Location of Heart

- Approximately the size of your fist

Location
- Superior surface of diaphragm
- Left of the midline in mediastinum
- Anterior to the vertebral column, posterior to the sternum
- Posteriorly the heart rests on the bodies of vertebrae T5-T8
- Apex lies on the diaphragm, pointing to the left
- Base lies just below the second rib
- PMI – point of maximal intensity is the place where you feel and hear the heart the best
  - It is located between the 5th and 6th rib on the left.
Coverings of the Heart: Anatomy

- Pericardium – a double-walled sac around the heart composed of:
  - A superficial fibrous pericardium
  - A deep two-layer serous pericardium
    - The parietal layer lines the internal surface of the fibrous pericardium
    - The visceral layer or epicardium lines the surface of the heart
    - They are separated by the fluid-filled pericardial cavity
Coverings of the Heart: Physiology

- The pericardium:
  - Protects and anchors the heart
  - Prevents overfilling of the heart with blood
  - Allows for the heart to work in a relatively friction-free environment
Pericarditis – Inflammation of the Pericardium

- The serous membrane is roughened up
- When the heart beats, it rubs against the pericardial sac, creating a “grating” sound
- Characterized by deep pain
- In severe cases a large amount of inflammatory fluid seeps into the pericardial cavity causing a compression when the heart beats
  - Cardiac Tamponade
Structure of the heart

- Wall of the heart: composed of three distinct layers
  - Epicardium: outer layer of heart wall
  - Myocardium: thick, contractile middle layer of heart wall; compresses the heart cavities, and the blood within them, with great force
  - Endocardium: delicate inner layer of endothelial tissue
Gross Anatomy of Heart: Frontal Section

- Superior vena cava
- Right pulmonary artery
- Pulmonary trunk
- Right atrium
- Right pulmonary veins
- Fossa ovalis
- Pectinate muscles
- Tricuspid valve
- Right ventricle
- Chordae tendineae
- Trabeculae carneae
- Inferior vena cava
- Aorta
- Left pulmonary artery
- Left atrium
- Left pulmonary veins
- Mitral (bicuspid) valve
- Aortic semilunar valve
- Pulmonary semilunar valve
- Left ventricle
- Papillary muscle
- Interventricular septum
- Myocardium
- Visceral pericardium
Heart Chambers

Heart is divided into four cavities with the right and left chambers separated by the septum.
Atria of the Heart
Receiving Vessels

- Superior chambers
- Are the receiving chambers of the heart
- Atria alternately contract and relax to receive blood and then push it into ventricles
- Only a minimal contraction is needed to push the blood “downstairs” to the ventricles.
- Each atrium has a protruding auricle
- Blood enters right atria from superior and inferior venae cavae and coronary sinus
- Blood enters left atria from pulmonary veins
Ventricles of the Heart
Discharging Chambers

- Inferior chambers
- Ventricles are the discharging chambers of the heart – The actual heart pumps
- The ventricles make up most of the volume of the heart
- Right ventricle pumps blood into the pulmonary trunk
- Left ventricle pumps blood into the aorta
Heart valves ensure unidirectional blood flow through the heart

- Atrioventricular (AV) valves lie between the atria and the ventricles
  - Tricuspid and bicuspid
- Semilunar valve lies between the ventricles and the great vessels
  - Aortic and pulmonary
Atrioventricular (AV) valves: prevent blood from flowing back into the atria from the ventricles when the ventricles contract

- Tricuspid valve (right AV valve): guards the right atrioventricular orifice; free edges of three flaps of endocardium are attached to papillary muscles by chordae tendineae
- Bicuspid, or mitral, valve (left AV valve): similar in structure to tricuspid valve except has only two flaps
Semilunar (SL) Valves

- Semilunar valves: half-moon–shaped flaps growing out from the lining of the pulmonary artery and aorta; prevent blood from flowing back into the ventricles from the aorta and pulmonary artery
  - Pulmonary valve: valve at entrance of the pulmonary artery
  - Aortic valve: valve at entrance of the aorta

- Skeleton of the heart
  - Set of connected rings that serve as a semirigid support for the heart valves and the attachment of cardiac muscle of the myocardium
  - Serves as an electrical barrier between the myocardium of the atria and that of the ventricles
Heart Valves

- Pulmonary valve
- Aortic valve
- Area of cutaway
- Bicuspid valve
- Tricuspid valve

(a) Anterior

(b) Myocardium

- Tricuspid valve (right atrioventricular)
- Bicuspid (mitral) valve (left atrioventricular)
- Aortic semilunar valve
- Pulmonary semilunar valve

- Fibrous skeleton
Heart Valves

Chordae tendineae attached to tricuspid valve flap (c)

Papillary muscle

Opening of superior vena cava
Tricuspid valve
Myocardium of right ventricle

Bicuspid (mitral) valve
Chordae tendineae

Interventricular septum
Myocardium of left ventricle

Papillary muscles (d)
Fig. 18-32. **Stenosed mitral valve.** Note the calcific nodules (arrows) attached to the cusps, thus narrowing the opening and slowing blood flow.
Coronary circulation is the functional blood supply to the heart muscle itself.

Collateral routes ensure blood delivery to heart even if major vessels are occluded.

Angina pectoris – thoracic pain caused by blood deficiency to the heart.

MI is caused by prolonged blockage.

Blockage of the coronary artery can be fatal.
Coronary Circulation: Venous Supply

- Superior vena cava
- Anterior cardiac veins
- Great cardiac vein
- Coronary sinus
- Small cardiac vein
- Middle cardiac vein
Blood Supply of Heart Tissue

- Coronary arteries
  - Myocardial cells receive blood from the right and left coronary arteries
- Veins of the coronary circulation
  - As a rule, veins follow a course that closely parallels that of coronary arteries
Nerve Supply of the Heart

- Conduction system of the heart: composed of modified cardiac muscle, it generates and distributes the heart’s own rhythmic contractions; can be regulated by afferent nerves
- Most fibers end in the SA node, but some end in the AV node and in the atrial myocardium; the nodes are the heart’s pacemakers
- Sympathetic nerves: accelerator nerves
- Vagus fibers: inhibitory, or depressor, nerves
Blood is carried in a closed system of vessels that begins and ends at the heart.

The three major types of vessels are arteries, capillaries, and veins.

Arteries carry blood away from the heart, veins carry blood toward the heart.

Capillaries contact tissue cells and directly serve cellular needs.
Generalized Structure of Blood Vessels

- Layers
  - Tunica externa: found in arteries and veins (tunica adventitia)
  - Tunica media: found in arteries and veins
  - Tunica intima: found in all blood vessels
    - Lining endothelial cells
      - Only lining found in capillary
      - Line entire vascular tree
      - Provide a smooth luminal surface; protect against intravascular coagulation

- Lumen – central blood-containing space surrounded by tunics
Generalized Structure of Blood Vessels

- **Tunica interna**
  - Endothelium
  - Subendothelial layer
  - Internal elastic lamina

- **Tunica media**
  - External elastic lamina

- **Tunica externa**

- **Lumen**
  - Artery
  - Vein

- **Capillary network**

- **Endothelial cells**

- **Valve**
• Collagen fibers
  • Exhibit woven appearance
  • Have only a limited ability to stretch (2% to 3%) under physiological conditions
  • Strengthen and keep lumen of vessel open
Elastic fibers
- Form highly elastic networks
- Fibers can stretch more than 100% under physiological conditions
- Play important role in creating passive tension to help regulate blood pressure throughout the cardiac cycle

Smooth muscle fibers
- Most numerous in elastic and muscular arteries
- Exert active tension in vessels when contracting
Capillaries are the smallest blood vessels

- Types of blood vessels
  - Capillaries
    - Primary exchange vessels
    - Microscopic vessels
    - Carry blood from arterioles to venules; together, arterioles, capillaries, and venules constitute the microcirculation
    - Not evenly distributed; highest numbers in tissues with high metabolic rate; may be absent in some “avascular” tissues, such as cartilage
- Walls consisting of a thin tunica interna, one cell thick
- Allow only a single RBC to pass at a time
Capillary Beds

- A microcirculation of interwoven networks of capillaries.
- Precapillary sphincters control blood flow through the capillary beds
  - Cuff of smooth muscle that surrounds each true capillary
  - Regulates blood flow into the capillary
- Blood flow is regulated by vasomotor nerves and local chemical conditions, so it can either bypass or flood the capillary bed
Capillary Beds

- Precapillary sphincters
- Metarteriole
- Vascular shunt
- Thoroughfare channel
- True capillaries
- Terminal arteriole
- Postcapillary venule

(a) Sphincters open
Capillary Beds

Terminal arteriole

(b) Sphincters closed

Postcapillary venule
Veins are capacitance vessels (blood reservoirs) that contain 65% of the blood supply.

Veins have much lower blood pressure and thinner walls than arteries.

To return blood to the heart, veins have special adaptations:
- Large-diameter lumens, which offer little resistance to flow.
- Valves which prevent backflow of blood.
Varicose veins are veins that are tortuous and dilated because of leaky valves

- 15% of adult population
- Heredity, prolonged standing, obesity, pregnancy
The vascular system has two distinct circulations

- **Pulmonary circulation** – *short loop* that runs from the heart to the lungs and back to the heart
- **Systemic circulation** – routes blood through a *long loop* to all parts of the body and returns to the heart
Systemic Circulation

Capillary beds of head and upper limbs

Common carotid arteries to head and subclavian arteries to upper limbs

Superior vena cava

Aortic arch

Aorta

Azygos system

Venous drainage

Thoracic aorta

Arterial blood

Diaphragm

Abdominal aorta

Capillary beds of mediastinal structures and thorax walls

Inferior vena cava

Capillary beds of digestive viscera, spleen, pancreas, kidneys

Inferior vena cava

Capillary beds of gonads, pelvis, and lower limbs
Pathway of Blood Through the Heart and Lungs

Key:
- Red: Oxygen rich, CO₂-poor blood
- Blue: Oxygen poor, CO₂-rich blood

Capillary beds of lungs where gas exchange occurs
Pulmonary circuit
- Pulmonary arteries
- Pulmonary veins
- Aorta and branches

Heart
- Left atrium
- Left ventricle
- Right atrium
- Right ventricle

Systemic circuit
Capillary beds of all body tissues where gas exchange occurs
**MAJOR BLOOD VESSELS**

- Circulatory routes
  - **Systemic circulation**: blood flows from the left ventricle of the heart through blood vessels to all parts of the body (except gas exchange tissues of lungs) and back to the right atrium
  - **Pulmonary circulation**: venous blood moves from right atrium to right ventricle to pulmonary artery to lung arterioles and capillaries, where gases are exchanged; oxygenated blood returns to left atrium by pulmonary veins; from left atrium, blood enters the left ventricle
MAJOR BLOOD VESSELS

- Systemic circulation
  - Systemic arteries
    - Main arteries give off branches, which continue to rebranch, forming arterioles and then capillaries
    - End arteries: arteries that eventually diverge into capillaries
    - Arterial anastomoses: arteries that open into other branches of the same or other arteries; incidence of arterial anastomoses increases as distance from the heart increases
    - Arteriovenous anastomoses, or shunts, occur when blood flows from an artery directly into a vein
<table>
<thead>
<tr>
<th></th>
<th>Arteries</th>
<th>Veins</th>
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</thead>
<tbody>
<tr>
<td>Delivery</td>
<td>Blood pumped into single systemic artery – the aorta</td>
<td>Blood returns via superior and interior venae cavae and the coronary sinus</td>
</tr>
<tr>
<td>Location</td>
<td>Deep, and protected by tissue</td>
<td>Both deep and superficial</td>
</tr>
<tr>
<td>Pathways</td>
<td>Fair, clear, and defined</td>
<td>Convergent interconnections</td>
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<td>Supply/drainage</td>
<td>Predictable supply</td>
<td>Dural sinuses and hepatic portal circulation</td>
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Aorta and Major Arteries

- Internal carotid artery
- External carotid artery
- Vertebral artery
- Brachiocephalic trunk
- Ascending aorta
- Axillary artery
- Abdominal aorta
- Brachial artery
- Superior mesenteric artery
- Gonadal artery
- Inferior mesenteric artery
- Common iliac artery
- External iliac artery
- Digital arteries
- Femoral artery
- Popliteal artery
- Anterior tibial artery
- Posterior tibial artery
- Arcuate artery

Branches of celiac trunk:
- Left gastric artery
- Splenic artery
- Common hepatic artery
- Renal artery
- Radial artery
- Ulnar artery
- Internal iliac artery
- Deep palmar arch
- Superficial palmar arch
Arteries of the Head and Neck

- Superficial temporal artery
- Basilar artery
- Occipital artery
- Vertebral artery
- Internal carotid artery
- External carotid artery
- Common carotid artery
- Thyrocervical trunk
- Costocervical trunk
- Subclavian artery
- Axillary artery
- Ophthalmic artery
- Maxillary artery
- Facial artery
- Lingual artery
- Superior thyroid artery
- Larynx
- Thyroid gland (overlying trachea)
- Clavicle (cut)
- Brachiocephalic trunk
- Internal thoracic artery
Arteries of the Brain

Frontal lobe
Optic chiasma
Middle cerebral artery
Internal carotid artery
Pituitary gland
Temporal lobe
Pons
Occipital lobe

Anterior

Circle of Willis
- Anterior communicating artery
- Anterior cerebral artery
- Posterior communicating artery
- Posterior cerebral artery

Basilar artery
Vertebral artery
Cerebellum
Arteries of the Upper Limbs and Thorax

- Vertebral artery
- Thyrocervical trunk
- Costocervical trunk
- Suprascapular artery
- Thoracoacromial artery
- Axillary artery
- Subscapular artery
- Posterior circumflex humeral artery
- Anterior circumflex humeral artery
- Brachial artery
- Deep brachial artery
- Common interosseous artery
- Radial artery
- Ulnar artery
- Deep palmar arch
- Superficial palmar arch
- Digitals
- Common carotid arteries
- Right subclavian artery
- Left subclavian artery
- Left axillary artery
- Brachiocephalic trunk
- Posterior intercostal arteries
- Anterior intercostal artery
- Internal thoracic artery
- Lateral thoracic artery
- Descending aorta

Arteries of the Abdomen

- Liver (cut)
- Inferior vena cava
- Celiac trunk
- Hepatic artery proper
- Common hepatic artery
- Right gastric artery
- Gallbladder
- Gastroduodenal artery
- Right gastroepiploic artery
- Duodenum
- Abdominal aorta
- Diaphragm
- Esophagus
- Left gastric artery
- Left gastroepiploic artery
- Splenic artery
- Spleen
- Stomach
- Pancreas (major portion lies posterior to stomach)
- Superior mesenteric artery
Arteries of the Abdomen

- Foramen for inferior vena cava
- Hiatus (opening) for esophagus
- Celiac trunk
- Kidney
- Lumbar arteries
- Abdominal aorta
- Median sacral artery
- Diaphragm
- Inferior phrenic artery
- Suprarenal artery
- Renal artery
- Superior mesenteric artery
- Gonadal (testicular or ovarian) artery
- Inferior mesenteric artery
- Common iliac artery
- Ureter
Arteries of the Abdomen

- Celiac trunk
- Middle colic artery
- Right colic artery
- Ileocolic artery
- Ascending colon
- Ileum
- Superior rectal artery
- Cecum
- Appendix
- Transverse colon
- Superior mesenteric artery
- Intestinal arteries
- Left colic artery
- Inferior mesenteric artery
- Aorta
- Sigmoidal arteries
- Descending colon
- Left common iliac artery
- Sigmoid colon
- Rectum
Fig. 18-22. Major arteries of the lower extremity. A, Diagram of major arteries of lower extremity. Anterior view of the right hip and leg. B, Femoral arteriogram. Contrast material passing through the external iliac artery in the abdomen has entered the femoral artery and its branches in the thigh. C, Popliteal arteriogram.
Veins of the Head and Neck

- Ophthalmic vein
- Superficial temporal vein
- Facial vein
- Occipital vein
- Posterior auricular vein
- External jugular vein
- Vertebral vein
- Internal jugular vein
- Superior and middle thyroid veins
- Brachiocephalic vein
- Subclavian vein
- Superior vena cava
Veins of the Brain

- Superior sagittal sinus
- Falx cerebri
- Inferior sagittal sinus
- Straight sinus
- Cavernous sinus
- Junction of sinuses
- Transverse sinuses
- Sigmoid sinus
- Jugular foramen
- Right internal jugular vein
Veins of the Upper Limbs and Thorax

- Brachiocephalic veins
- Right subclavian vein
- Axillary vein
- Brachial vein
- Cephalic vein
- Basilic vein
- Median cubital vein
- Median vein antebrachial
- Cephalic vein
- Radial vein
- Basilic vein
- Ulnar vein
- Deep palmar venous arch
- Superficial palmar venous arch
- Digital veins
- Internal jugular vein
- External jugular vein
- Left subclavian vein
- Superior vena cava
- Azygos vein
- Accessory hemiazygos vein
- Hemiazygos vein
- Posterior intercostals
- Inferior vena cava
- Ascending lumbar vein
Fig. 18-27. Hepatic portal circulation. In this unusual circulatory route, a vein is located between two capillary beds (see Figure 18-16). The hepatic portal vein collects blood from capillaries in visceral structures located in the abdomen and empties it into the liver. Hepatic veins return blood to the inferior vena cava.
Veins of the Pelvis and Lower Limbs

- Common iliac vein
- Internal iliac vein
- External iliac vein
- Inguinal ligament
- Femoral vein
- Great saphenous vein (superficial)

- Popliteal vein
- Fibular (peroneal) vein
- Anterior tibial vein
- Dorsalis pedis vein
- Dorsal venous arch
- Metatarsal veins

- Great saphenous vein
- Popliteal vein
- Anterior tibial vein
- Fibular (peroneal) vein
- Small saphenous vein (superficial)
- Posterior tibial vein
- Plantar veins
- Plantar arch
- Digital veins
Veins of the Abdomen

- Hepatic veins
- Inferior vena cava
- Right suprarenal vein
- Right gonadal vein
- Inferior phrenic vein
- Left suprarenal vein
- Renal veins
- Left ascending lumbar vein
- Lumbar veins
- Left gonadal vein
- Common iliac vein
- Internal iliac vein
- External iliac vein
Veins of the Abdomen

- Hepatic veins
- Liver
- Hepatic portal vein
- Gastric veins
- Spleen
- Inferior vena cava
- Splenic vein
- Right gastroepiploic vein
- Inferior mesenteric vein
- Superior mesenteric vein
- Small intestine
- Large intestine
- Rectum
Fetal Circulation

- Placenta: where exchange of oxygen and other substances between the separate maternal and fetal blood occurs; attached to uterine wall
- Umbilical vein: returns oxygenated blood from the placenta to the fetus
Fetal Circulation

- Ductus venosus: continuation of the umbilical vein; drains into inferior vena cava
- Foramen ovale: opening in septum between the right and left atria
- Ductus arteriosus: small vessel connecting the pulmonary artery with the descending thoracic aorta
CYCLE OF LIFE: CARDIOVASCULAR ANATOMY

- Birth: change from placenta-dependent system
- Heart and blood vessels maintain basic structure and function from childhood through adulthood
  - Exercise thickens myocardium and increases the supply of blood vessels in skeletal muscle tissue
- Adulthood through later adulthood: degenerative changes
  - Atherosclerosis: blockage or weakening of critical arteries
  - Heart valves and myocardial tissue degenerate, reducing pumping efficiency