

# Introduction to Anatomy, Chapter 1

## Outline of class notes

### Objectives:

#### After studying this chapter you should be able to:

1. Define anatomy and physiology.
2. Explain why anatomy today is considered a relatively broad science and discuss its various disciplines.
3. List and describe the 6 levels of structural organization.
4. Name and give examples of the four tissue types of the body.
5. List the 11 principal systems of the body, their functions, and representative organs.
6. Describe anatomical position and the four major body reference planes
7. Describe the major body cavities and their representative organs.
8. Be able to use anatomical vocabulary utilizing directional terms, regional names and quadrants.
9. Describe (compare and contrast) the following common medical imaging procedures: Conventional Radiography (x-rays), Magnetic Resonance Imaging (MRI), Computed Tomography (CT), Ultrasound, Positron Emission Tomography (PET), and Digital Subtraction Angiography (DSA).

### Chapter Overview

- Divisions of Anatomy
- Structural and functional organization of the body
  - Levels of organization
  - Organ systems
- Properties of life
- Anatomical terminology
  - Directional terms
  - Body planes and sections
  - Body cavities
  - Abdominal regions and quadrants
- Medical Imaging Techniques



### Anatomy Defined

- **Anatomy** is the study of structure and the relationships among structures.
  - Structure refers to the shapes, sizes, and characteristics of the components of the human body.
- Anatomy is a Greek term that originates from 2 words:
  - *Ana* which means “up or apart”
  - *Tomos* which means “to cut”

### Physiology Defined

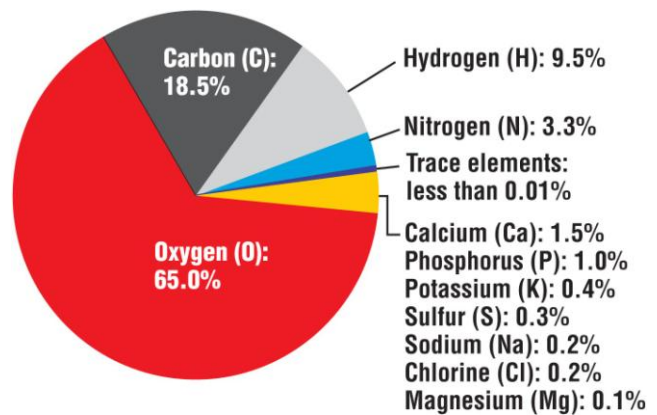
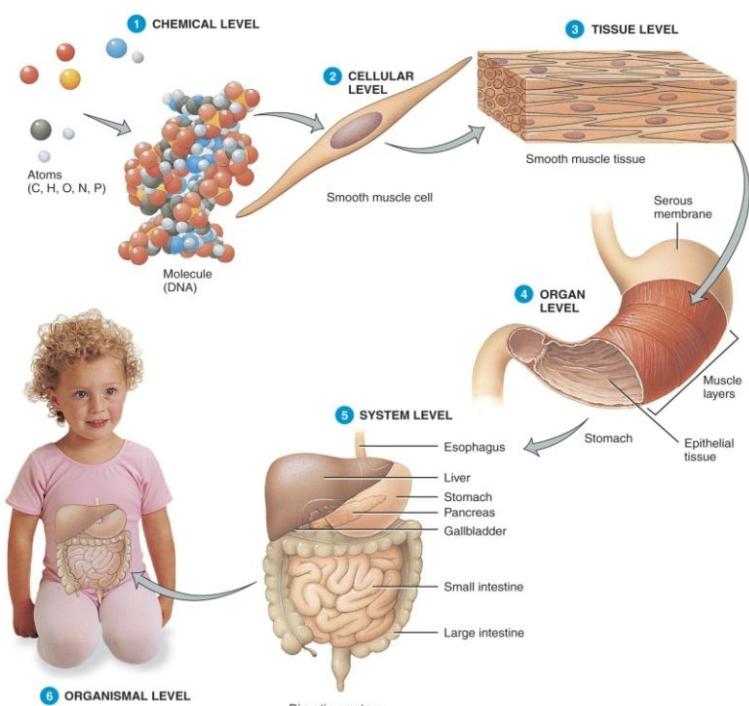
- Physiology is the study of how the body parts function
  - Explains the how and why
- Physiology is where we figure out how stuff works.
  - How do muscles contract?
  - How are neural impulses formed?
  - How do RBCs carry oxygen?



## Disciplines of Anatomy

- Anatomy is a relatively broad science because it can be divided into various disciplines.
  - Gross Anatomy** (macroscopic): Study of stuff seen by the naked eye.
  - Microscopic Anatomy**: Study of stuff seen ONLY with the microscope. Includes:
    - Histology** – Study of tissues
    - Cytology** – Study of individual cells and their internal structures
  - Surface anatomy**: Study of superficial markings.
  - Pathological anatomy**: Study of structural changes associated with disease.
  - Regional anatomy**: Study of the body by areas (head, trunk).
  - Systemic anatomy**: Study of the body by systems (renal, digestive)
  - Developmental anatomy**: Study of development from fertilized egg through adult.
  - Embryology**: Study of development from fertilized egg through the eighth week of utero.
  - Radiographic anatomy**: Use of imaging techniques (x-ray, ultrasound, MRI)

## Levels of Structural Organization



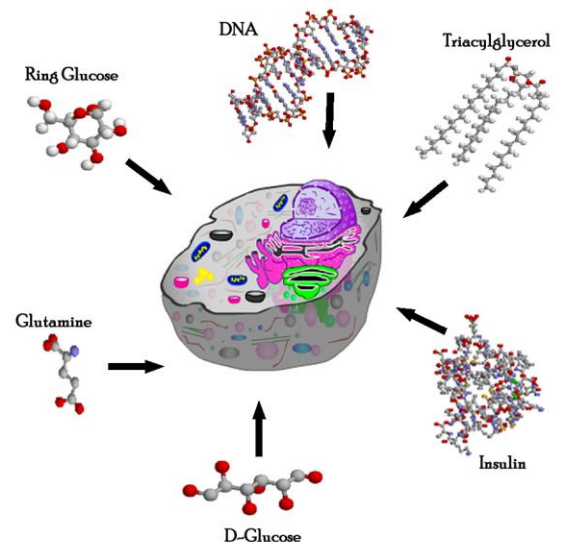
Percentage of elements that make up the human body

## Levels of Structural Organization

- The human body consists of several levels of structural organization, which interact to perform specific functions.

### 1. Chemical level: Atoms and molecules

- Atoms**: Made of subatomic particles: protons, neutrons and electrons.
  - C, H, O, N, Ca, P make up 99% of our body weight
- Molecules**: Two or more atoms held together by covalent bonds. Ex: water, DNA, proteins, carbohydrates, vitamins.
- Molecules are organized into organelles.

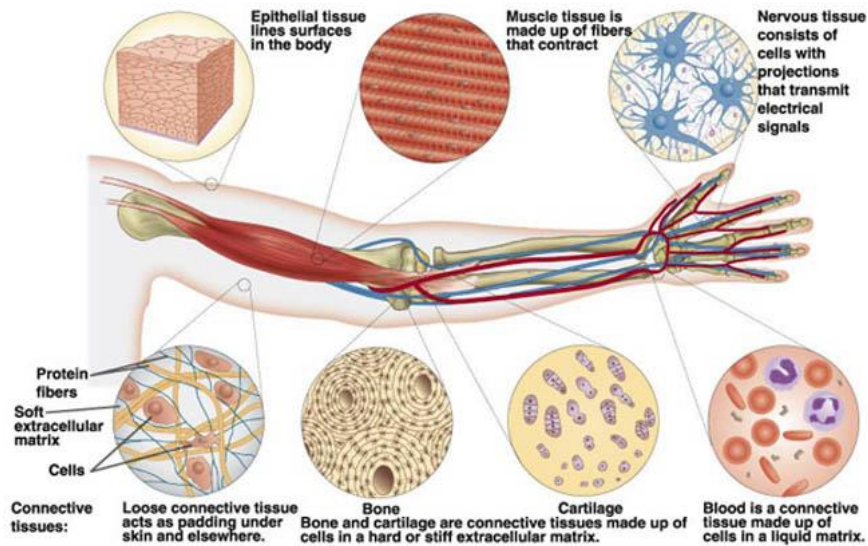


## 2. Cellular Level

- **Organelles:** Functional components of cells. Ex: nucleus, mitochondria
- **Cells:** Fundamental functional unit of life.
- **Cell theory** – 2 parts
  - All organisms are made of cells
    - Schleiden and Schwann (1839)
  - All cells come from pre-existing cells
    - Virchow (1839)

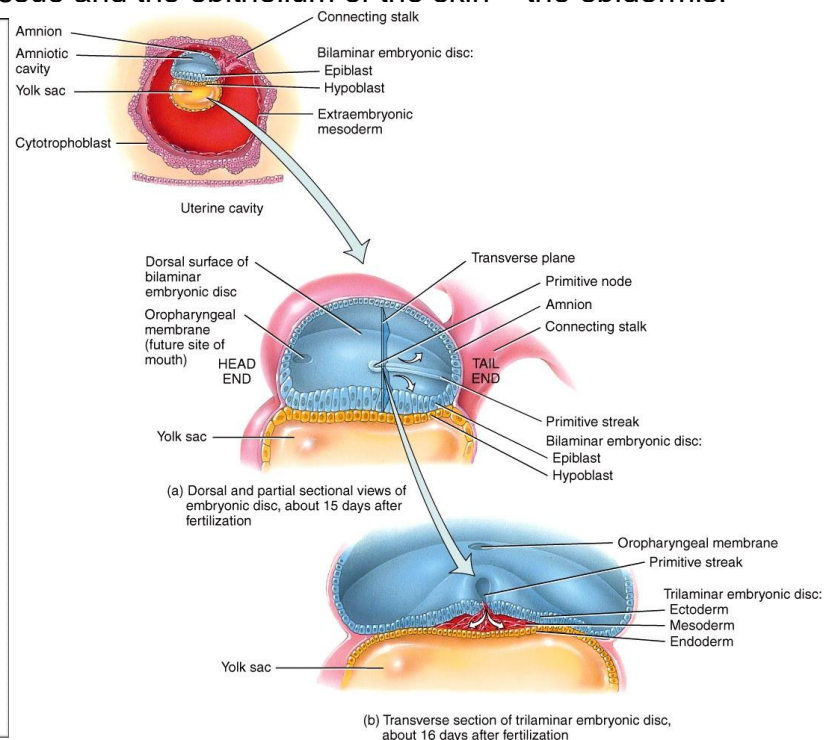
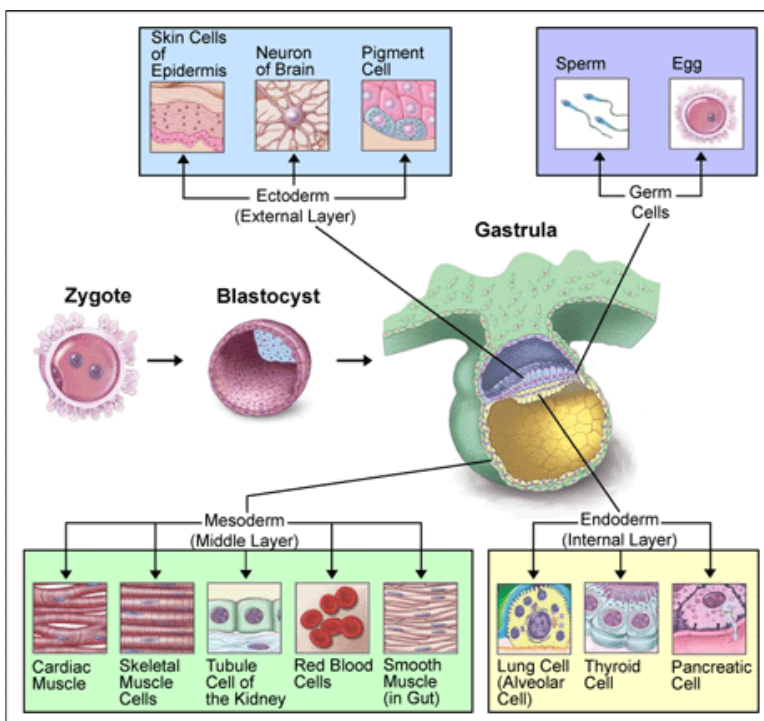
## 3. Tissue Level

- **Tissues:** Groups of similar cells and their extracellular matrix joined together to perform the same general function.
- Four types of tissues: Muscle, epithelial, connective, nervous



## Tissue Level (cont)

- Three embryonic tissues give rise to the 4 primary adult tissues and various organs.
  1. **Endoderm:** Endocrine glands, epithelium of the gastrointestinal tract, lungs, and many organs.
  2. **Mesoderm:** Blood, muscle, bone, and connective tissue.
  3. **Ectoderm:** All nervous tissue and the epithelium of the skin – the epidermis.



#### 4. Organ Level

- **Organs:** Combination of two or more different tissues that have specific functions
  - Ex: stomach, heart, lungs, brain

#### 5. Organ System

- **Organ system:** Two or more organs which function together for a common purpose
  - Ex: Digestive system includes the liver, stomach, intestines, pancreas, and salivary glands.

#### 6. Organism: All the body systems functioning together

#### Test Your Knowledge?

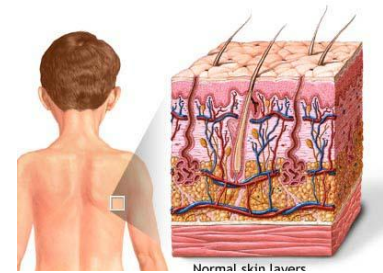
1. The smallest living units in the body are:
 

A. Elements	C. Cells
B. Subatomic particles	D. Molecules
2. The level of organization that reflects the interactions between organ systems is the:
 

A. Cellular Level	C. Molecular Level
B. Tissue Level	D. Organism

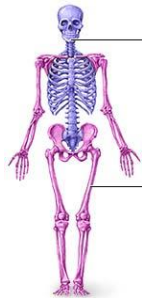
#### Overview of the 11 Organ Systems Integumentary System

- **Structures:**
  - Skin, hair, nails, sweat and oil glands
- **Functions:**
  - Provides a protective barrier for the body
  - Aids in vitamin D production
  - Helps in waste elimination
  - Prevents desiccation, heat loss, and pathogen entry
  - Contains sensory receptors for pain, touch, and temperature



#### Skeletal System

- **Structures:**
  - Bones (206 total) and associated joints, cartilages, and ligaments
- **Functions:**
  - Protects and supports body organs
  - Provides a framework that muscles can use to create movement
  - Hemopoiesis (synthesis of blood cells)
  - Mineral storage
    - Bone contains 99% of the body's store of what mineral? (Hint → you can get this mineral from drinking milk)



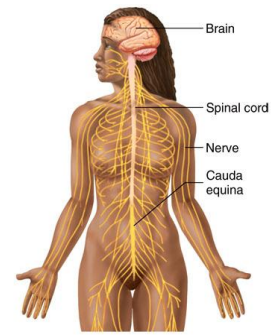
#### Muscular System

- **Structures:**
  - The 600+ skeletal muscles of the body
  - Attached to skeleton by tendons
- **Functions:**
  - Body movements
  - Maintains posture
  - Thermogenesis (generation of heat)



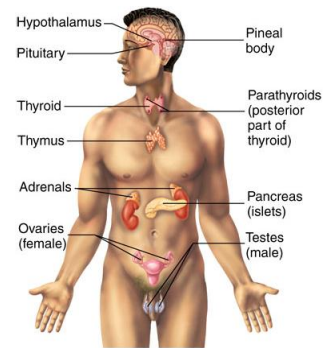
## Nervous System

- **Structures:**
  - Brain, spinal cord, peripheral nerves, and sense organs
- **Functions:**
  - Fast-acting control system of the body
    - Controls cell function with electrical signals called **action potentials**.
  - Monitoring of the internal and external environment and responding (when necessary) by initiating muscular or glandular activity



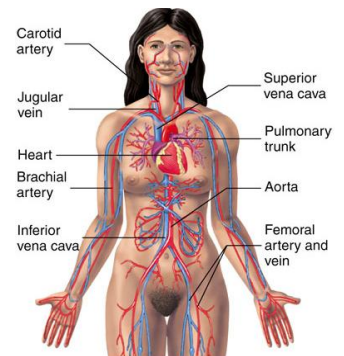
## Endocrine System

- **Structures:**
  - Discrete hormone producing glands:
    - Pituitary, Thyroid, Parathyroid, Pineal, and Adrenal glands.
  - Hormone producing cells within other organs and tissues:
    - Hypothalamus, Pancreas, Small Intestine, Stomach, Testes, Ovaries, Kidneys, Heart, Placenta and Thymus
- **Functions:**
  - Regulates body activities through **hormones**
  - **Long-term control system** of the body (slow acting)
  - Regulates growth, metabolism reproduction, and many other processes.



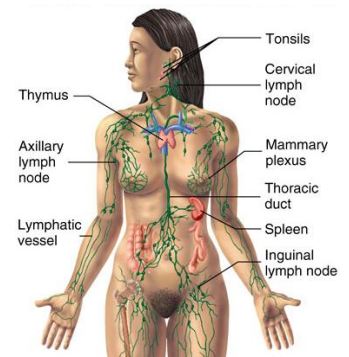
## Cardiovascular System

- **Structures:**
  - Heart, Blood vessels, and blood
- **Functions:**
  - Transports nutrients (glucose, amino acids, lipids), gases (O<sub>2</sub>, CO<sub>2</sub>), wastes (urea, creatinine), and hormones.
  - Helps regulate body temperature and protect against disease



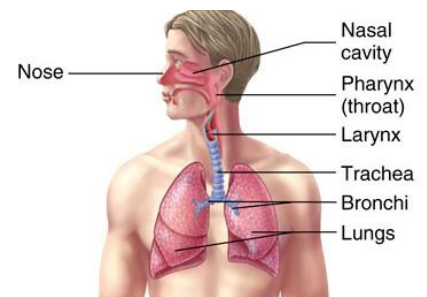
## Lymphatic System

- **Structures:**
  - Lymph, Lymphatic vessels, and organs containing lymphatic tissue such as lymph nodes, spleen, thymus, red bone marrow
- **Functions:**
  - Returning “leaked” fluid back to the bloodstream
  - Transports fats from GI tract
  - Filters (removes) foreign substances from blood and lymph
  - Combats disease (pathogens)



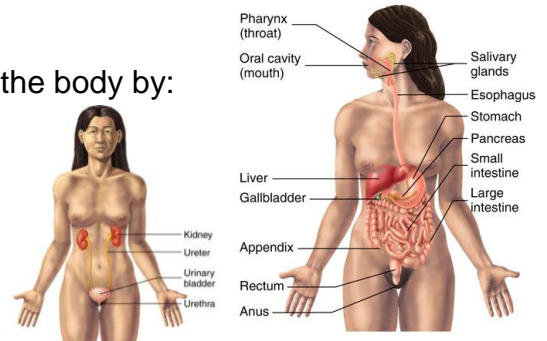
## Respiratory System

- **Structures:**
  - Lungs and associated passageways (Nasal cavity, pharynx, trachea, bronchi)
- **Functions:**
  - Supplies O<sub>2</sub> and eliminates CO<sub>2</sub>
  - Regulates blood pH
  - Produces vocal sounds



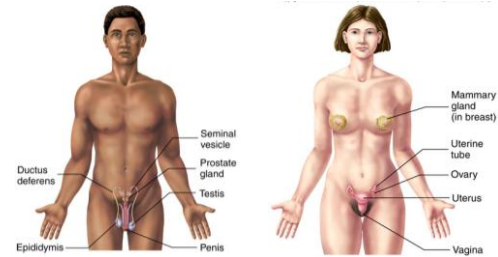
## Digestive System

- **Structures:**
  - Gastrointestinal tract (oral cavity, pharynx, esophagus, stomach, small intestine, large intestine, rectum, anus) and associated organs (teeth, salivary glands, pancreas, liver, gallbladder)
- **Functions:**
  - Breaks down food into units that can be absorbed by the body by:
    - Mechanical processes
    - Chemical processes



## Urinary System

- **Structures:**
  - Kidneys, ureters, urinary bladder, urethra
- **Functions:**
  - Removal of nitrogenous wastes (urea, uric acid, and ammonia) from protein and nucleic acid metabolism
  - Maintains the body fluid volume, pH, and electrolyte levels



## Reproductive System

- **Structures:**
  - Male:
    - Testes, epididymis, vas deferens, associated glands and penis
  - Female:
    - Ovaries, uterine (fallopian) tubes, uterus, cervix, vagina, mammary glands
- **Functions:**
  - Production of gametes (sperm and eggs) and ultimately the production of offspring.
  - Production of hormones that influence sexual function/behavior

## Organ Systems Interrelationships

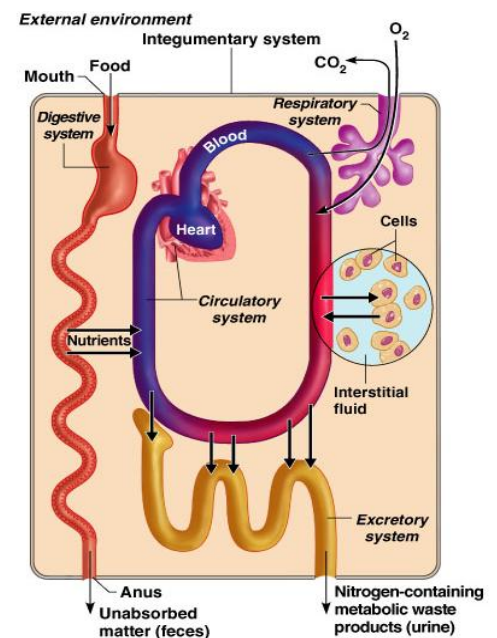
- The **integumentary system** protects the body from the external environment
- **Digestive** and **respiratory systems**, in contact with the external environment, take in nutrients and oxygen
- Nutrients and oxygen are distributed by the cardiovascular system
- Metabolic wastes are eliminated by the urinary and respiratory systems

## Test Your Knowledge?

1. Name the body system that functions in waste elimination, prevention of desiccation, heat loss, and pathogen entry, and is the site of pain and pressure receptors.
 

A. Urinary system	D. Integumentary System
B. Skeletal system	E. Circulatory
C. Reproductive system	
  
2. The two regulatory systems in the human body include the:
 

A. Nervous and endocrine	C. Muscular and skeletal
B. Digestive and reproductive	D. Cardiovascular and lymphatic

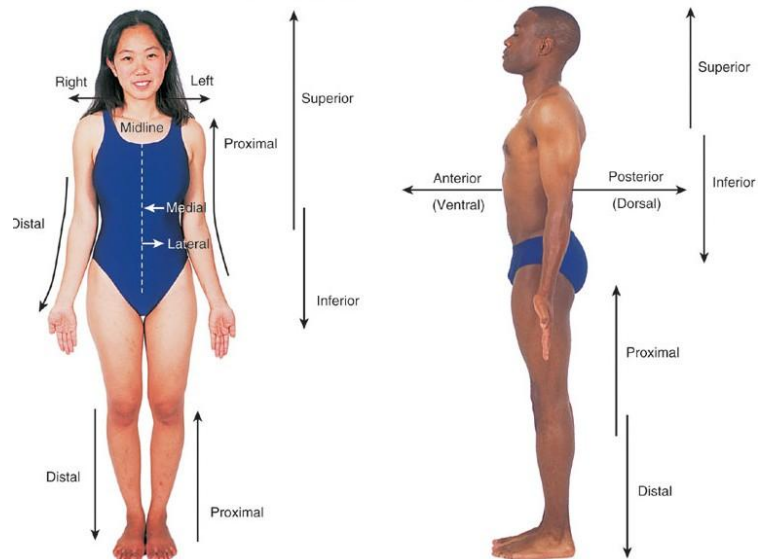


## Terminology and the Body Plan

Information is for both lecture and Lab

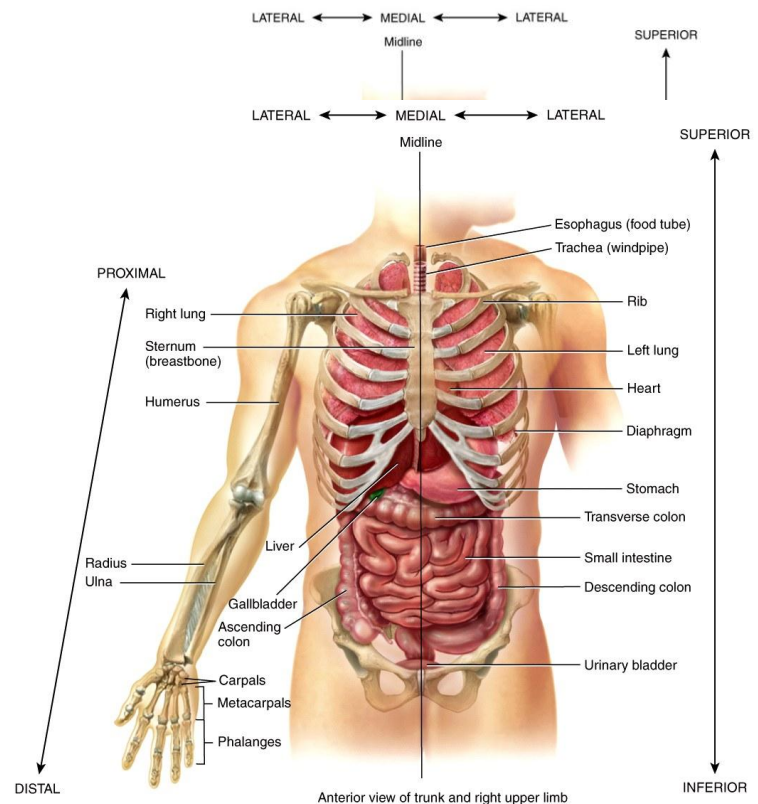
### Body Positions

- **Anatomical Position:** A reference standard position
  - Person standing erect
  - Face directed forward
  - Arms hanging to the sides
  - Palms facing forward
  - Feet flat and facing forward.
- **Supine:** Person lying face upward
- **Prone:** Person lying face downward



### Directional Terms

- **Superior:** Above or higher in position; toward the head end or upper part of a structure or the body. Ex: The heart is superior to the liver.
- **Cranial:** Relating to the skull or head (**cephalic**). Toward the head. This is a more flexible term than superior because it can be applied to all animals, whether they stand upright on two limbs (biped) or on all four limbs (quadruped). Ex: The stomach is cranial to the urinary bladder.
- **Inferior:** Below or lower in position; away from the head end or toward the lower part of a structure or the body. Ex: The stomach is inferior to the lungs.
- **Caudal:** Relating to the tail; at or near the tail or posterior part of the body. Ex: The lumbar vertebrae are caudal to the cervical vertebrae.
- **Ventral:** Relating to the belly side of the body; toward the front. Used synonymously with anterior in human anatomy. Ex: The intestines are ventral to the vertebral column.
- **Dorsal:** Relating to the back side of the body; toward the back. Used synonymously with posterior in human anatomy. Ex: The vertebrae are dorsal to the heart.
- **Medial:** Toward or at the midline of the body. Ex: The ulna is medial to the radius.
- **Lateral:** Away from the midline of the body. Ex: The lungs are lateral to the heart.
- **Proximal:** Close to the origin of a structure or the point of attachment of a limb to the body trunk. Ex: The humerus (arm bone) is proximal to the radius (one of the forearm bones).
- **Distal:** Farther from the origin of a structure or the point of attachment of a limb to the body trunk. Ex: The phalanges (finger bones) are distal to the carpals (wrist bones).
- **Superficial:** Toward or on the surface of the body. Ex: The ribs are superficial to the lungs.
- **Deep:** Away from the body surface more internal. Ex: The ribs are deep to the skin of the chest and back.

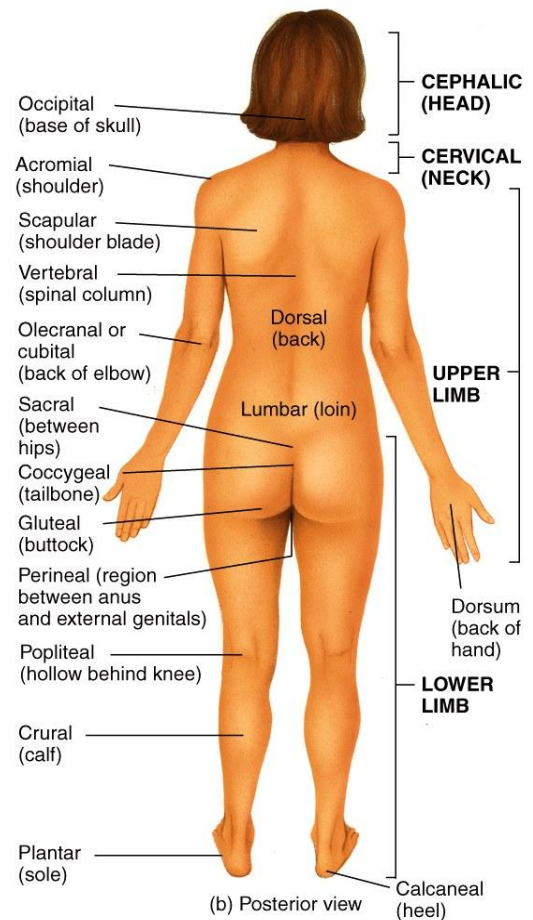
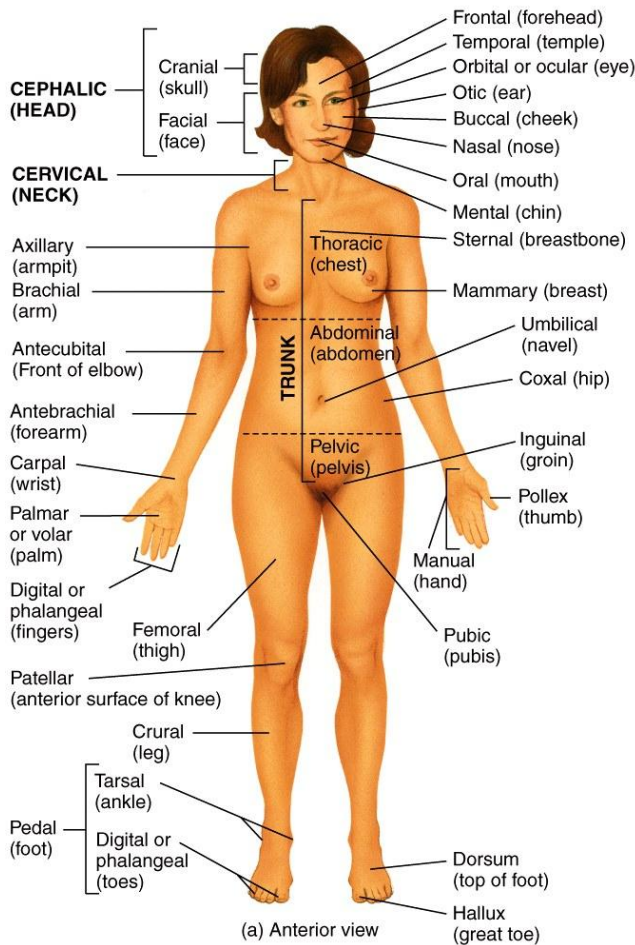


- **Ipsilateral:** On the same side of the body's midline as another structure. Ex: The right eye and right arm are ipsilateral.
- **Contralateral:** On the opposite side of the body's midline from another structure. Ex: The right eye and left eye are contralateral.
- **External:** Toward the outside of a structure. It is typically used when describing relationships of individual organs. Ex: The visceral pleura is on the external surface of the lungs.
- **Internal:** Toward the inside of a structure. It is typically used when describing relationships of individual organs. Ex: The mucosa forms the internal lining of the stomach.
- **Intermediate:** Between two structures. Ex: The transverse colon is intermediate to the ascending colon and descending colon.

### Directional Terms: Terms of Relative Position

- Anterior/Ventral vs Posterior/Dorsal
- Superior/Cranial vs Inferior/Caudal
- Ipsilateral vs Contralateral
- Medial vs Lateral
- Proximal vs Distal
- Superficial vs Deep
- Parietal vs Visceral

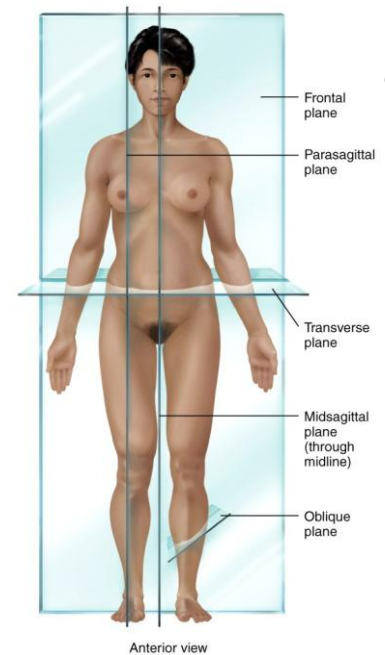
### Body Regions:





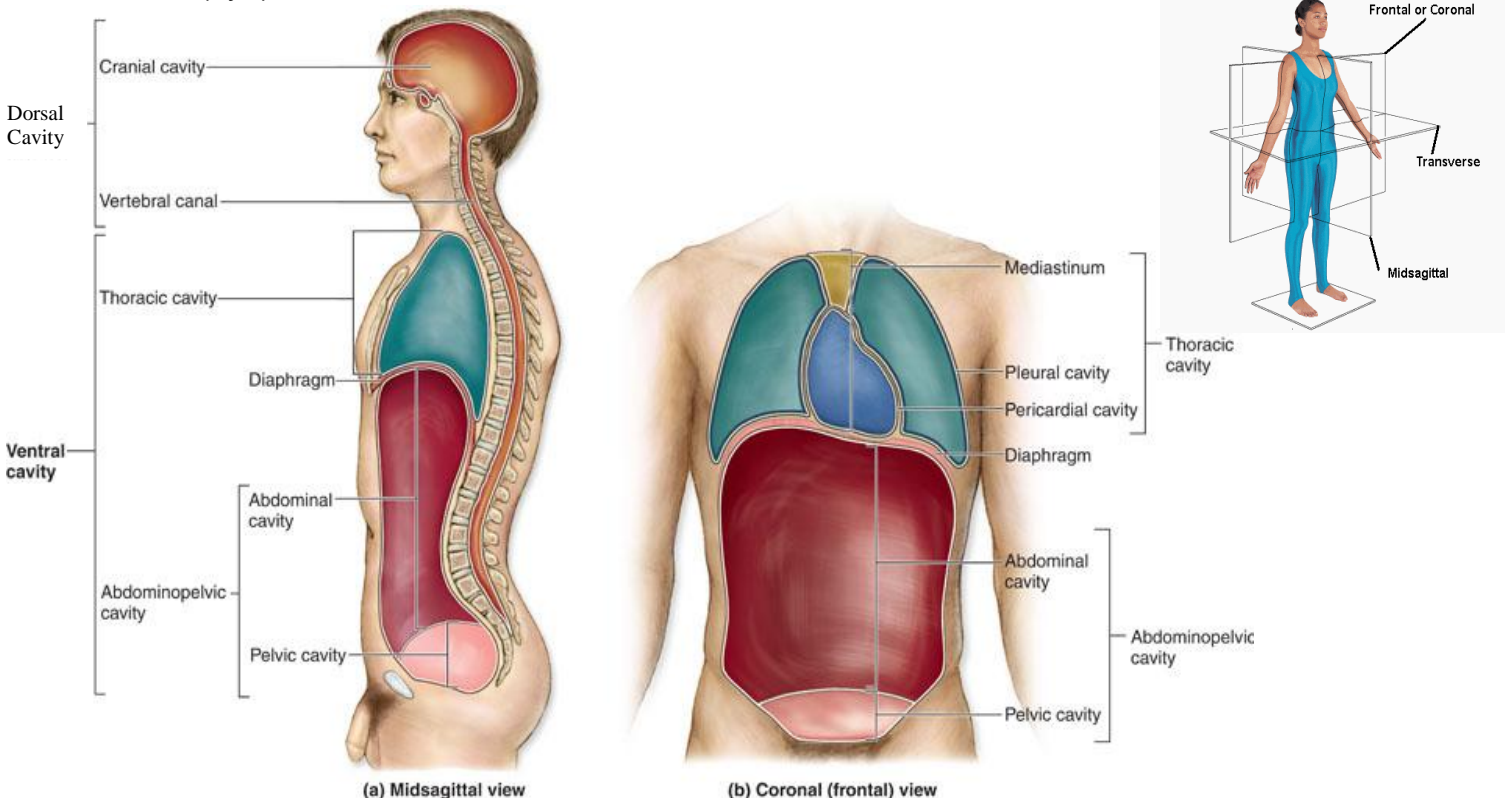
## Body Planes and Sections

- **Sagittal section** passes vertically thru the body
  - Divides the body into right and left portions.
  - Midsagittal vs Parasagittal
- **Transverse section** passes horizontally thru the body
  - Divides the body into superior and inferior portions.
- **Frontal (coronal) section** passes vertically thru the body
  - Divides the body into anterior and posterior sections.
- **Oblique section** passes thru the body at an angle



## Body Cavities

- **Body cavities** are spaces within the body that house the internal organs (viscera); the body is divided into two major **closed** cavities: **Dorsal** and **Ventral**.
  - **Open** cavities include the oral cavity, nasal cavity, orbital (eye) cavities, middle ear cavities.



## Dorsal Body Cavity

- **Dorsal Body Cavity** contains 2 subdivisions
  1. **Cranial** cavity encases the brain
  2. **Vertebral** cavity (canal) encloses the spinal cord

## Ventral Body Cavity

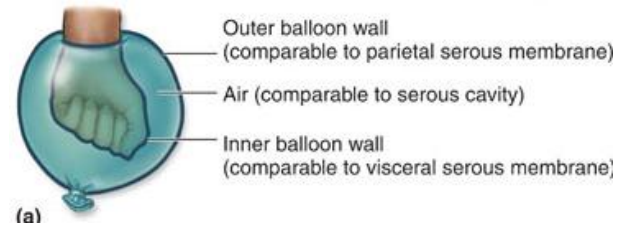
- **Ventral Body Cavity** contains 2 subdivisions: Thoracic and Abdominopelvic cavities (separated by the diaphragm)
  1. **Thoracic cavity** is subdivided into 2 pleural cavities and the mediastinum
    - Each **pleural cavity** contains a lung
    - **Mediastinum**: region between the sternum, vertebrae and lungs.
      - Contains the esophagus, trachea, blood vessels, thymus and pericardial cavity
      - Clinical Importance

**2. Abdominopelvic cavity** contains 2 subdivisions separated by imaginary line running from symphysis pubis to sacral promontory

1. **Abdominal cavity** contains most of the viscera (stomach, small intestine, spleen, and liver etc.)
2. **Pelvic cavity** contains the urinary bladder, portions of the large intestine and internal reproductive organs.

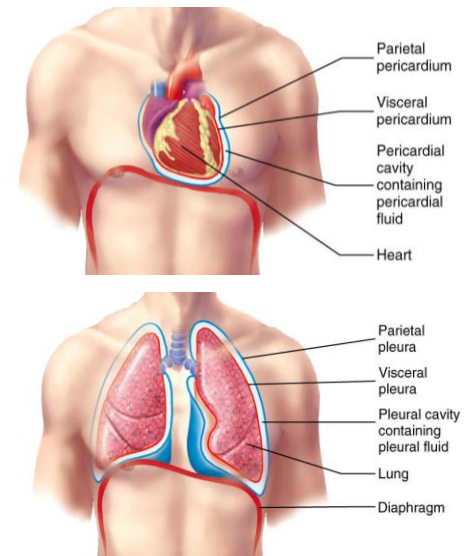
### Serous Membranes

- **Serous membranes** line the ventral cavities and organs.
  - Produce serous fluid (lubricant) to reduce friction.
- Serous membranes are classified based on their location
  - **Visceral (organ) serous membranes** cover the surfaces of organs
  - **Parietal (wall) serous membranes** line the cavity walls



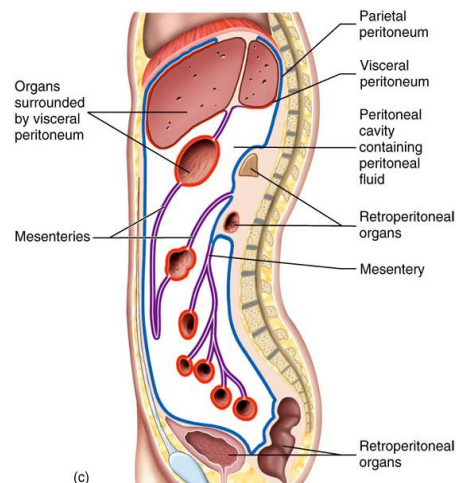
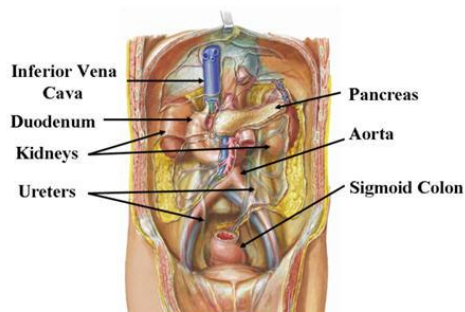
### Serous Membranes of Thoracic Cavity

- Serous membranes of the thoracic cavity
  1. **Pericardial cavity** surrounds the heart and contains pericardial fluid
    - **Visceral pericardium** covers the heart
    - **Parietal pericardium** lines the connective tissue sac that contains the heart
    - **Pericarditis** is inflammation of the pericardium
  2. **Pleural cavity** surrounds each lung and contains pleural fluid.
    - **Visceral pleural** covers each lung
    - **Parietal pleural** lines the inner surface of the thoracic wall and diaphragm
    - **Pleurisy** is inflammation of the pleura



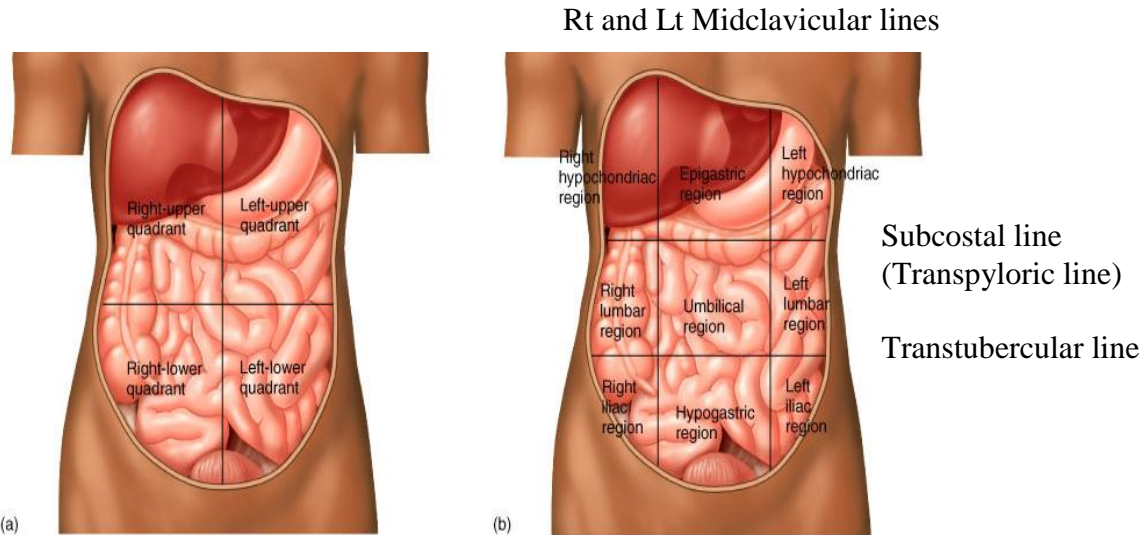
### Retroperitoneal

- **Retroperitoneal** refers to abdominopelvic organs that out side of the parietal peritoneum
  - Includes: Kidneys, adrenal glands, pancreas, urinary bladder and parts of the intestine (duodenum, ascending and descending colon)



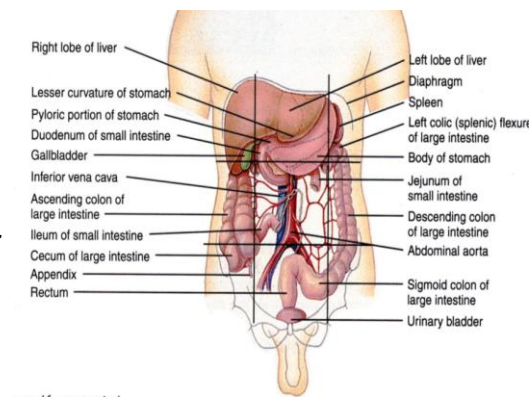
## Abdominopelvic Quadrants and Regions

- **Abdominal quadrants (4)** – useful in clinical examinations.
  - Area is divided into four segments by using a pair of imaginary lines that intersect at the umbilicus (naval)
- **Abdominopelvic regions (9)** – useful in gross anatomic studies
  - Grid made of **two horizontal lines** (one just below the ribs - subcostal, the other at the iliac tubercles near the top of the hip bones - transtubercular) and **two vertical lines** (Midclavicular, midpoints of the clavicles just medial to the nipples). Forms an imaginary tic-tac-toe grid.



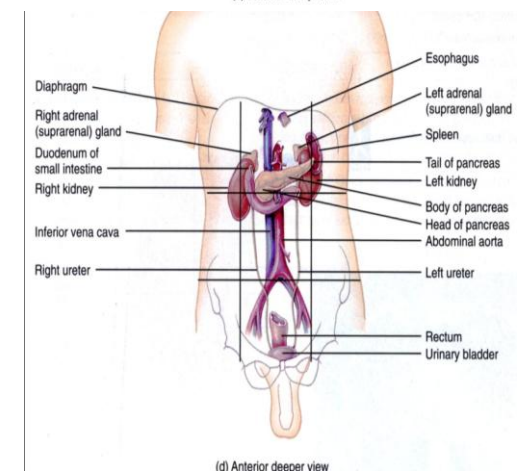
## Major Organs Found in the Abdominopelvic Body Regions

- **Right hypochondriac region:** Liver, gallbladder
- **Epigastric region:** Liver, stomach, pancreas, Lg and sm intestine
- **Left hypochondriac region:** Spleen, stomach, pancreas
- **Right lumbar region:** Lg and sm intestine, Rt kidney, Rt ureter
- **Umbilical region:** Lg (transverse) and sm intestine
- **Left lumbar region:** Lg and sm intestine, Lt kidney, Lt ureter
- **Right iliac region:** Appendix, Lg and sm intestine
- **Hypogastric region:** Urinary bladder, Lg and sm intestine
- **Left iliac region:** Lg and sm intestine, Lt ureter



used for anatomical

(c) Anterior deep view



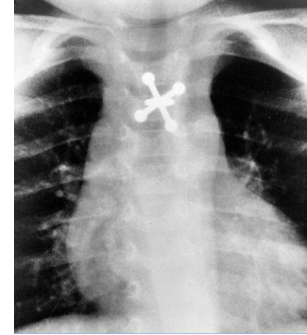
(d) Anterior deeper view

## Medical Imaging Procedures

1. Conventional Radiography (X-Rays)
2. Magnetic Resonance Imaging (MRI)
3. Computed Tomography (CT)
4. Ultrasound
5. Positron Emission Tomography (PET)
6. Digital Subtraction Angiography (DSA).

### Conventional Radiology (CR, x-rays)

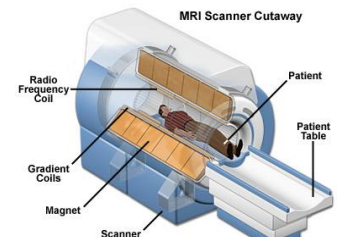
- **Conventional Radiology (CR or x-rays):** Beam of x-rays pass through the body and strike a photographic plate – image dependent on different absorption properties of tissues to the x-rays.
  - Resistance to x-ray penetration is called **radiodensity** and increases in the following sequence: air, fat, blood, liver, muscle, bone
  - At low doses, x-rays can be used to examine soft tissue such as the breast (mammography) and for determining bone density (bone densitometry).
- **Use of a contrast medium**
  - A **contrast medium** (ex: **Barium**) can be used to make hollow or fluid-filled structures visible in radiographs.
    - Used to image blood vessels (angiography), the urinary system (intravenous urography), and the gastrointestinal tract (barium contrast x-rays)



Barium contrast x-ray showing a cancer of the ascending colon (arrow)

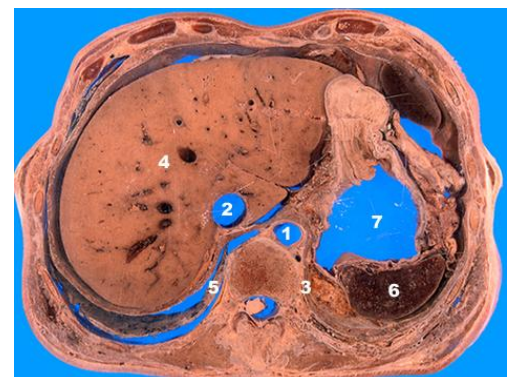
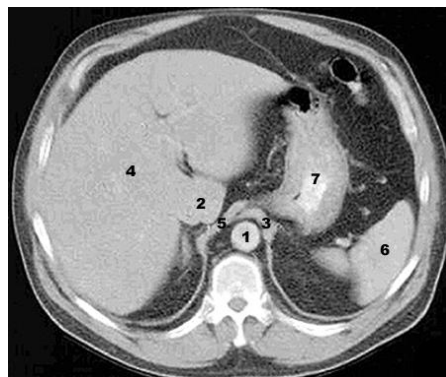
### Magnetic Resonance Imaging (MRI)

- **Magnetic Resonance Imaging (MRI)** Uses magnetic field and radio waves to produce image – no radiation.
  - Protons line up along the magnetic field; pulse of radio waves are absorbed by protons and when released this pattern of energy is detected and used to construct images.
  - Shows fine details of soft tissues but is not so good for showing the fine details of bone.
  - Not to be used on patients with certain metals in their bodies (**pace maker, defibrillator, cochlear implants**, etc.)



#### Key:

- #1 = Abdominal Aorta
- #2 = Inferior Vena Cava
- #3 = Left Crus of Diaphragm
- #4 = Liver
- #5 = Right Crus of Diaphragm
- #6 = Spleen
- #7 = Stomach



## Computed Tomography (CT)

- **Computed Tomography (CT):** X-ray beam traces an arc at multiple angles around a section of the body
  - Image shown on a video monitor – 3D images can be constructed
  - Visualizes soft tissues and organs with greater detail than conventional radiographs
    - Used to screen for cancers and coronary artery disease.

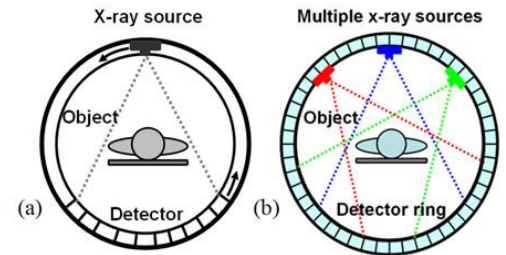


Figure 1: (a) Configuration of the conventional third generation CT scanner. (b) The multiplexing CT scanner enables simultaneous collection of multiple projection images due to the multiplexing principle.

## Ultrasound Scanning

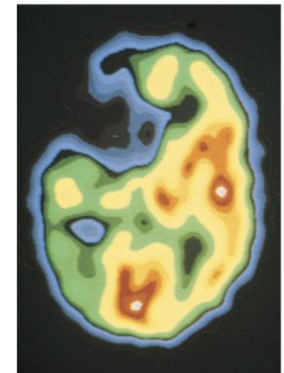
- **Ultrasound scanning:** High-frequency sound waves reflect off body tissues and are detected by the same instrument.
  - An echogram (picture) is assembled from the pattern of echoes
  - Image which may be still or moving is called a **sonogram** – visualized on a video monitor
  - Safe, noninvasive, painless, and uses no dyes.



ANTERIOR

## Positron Emission Tomography (PET)

- **Positron Emission Tomography (PET)**
  - Radioactive isotopes are injected and later detected by gamma-ray cameras and interpreted by computers
  - Provides information on **structure and function** (metabolism of brain, heart, etc).



POSTERIOR

Positron emission tomography scan of a transverse section of the brain (darkened area at upper left indicates where a stroke has occurred)

## Digital Subtraction Angiography (DSA)

- **Digital Subtraction Angiography (DSA)**
  - A computer compared an x-ray image of a region of the body before and after a contrast dye has been introduced.
    - Computer “subtracts” details common to both images.
  - Used to monitor blood flow through specific organs, such as the brain, heart, lungs or kidneys.

Position of a covered stent (arrow) placed over the area of the tear of the right common femoral artery.

