland and sphenoid sinuses
Figure 67. APPENDICULAR SKELETON
APPENDICULAR SKELETON

The appendicular skeleton is composed of 126 bones.

**Upper extremity** (32 bones on each side):
- Clavicle: collar bone connects the sternum to the scapula
- Scapula: shoulder blade lies on the upper part of the back
- Humerus: upper arm bone articulates with the scapula at the upper end and with the ulna and radius at its lower end
- Ulna: medial lower arm bone
- Radius: lateral lower arm bone
- Carpals: wrist bones in 2 rows of 4 bones (total of 8 bones on each hand)
- Metacarpals: bones which form the bony structure of the palm of the hand (total of 5 bones on each hand)
- Phalanges: bones which form the fingers. Each finger, except the thumb, has 3 phalanges; the thumb has only 2 (total of 14 bones on each hand).

**Lower extremity** (31 bones on each side)
- Hip bones: ilium, ischium, and pubis form the lateral and anterior walls of the pelvis
- Femur: thigh bone articulates with the tibia at the distal end
- Patella: kneecap
- Tibia (shin bone): The larger of the two lower leg bones articulates with the femur at upper end and with the fibula at both upper and lower ends.
- Tarsals: ankle bones, the highest of which articulates with the tibia and fibula (total of 7 bones on each foot)
- Metatarsals: bones which form the bony structure of the foot (total of 5 bones on each foot)
- Phalanges (toe bones): Each toe, except the big toe, has 3 phalanges; the big toe has only 2 (total of 14 bones on each foot).
Malignant Tumors

Bone is derived from three cell lines each of which can produce tumors: osteogenic, chondrogenic, and collagenic. Bone also houses the marrow which contains hematopoietic precursors of myelogenic tumors. All are derived from mesoderm. Only malignant tumors are discussed here.

- **Osteogenic Sarcoma** (osteosarcoma) is the second most common bone malignancy after myeloma. It occurs mainly in males between the ages of 10 and 20 years. It grows rapidly in the long bones of the extremities and metastasizes quickly via the blood stream to the lungs. It may perforate the periosteum and invade the surrounding soft tissues.

- **Periosteal Sarcoma** is a rare, slow-growing malignancy. It arises from periosteal fibrous tissue. The posterior aspect of the distal femur is the most common site.

- **Giant Cell Tumor, Malignant** (malignant osteoclastoma) is a tumor which arises from the connective tissue of the medullary cavity. The malignant type expands rapidly.

- **Chondrosarcoma** is a tumor arising from the chondrogenic line. There are two distinct types of this tumor: peripheral, which develops on the surface of the bone, and central, which develops in the interior. The peripheral chondrosarcoma tends to affect flat bones such as ilium, sacrum, or scapula. The central chondrosarcoma occurs most often in the femur, tibia, or humerus.

- **Ewing's Sarcoma** is a highly malignant sarcoma usually occurring in males under 25 years of age. It is multicentric, originates from the reticulum cell, and usually begins in the metaphysis or wide part at the extremity of a long bone.

Closely associated with bone tumors are the following soft tissue tumors:

- **Fibrosarcoma** and **Angiosarcoma**: Malignant tumors which come from the connective tissue line. **Fibrosarcoma**, affecting mainly young adults, causes local bone destruction, particularly of the long bones. **Angiosarcoma** is a rare tumor arising primarily from capillary endothelial cells (vascular tissue within the bone).

Tumors of myelogenic (bone marrow) origin, other than the myeloproliferative disorders, are malignant, for example:

- **Multiple Myeloma**: A systemic disease found most often between ages 40 to 60 years. It originates in the reticular stem cell in the marrow spaces of the bone and is characterized by overproduction of plasma cells by the marrow. It is the most common bone tumor.

Bone is a common metastatic site for malignant cancer cells which are usually transported by way of the blood stream. The primary sites from which metastases to bone most often occur are breast, prostate, lung, colon, stomach, and urinary bladder.

1Collagenic—containing fibrous connective tissue.
Q18

Match the descriptions on the left with the terms on the right.

__ 1. A bone which connects the sternum to the scapula  a. Carpals
__ 2. The 8 bones of the wrist  b. Patella
__ 3. The 5 bones which form the bony structure of the hand  c. Hip
__ 4. The kneecap  d. Clavicle
__ 5. The smaller of the 2 lower leg bones  e. Tarsals
__ 6. The ankle bones  f. Metacarpals
__ 7. The ilium, ischium, and pubis  g. Femur
__ 8. The bones of the toes  h. Humerus
__ 9. The shoulder blade  i. Fibula
__ 10. The lateral lower arm  j. Scapula
__ 11. The bone which articulates with the tibia at the distal end  k. Phalanges
__ 12. The bones which form the fingers  l. Tibia
__ 13. The bones which form the long structure of the foot  m. Metatarsals
__ 14. The shin bone  n. Radius
__ 15. The upper arm bone  o. Ulna
__ 16. The medial lower arm bone  p. Long

Q19

Primary malignancies elsewhere in the body frequently metastasize to the bone via the _____

______.
Q20

Sites from which metastases to bone most frequently occur are:

1. ________
2. ________
3. ________
4. ________
5. ________
6. ________
Q21

Match each of the tumors on the left with its description on the right.

___  1. Angiosarcoma   a. A tumor composed of both osteogenic and chondrogenic elements

___  2. Giant cell tumor   b. A rare, slow-growing malignancy arising from fibrous tissue of the periosteum

___  3. Osteosarcoma   c. A malignant tumor arising in the vascular tissue within the bone

___  4. Periosteal sarcoma   d. A common bone tumor, second only to myeloma, which occurs mainly in males

___  5. Osteochondrosarcoma   e. A bone tumor which arises from connective tissue of the medullary cavity

___  6. Multiple myeloma   f. A highly malignant, multicentric sarcoma originating from the reticulum cell

___  7. Ewing's sarcoma   g. A systemic disease originating in the reticular stem cell in the marrow spaces of the bone
Match the description on the left with one of the terms on the right.

____ 1. Outer membrane covering bone tissue
____ 2. Flexible, connective tissue found in the ribs, nasal septum, external ear, joints, and respiratory tubes of an adult
____ 3. Skull bones: parietal, occipital, frontal, ethmoid, sphenoid, and temporal bones
____ 4. Shaft of the long bone
____ 5. Bones found in sternum, pelvis, and ribs;
____ 6. Bone cell

a. Epiphysis
b. Diarthrosis
c. Fascia
d. Cartilage
e. Diaphysis
f. Osteocyte
g. Tendon
h. Ligament
i. Haversian system
j. Cranial bones
k. Flat bones
l. Conchae
m. Periosteum
n. Joints
o. Fossa
p. Sulcus
Answer: Q18

1. A bone which connects the sternum to the scapula: Clavicle
2. The 8 bones of the wrist: Carpals
3. The 5 bones which form the bony structure of the hand: Metacarpals
4. The kneecap: Patella
5. The smaller of the 2 lower leg bones: Fibula
6. The ankle bones: Tarsals
7. The ilium, ischium, and pubis: Hip
8. The bones of the toes: Phalanges
9. The shoulder blade: Scapula
10. The lateral lower arm: Radius
11. The bone which articulates with the tibia at the distal end: Femur
12. The bones which form the fingers: Phalanges
13. The bones which form the long structure of the foot: Metatarsals
14. The shin bone: Tibia
15. The upper arm bone: Humerus
16. The medial lower arm bone: Ulna

Answer: Q19

Primary malignancies elsewhere in the body frequently metastasize to the bone via the bloodstream.

Answer: Q20

Sites from which metastases most frequently occur are:

1. Breast
2. Prostate
3. Lung
4. Colon
5. Stomach
6. Urinary bladder
<table>
<thead>
<tr>
<th>Answer: Q21</th>
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<tr>
<td><em>c</em></td>
<td>1. Angiosarcoma</td>
<td>A malignant tumor arising in the vascular tissue within the bone</td>
</tr>
<tr>
<td><em>e</em></td>
<td>2. Giant cell tumor</td>
<td>A bone tumor which arises from connective tissue of the medullary cavity</td>
</tr>
<tr>
<td><em>d</em></td>
<td>3. Osteosarcoma</td>
<td>A common bone tumor, second only to myeloma, which occurs mainly in males</td>
</tr>
<tr>
<td><em>b</em></td>
<td>4. Periosteal sarcoma</td>
<td>A rare, slow-growing malignancy arising from fibrous tissue of the periosteum</td>
</tr>
<tr>
<td><em>a</em></td>
<td>5. Osteochondrosarcoma</td>
<td>A tumor composed of both osteogenic and chondrogenic elements</td>
</tr>
<tr>
<td><em>g</em></td>
<td>6. Multiple myeloma</td>
<td>A systemic disease originating in the reticular stem cell in the marrow spaces of the bone</td>
</tr>
<tr>
<td><em>f</em></td>
<td>7. Ewing's sarcoma</td>
<td>A highly malignant, multicentric sarcoma originating from the reticulum cell</td>
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<th>Answer: Q22</th>
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<tbody>
<tr>
<td><em>m</em></td>
<td>1. Outer membrane covering bone tissue</td>
<td>Periosteum</td>
</tr>
<tr>
<td><em>d</em></td>
<td>2. Flexible, connective tissue found in the ribs, nasal septum, external ear, joints, and respiratory tubes of an adult</td>
<td>Cartilage</td>
</tr>
<tr>
<td><em>i</em></td>
<td>3. Skull bones: parietal, occipital, frontal, ethmoid, sphenoid, and temporal bones</td>
<td>Cranial bones</td>
</tr>
<tr>
<td><em>e</em></td>
<td>4. Shaft of the long bone</td>
<td>Diaphysis</td>
</tr>
<tr>
<td><em>k</em></td>
<td>5. Bones found in sternum, pelvis, and ribs; protect soft parts</td>
<td>Flat bones</td>
</tr>
<tr>
<td><em>f</em></td>
<td>6. Bone cell</td>
<td>Osteocyte</td>
</tr>
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SECTION L

THE MUSCULAR SYSTEM
Figure 68. MUSCLE TYPES
 SECTION L

THE MUSCULAR SYSTEM

The muscular system is composed of specialized cells called muscle fibers. Their predominant function is contractibility. Muscles, where attached to bones or internal organs and blood vessels, are responsible for movement. Internal movement involves the contraction and relaxation of muscles which are a part of the viscera; external movement is accomplished by the contraction and relaxation of muscles which are attached to bones.

Muscle Types

In the body are found three types of muscle: skeletal, smooth, and cardiac.

- **Skeletal muscle**, attached to bones, is responsible for skeletal movements. The peripheral portion of the central nervous system (CNS) controls the skeletal muscles. Thus, these muscles are under conscious, or voluntary, control. The basic unit is the muscle fiber with many nuclei. These muscle fibers are striated (having transverse streaks) and each acts independently of neighboring muscle fibers.

- **Smooth muscle**, found in the walls of the hollow internal organs such as blood vessels, the gastrointestinal tract, bladder, and uterus, is under control of the autonomic nervous system. Smooth muscle cannot be controlled consciously and thus acts involuntarily. The nonstriated (smooth) muscle cell is spindle-shaped and has one central nucleus. Smooth muscle contracts slowly and rhythmically.

- **Cardiac muscle**, found in the walls of the heart, is also under control of the autonomic nervous system. The cardiac muscle cell has one central nucleus, like smooth muscle, but it also is striated, like skeletal muscle. The cardiac muscle cell is rectangular in shape. The contraction of cardiac muscle is involuntary, strong, and rhythmical.

Muscle tissue receives a rich supply of blood which is carried by the arteries into the very substance of the muscle. Most of the arterioles run parallel with muscle fibers and branch off into capillaries at right angles into the fibers.

Muscle tumors tend to spread by way of the blood stream rather than to the lymphatics. Lymph node metastasis does not often occur.

Smooth and cardiac muscle are discussed in more detail with respect to their appropriate systems. This section explains mainly the skeletal muscular system.
Figure 69. HISTOLOGICAL COMPARISONS OF MUSCLE TYPES

SKELETAL MUSCLE

Voluntary muscles of the mouth attach to maxilla and mandible

50 μ

CARDIAC MUSCLE

Myocardium of the heart

Endocardium

10 μ

SMOOTH MUSCLE

Muscularis propria

Circular layer

Longitudinal layer

Lumen of the small intestine

10 μ
Q1

Name the three types of muscle found in the body:

1. 
2. 
3. 

Q2

The two types of muscle that act without voluntary control are ________ and ______ muscle.

Q3

________ muscle is under voluntary control.

Q4

Which muscle types are described as striated and which is described as nonstriated muscle?

________________________

________________________

Q5

The ________ and ________ muscle cells have one nucleus, while the ________ muscle cell has many nuclei.
Answer: Q1

The three types of muscle found in the body are:

1. Skeletal muscle
2. Smooth muscle
3. Cardiac muscle

Answer: Q2

The two types of muscle that act without voluntary control are smooth and cardiac muscle.

Answer: Q3

Skeletal muscle is under voluntary control.

Answer: Q4

Skeletal and cardiac muscle are described as striated while smooth muscle is described as nonstriated muscle.

Answer: Q5

The smooth and cardiac muscle cells have one nucleus, while the skeletal muscle cell has many nuclei.
Tendons, Fascia, and Ligaments

Each muscle merges into a tendon, a tough nonelastic fibrous band of connective tissue which attaches to the fibrous covering of bone (the periosteum), so that the action of the muscle will be transferred to the bone, causing movement of the joint. Perhaps the most well-known is the Achilles tendon, where the posterior muscles of the calf of the leg merge and attach to the calcaneus (heel) bone of the foot.

Fascia is a fibrous sheet of connective tissue which covers and separates muscles. It also encloses the viscera, glands, blood vessels, and nerves. Some fasciae are located superficially under the skin while other fasciae associated with muscles lie deeper within the body.

Ligaments are fibrous bands of connective tissue which anchor bones together thereby strengthening and supporting the joints. Ligaments also serve to hold organs in place.
Q6

☐ True  ☐ False  1. Muscles have a rich blood supply, therefore, malignant tumors of muscle often invade blood vessels by virtue of their proximity.

☐ True  ☐ False  2. The periosteum is the outer covering of the bone.

☐ True  ☐ False  3. The fascia is a tough fibrous band of connective tissue which attaches to the fibrous covering of the bone.

☐ True  ☐ False  4. The force of a muscle contraction is transferred to the bone by way of the tendon.

☐ True  ☐ False  5. Fasciae are associated only with skeletal muscles.

Q7

Match the descriptions on the left with one of the terms on the right.

___ 1. A fibrous cord of connective tissue binding muscle to bone  a. Epiphysis

___ 2. A fibrous sheet of connective tissue covering and separating muscle  b. Diarthrosis

___ 3. Connective tissue binding bones to bones  c. Fascia
d. Cartilage
e. Ligament
f. Osteocyte
g. Tendon
1. True  Malignant tumors of muscles often invade blood vessels.
2. True  The periosteum is the outer covering of the bone.
3. False  Tendons, not fasciae, attach to the fibrous covering of bones.
4. True  The force of a muscle contraction is transferred to the bone by way of the tendon.
5. False  Fasciae are associated with all muscles as well as the viscera, glands, blood vessels, and nerves.

Answer: Q7

**g**  1. A fibrous cord of connective tissue binding muscle to bone  Tendon
**c**  2. A fibrous sheet of connective tissue covering and separating muscle  Fascia
**e**  3. Connective tissue binding bones to bones  Ligament
Skeletal Muscles

Some of the skeletal muscles are shown in Figure 68. An extensive list of skeletal muscles is found in your medical dictionary under "muscle." Dorland's dictionary also contains five plates which show most of the more than 600 muscles of the body. Two prominent groups of muscles which have been given characteristic names are the hamstrings (lower extremity) and the biceps (upper extremity).

The five functional characteristics of muscle tissue are:

- **Irritability**: ability to respond to a stimulus
- **Conductivity**: ability to transmit impulses
- **Extensibility**: ability to stretch
- **Elasticity**: ability to resume former length when the stretching force is removed
- **Contractibility**: ability to shorten

The three general functions of skeletal muscle are:

- **Movement**: sometimes locomotion and sometimes movement within a given area
- **Heat production**: developed by muscle contraction
- **Posture**: alignment of body parts.

Posture is maintained by a continual pull of muscles on bones in a direction opposite to the pull of gravity, i.e., by the continual partial contraction of muscles, known as muscle tone. Therefore, posture is indirectly dependent on many other factors, such as a normal nervous system and health in general.

The names given to muscles describe one or more of the following features of muscle: action, direction of fibers, location, number of divisions, shape, and points of attachment to bone. Muscles may be classified into groups according to the action or movement performed.

- **Flexors** decrease the angle in a joint.
- **Extensors** increase the angle in a joint and also return a body part to neutral position after flexion.
- **Abductors** move a body part away from the midline.
- **Adductors** move a body part towards the midline.
- **Rotators** cause a body part to pivot on its axis.
- **Levators/elevators** raise a body part.

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• **Supinators** turn the palm upward or forward.
• **Pronators** turn the palm downward or backward.
• **Sphincters** reduce the size of an opening.
• **Tensors** make a body part more rigid.

**Malignant Tumors**

Malignant tumors of muscle tissue are known as sarcomas. Refer to *The International Classification of Diseases for Oncology, Second Edition*, (8890-8920), p. 37, for a list of myomatous (muscle) tumors.

All sarcomas usually present as firm masses in the subcutaneous tissue or deep within or between muscles. However, there are many different varieties of malignant soft tissue tumors:

• **Leiomyosarcoma** is a tumor of smooth muscle.
• **Rhabdomyosarcoma** is a tumor of striated muscle.
• **Angiomyosarcoma** is a tumor composed of blood vessels and muscular tissue.

Malignant tumors closely associated with muscle tissue:

• **Synovial sarcoma** is a tumor arising in the tendon sheaths, bursa, and joints.
• **Fibrosarcoma** is a tumor of fibrous tissue which may arise in association with striated muscle or fascia.

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Q8

What are the three general functions of the skeletal muscle?

1. ______________________
2. ______________________
3. ______________________

Q9

How is the posture of the body maintained?

________________________________________________________________________

Q10

What are the functional characteristics of muscle tissue?

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________
The three general functions of skeletal muscle are:

1. Movement
2. Heat production
3. Posture

Posture is maintained by continual partial contraction of the muscles.

1. Irritability
2. Conductivity
3. Extensibility
4. Elasticity
5. Contractibility
Q11

Match the muscle groups on the left with the descriptions on the right.

___ 1. Supinators a. Decrease the angle in a joint
___ 2. Sphincters b. Move a body part away from the midline
___ 3. Abductors c. Lower a body part
___ 4. Flexors d. Turn the palm upward or forward
___ 5. Depressors e. Reduce the size of an opening

Q12

Match each description on the left with one of the terms on the right.

___ 1. Heart muscle, involuntary and striated a. Fasciae
___ 2. Fibrous sheets of connective tissue which cover the muscles b. Visceral muscle
g. Cardiac muscle
___ 3. The hamstring muscles and the biceps muscles c. Leiomyosarcoma
___ 4. A malignant tumor of smooth muscle d. Striation
___ 5. A characteristic of skeletal muscle e. Tendons
___ 6. Connective tissue binding muscle to bone f. Rhabdomyosarcoma
___ 7. Involuntary, visceral muscle g. Cardiac muscle h. Ligaments
   i. Skeletal muscle
   j. Angiomyosarcoma
   k. Smooth muscle
Answer: Q11

Match the muscle groups on the left with the descriptions on the right.

_d_ 1. Supinators turn the palm upward or forward
_e_ 2. Sphincters reduce the size of an opening
_b_ 3. Abductors move a body part away from the midline
_a_ 4. Flexors decrease the angle in a joint
_c_ 5. Depressors lower a body part

Answer: Q12

Match each description on the left with one of the terms on the right.

_g_ 1. Heart muscle, involuntary and striated  Cardiac muscle
_a_ 2. Fibrous sheets of connective tissue which cover the muscles  Fasciae
_i_ 3. The hamstring muscles and the biceps muscles  Skeletal muscle
_c_ 4. A malignant tumor of smooth muscle  Leiomyosarcoma
_d_ 5. A characteristic of skeletal muscle  Striation
_e_ 6. Connective tissue binding muscle to bone  Tendons
SECTION M

THE NERVOUS SYSTEM
The nervous system provides the integration and control of body processes. It is customarily divided into: 1) the central nervous system which consists of the brain and spinal cord and their coverings which are called meninges and 2) the peripheral nervous system which consists of the nerves that connect the brain and spinal cord to the tissues and organs of the body.

Nervous Tissue

Nervous tissue is composed of three types of cells:

- **Neuron**

  The nerve cell (neuron) is the basic structural and functional unit of the nervous system. Each neuron consists of a cell body which contains a large nucleus surrounded by cytoplasm and processes called dendrites and axons. These processes are peculiar to neurons and are responsible for the conduction and transmission of neural information. Dendrites carry impulses toward the cell body; a single axon conducts impulses away from the cell body. Axons (nerve fibers) in the peripheral nervous system may be covered by a myelin sheath and by neurilemma, which is a membranous sheath that covers the axon directly or covers the myelin sheath when it is present. Not only does the myelin sheath increase the speed of nerve impulse conduction, but it insulates and maintains the axon; the neurilemma assists in the regeneration of injured axons. Nerve tissue of the brain and spinal cord has no neurilemma, and, thus, it does not regenerate. Instead, the central nervous system contains neuroglial cells, called oligodendrocytes, which form a myelin covering for the brain and spinal cord.

- **Neuroglia (glial cells)**

  The neuroglial cells of the nervous system provide the connective tissue which binds together the neurons in the central nervous system giving support and protection. They consist of astrocytes, oligodendrites, ependymal cells, and microglial cells. Most central nervous system (CNS) tumors arise in the neuroglial cells.

- **Schwann cells**

  The Schwann cells form a sheath (neurilemma) covering the axons of peripheral nerve fibers.

The processes of the neurons (nerve fibers) may serve sensory or motor functions. *Sensory nerve fibers* carry messages of sensation and feeling from the tissues and organs to the brain and spinal cord. *Motor nerve fibers* carry messages pertaining to movement from the brain and spinal cord to tissues and organs.
Figure 70. NERVE CELL (neuron)

- **Dendrite** - conducts impulses to cell body
- **Cell Body**
- **Axon** - conducts impulses away from cell body
- **Myelin sheath**
- **Neurilemma** (outer covering)
- **Terminal Axon** (terminal end fibers)
Q1

The central nervous system is made up of the ________ and the ________________ ________.

Q2

The nerves outside the central nervous system comprise the ________________ nervous system.

Q3

Match each nerve on the left with its function on the right.

___  1. Motor nerves   a. Carry messages to the brain from the tissues and organs

___  2. Sensory nerves b. Carry messages from the brain to the tissues and organs

Q4

A neurilemma is found only on nerves of the ______________________________ nervous system.

What is the significance of the neurilemma? ____________________________________________________________

Q5

Name the parts of the nerve cell:

1. ______________________

2. ______________________

3. ______________________

4. ______________________

5. ______________________
The central nervous system is made up of the brain and the spinal cord.

The nerves outside the central nervous system comprise the peripheral nervous system.

Motor nerves Carry messages from the brain to the tissues and organs
Sensory nerves Carry messages from the tissues and organs to the brain

A neurilemma is found only on nerves of the peripheral nervous system. The neurilemma promotes peripheral nerve fiber regeneration.

The names of the parts of the nerve cell are as follows:
1. Dendrites
2. Cell body
3. Axons
4. Myelin sheath
5. Neurilemma
CENTRAL NERVOUS SYSTEM

The central nervous system (CNS) consists of the brain (encephalon), spinal cord, and meninges.

Brain

The brain lies within the cranial cavity of the skull. It may be described in terms of three main subdivisions: forebrain, midbrain, and hindbrain.

Forebrain

The forebrain consists of the cerebrum (telencephalon) and the diencephalon.

- The cerebrum is the largest part of the human brain, and controls, for example, voluntary muscular activity, speech, thought, memory, vision, taste, and hearing. It is made up of two cerebral hemispheres. The folds on the surface of the brain are known as convolutions. The cerebral hemispheres enclose the lateral ventricles (canals in the interior of the brain filled with cerebrospinal fluid). The two hemispheres are connected by the corpus callosum. Each hemisphere consists of:

1. The cerebral cortex forms the outer layer. It contains the cell bodies of neurons often called the "gray matter" of the brain. (The inner "white matter" is made up of myelinated nerve fibers.)

2. The basal ganglia lie deep within the hemispheres and are responsible for voluntary muscle movement. Basal ganglia are masses of gray matter.

3. Olfactory bulbs (rhinocephalon) lie on the ventral surface of each cerebral hemisphere and are associated with the sense of smell (cranial nerve I). The cerebrum is divided into lobes designated as frontal, temporal, parietal and occipital (see Figure 71).

- The diencephalon or thalamencephalon connects the cerebral hemispheres with the midbrain and forms the walls of the third ventricle.

1. The thalamus is an important relay center for sensory fibers on their way to the cerebral cortex; crude sensation and pain may be registered here.

2. The hypothalamus contains the centers for the autonomic nervous system controlling sleep, water balance, temperature regulation, and secretions from the pituitary gland.

3. The epithalamus contains the pineal body (gland).
Figure 71. CEREBRUM

Figure 72. SPINAL CORD
Midbrain (mesencephalon)

The midbrain receives impulses from the eye and ear. It serves as a center for visual and auditory reflexes. It also connects the forebrain to the hindbrain. Cranial nerves III and IV stem from the midbrain.

Hindbrain (rhombencephalon)

The hindbrain consists of the pons, the cerebellum, and the medulla oblongata. It surrounds the fourth ventricle.

- The pons (pons - bridge) bridges the cerebrum and cerebellum. It contains nerve fibers which link the cerebral cortex with the medulla oblongata and the spinal cord.

  The nuclei of the cranial nerves V, VI, VII, and VIII are situated in the pons.

- The medulla oblongata controls breathing and heartbeat. It consists of neurons which form the nuclei of the cranial nerves IX, X, XI, and XII.

- The cerebellum has centers which are concerned with balance and equilibrium. The function of the cerebellum is coordinating groups of muscles to work together smoothly.

Spinal Cord

The spinal cord lies in the vertebral canal of the spinal column and extends from the medulla oblongata to the lumbar vertebrae. There are 31 pairs of spinal nerves, both motor and sensory. The spinal cord also serves as a reflex center.

In certain areas of the spinal cord the anterior rami (branches) of the spinal nerves combine to form networks of nerve fibers called plexuses. These are the cervical (first 4 cervical spinal nerves) branchial (last 4 cervical and first thoracic spinal nerve), lumbar (first 4 lumbar nerves), sacral (fourth and fifth lumbar and first sacral nerve), pudendal (third and fourth sacral nerves), and coccygeal (fifth sacral and coccygeal nerve) plexuses.

Meninges

The meninges are comprised of three membranes which surround the brain and spinal cord. The dura mater is a thick, tough membrane lining the skull. The pia mater is the thin innermost layer which is in contact with the brain. The arachnoid mater lies between the two; it is a thin covering and contains the blood vessels.

Cerebrospinal Fluid (CSF)

Cerebrospinal fluid is found in each ventricle and is formed by filtration out of the blood in networks of capillaries known as choroid plexuses.¹

¹choroid plexus--vascular fringelike folds in the pia mater of the cerebral ventricles.
Figure 73. DIAGRAM SHOWING BRAIN, VENTRICLES, MENINGES AND INTERMENINGEAL SPACES

Meninges:
- Pia mater
- Subarachnoid space
- Arachnoid membrane
- Subdural space
- Dura mater
PERIPHERAL NERVOUS SYSTEM

The peripheral nervous system (PNS) consists of nerves and ganglia outside the brain and spinal cord. It (PNS) serves to interconnect all other tissues with the central nervous system.

Peripheral nerves are connected to the spinal cord by two roots: the anterior, ventral, or motor root and the posterior, dorsal, or sensory root.

Peripheral nervous system innervates all voluntary muscles and transmits the sensory impulses from the whole body. It is largely under conscious (cerebral) control.

Thus, injury or disease of peripheral nerves usually results in both sensory and motor loss. Because of the regenerative ability of the neurilemma, however, eventual recovery is possible if the nerve is largely intact or the ends of the divided nerve are placed close together.

Autonomic Nervous System

The autonomic nervous system is a subdivision of the peripheral nervous system and carries impulses from the brain and spinal cord to body organs. It controls and regulates largely by involuntary action of the glands, heart, and smooth muscle tissues (e.g., smooth muscle in the intestines and blood vessel walls).

Autonomic nerves arise at different levels of the central nervous system. The autonomic nerves arising from the spinal cord comprise the sympathetic (thoracolumbar) and parasympathetic (craniosacral) nervous system.

Spinal Nerves

There are 31 pairs of spinal nerves: 9 pairs of cervical nerves, 12 pairs of thoracic nerves, 5 pairs of lumbar nerves, 5 pairs of sacral nerves, and 1 pair of coccygeal nerves. All spinal nerves carry impulses between the spinal cord and the abdomen, chest, and extremities.
Figure 74 CRANIAL NERVES

I Olfactory nerve
II Optic nerve
III Oculomotor nerve
IV Trochlear nerve
V Trigeminal nerve
VI Abducens nerve
VII Facial nerve
VIII Acoustic nerves (2 branches)
   Cochlear
   Vestibular
IX Glossopharyngeal nerve
X Vagus nerve
XI Spinal accessory nerve
XII Hypoglossal nerve
Cranial Nerves

The cranial nerves carry impulses to or from the brain.

<table>
<thead>
<tr>
<th>Cranial Nerves</th>
<th>Motor Function</th>
<th>Sensory Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>I  Olfactory</td>
<td>None</td>
<td>Smell</td>
</tr>
<tr>
<td>II Optic</td>
<td>None</td>
<td>Sight</td>
</tr>
<tr>
<td>III Oculomotor</td>
<td>All eye muscles except the superior oblique and the external rectus; also innervates the iris and ciliary body</td>
<td></td>
</tr>
<tr>
<td>IV Trochlear</td>
<td>Superior oblique muscle Eye movement</td>
<td></td>
</tr>
<tr>
<td>V  Trigeminal</td>
<td>Muscles of mastication</td>
<td>Sensations from eye, face, sinuses, and teeth</td>
</tr>
<tr>
<td>VI Abducens</td>
<td>External rectus muscle Eye movement</td>
<td></td>
</tr>
<tr>
<td>VII Facial</td>
<td>Facial muscles, submaxillary and sublingual salivary glands</td>
<td>Tactile and taste sensations from the anterior 2/3's of tongue and soft palate</td>
</tr>
<tr>
<td>VIII Acoustic: (2 branches) Cochlear Vestibular</td>
<td>None</td>
<td>Hearing Equilibrium/balance</td>
</tr>
<tr>
<td>IX Glossopharyngeal</td>
<td>Pharyngeal muscles and parotid gland</td>
<td>Tactile and taste sensations from the posterior 1/3 of tongue, tonsils, pharynx, and carotid sinuses</td>
</tr>
<tr>
<td>X Vagus</td>
<td>Pharynx, larynx, heart, lungs, bronchi, and digestive tract</td>
<td>Sensations to the heart, lungs, bronchi, trachea, pharynx, digestive system, and external ear</td>
</tr>
<tr>
<td>XI Spinal Accessory</td>
<td>Sternomastoid, trapezius, and constrictor muscles of pharynx, larynx, and soft palate</td>
<td></td>
</tr>
<tr>
<td>XII Hypoglossal</td>
<td>Strap muscles of neck and tongue muscles</td>
<td></td>
</tr>
</tbody>
</table>
Malignant Tumors

Gliomas are tumors of the neuroglia which comprise the non-nervous, supporting tissue of the brain derived chiefly from ectoderm. The most frequently occurring types are:

- **Astrocytoma** arises from glial cells known as astro- (star-shaped) cytes (cells). Glial cells (neuroglia), which may be either protoplasmic or fibrous, provide the connective tissue which binds together the neurons of the central nervous system. This tumor generally occurs in the cerebrum of adults and the cerebellum of children and is the most common type of glioma.

- **Glioblastoma** (multiforme) is derived from embryonal astrocytes and is sometimes called Grade IV astrocytoma. It is the most malignant of all brain tumors and occurs most frequently in adults arising in the cerebral hemispheres.

- **Oligodendroglioma** arises from glial cells known as oligo- (small, few) dendro- (branching) glia. These supporting cells are located as satellites about the nerve cells, between nerve fibers, and along blood vessels. These tumors occur more commonly in the cerebral hemispheres of adults.

- **Medulloblastoma** is composed of undifferentiated neuroepithelial cells. It is one of the most frequent gliomas of childhood and tends to occur at the midline of the cerebellum; in young adults it is found more often in the lateral lobes of the cerebellum. These tumors have a proclivity for intercranial or intraspinal metastases.

- **Ependymoma** arises from the ependymal cells which line the ventricles of the brain and the central canal of the spinal cord. It is found most often in the fourth ventricle occurring in children and young adults.

Nerve Sheath Tumors

- **Neurilemmoma** (neurinoma, schwannoma) arises from the neur- (nerve) (e)ilemma (covering) which is the thin membrane covering the peripheral nerves, also called the sheath of Schwann. These tumors are usually benign, but may occasionally occur in a malignant form. In the cranial cavity, they frequently arise at the root of the VIIIth nerve (cerebellopontine angle) and are called acoustic neuromas.

- **Neurofibrosarcoma** is composed of interlacing bundles of anaplastic spindle-shaped cells which resemble those of nerve sheaths.

Neuroepitheliomatous Neoplasms

- **Neuroblastoma** is derived from embryonic nerve tissue (neuroblasts) arising primarily in the autonomic nervous system and adrenal medulla, but not in the brain or spinal cord.

- **Meningiomas** arise in the meninges, the membranes that envelop the brain and spinal cord: the dura mater, pia mater, and arachnoid. These are slow growing tumors and are most always benign. They are rare in children.
Benign Tumors

Benign tumors of the brain, while not invasive, do consume space and press upon vital tissues. These tumors are, thereby, potentially lethal, although they do allow for more prolonged survival than do malignant brain tumors. Consequently, cancer registries generally collect information on benign brain tumors as well as malignant brain tumors.

Some benign tumors are collected because they arise in the cranial vault, although they are not central nervous system (CNS) tumors.

- **Hemangioblastoma** is a hemangioma of the brain derived from blood vessel-forming cells (angioblasts).

- **Craniopharyngioma** is a tumor arising from embryonic cells of the craniopharyngeal canal (Rathke's pouch) and involving the pituitary gland. The tumor usually occurs in children.

- **Chromophobe Adenoma** is a benign tumor of the anterior pituitary gland. It is associated with hypopituitarism and occurs mainly in adults.
Q6

Match each term on the left with one of the descriptions on the right.

1. Astrocytoma  a. Tumor of the membranes surrounding the brain and spinal cord
2. Neuroglia  b. The most common malignant brain tumor
3. Medulloblastoma  c. The most malignant of all brain tumors
4. Meningioma  d. Non-nervous tissue which supports the nerve cells
5. Glioblastoma  e. Tumor of the brain which is most common in the cerebellum of children.

Q7

Which of the following are nerves of the autonomic nervous system?

☐ a. Sympathetic nerves

☐ b. Spinal nerves

☐ c. Cranial nerves
Match each term on the left with one of the descriptions on the right.

b 1. Astrocytoma The most common malignant brain tumor
d 2. Neuroglia Non-nervous tissue which supports the nerve cells
e 3. Medulloblastoma Tumor of the brain which is most common in the cerebellum of children.
a 4. Meningioma Tumor of the membranes surrounding the brain and spinal cord
c 5. Glioblastoma The most malignant of all brain tumors

The sympathetic nerves are nerves of the autonomic nervous system.
SECTION N

SENSORY ORGANS
SECTION N

SENSORY ORGANS

There are five major senses of the body: vision, taste, smell, hearing, and touch. The body, however, has literally millions of sensory organs (or receptors), each associated with one or more nerves whose function is to convert the energy of a stimulus into a sensation or reflex. Receptors detect changes in our external and internal environment and initiate the responses necessary for adjusting the body to these changes. It is the dendrite portion of the sensory neuron which serves as the receptor of a sense organ.

Receptors may be classified according to their locations as follows:

*Exteroceptors* are surface receptors. They are located in the skin, mucosa, eye, and ear.

*Visceroceptors* (interoceptors) are located in the walls of the blood vessels in the stomach, intestines, and various other organs.

*Proprioceptors* are located in muscles, tendons, joints, and the internal ear.

In this section, we will not cover all the body senses. Rather, the discussion will be restricted to four of the major senses: vision, taste, smell, and hearing.
Q1

What are the five major senses of the body?

1. ________
2. ________
3. ________
4. ________
5. ________

Q2

Match the receptors on the left with a location on the right.

<table>
<thead>
<tr>
<th>Receptors</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>__ 1. Exteroceptors</td>
<td>a. Located in the walls of blood vessels in the stomach, intestines, and other organs</td>
</tr>
<tr>
<td>__ 2. Proprioceptors</td>
<td>b. Located in the skin, mucosa, eye, and ear</td>
</tr>
<tr>
<td>__ 3. Visceroceptors</td>
<td>c. Located in the muscles, tendons, joints, and the internal ear</td>
</tr>
</tbody>
</table>
Answer: Q1

The five major senses of the body are:

1. Vision
2. Hearing
3. Taste
4. Smell
5. Touch

Answer: Q2

b 1. Exteroceptors  Located in the skin, mucosa, eye, and ear

c 2. Proprioceptors  Located in the muscles, tendons, joints, and the internal ear

a 3. Visceroceptors  Located in the walls of blood vessels in the stomach, intestines, and other organs
The Sense of Vision (Eye)

The eye is set in a bony socket, the orbit. The visible portion of the eye is covered by a thin transparent membrane called the conjunctiva\textsuperscript{1}.

The eyeball is not a solid sphere. It contains a large interior cavity that is divided into two parts, the anterior and posterior cavities. The anterior cavity, in turn, has two subdivisions known as the anterior chamber and the posterior chamber. Most of the eyeball (Figure 76) is recessed in the orbit, protected by the walls of this bony cavity. The wall of the eyeball is composed of three layers; from the outside to the inside, they are the sclera, the choroid, and the retina.

- The sclera, composed of tough fibrous tissue, is the protective and supportive layer of the eye. The anterior portion of the sclera, called the cornea, lies over the colored part of the eye (iris) and the pupil. The cornea is transparent and allows passage of light.

- The middle or choroid layer (the pigmented vascular coat) of the eye contains a great many blood vessels. The iris, the colored muscular ring, controls the size of the pupil and the amount of light entering the eye. The anterior portion is modified to form the ciliary body, the main part of which is ciliary muscle. Its function is the adjustment of the lens of the eye for vision at different distances. The crystalline lens is suspended from the inner surface of the ciliary body by circular ligaments called the suspensory ligaments. The function of the lens is to bend light rays in order to focus an image on the retina.

- The retina is the innermost layer of the eye. It is composed of two sections: the outer is pigmented and attached to the choroid layer, and the inner is composed of nervous tissue. The retina is the light sensitive layer.

Figure 75. EYE

\textsuperscript{1}conjunctiva—mucous membrane covering the anterior portion of the eyeball, and lining the eyelids.
Q3

What are the three layers which compose the wall of the eyeball?

1. __________
2. __________
3. __________

Q4

The retina is composed of _________________ tissue.
Answer: Q3

The three layers which compose the wall of the eyeball are:

1. Sclera
2. Choroid
3. Retina

Answer: Q4

The retina is composed mainly of nervous tissue.
The *accessory structures* of the eye include the eyebrow, eyelashes, and eyelid. The eyebrow and eyelashes serve a protective function. The eyelid is lined with mucous membrane (called conjunctiva) which continues over the surface of the eyeball. The corner where the upper and lower eyelids join is called the *canthus*, the medial canthus being on the inserside, the internal (temporal) canthus being on the outer side. The *lacrimal apparatus* consists of four structures: the lacrimal glands, lacrimal ducts, lacrimal sac, and nasolacrimal duct. These structures perform the functions of secreting and draining tears on the surface of the eyeball (Figures 76 and 77).

**Figure 76. EYEBALL (sagittal view)**  
**Figure 77. EYEBALL (frontal view)**

**Figure 78. LACRIMAL APPARATUS**
Q5

The eyeball is/is not a solid sphere. It is divided into two large _____________.

Q6

The corner where the upper and lower eyelids meet is called the _____________.

Q7

The __________ apparatus performs the function of secreting tears.
Answer: Q5

The eyeball is not a solid sphere. It is divided into two large cavities.

Answer: Q6

The corner where the upper and lower eyelids meet is called the canthus.

Answer: Q7

The lacrimal apparatus performs the function of secreting tears.
Regional Lymph Nodes

Much of the eye does not have true lymphatics, i.e., cornea, sclera, uveal tract, lens, retina, and orbit. The conjunctiva and the eyelid are drained by the submandibular, preauricular and infra-auricular (parotid) and cervical lymph nodes.

Malignant Tumors

- Malignant melanoma is the most common intraocular tumor.
- Retinoblastoma, a tumor arising from the retinal germ cells, is the most common intraocular neoplasm in children.
- Epidermoid carcinoma may arise from conjunctiva.

Figure 79. LYMPHATIC DRAINAGE OF THE HEAD (sensory organs)
Q8

Name the lymph nodes which drain each of the following areas of the eye:

1. Cornea, sclera, and lens: ________________________________.

2. Eyelid: ________________, ________________, and ________________.

Q9

The most common malignancy of the eye is ____________ ____________.

Q10

The most common eye malignancy in children is ________________.
Answer: Q8

Name the lymph nodes which drain each of the following areas of the eye:

1. Cornea, sclera, and lens: no true lymphatics
2. Eyelid: submandibular, preauricular (parotid), and cervical.

Answer: Q9

The most common malignancy of the eye is malignant melanoma.

Answer: Q10

The most common eye malignancy in children is retinoblastoma.
The Sense of Taste (Gustatory Sense Organ)

Receptors for the sense of taste are known as taste buds. These are located on the tongue, palate, pharynx, and epiglottis. They are most numerous on the tongue. Different taste receptors are stimulated by different kinds of substances. There are separate taste buds for sweet, sour, bitter, and salt substances (see Figure 80). All other qualities of experienced taste are a result of the fusion of two or more of the four primary tastes and as a result of the stimulation of the olfactory receptors. Therefore, the numerous tastes recognized are not taste alone but taste plus odors.

The four kinds of taste buds or corpuscles are not evenly distributed over the tongue. Most of those sensitive to bitter are located at the back of the tongue, those sensitive to sweet at the tip, and those sensitive to salt and sour along the sides and tip. (Refer to the Digestive System for the anatomy of the tongue.)

Regional Lymph Nodes

The regional lymph nodes are submandibular (submaxillary), submental and internal jugular (upper and lower deep cervical): jugulodigastric and jugulo-omohyoid.

Malignant Tumors

Malignant lesions are more common on the anterior two-thirds than on the posterior one-third of the tongue. Squamous cell carcinomas constitute 90 percent of all malignant tumors of the tongue. The other 10 percent are made up primarily of lymphoepitheliomas and lymphosarcomas.

Lymphosarcomas will arise in the lymphoid tissue (lingual tonsil) found at the base of the tongue.
Figure 80. TONGUE: Areas of taste

![Diagram of the tongue showing areas of taste](image)

- Palate
- Uvula
- Anterior faucial pillars
- Taste buds

Areas of taste:
- Sweet
- Salt
- Sour
- Bitter
Q11

Receptors for the sense of taste called ________________ ________________ are most numerous in the ________________.

Q12

Separate receptors sense the tastes of ____________, ____________, ____________, and ____________; but all other qualities of taste are a result of a fusion of two or more primary tastes and the stimulation of the ________________ ________________.
Receptors for the sense of taste called taste buds are most numerous in the tongue.

Separate receptors sense the taste of sweet, sour, bitter, and salt, but all other qualities of taste are a result of a fusion of two or more primary tastes and the stimulation of the olfactory receptors.
The Sense of Smell (Olfactory Sensory Organs)

The receptors for the sense of smell lie in the mucosa of the upper part of the nasal cavity. These receptors respond to chemical stimuli. Their location explains the necessity for sniffing or draining air forcibly into the nose in order to smell delicate odors. The olfactory sensory organs consist of hair cells which are extremely sensitive to stimulation by even very slight odors. However, they are also easily fatigued. This explains why odors that are at first very noticeable are not sensed at all after a short time.

The term "nasal fossa" is the name for the entire nasal chamber. This chamber is divided physiologically into:

- A lower or respiratory portion of the nasal fossa
- An upper or olfactory portion of the nasal fossa. The term "nasal cavity" most properly belongs to this upper portion of the nasal fossa.

Regional Lymph Nodes

The regional lymph nodes are the submental, submandibular (submaxillary), and internal jugular (upper and lower deep cervical) nodes: jugulodigastric and jugulo-omohyoid, and the retropharyngeal.

Figure 81. NOSE: Olfactory receptors
Malignant Tumors

Tumors of the nasal fossa are rare. The most common type is squamous cell (epidermoid) carcinoma. Other types which occur less frequently are:

- Adenocarcinoma
- Adenoid cystic
- Melanoma
- Lymphoma

A malignant tumor known as esthesioneuroblastoma or esthesioneuroepithelioma, which arises in the olfactory nerve, will be found occasionally in the nasal cavities.
Q13

The nasal fossa is divided into a lower or _______________ portion and an upper or _______________ portion.

Q14

The receptors for the sense of smell lie in the mucosa of the _______________ part of the _______________ cavity.

Q15

The most common type of tumor in the nasal cavities is ____________________
____________________.
Answer: Q13

The nasal fossa is divided into a lower or respiratory portion and an upper or olfactory portion.

Answer: Q14

The receptors for the sense of smell lie in the mucosa of the upper part of the nasal cavity.

Answer: Q15

The most common type of tumor in the nasal cavities is squamous cell carcinoma.
The Sense of Hearing (Ear)

The organ for hearing (see Figure 82) consists of three main parts: the external ear, the middle ear, and the inner ear.

- The *external ear* is made up of the pinna (or auricle) and the auditory canal. The pinna (pinna-wing) is made up of cartilage covered by skin. It collects the sound which is transmitted through the external auditory canal, leading to the tympanic membrane (or eardrum).

- The *middle ear* lies in a cavity in the temporal bone and is separated from the external ear by the tympanic membrane which transmits sounds to the internal ear. The middle ear is connected with the nasopharynx by the Eustachian tube. The function of the Eustachian tube is to equalize pressure on the eardrum. It opens when yawning or swallowing takes place.

- The *inner ear* is comprised of membranous tissue contained within a bony structure. The bony labyrinth has three divisions: the vestibule and two extensions of the vestibule called the cochlea and the semicircular canals. The cochlea is a spiral canal containing a receptor for hearing called the Organ of Corti. It has hair cells which pick up impulses transmitted from the inner ear.

The semicircular canals form the organ of balance. The superior, posterior, and lateral semicircular canals each connect by an ampulla (jug) to the utricle (a small sac), from which impulses travel to the brain by the vestibular branch of the VIIIth cranial nerve.

Figure 82. EAR: Coronal section
Regional Lymph Nodes

The lymphatics of the external and middle ear drain to parotid (preauricular) lymph nodes. The middle ear lymphatics, in addition, drain to retropharyngeal nodes. Lymphatics from both parts of the ear go directly or indirectly to the internal jugular (upper and lower deep cervical) nodes. The inner ear has no lymphatics.

Benign Tumors

Acoustic neuroma, a benign tumor of the auditory nerve, is the most common tumor of the ear.
Match the parts of the ear on the left with the descriptions on the right.

1. External ear  
   a. Contains the receptors for hearing
2. Middle ear  
   b. Made up of the auricle and the auditory canal
3. Inner ear  
   c. Contains the opening from the Eustachian tube
Answer: Q16

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>b</td>
<td>1. External ear</td>
<td>Made up of the auricle and the auditory canal</td>
</tr>
<tr>
<td>c</td>
<td>2. Middle ear</td>
<td>Contains the opening from the Eustachian tube</td>
</tr>
<tr>
<td>a</td>
<td>3. Inner ear</td>
<td>Contains the receptors for hearing</td>
</tr>
</tbody>
</table>
APPENDIX A

HISTOLOGIC TYPE/PRIMARY SITE
### APPENDIX A: HISTOLOGIC TYPE/PRIMARY SITE

<table>
<thead>
<tr>
<th>HISTOLOGIC TYPE</th>
<th>PRIMARY SITE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Squamous cell carcinoma</td>
<td>Oral and nasal cavities</td>
</tr>
<tr>
<td></td>
<td>Pharynx and larynx</td>
</tr>
<tr>
<td></td>
<td>Trachea, bronchus, and lung</td>
</tr>
<tr>
<td></td>
<td>Esophagus</td>
</tr>
<tr>
<td></td>
<td>Cervix, vagina, and vulva</td>
</tr>
<tr>
<td></td>
<td>Anus and penis</td>
</tr>
<tr>
<td></td>
<td>Skin</td>
</tr>
<tr>
<td>Adenocarcinoma</td>
<td>Stomach</td>
</tr>
<tr>
<td></td>
<td>Small intestine</td>
</tr>
<tr>
<td></td>
<td>Colon and rectum</td>
</tr>
<tr>
<td></td>
<td>Pancreas and gallbladder</td>
</tr>
<tr>
<td></td>
<td>Endometrium and endocervix</td>
</tr>
<tr>
<td></td>
<td>Breast</td>
</tr>
<tr>
<td></td>
<td>Prostate</td>
</tr>
<tr>
<td>Transitional cell carcinoma</td>
<td>Bladder and urethra</td>
</tr>
<tr>
<td></td>
<td>Renal pelvis and ureters</td>
</tr>
<tr>
<td>Hepatoma</td>
<td>Liver</td>
</tr>
<tr>
<td>Liver cell carcinoma</td>
<td></td>
</tr>
<tr>
<td>Cholangiocarcinoma</td>
<td>Bile ducts (intrahepatic and extrahepatic)</td>
</tr>
<tr>
<td>Hypernephroma</td>
<td>Kidney parenchyma</td>
</tr>
<tr>
<td>Renal cell carcinoma</td>
<td></td>
</tr>
<tr>
<td>Wilms' Tumor</td>
<td></td>
</tr>
<tr>
<td>Seminoma</td>
<td>Testis</td>
</tr>
<tr>
<td>Dysgerminoma</td>
<td>Ovary</td>
</tr>
<tr>
<td>Cystadenocarcinoma</td>
<td></td>
</tr>
<tr>
<td>Granulosa/theca cell carcinoma</td>
<td></td>
</tr>
<tr>
<td>Liposarcoma</td>
<td>Adipose soft tissue</td>
</tr>
<tr>
<td>Fibrosarcoma</td>
<td>Fibrous soft tissue</td>
</tr>
<tr>
<td>Leiomyosarcoma</td>
<td>Smooth muscle, muscularis of organ walls</td>
</tr>
<tr>
<td>Rhabdomyosarcoma</td>
<td>Striated muscle, skeletal muscle</td>
</tr>
<tr>
<td>Mesothelial sarcoma</td>
<td>Pleura and peritoneum</td>
</tr>
<tr>
<td>Osteogenic sarcoma</td>
<td>Bone</td>
</tr>
<tr>
<td>Ewing's sarcoma</td>
<td>Cartilage</td>
</tr>
<tr>
<td>Chondrosarcoma</td>
<td></td>
</tr>
<tr>
<td>Lymphosarcoma</td>
<td>Lymph nodes and other aggregates of lymphoid tissue</td>
</tr>
<tr>
<td>HISTOLOGIC TYPE</td>
<td>PRIMARY SITE</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Leukemias</td>
<td>Bone marrow</td>
</tr>
<tr>
<td>Multiple myeloma</td>
<td>Brain</td>
</tr>
<tr>
<td>Astrocytoma</td>
<td></td>
</tr>
<tr>
<td>Glioblastoma multiforme</td>
<td></td>
</tr>
<tr>
<td>Medulloblastoma</td>
<td></td>
</tr>
<tr>
<td>Melanoma</td>
<td>Skin</td>
</tr>
<tr>
<td></td>
<td>Eye</td>
</tr>
</tbody>
</table>
APPENDIX B

RULES FOR DETERMINING MULTIPLE PRIMARIES FOR LYMPHATIC AND HEMATOPOIETIC DISEASES
APPENDIX B

RULES FOR DETERMINING MULTIPLE PRIMARIES FOR LYMPHATIC AND HEMATOPOIETIC DISEASES

The table on pages 446-468 is to be used to help determine multiple primaries of the lymphatic and hematopoietic diseases. Because of the rarity of subacute leukemias and aleukemias, they have been excluded from this table. Similarly, malignant myeloproliferative and immunoproliferative diseases, except Waldenstrom's macroglobulinemia, are not included.

RULES:

1. No topography (site) is to be considered in determining multiple primaries of lymphatic and hematopoietic diseases.

2. The interval between diagnoses is NOT to enter into the decision.

Example: A lymphocytic lymphoma (M-9670/3) diagnosed in March, 1987 and an unspecified non-Hodgkin's lymphoma (M-9590/3) diagnosed in April, 1988 would be considered one primary, a lymphocytic lymphoma diagnosed in March, 1987 (the earlier diagnosis).

To use this table locate the first diagnosis in the left column of the table, then locate the second diagnosis in the other columns. If the second primary appears in the middle column, the diagnoses are usually considered two separate primaries. If the second diagnosis appears in the right hand column, then the two diagnoses are usually considered one primary. Select the disease mentioned in the first column unless there is an indication in the right hand column to do otherwise. If the pathology report specifically states differently, use the pathology report. Consult your medical advisor or pathologist if questions remain.

For example,

1) a. first diagnosis: small cleaved cell, diffuse lymphoma
   b. second diagnosis: Hodgkin's disease, mixed cellularity

   This case would be considered two primaries.

2) a. first diagnosis: small cleaved cell, diffuse lymphoma
   b. second diagnosis: acute lymphocytic leukemia

   This case would be considered one primary.
### DETERMINATION OF SUBSEQUENT PRIMARIES OF LYMPHATIC (NODAL AND EXTRANODAL) AND HEMATOPOIETIC DISEASES

<table>
<thead>
<tr>
<th>First Primary</th>
<th>Presumably a Second Primary</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Burkitt’s lymphoma (9687)</td>
<td>Malignant lymphoma, NOS (9590)</td>
</tr>
<tr>
<td></td>
<td>Mycosis fungoides or Sézary's disease (9700-9701)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Malignant histiocytosis or Letterer-Siwe's disease (9720, 9722)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>True histiocytic lymphoma (9723)</td>
<td></td>
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<td></td>
<td>Plasmacytoma or multiple myeloma (9731, 9732)</td>
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<td>Mast cell tumor (9740-9741)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Waldenstrom's macroglobulinemia (9761)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Any leukemia (9800-9941)</td>
<td></td>
</tr>
</tbody>
</table>

¹Code to the term with the higher histology code.
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LYMPHATIC (NODAL AND EXTRANODAL) AND HEMATOPOIETIC DISEASES

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<td>Burkitt's lymphoma (9687)</td>
<td>Non-Hodgkin's lymphoma(^2) (9590-9595, 9670-9686, 9690-9698, 9702-9714)</td>
</tr>
<tr>
<td></td>
<td>Mycosis fungoides or Sézary's disease (9700, 9701)</td>
<td>Hodgkin's disease(^2) (9650-9667)</td>
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<td></td>
<td>Acute leukemia, NOS (9801)</td>
<td>Leukemia, NOS (9800)</td>
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<tr>
<td></td>
<td>Non-lymphocytic leukemias (9840-9842, 9860-9910)</td>
<td>Chronic leukemia, NOS (9803)</td>
</tr>
<tr>
<td></td>
<td>Myeloid sarcoma (9930)</td>
<td>Lymphoid or lymphocytic leukemia (9820-9827)</td>
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<td></td>
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<td>Lymphosarcoma cell leukemia (9850)</td>
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\(^1\)If the diagnosis includes "can't rule out leukemia" or "consistent with chronic lymphocytic leukemia," and a bone marrow or peripheral blood study within two months confirms the chronic lymphocytic leukemia diagnosis; then code only to chronic lymphocytic leukemia (9823/3). If not confirmed as chronic lymphocytic leukemia, then code as the lymphoma.

\(^2\)Presumably this is the correct diagnosis. Code the case to this histology.

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<td></td>
<td>Malignant histiocytosis or Letterer-Siwe's disease (9720, 9722)</td>
<td>Leukemia, NOS (9800)</td>
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<td></td>
<td>Mast cell tumor (9740-9741)</td>
<td>Chronic leukemia, NOS (9803)</td>
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<td></td>
<td>Acute leukemia, NOS (9801)</td>
<td>Lymphoid or lymphocytic leukemia (9820-9827)</td>
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\(^2\) Code to the term with the higher histology code.

\(^3\) Presumably this is the correct diagnosis. Code the case to this histology.
### Determination of Subsequent Primaries of Lymphatic (Nodal and Extranodal) and Hematopoietic Diseases

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<td>Burkitt's lymphoma (9687)</td>
<td>Specific non-Hodgkin's lymphoma (9593-9594, 9670-9686, 9690-9698, 9702-9714)</td>
<td>Malignant lymphoma, NOS (9590-9591, 9595)</td>
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<td>Hodgkin's disease (9650-9667)</td>
<td>Lymphosarcoma (9592)</td>
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<td>Mycosis fungoides or Sezary's disease (9700, 9701)</td>
<td>Burkitt's lymphoma (9687)</td>
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<td>Malignant histiocytosis or Letterer-Siwe's disease (9720, 9722)</td>
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<td>Plasmacytoma or multiple myeloma (9731, 9732)</td>
<td>Lymphoid or lymphocytic leukemia (9820-9822, 9824-9825, 9827)</td>
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<td></td>
<td>True histiocytic lymphoma (9723)</td>
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<td>Leukemia, NOS (9800)</td>
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<tr>
<td></td>
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<tr>
<td></td>
<td>Myeloid sarcoma (9930)</td>
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<tr>
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<tr>
<td>Cutaneous and peripheral T-cell lymphomas (9700-9709)</td>
<td>Specific non-Hodgkin's lymphoma (9593-9594, 9670-9687, 9690-9698, 9711-9714)</td>
<td>Malignant lymphoma, NOS (9590-9591, 9595)</td>
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<td>Hodgkin's disease (9650-9667)</td>
<td>Lymphosarcoma (9592)</td>
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<td>Malignant histiocytosis or Letterer-Siwe's disease (9720, 9722)</td>
<td>Cutaneous and peripheral T-cell lymphomas (9700-9709)</td>
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<tr>
<td></td>
<td>True histiocytic lymphoma (9723)</td>
<td>Leukemia, NOS (9800)</td>
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<tr>
<td></td>
<td>Plasmacytoma or multiple myeloma (9731, 9732)</td>
<td>Acute leukemia, NOS (9801)</td>
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<td></td>
<td>Mast cell tumor (9740, 9741)</td>
<td>Chronic leukemia, NOS (9803)</td>
</tr>
<tr>
<td></td>
<td>Waldenstrom's macroglobulinemia (9761)</td>
<td>Lymphoid or lymphocytic leukemia unless specifically identified as B-cell (9820-9827)</td>
</tr>
<tr>
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<td>Lymphoid or lymphocytic leukemia specified as B-cell (9820-9827)</td>
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<td>Plasma cell leukemia (9830)</td>
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<td></td>
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<td>Cutaneous and peripheral T-cell lymphomas (9700-9709) (cont'd)</td>
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<td>Specific non-Hodgkin's lymphoma (9592-9594, 9670-9686, 9690-9698, 9702-9714)</td>
<td>Non-Hodgkin's lymphoma, NOS (9590-9591, 9595)</td>
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<tr>
<td></td>
<td>Hodgkin's disease (9650-9667)</td>
<td>Malignant histiocytosis or Letterer-Siwe's disease (9720, 9722, 9723)</td>
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<td></td>
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<tr>
<td></td>
<td>Leukemia except hairy cell and leukemic reticuloendotheliosis (9800-9932)</td>
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<tr>
<td>------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Plasmacytoma or multiple myeloma (9731, 9732)</td>
<td>Non-Hodgkin's lymphoma except immunoblastic or large-cell lymphoma (9592-9594, 9670, 9672-9677, 9683, 9685-9686, 9690-9697, 9702-9713)</td>
<td>Malignant lymphoma, NOS (9590, 9591, 9595)</td>
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<tr>
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<td>Hodgkin's disease (9650-9667)</td>
<td>Immunoblastic or large cell lymphoma¹ (9671, 9680-9682, 9684, 9698, 9714)</td>
</tr>
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<td>Plasmacytoma or multiple myeloma (9731, 9732)</td>
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<td>Leukemia except plasma cell (9800-9827, 9840-9941)</td>
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Occasionally multiple myeloma develops an immunoblastic or large cell lymphoma phase. This is to be considered one primary, multiple myeloma. Consult your medical advisor or pathologist if questions remain.
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<td>Chronic leukemia, NOS (9803)</td>
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<td>True histiocytic lymphoma (9723)</td>
<td>Monocytic leukemia (9890-9894)</td>
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<td>Hairy cell Leukemia (9940)</td>
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<td>Non-Hodgkin’s lymphoma except immunoblastic or large cell lymphoma (9593-9594, 9673-9677, 9683, 9685-9686, 9690-9697, 9702-9713)</td>
<td>Malignant lymphoma, NOS (9590, 9591, 9595)</td>
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<td>Immunoblastic or large cell lymphoma (9671, 9680-9682, 9684, 9698, 9714)</td>
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<td>Malignant lymphoma, lymphocytic (9670, 9672)</td>
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<td>Plasmacytoma or multiple myeloma (9731, 9732)</td>
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<td>Plasma cell leukemia (9830)</td>
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<td>Leukemia except plasma cell (9800-9827, 9840-9941)</td>
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<td>Any leukemia(^2) (9800-9941)</td>
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<td>Sezary's disease(^3) (9701)</td>
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\(^2\)Note: Leukemia, NOS (9800) should be upgraded to a more specific leukemia diagnosis (higher number) when it is found but not considered a second primary.

\(^3\)Presumably this is the correct diagnosis. Code the case to this histology.
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<tr>
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<td>Malignant histiocytosis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Letterer-Siwe's disease (9720, 9722)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>True histiocytic lymphoma (9723)</td>
<td></td>
</tr>
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<td></td>
<td>Plasmacytoma or multiple myeloma (9731, 9732)</td>
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</tr>
<tr>
<td></td>
<td>Mast cell tumor (9740, 9741)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Waldenstrom's macroglobulinemia (9761)</td>
<td></td>
</tr>
</tbody>
</table>

\(^1\)Note: Acute leukemia, NOS (9801) should be upgraded to a more specific type of acute leukemia (higher number) when it is found, but not considered a second primary.

\(^2\)Presumably this is the correct diagnosis. Code the case to this histology.
**DETERMINATION OF SUBSEQUENT PRIMARIES OF LYMPHATIC (NODAL AND EXTRANODAL) AND HEMATOPOIETIC DISEASES**

<table>
<thead>
<tr>
<th>First Primary</th>
<th>Presumably a Second Subsequent Primary</th>
<th>Presumably NOT a Subsequent Primary (only One Primary)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Malignant histiocytosis or Letterer-Siwe’s disease (9720, 9722)</td>
<td>Burkitt’s lymphoma (9687)</td>
</tr>
<tr>
<td></td>
<td>Mast cell tumor (9740, 9741)</td>
<td>Mycosis fungoides or Sezary’s disease (9700, 9701)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>True histiocytic lymphoma (9723)</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>Waldenstrom’s macroglobulinemia (9761)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Any leukemia[^2] (9800-9941)</td>
</tr>
</tbody>
</table>

[^1]: If the diagnosis includes "can’t rule out leukemia" or "consistent with chronic lymphocytic leukemia," and a bone marrow or peripheral blood study within two months confirms the chronic lymphocytic leukemia diagnosis; then code only to chronic lymphocytic leukemia (9823/3). If not confirmed as chronic lymphocytic leukemia, then code as the lymphoma.

[^2]: Note: Chronic leukemia, NOS (9803) should be upgraded to a more specific type of chronic leukemia (higher number) when it is found, but not considered a second primary.
DETERMINATION OF SUBSEQUENT PRIMARIES OF LYMPHATIC (NODAL AND EXTRANODAL) AND HEMATOPOIETIC DISEASES

<table>
<thead>
<tr>
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<th>Presumably a Second Subsequent Primary</th>
<th>Presumably NOT a Subsequent Primary (only One Primary)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lymphocytic leukemia</td>
<td>Hodgkin's disease (9650-9667)</td>
<td>Non-Hodgkin's lymphoma (9592-9595, 9670-9687, 9690-9698, 9702-9714)</td>
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<tr>
<td>(9820-9827)</td>
<td>Malignant histiocytosis or Letterer-Siwe's disease (9720, 9722)</td>
<td>Malignant lymphoma, NOS (9590-9591)</td>
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<tr>
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<td>Plasmacytoma or multiple myeloma (9731, 9732)</td>
<td>Mycosis fungoides or Sézary's disease (9700, 9701)</td>
</tr>
<tr>
<td></td>
<td>Mast cell tumor (9740, 9741)</td>
<td>True histiocytic lymphoma (9723)</td>
</tr>
<tr>
<td></td>
<td>Waldenstrom's macroglobulinemia (9761)</td>
<td>Leukemia, NOS (9800)</td>
</tr>
<tr>
<td></td>
<td>Non-lymphocytic leukemias (9840-9842, 9860-9910)</td>
<td>Acute leukemia, NOS (9801)</td>
</tr>
<tr>
<td></td>
<td>Myeloid sarcoma (9930)</td>
<td>Chronic leukemia, NOS (9803)</td>
</tr>
<tr>
<td></td>
<td>Acute panmyelosis (9931)</td>
<td>Lymphocytic leukemia (9820-9827)</td>
</tr>
<tr>
<td></td>
<td>Acute myelofibrosis (9932)</td>
<td></td>
</tr>
</tbody>
</table>

1If any of these diagnoses are made within 4 months of lymphocytic leukemia, NOS (9820) or acute lymphocytic leukemia (9821), one of the two diagnoses probably is wrong. The case should be reviewed.

2If the diagnosis includes "can't rule out leukemia" or "consistent with chronic lymphocytic leukemia," and a bone marrow or peripheral blood study within two months confirms the chronic lymphocytic leukemia diagnosis; then code only to chronic lymphocytic leukemia (9823). If not confirmed as chronic lymphocytic leukemia, then code as the lymphoma.

3Note: Lymphocytic leukemia, NOS (9820) should be upgraded to a more specific diagnosis that is not considered a second primary.
# DETERMINATION OF SUBSEQUENT PRIMARIES OF LYMPHATIC (NODAL AND EXTRANODAL) AND HEMATOPOIETIC DISEASES

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<tbody>
<tr>
<td>Lymphocytic leukemia (9820-9827) (cont'd)</td>
<td></td>
<td>Plasma cell leukemia¹ (9830)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lymphosarcoma cell leukemia¹ (9850)</td>
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<tr>
<td></td>
<td></td>
<td>Hairy cell leukemia¹ (9940)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Leukemic reticuloendotheliosis¹ (9941)</td>
</tr>
</tbody>
</table>

¹Note: Lymphocytic leukemia, NOS (9820) should be upgraded to a more specific diagnosis that is not considered a second primary.
## DETERMINATION OF SUBSEQUENT PRIMARIES OF LYMPHATIC (NODAL AND EXTRANODAL) AND HEMATOPOIETIC DISEASES

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<tr>
<td>Plasma cell leukemia (9830)</td>
<td>Non-Hodgkin's lymphoma (9590-9595, 9670-9686, 9690-9698, 9702-9714)</td>
<td>Plasmacytoma or multiple myeloma (9731, 9732)</td>
</tr>
<tr>
<td></td>
<td>Hodgkin's disease (9650-9667)</td>
<td>Waldenstrom's macroglobulinemia (9761)</td>
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<tr>
<td></td>
<td>Burkitt's lymphoma (9687)</td>
<td>Leukemia, NOS (9800)</td>
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<td>Mycosis fungoides or Sezary's disease (9700, 9701)</td>
<td>Acute leukemia, NOS (9801)</td>
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## DETERMINATION OF SUBSEQUENT PRIMARIES OF LYMPHATIC (NODAL AND EXTRANODAL) AND HEMATOPOIETIC DISEASES

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<td>Lymphosarcoma cell leukemia (9850)</td>
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Determinations of Subsequent Primaries of Lymphatic (Nodal and Extranodal) and Hematopoietic Diseases

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\(^1\)Code to the term with the higher histology code.
## Determination of Subsequent Primaries of Lymphatic (Nodal and Extranodal) and Hematopoietic Diseases

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<tr>
<td></td>
<td>Waldenstrom’s macroglobulinemia (9761)</td>
<td></td>
</tr>
<tr>
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<td>Any non-lymphocytic leukemia (9800-9804, 9830-9932)</td>
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<tr>
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<td>Lymphocytic leukemia (9821-9827)</td>
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APPENDIX C

OTHER ICD-O-2 CODES TO BE CONSIDERED ONE PRIMARY SITE WHEN DETERMINING MULTIPLE PRIMARIES
### APPENDIX C

**OTHER ICD-O-2 CODES TO BE CONSIDERED ONE PRIMARY SITE WHEN DETERMINING MULTIPLE PRIMARIES**

<table>
<thead>
<tr>
<th>ICD-O-2 Codes</th>
<th>Site Groupings</th>
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<tbody>
<tr>
<td>C01</td>
<td>Base of tongue</td>
</tr>
<tr>
<td>C02</td>
<td>Other and unspecified parts of tongue</td>
</tr>
<tr>
<td>C05</td>
<td>Palate</td>
</tr>
<tr>
<td>C06</td>
<td>Other and unspecified parts of tongue</td>
</tr>
<tr>
<td>C07</td>
<td>Parotid gland</td>
</tr>
<tr>
<td>C08</td>
<td>Other and unspecified salivary glands</td>
</tr>
<tr>
<td>C09</td>
<td>Tonsil</td>
</tr>
<tr>
<td>C10</td>
<td>Oropharynx</td>
</tr>
<tr>
<td>C12</td>
<td>Pyriform sinus</td>
</tr>
<tr>
<td>C13</td>
<td>Hypopharynx</td>
</tr>
<tr>
<td>C23</td>
<td>Gallbladder</td>
</tr>
<tr>
<td>C24</td>
<td>Other and unspecified parts of biliary tract</td>
</tr>
<tr>
<td>C30</td>
<td>Nasal cavity and middle ear</td>
</tr>
<tr>
<td>C31</td>
<td>Accessory sinuses</td>
</tr>
<tr>
<td>C33</td>
<td>Trachea</td>
</tr>
<tr>
<td>C34</td>
<td>Bronchus and lung</td>
</tr>
<tr>
<td>C37</td>
<td>Thymus</td>
</tr>
<tr>
<td>C38.0</td>
<td>Heart</td>
</tr>
<tr>
<td>C38.1-.3</td>
<td>Mediastinum</td>
</tr>
<tr>
<td>C38.8</td>
<td>Overlapping lesion of heart, mediastinum, and pleura</td>
</tr>
<tr>
<td>C38.4</td>
<td>Pleura</td>
</tr>
<tr>
<td>C51</td>
<td>Vulva</td>
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<tr>
<td>C52</td>
<td>Vagina</td>
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<tr>
<td>C57.7</td>
<td>Other specified female genital organs</td>
</tr>
<tr>
<td>C57.8-.9</td>
<td>Unspecified female genital organs</td>
</tr>
<tr>
<td>C56</td>
<td>Ovary</td>
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<tr>
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<td>Fallopian tube</td>
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<td>C57.1</td>
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<td>C57.3</td>
<td>Parametrium</td>
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<tr>
<td>C57.4</td>
<td>Uterine adnexa</td>
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OTHER ICD-O-2 CODES TO BE CONSIDERED ONE PRIMARY SITE
WHEN DETERMINING MULTIPLE PRIMARIES (Cont.)

<table>
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<tr>
<th>ICD-O-2 Codes</th>
<th>Site Groupings</th>
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<td>C60</td>
<td>Penis</td>
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</tr>
<tr>
<td>C64</td>
<td>Kidney</td>
</tr>
<tr>
<td>C65</td>
<td>Renal pelvis</td>
</tr>
<tr>
<td>C66</td>
<td>Ureter</td>
</tr>
<tr>
<td>C68</td>
<td>Other and unspecified urinary organs</td>
</tr>
<tr>
<td>C74</td>
<td>Adrenal gland</td>
</tr>
<tr>
<td>C75</td>
<td>Other endocrine glands and related structures</td>
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