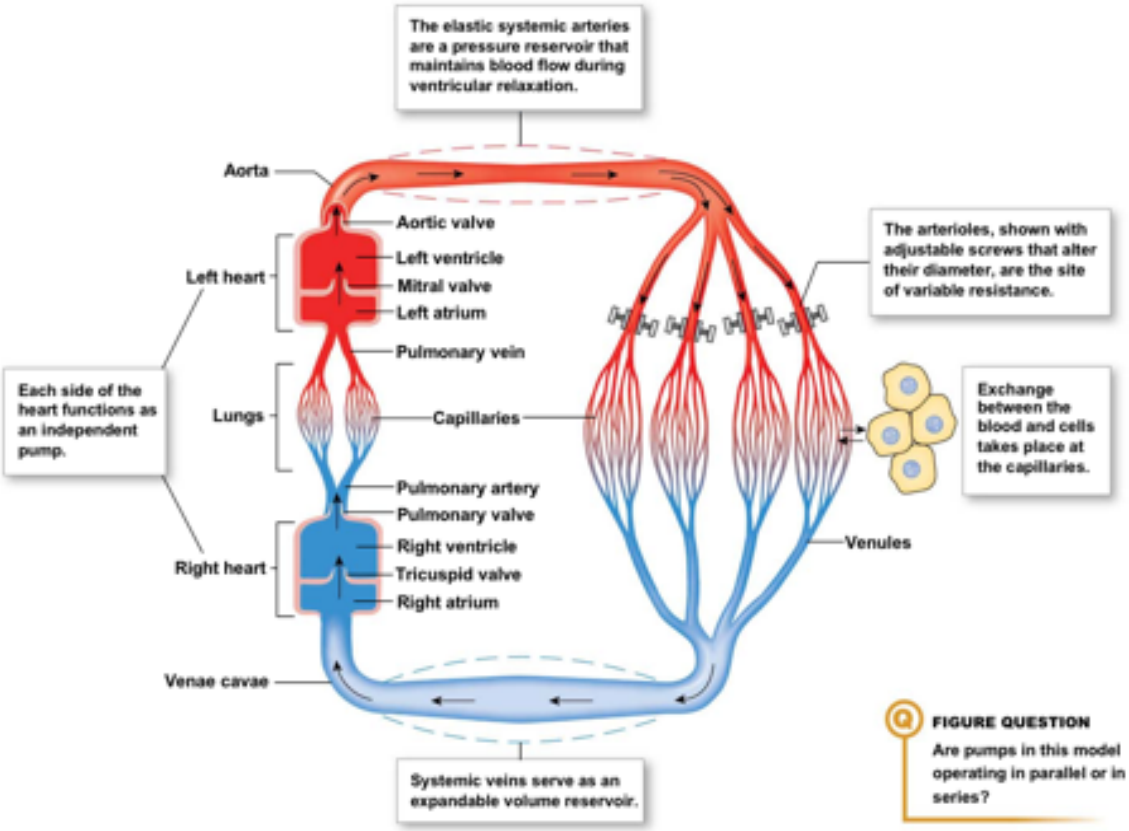
Blood Vessels

Dr. Gary Mumaugh – Campbellsville University

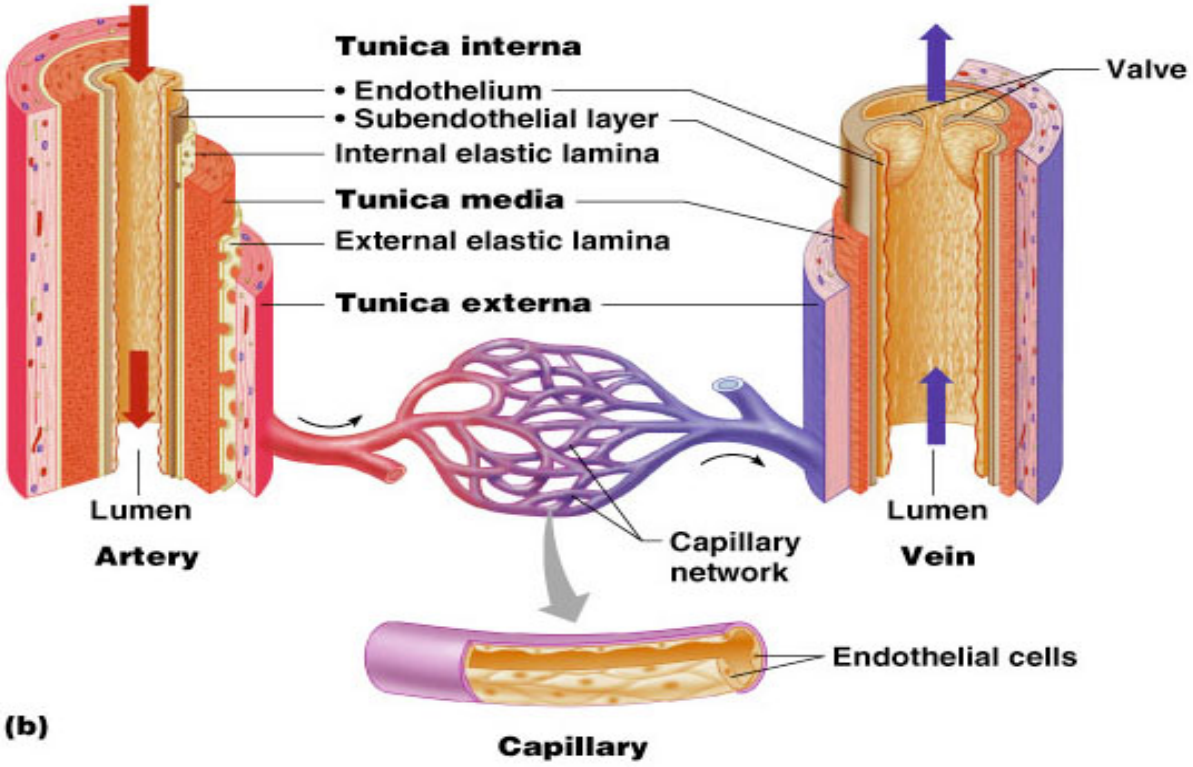
Blood Vessels

- 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

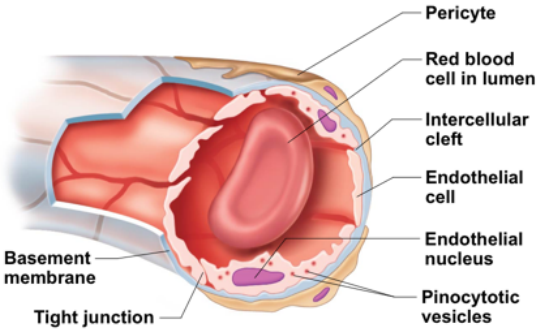


Blood vessels

- 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
  - Diameters range from 2.5 cm to 1 cm
  - Includes the aorta and its major branches
  - High elastin content dampens surge of blood pressure
- Smooth muscle fibers
  - Most numerous in elastic and muscular arteries
  - Exert active tension in vessels when contracting
  - Lie distal to elastic arteries
  - Diameters range from 1 cm to 0.3 mm
  - Includes most named arteries
  - Tunica media is thick
  - Unique features
    - Internal and external elastic laminae

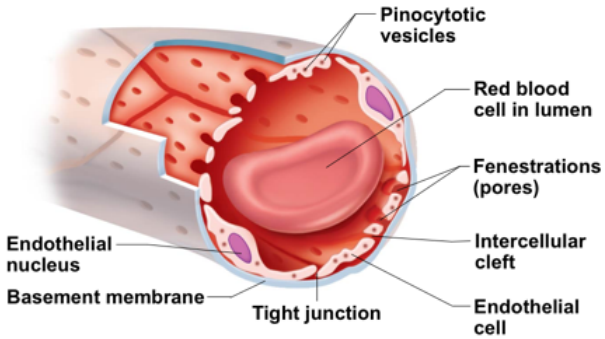
Capillaries are the smallest blood vessels

- 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
- Smallest blood vessels
    - Diameter from 8 to 10 μm
        - Red blood cells pass through single file
    - Site-specific functions of capillaries
        - Lungs—oxygen enters blood, carbon dioxide leaves
        - Small intestines—receive digested nutrients
        - Endocrine glands—pick up hormones
        - Kidneys—remove of nitrogenous wastes



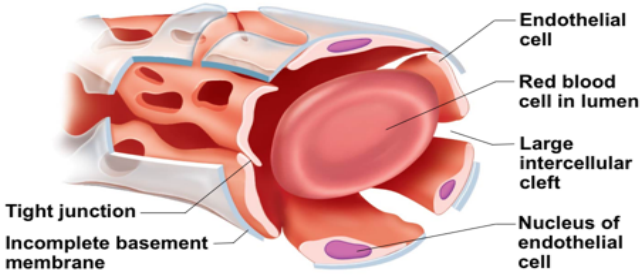
Continuous Capillaries

- Most common type of capillary
- Occur in most organs, found in skin and muscle
- Tight junctions and desmosomes join epithelial cells
- Allow small molecules in and out of capillaries



Fenestrated Capillaries

- Large pores in their endothelium increases permeability
- Occur where high rates of exchange occur
    - Intestines
    - Glomeruli of kidneys
    - Endocrine glands



Sinusoids

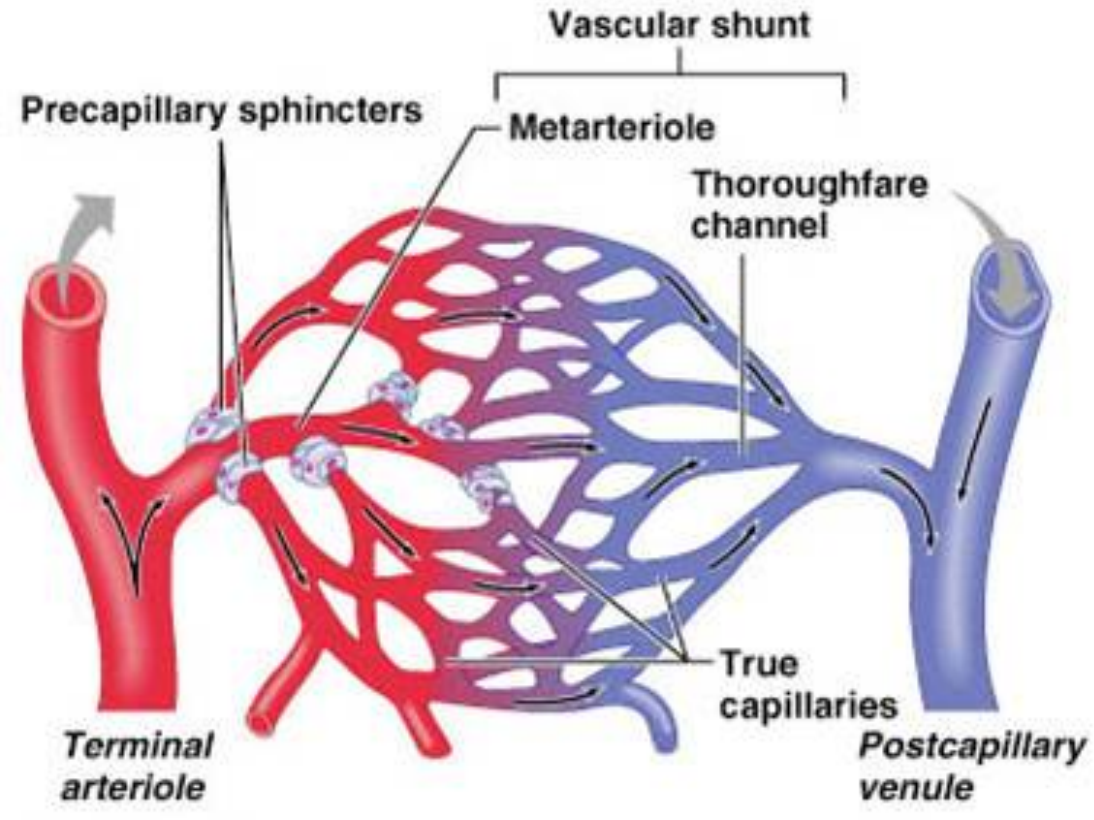
- Most permeable
- Occur in bone marrow and spleen

Low-Permeability Capillaries

- Blood brain barrier
    - Capillaries have complete tight junctions
    - No intercellular clefts are present
    - Vital molecules pass through
        - Highly selective transport mechanisms
    - Not a barrier against:
        - Oxygen, carbon dioxide, and some anesthetic

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 beds
- Network of capillaries running through tissues
- Tendons and ligaments—poorly vascularized
- Epithelia and cartilage—avascular
    - Receive nutrients from nearby connective tissue



Venous Vessels

- Conduct blood from capillaries toward the heart
- Blood pressure is much lower than in arteries
- Venules are the smallest veins
    - Diameters from 8 to 100 μm
    - Smallest venules—called postcapillary venules
- Venules join to form veins
- 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

Veins

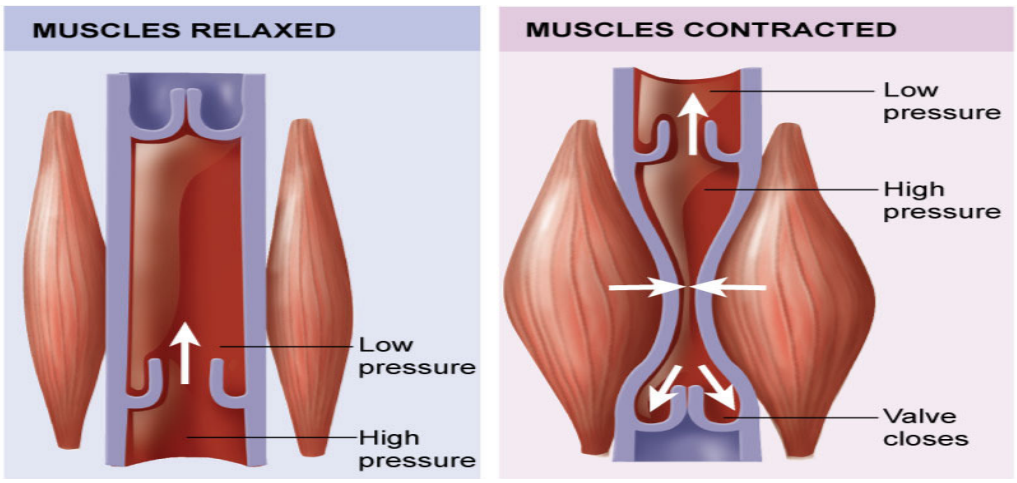
- Structural differences from arteries
    - Lumens are larger
        - *65% of blood in veins at any given time*
    - Tunica externa is thicker
    - Less elastin in walls
    - Walls are thinner than those of comparable arteries

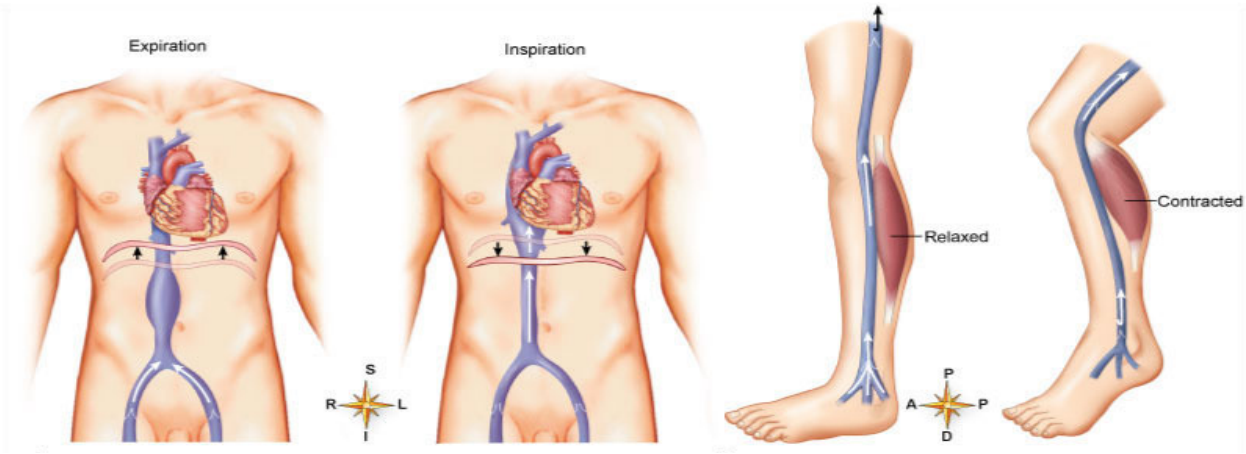
Mechanisms to Counteract Low Venous Pressure

- **Valves** *in some veins*
    - Particularly in limbs
    - Prevent backflow of blood
    - Not located in veins of thoracic and abdominal cavities
- **Skeletal muscle pump**
    - Muscles press against thin-walled veins

Venous Return to the Heart

- Venous return: amount of blood returned to the heart by the veins
- Gravity: the pull of gravity on venous blood while sitting or standing tends to cause a decrease in venous return (orthostatic effect)
- Venous pumps: blood-pumping action of respirations and skeletal muscle contractions facilitate venous return by increasing pressure gradient between peripheral veins and venae cavae
- Three main mechanisms of venous return to the heart:
    - Respiratory pump mechanism- pressure changes occur in the thoracic and abdominal cavities during inspiration and expiration. This compresses veins and assists blood return to the heart.
    - Skeletal muscle contractions: promote venous return by squeezing veins through a contracting muscle and milking the blood toward the heart
    - One-way valves in veins prevent backflow





Vascular Anastomoses

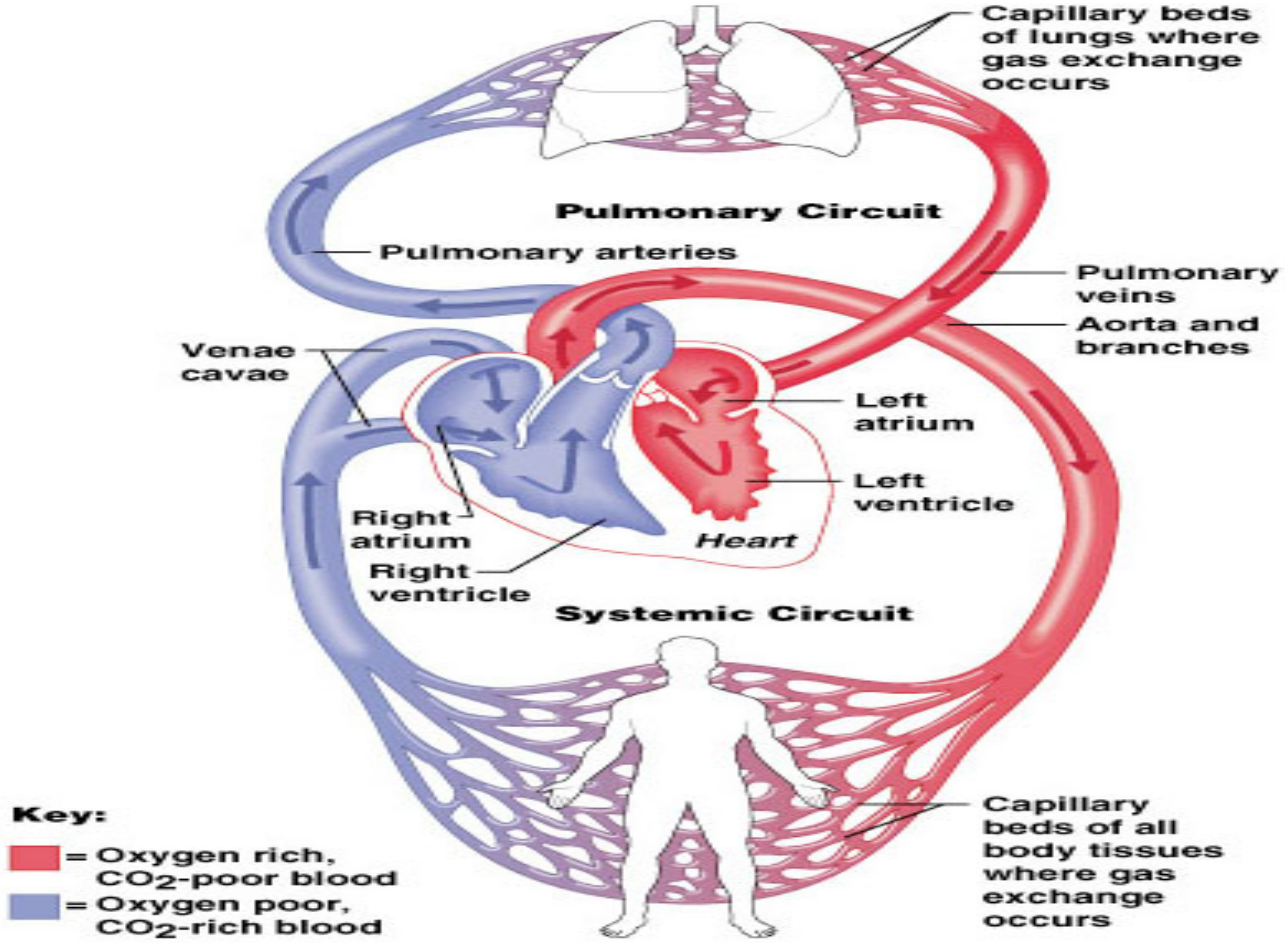
- Vessels interconnect to form **vascular anastomoses**
    - Organs receive blood from more than one arterial source
- Neighboring arteries form **arterial anastomoses**
    - Provide collateral channels
- Veins anastomose more frequently than arteries

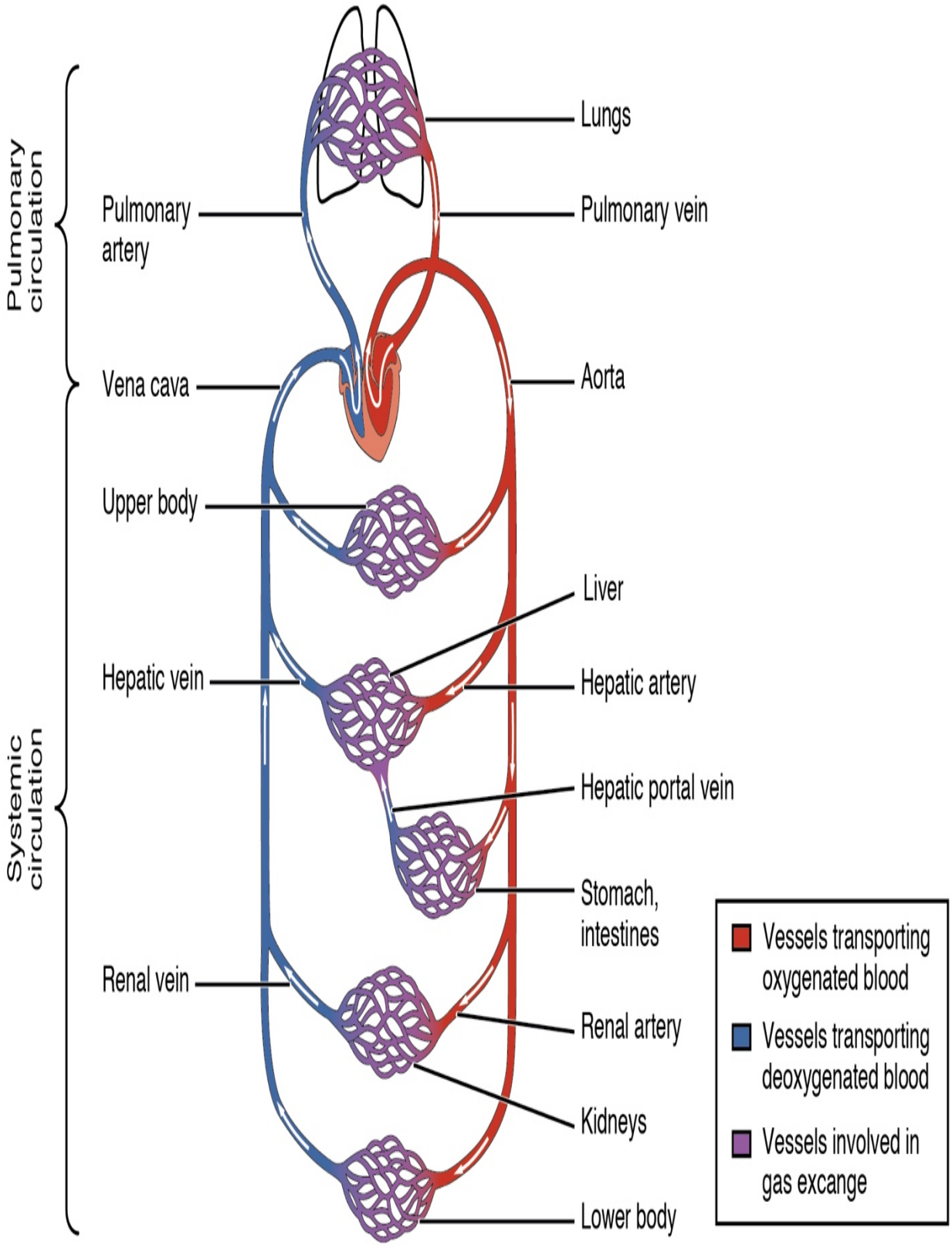
Circulatory Pathways

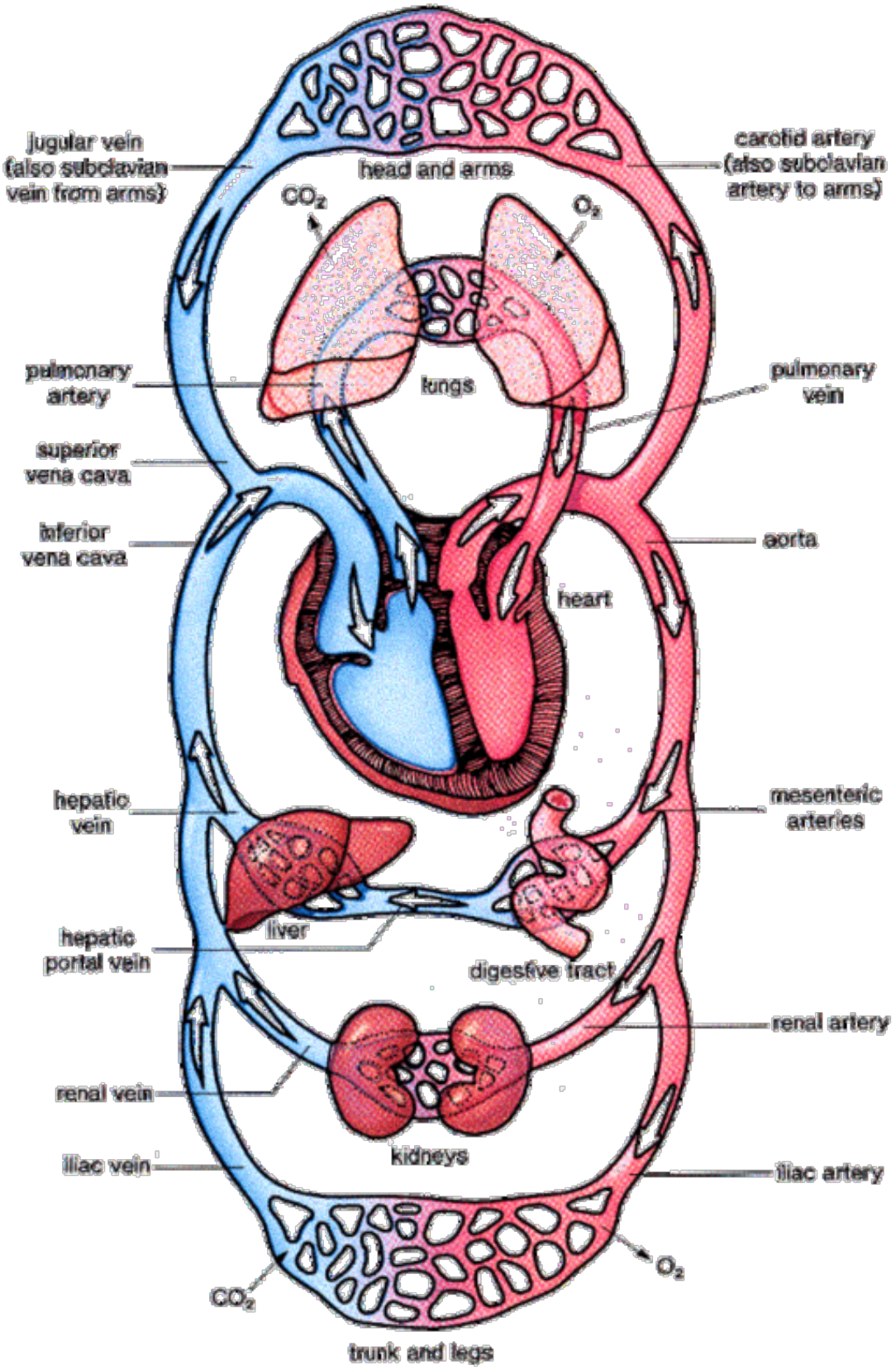
- The vascular system has two distinct circulations
    - **Pulmonary Circulation**
        - Short loop that runs from the heart to the lungs and back to the heart
        - **Pulmonary trunk**
            - Leaves the right ventricle
            - Divides into right and left pulmonary arteries
        - Superior and inferior pulmonary veins
        - Carry oxygenated blood into the left atrium
        - Vessels of pulmonary circuit
            - Thinner walls than systemic vessels
            - Maximum arterial pressure lower in pulmonary circuit

Circulatory Pathways

- **Systemic Circulation**
  - Routes blood through a long loop to all parts of the body and returns to the heart Systemic arteries
  - Carry oxygenated blood away from the heart
  - **Aorta**—largest artery in the body




Pulmonary circulation
Systemic circulation
Lungs
Pulmonary artery
Pulmonary vein
Vena cava
Aorta
Upper body
Liver
Hepatic vein
Hepatic artery
Hepatic portal vein
Stomach, intestines
Renal vein
Renal artery
Kidneys
Lower body
Vessels transporting oxygenated blood
Vessels transporting deoxygenated blood
Vessels involved in gas excange


jugular vein
(also subclavian
vein from arms)
head and arms
carotid artery
(also subclavian
artery to arms)
CO_2
O_2
pulmonary
artery
lungs
pulmonary
vein
superior
vena cava
inferior
vena cava
aorta
heart
hepatic
vein
mesenteric
arteries
liver
hepatic
portal vein
digestive tract
renal artery
renal vein
kidneys
iliac vein
iliac artery
O_2
CO_2
trunk and legs

Localized Blood Flow

- Blood flow to skeletal muscle
    - When muscles become active, hyperemia is directly proportional to greater metabolic activity of the muscle (active or exercise hyperemia)
    - Muscle blood flow can increase tenfold or more during physical activity as vasodilation occurs
- Blood flow to skin
    - Helps maintain body temperature
    - Provides a blood reservoir
- Blood flow to the brain
    - Is constant, as neurons are intolerant of ischemia
    - Brain is extremely sensitive to declines in pH
    - The brain can regulate its own blood flow in certain circumstances, such as ischemia caused by a tumor
    - The brain is vulnerable under extreme systemic pressure changes
        - MAP below 60mm Hg can cause syncope (fainting)
        - MAP above 160 can result in cerebral edema
- Blood flow to the lungs
    - Blood flow in the pulmonary circulation is unusual in that:
        - The pathway is short
        - Arteries/arterioles are more like veins/venules (thin-walled, with large lumens)

Measuring Blood Pressure

- Arterial blood pressure
    - Measured with a sphygmomanometer and stethoscope; listen for Korotkoff sounds as the pressure in the cuff is gradually decreased
    - Systolic blood pressure: force of the blood pushing against the artery walls while ventricles are contracting
    - Diastolic blood pressure: force of the blood pushing against the artery walls when ventricles are relaxed
    - Pulse pressure: difference between systolic and diastolic blood pressure
- The first sound heard is recorded as the systolic pressure
- The pressure when sound disappears is recorded as the diastolic pressure

Variations in Blood Pressure

- Blood pressure cycles over a 24-hour period
- BP peaks in the morning due to waxing and waning levels of retinoic acid
- Extrinsic factors such as age, sex, weight, race, mood, posture, socioeconomic status, and physical activity may also cause BP to vary
- Alterations in Blood Pressure
    - Hypotension – low BP in which systolic pressure is below 100 mm Hg
    - Hypertension – condition of sustained elevated arterial pressure of 140/90 or higher

Hypertension

- Hypertension maybe transient or persistent
- Primary or essential hypertension – risk factors in primary hypertension include diet, obesity, age, race, heredity, stress, and smoking
- Secondary hypertension – due to identifiable disorders, including excessive renin secretion, arteriosclerosis, and endocrine disorders

Developmental Aspects

- Blood vessels are trouble-free during youth
- Vessel formation occurs:
    - As needed to support body growth
    - For wound healing
    - To rebuild vessels lost during menstrual cycles
- With aging, varicose veins, atherosclerosis, and increased blood pressure may arise

Blood Vessels in Adulthood

- **Atherosclerosis** begins in youth
- Consequences evident in middle to old age
- Males
- Between ages 45 and 65, more males than females experience atherosclerosis
- Experience heart disease and atherosclerosis later in life