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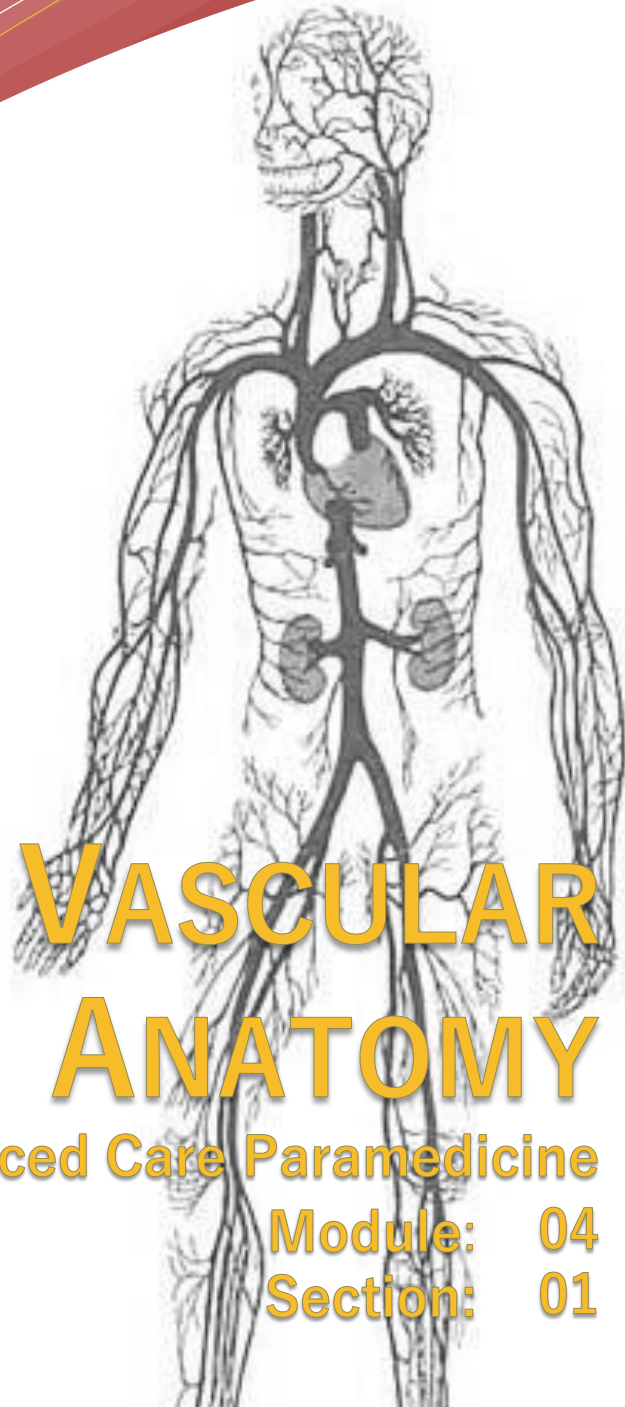


Vascular Anatomy

Advanced Care Paramedicine

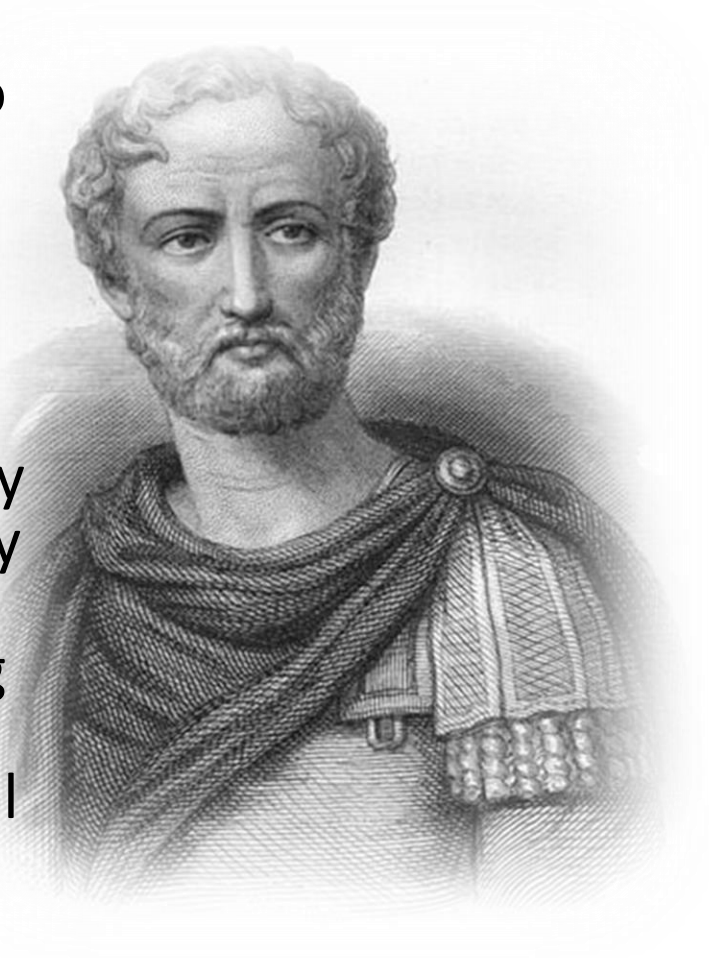
Module: 04
Section: 01

Objectives

- Understand the historical progression of knowledge regarding the components and function of the cardiovascular system.
- Identify the blood vessels of the body used for intravenous cannulation and phlebotomy.
- Recognize the anatomical components of the vasculature.

Pliny the Elder
Rome 23-79 A.D.

- "The arteries have no sensation, for they even are without blood, nor do they all contain the breath of life; and when they are cut only the part of the body concerned is paralyzed...the veins spread underneath the whole skin, finally ending in very thin threads, and they narrow down into such an extremely minute size that the blood cannot pass through them nor can anything else but the moisture passing out from the blood in innumerable small drops which is called sweat."



Galen, Greece
2nd Century A.D.

- Believed and taught
- The heart was a "sucking" organ.
- Two distinct types of blood.
  - Nutritive blood
  - Vital blood

William Harvey, England
1578 - 1657

- The father of cardiovascular medicine
- Physician to King James I and King Charles I
- Studied the cardiovascular system in cadavers and live animals
- Proved Galen wrong

William Harvey
1578 - 1657

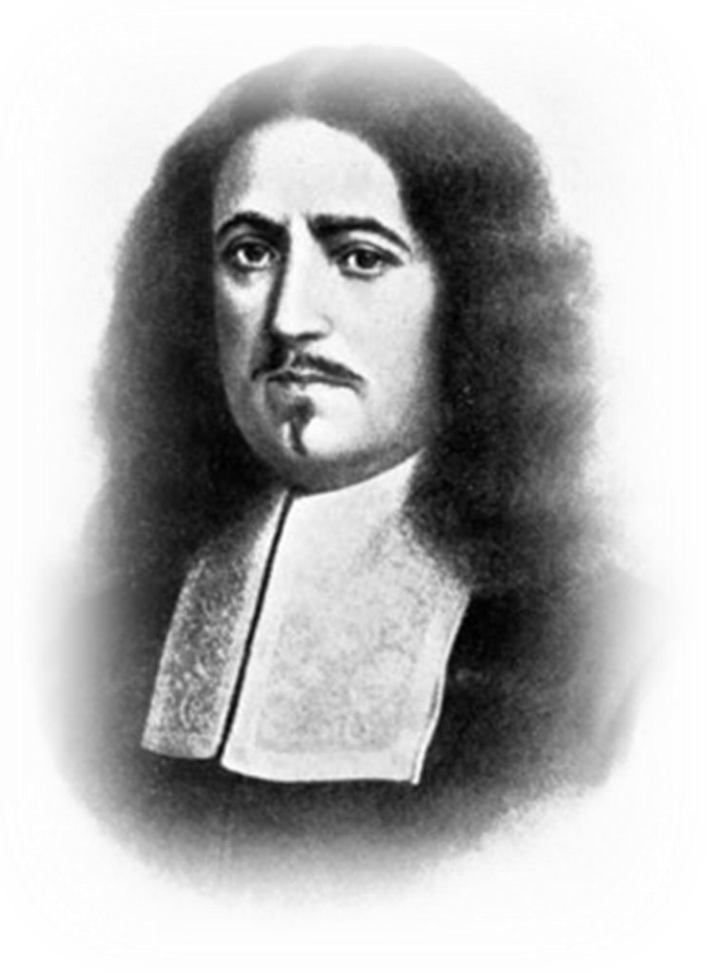
- Discovered the veins and arteries in the septum
- Theorized that arteries and veins were connected by capillaries

William Harvey
1578 - 1657

- Harvey's "On the Movement of the Heart and Blood in Animals" - 1628
- Identified
  - heart circulates the same blood
  - physically impossible to eat/drink enough to replace blood volume daily
- Was not published for thirteen years due to fear
- Was not accepted for more than twenty years
- More questions raised than answered

Marcello Malpighi, Italy
1628 - 1694

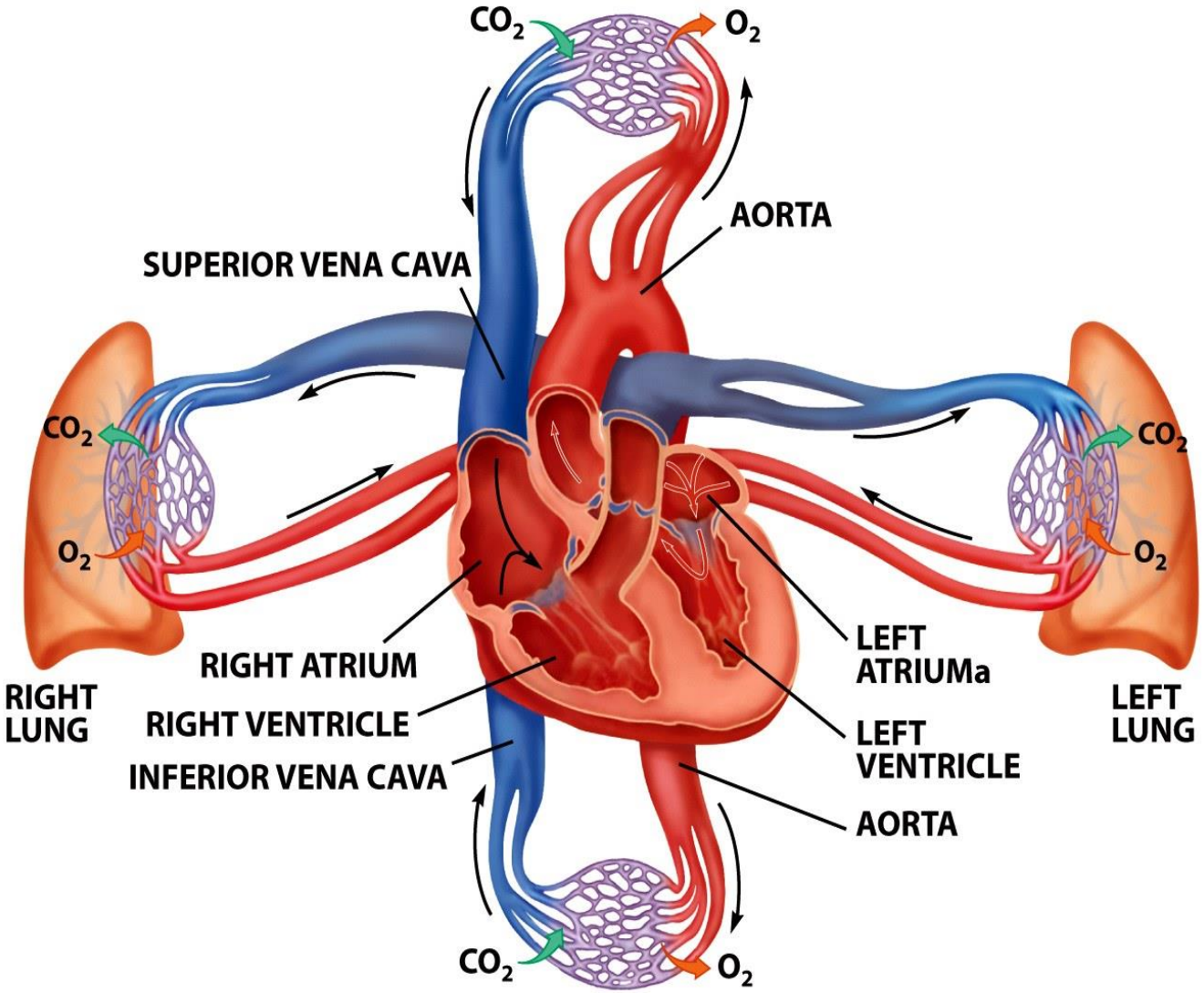
- First serious biological student using the microscope.
- Discovered capillaries under microscopy after Harvey's death



The Vessels

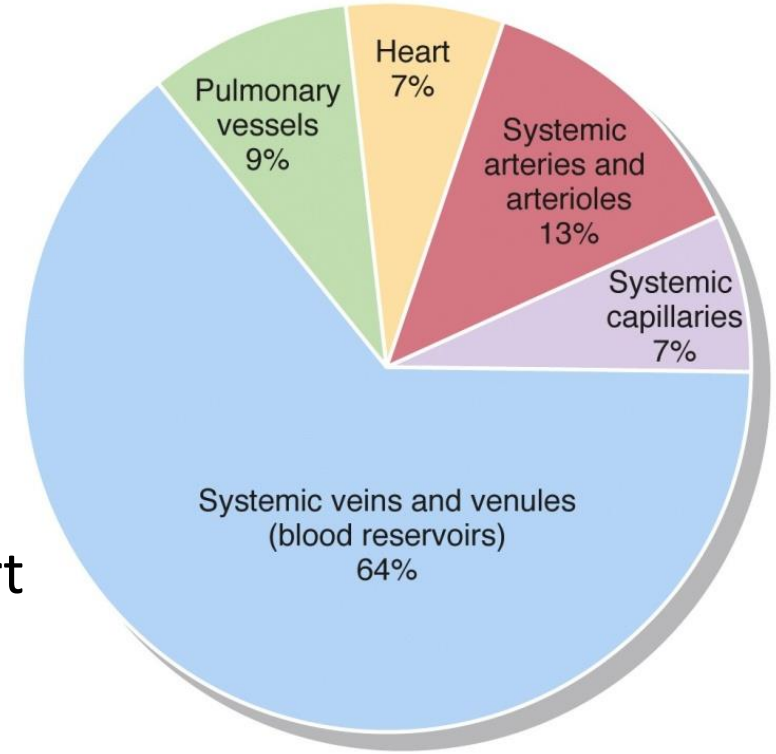
- Are the channels where blood is distributed throughout the body to the tissues
- Make up the two closed systems
  - Pulmonary Vessels
  - Systemic Vessels
- Are classified as:
  - Arteries
  - Capillaries
  - Veins

The Vessels


CO_2
O_2
AORTA
SUPERIOR VENA CAVA
CO_2
O_2
CO_2
O_2
RIGHT ATRIUM
RIGHT VENTRICLE
INFERIOR VENA CAVA
LEFT ATRIUMa
LEFT VENTRICLE
AORTA
RIGHT LUNG
LEFT LUNG
CO_2
O_2

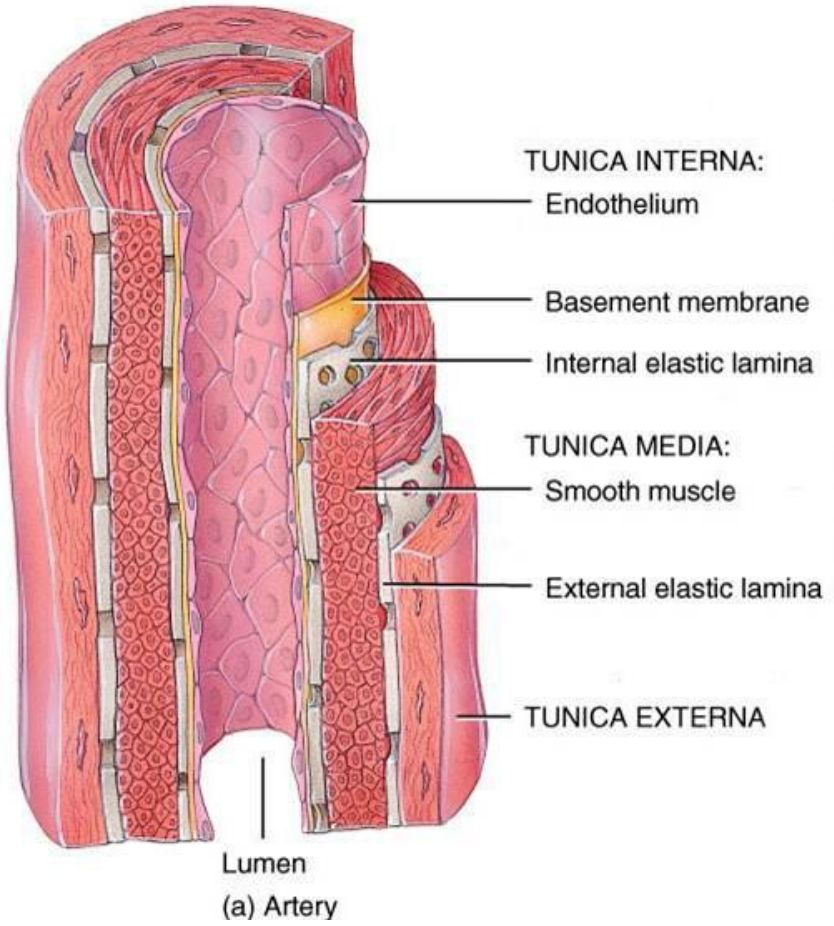
Vessel Structure and Function

- Blood Vessel Types
  - Arteries
    - Carries blood away from the heart
  - Capillaries
    - Site of nutrient and gas exchange
  - Veins
    - Carry blood towards the heart



Arteries

- Carry blood away from the heart
- Typically contains oxygenated blood
- Have about 10% of total volume



Arteries

- Composed of three layers
  - Inner
    - Tunica Intima (tunica interna)
    - Continuous smooth lining of endothelium cells
  - Middle
    - Tunica Media (THICKEST)
    - Smooth muscle layer
    - Contain Vasa Vasorum that provide blood supply to the vessel
  - Outer
    - Tunica Externa (tunica adventitia)
    - Strong flexible tissue which helps hold the vessel open and prevents tearing during movement
    - Contain Vasa Vasorum that provide blood supply to the vessel

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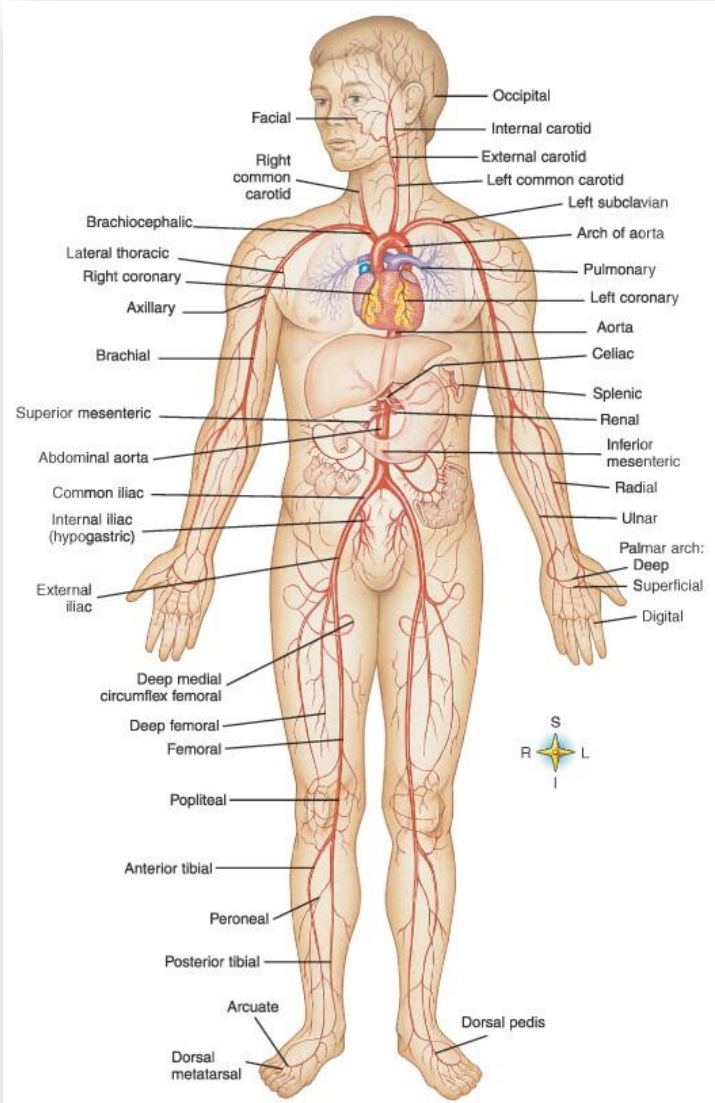
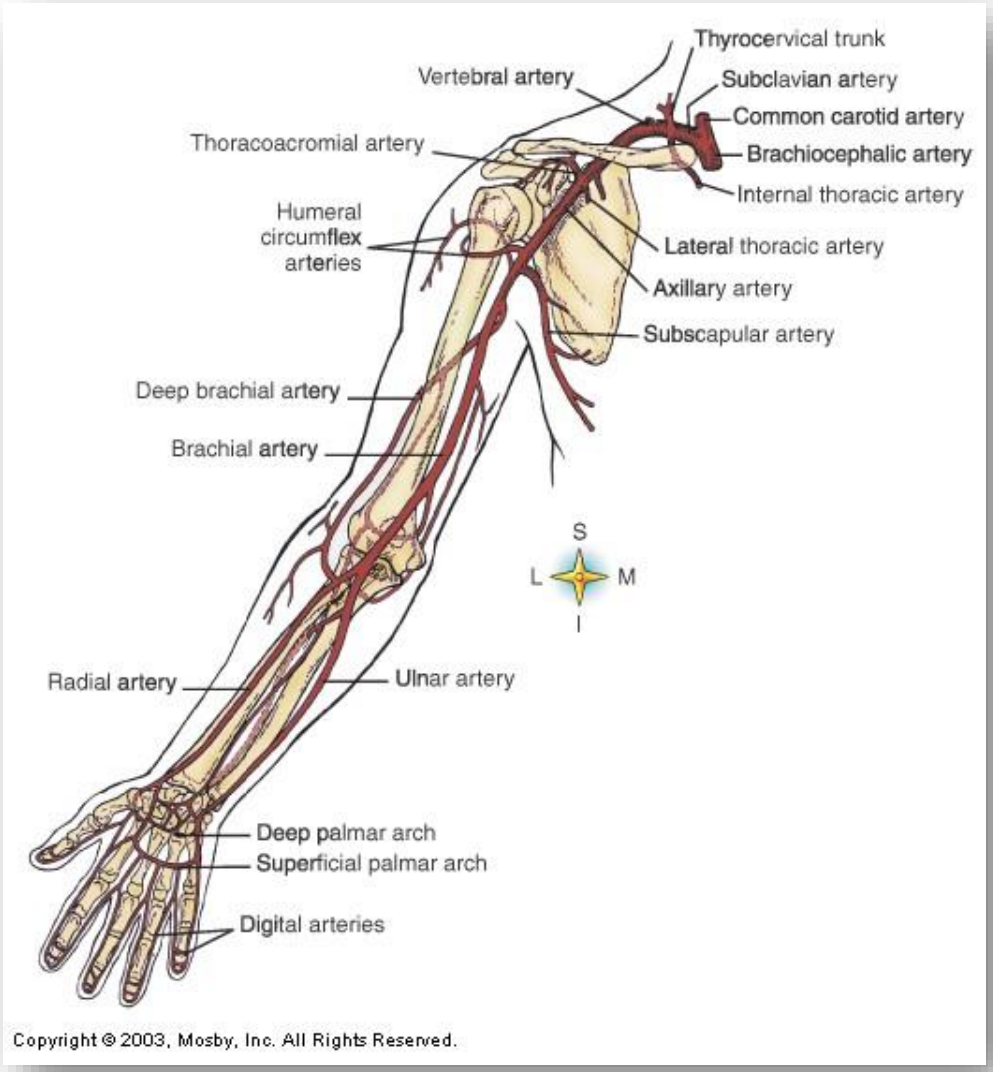
Arteries



Arteries


Thyrocervical trunk
Vertebral artery
Subclavian artery
Common carotid artery
Thoracoacromial artery
Brachiocephalic artery
Internal thoracic artery
Humeral circumflex arteries
Lateral thoracic artery
Axillary artery
Subscapular artery
Deep brachial artery
Brachial artery
S
L
M
I
Radial artery
Ulnar artery
Deep palmar arch
Superficial palmar arch
Digital arteries
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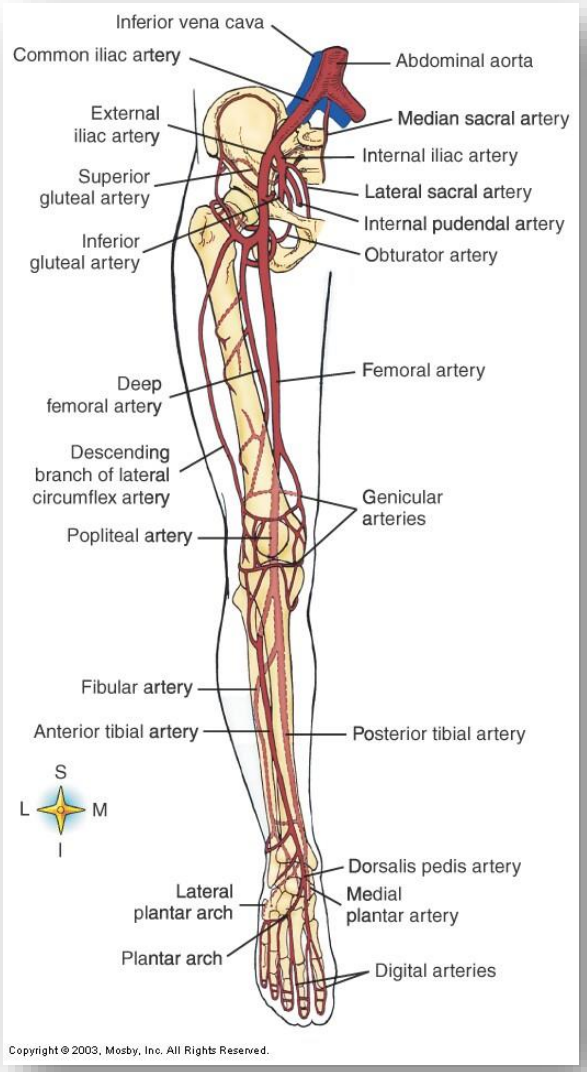
Inferior vena cava
Common iliac artery
Abdominal aorta
External iliac artery
Median sacral artery
Internal iliac artery
Superior gluteal artery
Lateral sacral artery
Internal pudendal artery
Inferior gluteal artery
Obturator artery
Femoral artery
Deep femoral artery
Descending branch of lateral circumflex artery
Genicular arteries
Popliteal artery
S
L
M
I
Fibular artery
Anterior tibial artery
Posterior tibial artery
Dorsalis pedis artery
Lateral plantar arch
Medial plantar artery
Plantar arch
Digital arteries
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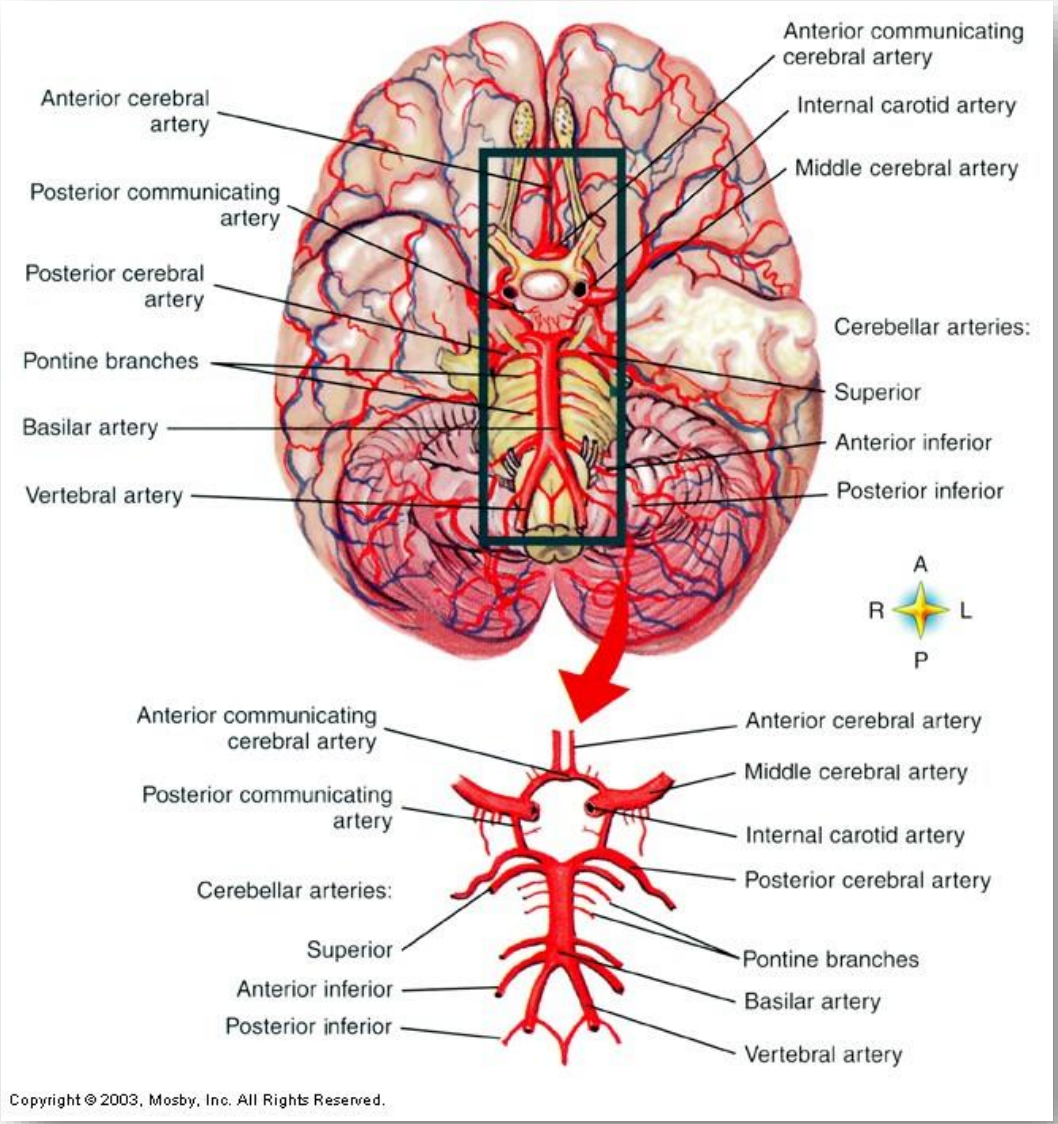
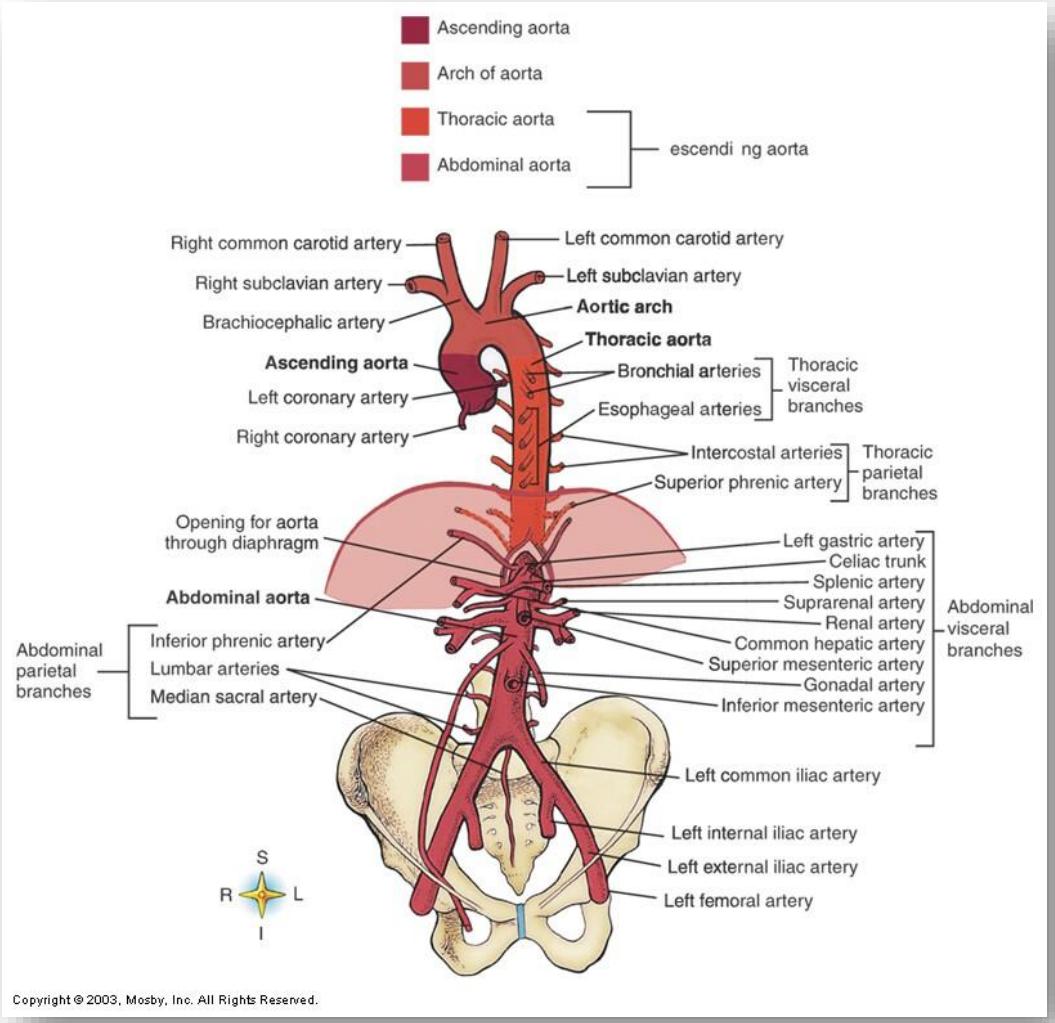
Arteries



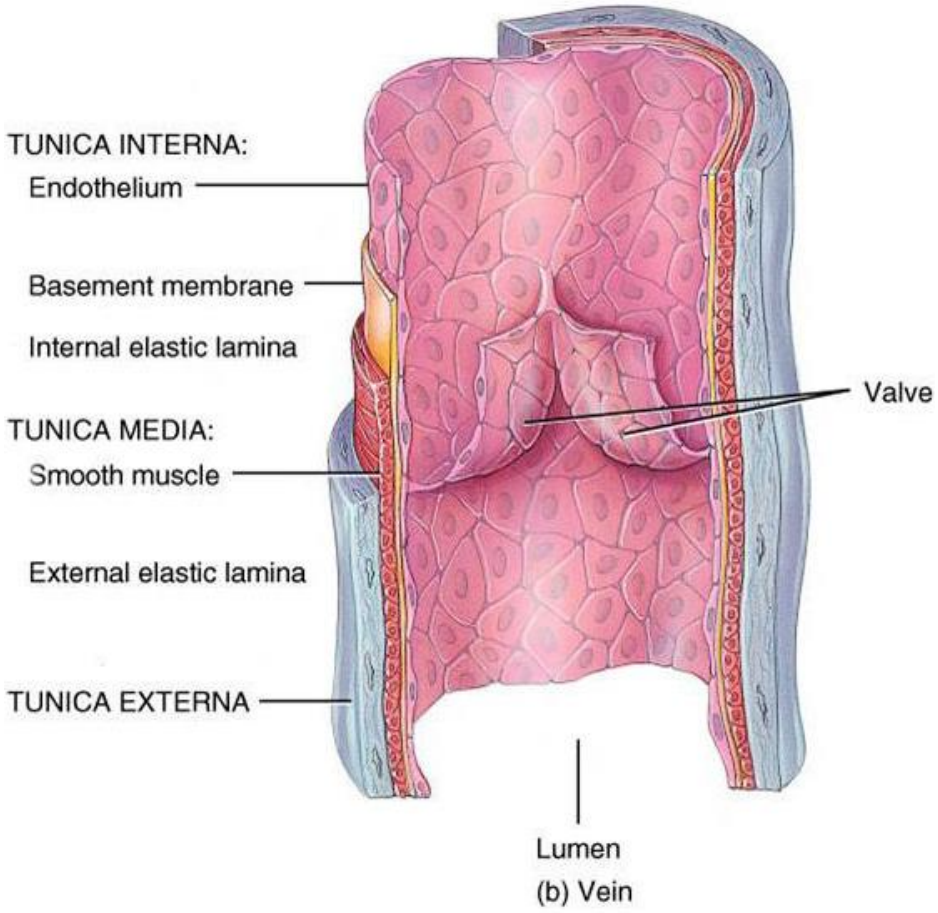
Aorta

- Largest artery
- Branches lead to all the organs of the body, supplying them with oxygen and nutrients.



Veins

- Carry blood towards the heart
- Typically contains deoxygenated blood
- Leaving capillaries, it enters venules and enlarges to form veins
- Are less rigid so can hold more blood (70% of total volume)

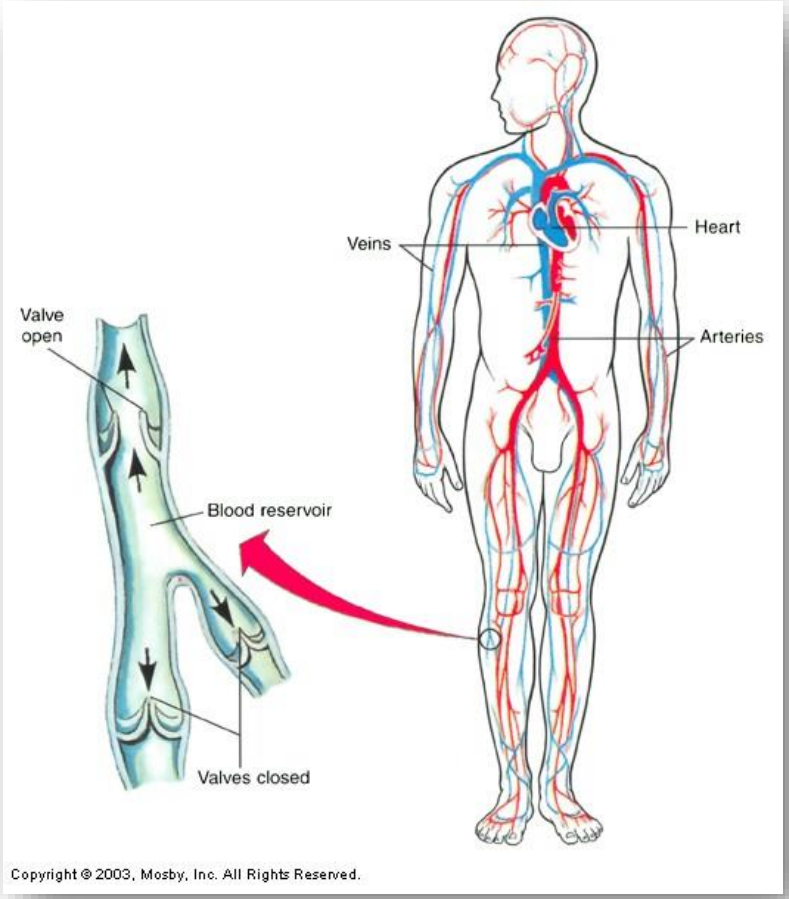


Veins

- 3 Layers
  - Inner
    - Tunica Intima (tunica interna)
    - Endothelium cells produce semi-lunar valves
  - Middle
    - Tunica Media
    - Smooth muscle layer (thinner than arteries)
  - Outer
    - Tunica Externa (tunica adventitia)

Venous Blood Reservoir

- Have great capacity to stretch (capacitance)
- Allows for accommodation of large amounts of blood with NO change in BP
- Allows for venous circulation based on pressure from valve below



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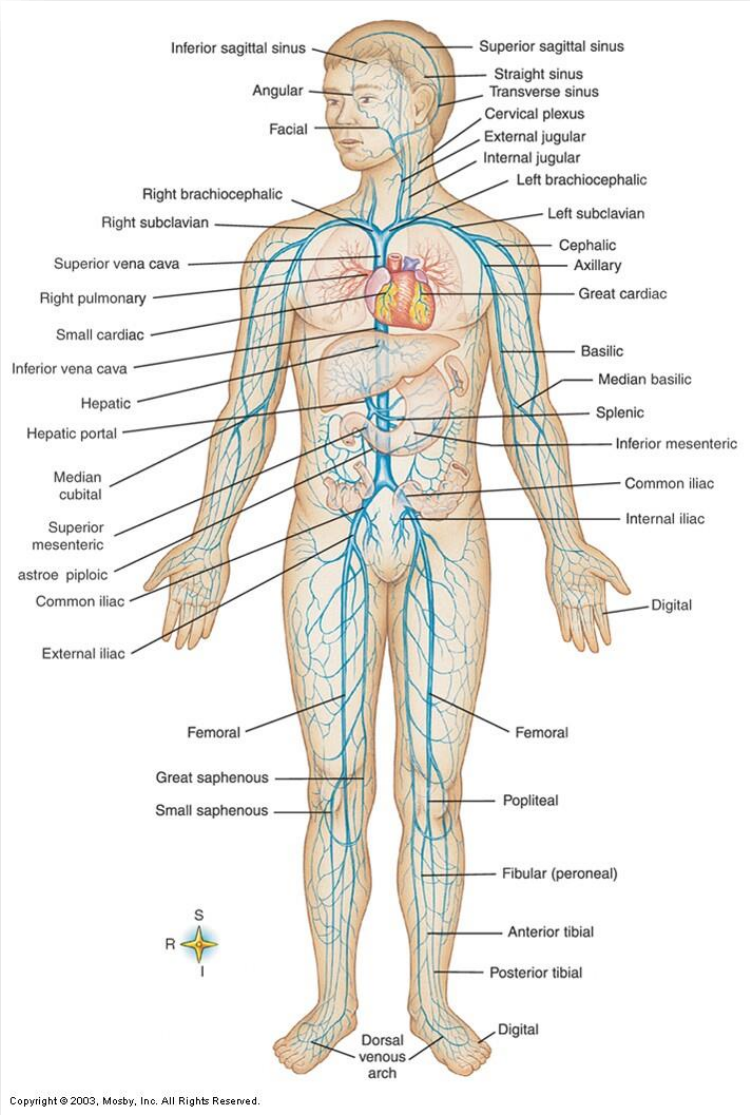
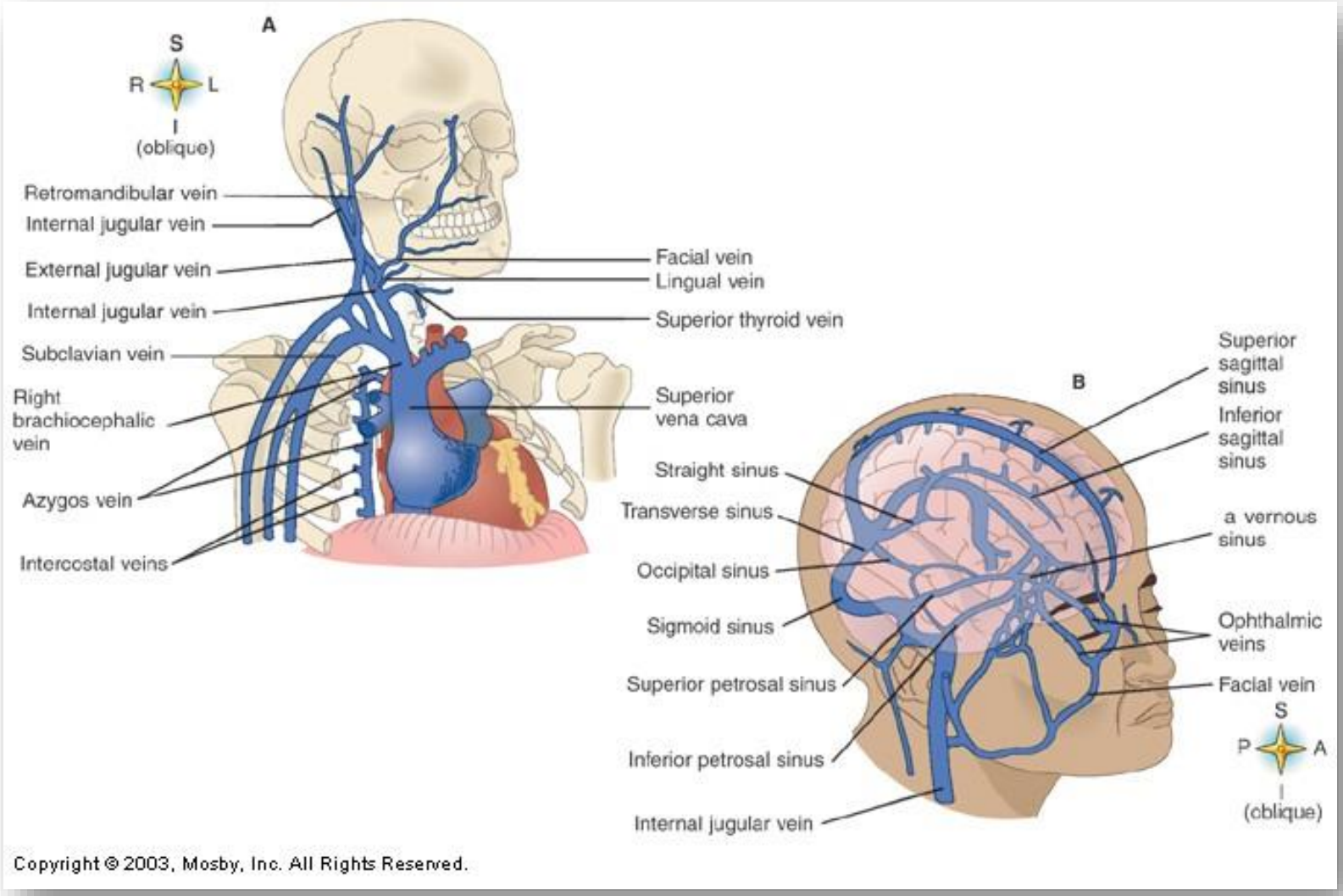
Veins



Veins



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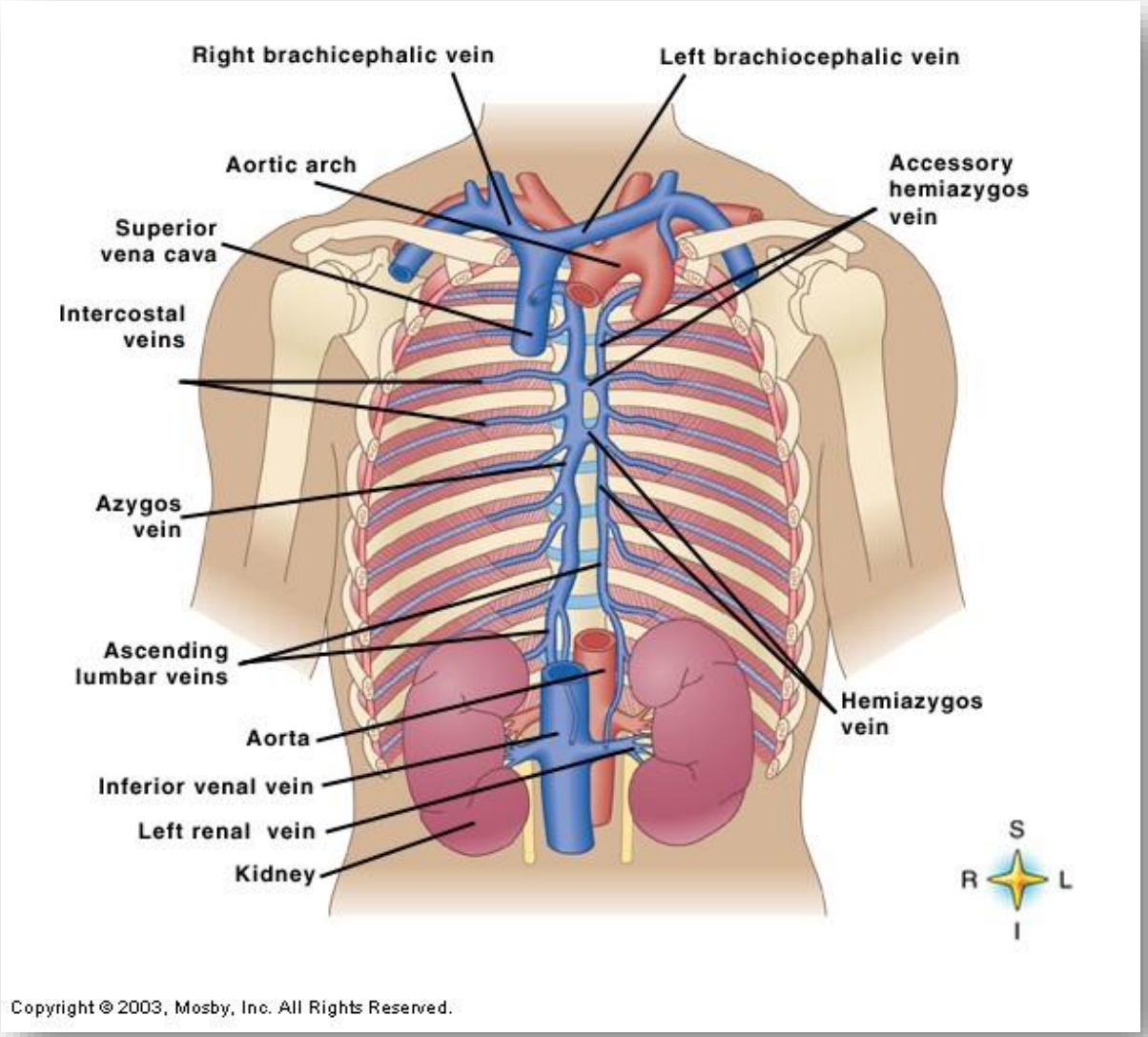
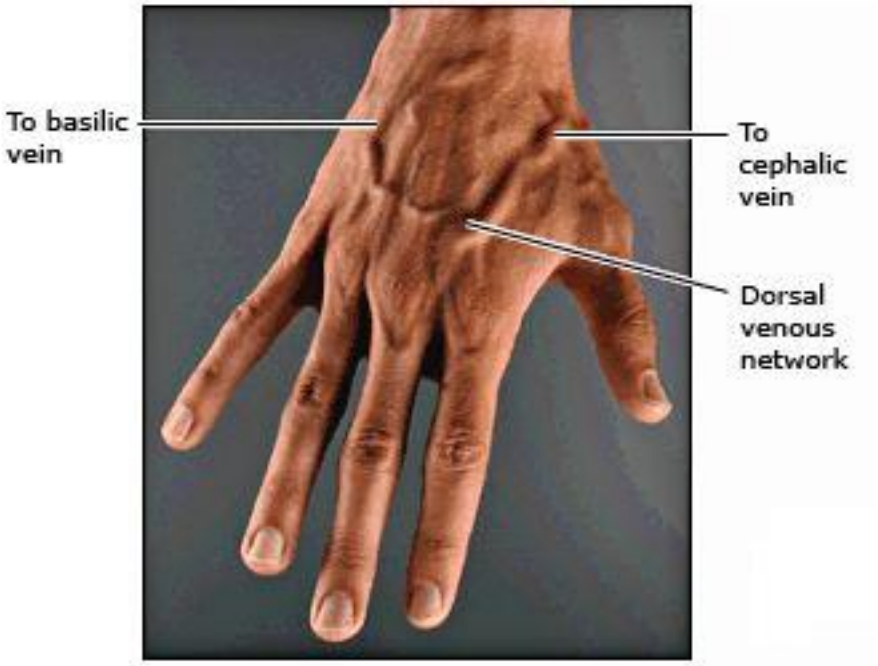
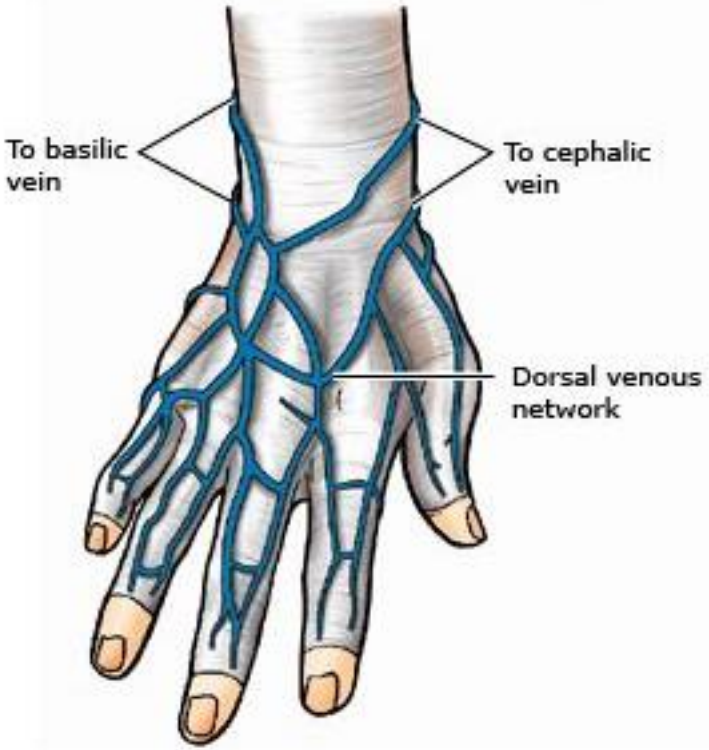
Veins

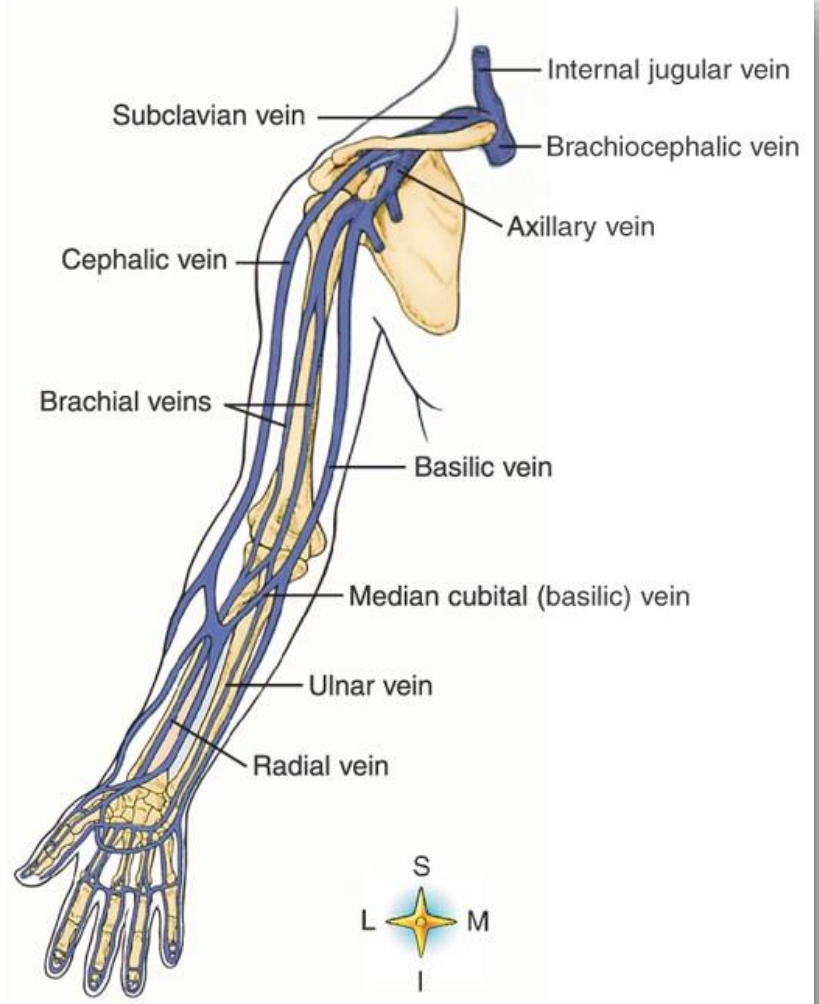


Veins


To basilic vein
To cephalic vein
Dorsal venous network


To basilic vein
To cephalic vein
Dorsal venous network

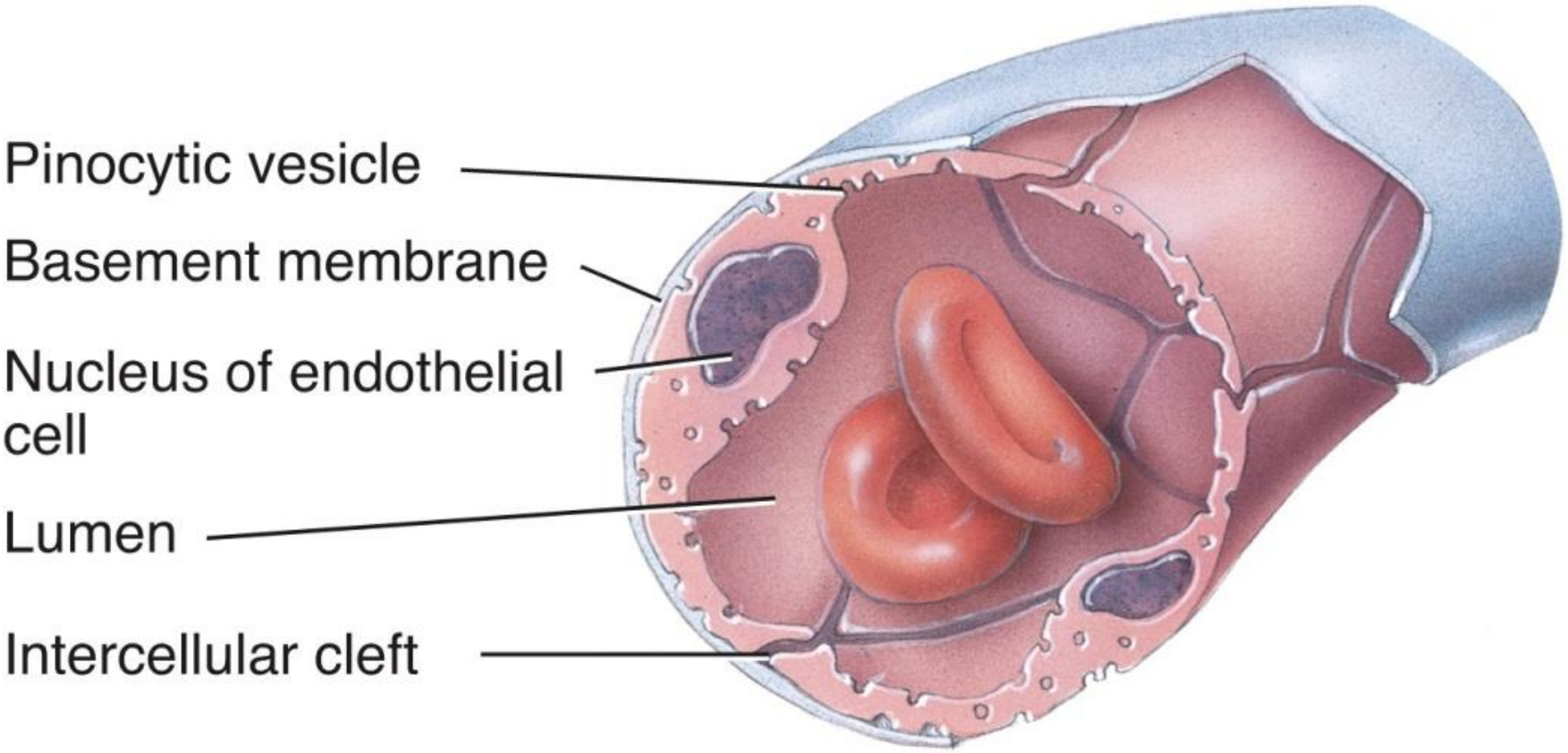
Veins



Capillaries

- Smallest and most numerous
  - Contain about 5% of total volume
- Are the connection between the arteries to the veins
- Are composed of only the endothelium
- Distribution is based on metabolic needs
  - Liver, muscle, kidneys have extensive network
  - Epidermis, lens and cornea have none

Capillaries

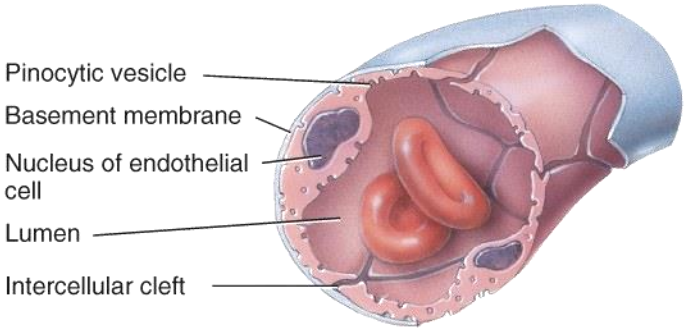


(a) Continuous capillary formed by endothelial cells

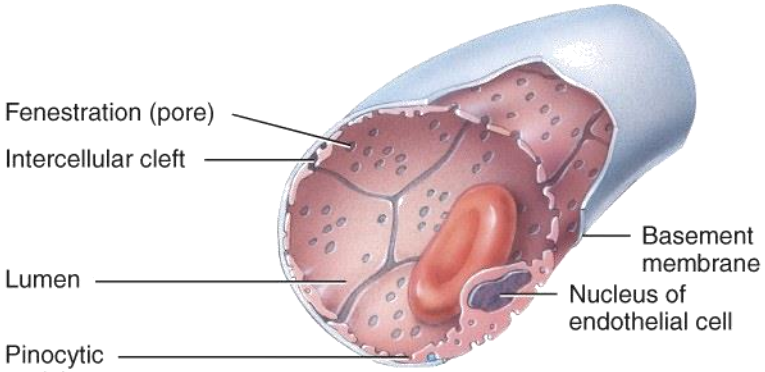
Vessel Structure and Function

- The body contains three types of capillaries:
  - Continuous capillaries are the most common with endothelial cells forming a continuous tube, interrupted only by small intercellular clefts.
  - Fenestrated capillaries (fenestra = windows), found in the kidneys, villi of small intestines, and endocrine glands are much more porous.
  - Sinusoids form very porous channels through which blood can percolate, e.g., in the liver and spleen.

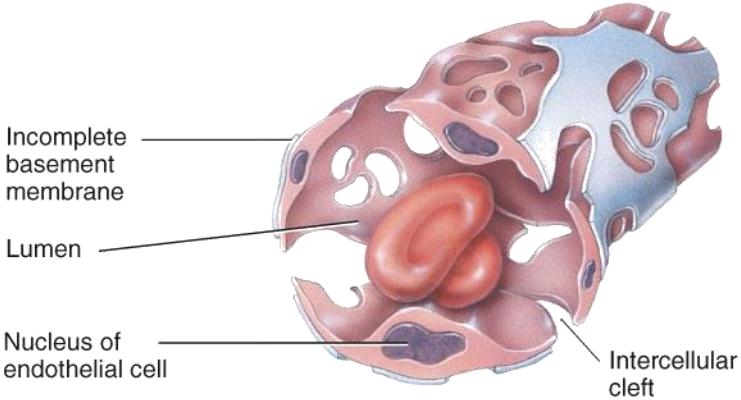
Vessel Structure and Function



(a) Continuous capillary formed by endothelial cells



(b) Fenestrated capillary



(c) Sinusoid

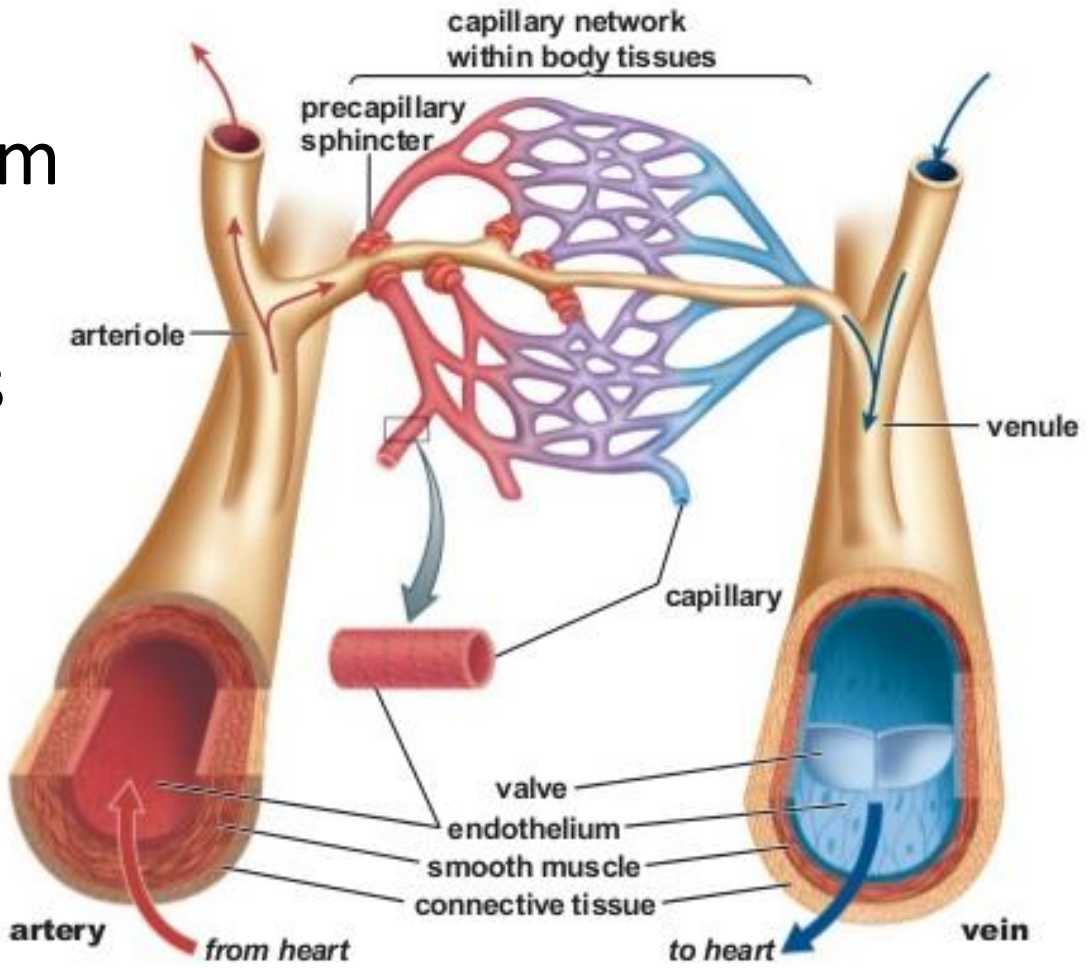
3 Types of capillaries in the body

Capillaries

- Have vital role in exchange of gases, nutrients and waste between blood and tissue
  - Thin wall (one cell thick) with fenestrations
  - Provide the slowest rate of speed of blood in the system
  - Tissues are surrounded by extracellular fluid called interstitial fluid
- Blood flow into capillaries is regulate by smooth muscle (pre-capillary sphincters)
  - If constricted blood is directed through metarterioles (arteriovenous anastomoses or AV shunts)

Capillary Microcirculation

- 90% of fluid is returned to system
- 10% collected by lymphatic vessels and returned to circulation in venous blood



Factors Affecting Movement

- Net Filtration (Starling's law of the capillaries)
- Net filtration = forces favoring filtration vs. forces opposing filtration
  - Forces favoring filtration
    - Blood Hydrostatic pressure (BHP)
    - Interstitial fluid colloid osmotic pressure (IFCOP)
  - Forces opposing filtration
    - Blood Colloid Osmotic pressure (BCOP)
    - Interstitial fluid hydrostatic pressure (IFHP)
  - Other factors
    - Tonicity
    - Membrane permeability

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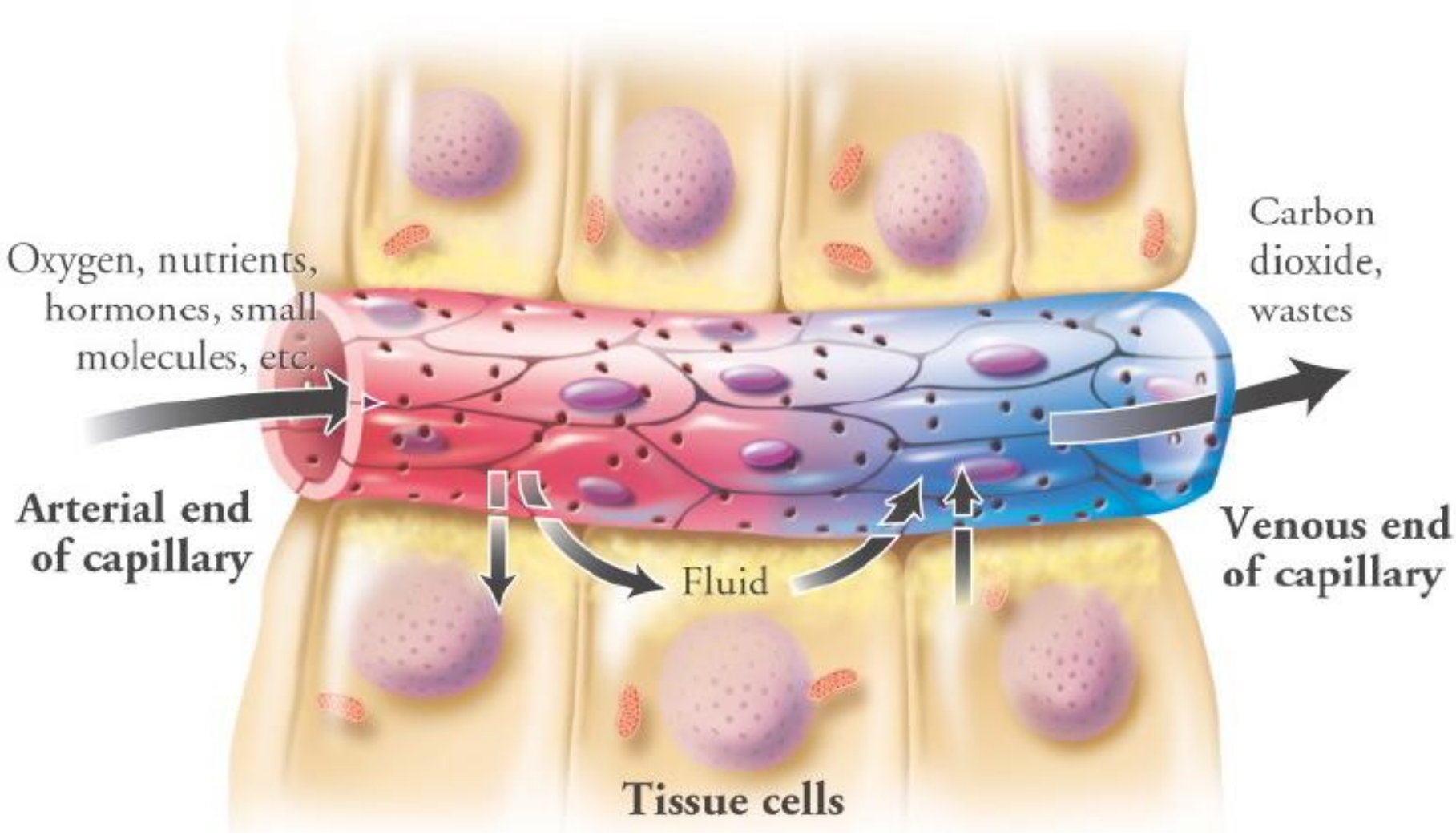
Factors Affecting Movement

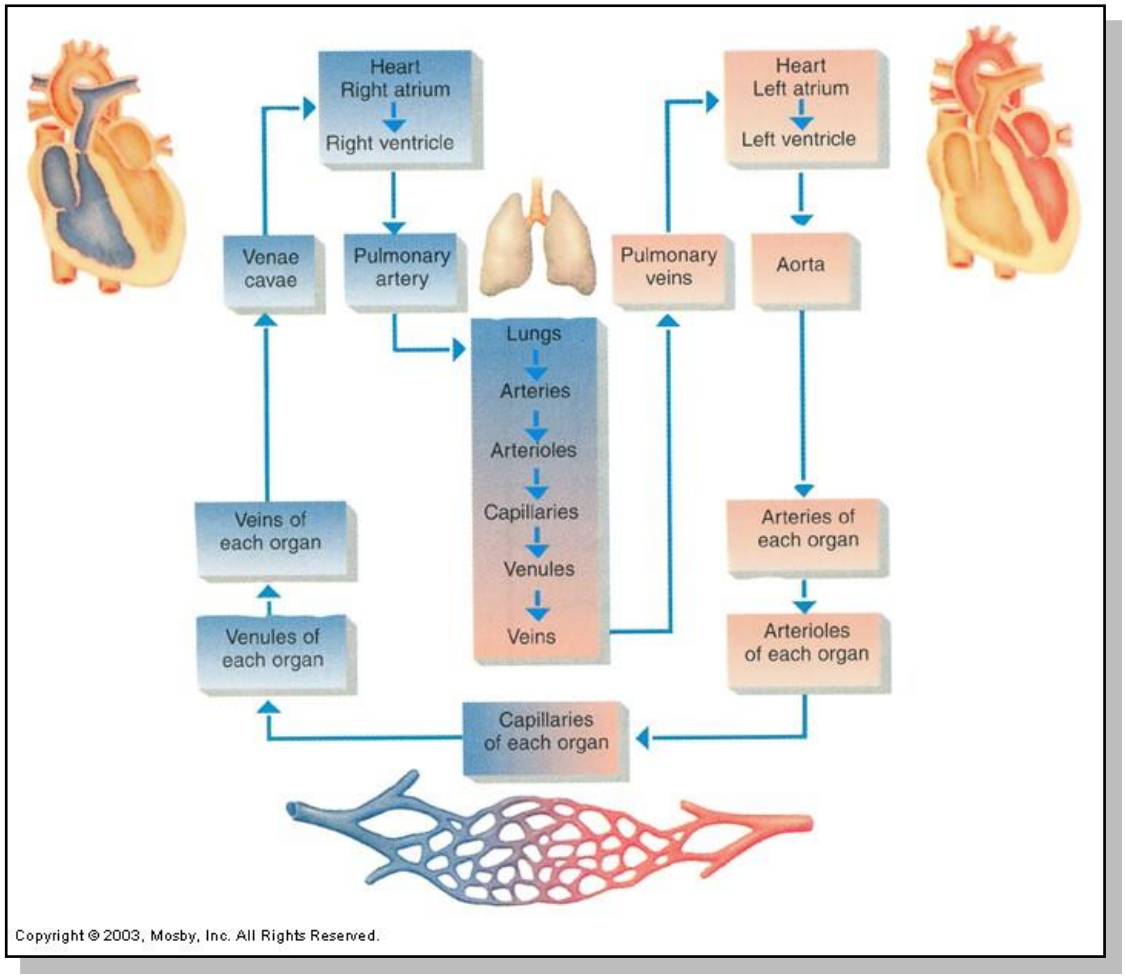


Blood Flow

- Is the movement of blood through the body
- Moves from an area of high pressure to an area of low pressure
  - Highest pressure
    - with systolic contraction of heart
  - Lowest pressure
    - found in vena cava as it enters the R atrium (pressure in R atrium is also known as central venous pressure)

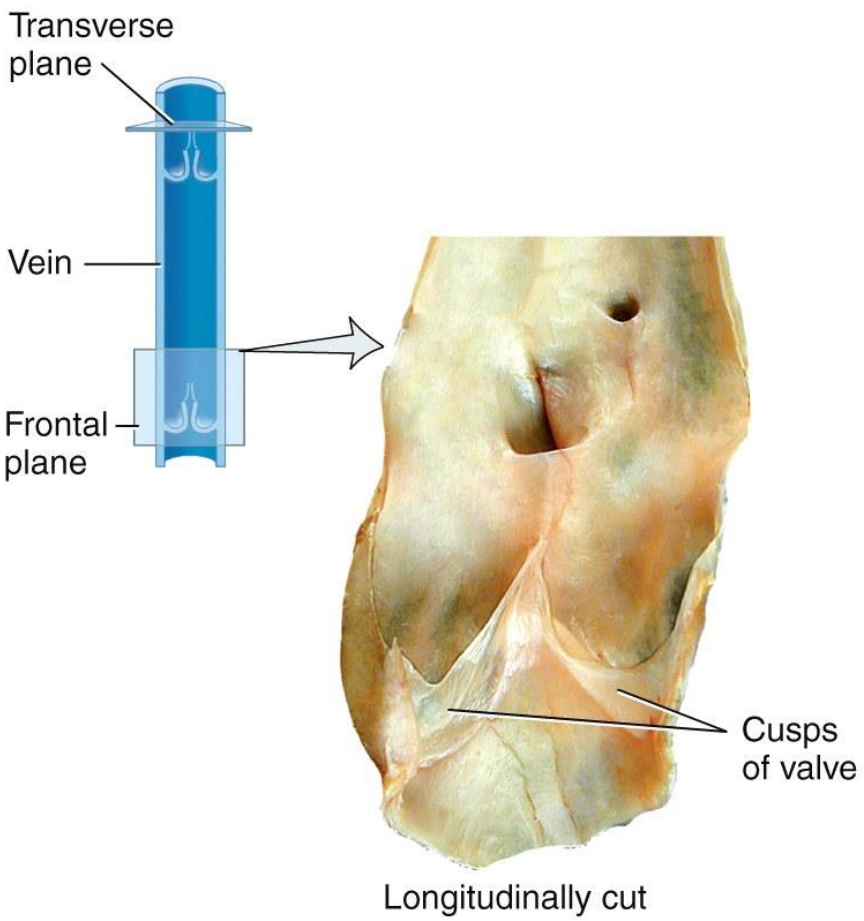
Blood Velocity

- Is the rate at which blood flows
- Varies depending on size of vessel
  - Is greatest in aorta and decreases as vessels decrease in size
  - Slowest in capillaries
  - Regains some speed as enters venules and veins



Venous Return

- The volume of blood returning through the veins to the right atrium must be the same amount of blood pumped into the arteries from the left ventricle – this is called the venous return.

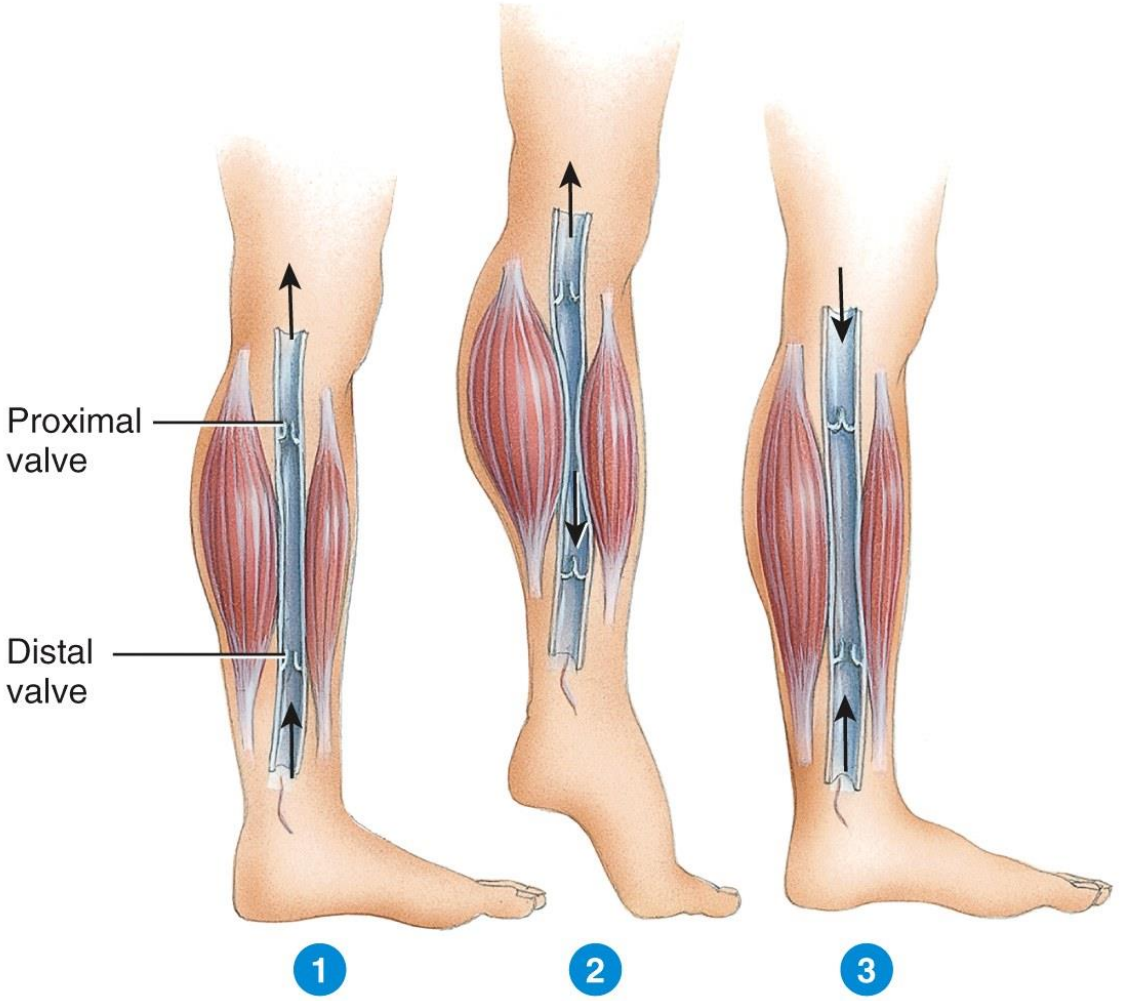


Venous Blood Flow

- Very little pressure in veins
- Venous return is dependant on:
  - Muscle action
    - Muscle contracts, thickens and squeezes veins next to it
  - Respiratory movements
    - As diaphragm contracts changes thoracic pressure causing abdominal blood to move
  - Contraction of veins
    - Sympathetic reflexes cause constriction

Venous Return

- The skeletal muscle pump uses the action of muscles to move blood in one direction (due to valves).
- The respiratory pump uses the negative pressures in the thoracic and abdominal cavities generated during inspiration to pull venous blood towards the heart.



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Vascular Anatomy

BLOOD

The Blood

Functions and Characteristics

- Is a liquid connective tissue
- Consists of formed elements (Cells and fragments) suspended in intracellular material (plasma)
- Total volume (Average): 70 ml/kg
  - Male 5 – 6 L
  - Female 4 – 5 L
- Accounts for approximately 8% of TBW

The Blood

Activities

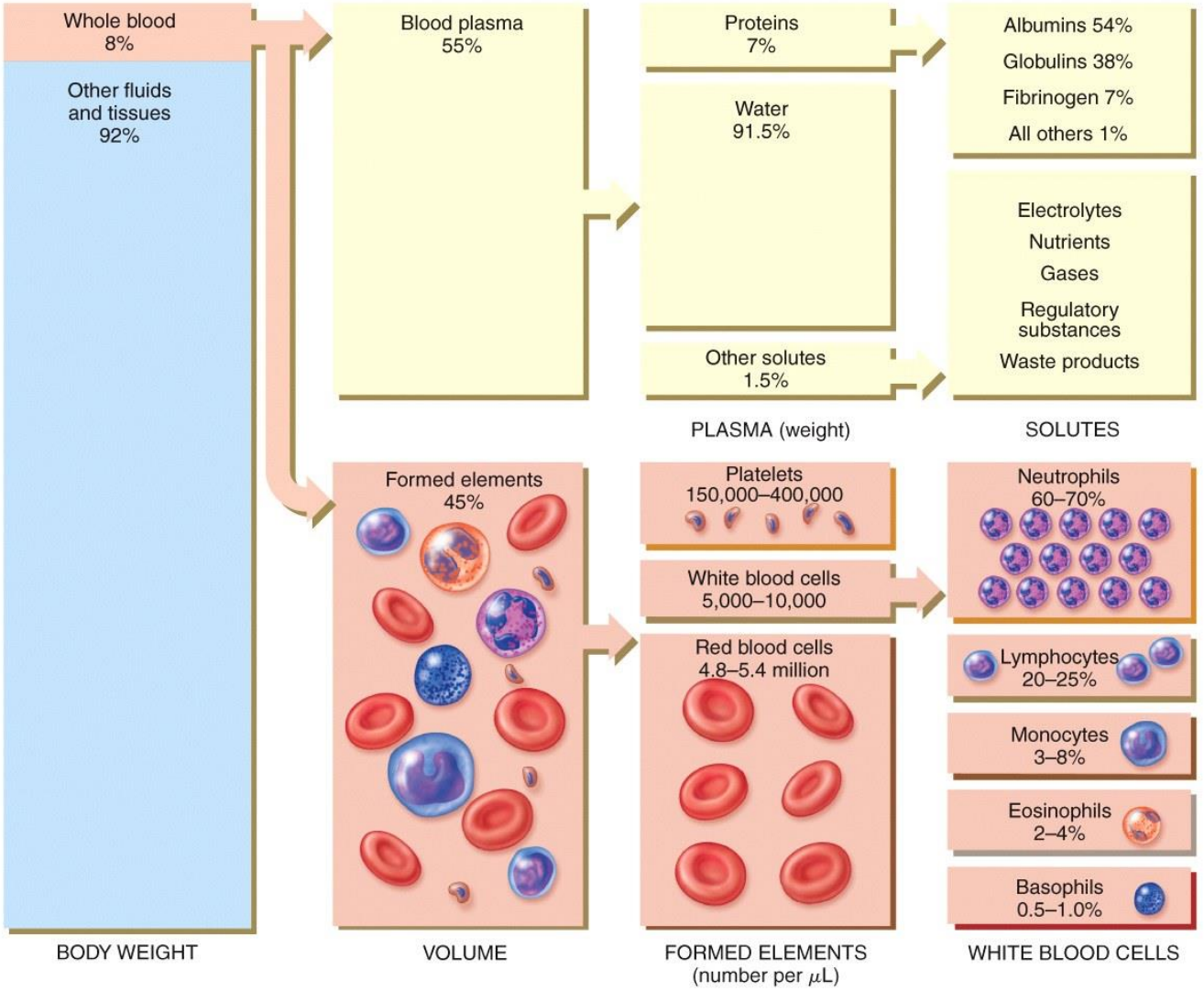
- Transportation
  - Carries O_2, CO_2 and waste products to lungs and kidneys
  - Carries hormones from endocrine system to target tissues
- Regulation
  - Maintain body temperature
  - Fluid and electrolyte balance (pertains to osmotic pressure)
  - Functions in pH regulation with buffers
- Protection
  - Clotting mechanisms
  - Infection control (WBC)
  - Antibodies found in blood

The Blood

- Composition of Blood
  - Plasma 55%
  - Formed Elements 45%
    - Include:
      - Leukocytes
      - Thrombocytes (platelets)
      - Erythrocytes (Largest portion)

(Hematocrit is percentage of RBC's)

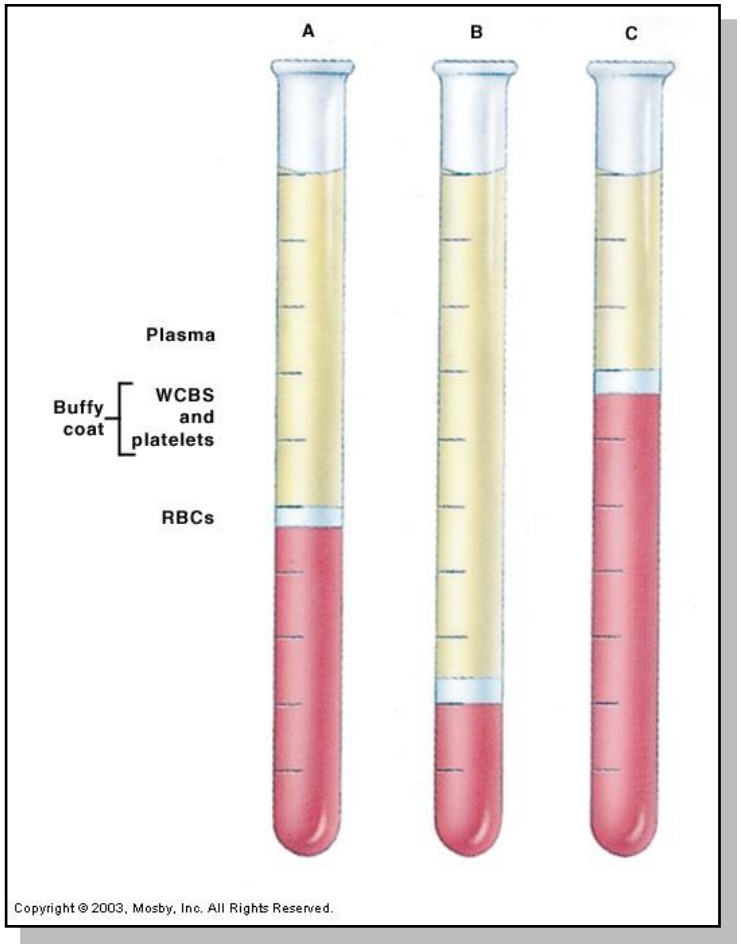
Constituents of Blood



(b) Components of blood

The Blood

- Hematocrit
  - A Normal
    - Male 40 – 54%
    - Female 38 – 47%
  - B Anemia
    - Decrease in RBC
  - C Polycythemia
    - High altitudes

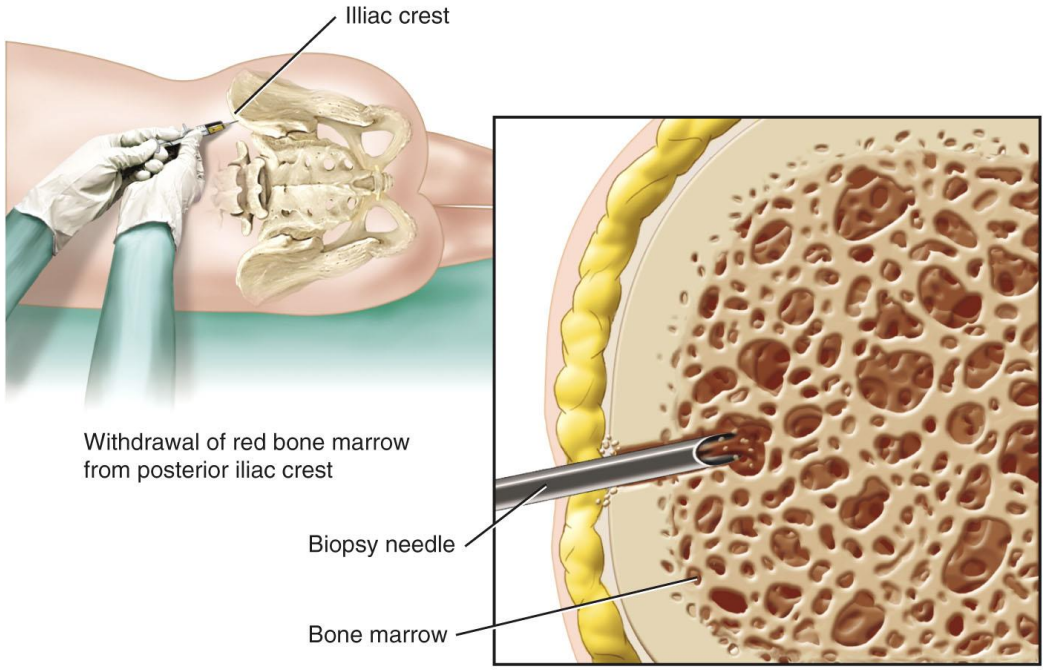


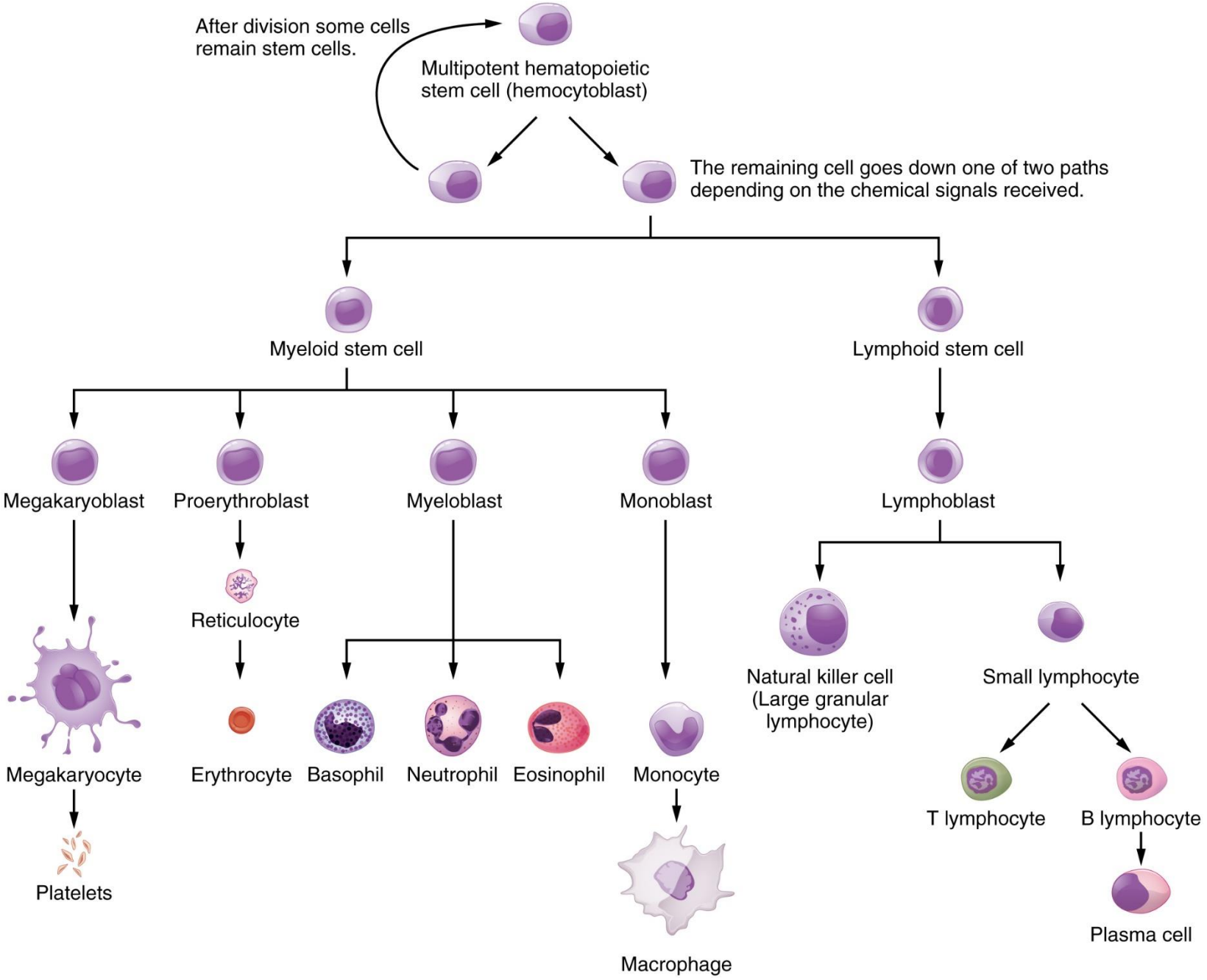
The Blood

- Formed elements
  - All elements are formed from a hemocytoblast
  - The formation of the elements is called hematopoiesis
  - 3 main types
    - Erythrocytes
    - Leukocytes
    - Thrombocytes

Hematopoiesis

- The process by which the formed elements of blood develop is called hemopoiesis (hematopoiesis).
- In adults, blood cells are formed in red bone marrow from pluripotent stem cells.
- They mature in bone marrow or lymphoid tissue.



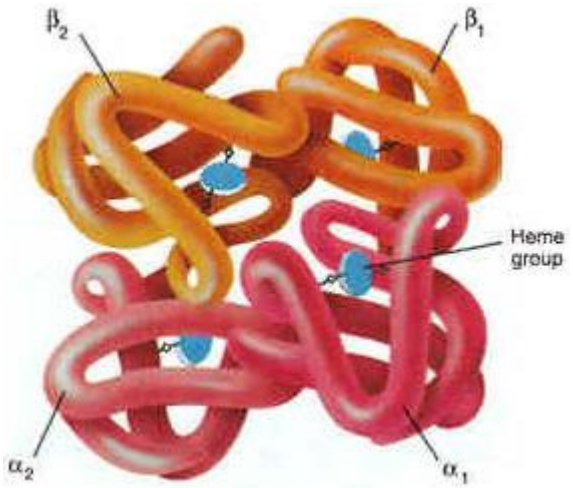

After division some cells remain stem cells.
Multipotent hematopoietic stem cell (hemocytoblast)
The remaining cell goes down one of two paths depending on the chemical signals received.
Myeloid stem cell
Lymphoid stem cell
Megakaryoblast
Proerythroblast
Myeloblast
Monoblast
Lymphoblast
Reticulocyte
Megakaryocyte
Erythrocyte
Basophil
Neutrophil
Eosinophil
Monocyte
Natural killer cell (Large granular lymphocyte)
Small lymphocyte
T lymphocyte
B lymphocyte
Plasma cell
Platelets
Macrophage

Erythrocytes

- The most abundant (4.5 – 6 million/mm3)
- Biconcave discs
- Mature cells are anucleated
  - Mature cells cannot enter mitosis so new cells are created from stem cells
- Immature cells move from bone marrow to the blood (are called reticulocytes)
- Also contain spectrin fibers which are part of the cytoskeleton and give it flexibility

Erythrocytes

- Found inside each RBC is an estimated 200 – 300 million hemoglobin molecules
- Consists of 4 protein chains (globin) which are bound together by heme groups
- Each heme group contains an iron atom (4 in total)
- This allows the hemoglobin to attach to 4 oxygen molecules or 4 carbon dioxide molecules



Erythrocytes

- Primary function to transport O_2 and CO_2
- Directly related to:
  - Hemoglobin
    - Oxyhemoglobin (97% of transport)
    - Deoxyhemoglobin when O_2 released (darker in color)
  - Carbonic anhydrase
    - Causes the conversion of CO_2 and water into bicarbonate (or reverse)

Erythrocytes

- Production (Erythropoiesis)
  - Produce from stem cells which mitosis through several stages to reach the mature blood cell into the blood stream
  - Usually an equal number produced as is destroyed
    - Estimated 200 billion per minute produced

Erythrocytes

- Oxygen factor
  - If oxygen levels reaching the tissue decreases then it stimulates the release of erythropoietinogen
  - Kidneys produce and release renal erythropoietic factor (REF)
  - Activates erythropoietinogen to form erythropoietin to stimulate red bone marrow to produce RBC's
- Iron, vitamin B12 and folic acid are essential to normal RBC production

Erythrocytes

- Destruction
  - Normal cells live for about 120 days
  - When they are defective or worn out macrophages in spleen and liver remove them
  - Hemoglobin is broken down and reuses heme for production (is broken into iron and bilirubin) and sends the iron to the bone marrow and bilirubin is excreted into the bile of the liver

Leukocytes

- Usually larger than RBC's but are fewer in # (5,000 - 9,000/mm^3)
  - Formed in the lymphatic system (agranulocytes) and in the red bone marrow (granulocytes)
  - Also derived from hemocytoblast stem cells but do not lose nuclei or accumulate hemoglobin (why they appear white)
- Do most of their work in the tissues
- They can be Phagocytic, produce antibodies, secrete histamine and heparin while others neutralize histamine

Leukocytes

- Leukocytosis
  - Increase in the # of WBC's
  - Appendicitis
- Leukopenia
  - Decrease in the # of WBC's
  - Result of infect, may be born with
- Leukemia
  - Cancer of the lymph glands and bone marrow resulting in overproduction of white blood cells

Types of Leukocytes

- Granulocytes
  - Neutrophils
    - Most common (60 - 70 %), have multi-lobed nuclei
    - Can move from blood vessels to enter tissue spaces (diapedesis)
    - First to respond to tissue damage where they engulf bacteria (phagocytosis)

Types of Leukocytes

- Granulocytes
  - Eosinophils
    - 2 - 5% with 2 lobed nucleus
    - Found in respiratory and digestive tracts
    - neutralize histamine and destroy parasitic worms
    - Increase in # during allergic reaction

Types of Leukocytes

- Granulocytes
  - Basophils
    - Least numerous (1%), U shaped nuclei
    - Capable of diapedesis
    - When they leave the blood and enter the tissue they are considered Mast Cells
    - There they secret histamine (dilates vessels) and heparin (anticoagulant)

Types of Leukocytes

- Agranulocytes
  - Monocytes
    - 3-8%, U or bean shaped nuclei
    - When they leave the blood and enter the tissue the are called macrophages
    - Capable of engulfing bacteria and virus infected cells
    - Finish the clean-up of cellular debris initially started by the neutrophils

Monocyte

Lymphocyte

Types of Leukocytes

- Agranulocytes
  - Lymphocytes
    - 20 - 25%, spherical shaped nuclei
    - Abundant in lymphoid tissue
    - Important in defense
    - T Cells attack bacteria and viruses
    - B Cells produce antibodies

Monocyte

Lymphocyte

Thrombocytes (Platelets)

- Not complete cells, actually parts of megakaryocytes from the red bone marrow
- 250,000 - 500,000/mm^3
- Properties
  - Agglutination
  - Adhesiveness
  - Aggregation

Thrombocytes (Platelets)

- Thrombocytopenia
  - A decrease in the number of platelets in the blood, resulting in the potential for increased bleeding and decreased ability for clotting
  - Side effect of chemotherapy (immune response), some drugs may cause decrease, Idiopathic thrombocytopenic purpura (ITP)
- Thrombocytosis
  - An increase in the number of platelets in the blood
  - Can be as a result of:
    - Splenectomy, following acute hemorrhage, rheumatoid arthritis, infections and even a malignancy

Plasma Proteins

- Most abundant of solutes
- Remain in blood or interstitial fluid and are not used for energy
- 3 major classes
  - Albumins
  - Globulins
  - Fibrinogens

Plasma Proteins

- Albumins
  - Account for 60% of proteins
  - Attribute to osmotic pressure
- Globulins
  - Account for 36%
  - Alpha and Beta
    - Produced in liver and transport lipids and vitamins
  - Gamma
    - Produced in lymphoid tissue and are antibodies

Plasma Proteins

- Fibrinogen
  - Account for 4%
  - Largest of the molecules
  - Produced in liver
  - Functions in clotting

Hemostasis

"The stoppage of bleeding"

- Occurs with:
  - Vasoconstriction
  - Platelet plug formation
  - Coagulation

Hemostasis

- Vasoconstriction
  - Restricts flow of blood through vessels by constricting (spasms)
- Platelet plug formation
  - Platelets attracted to the collagen in the connective tissue
  - As they accumulate they release serotonin (stimulates smooth muscles to contract)
  - This prolongs vasoconstriction

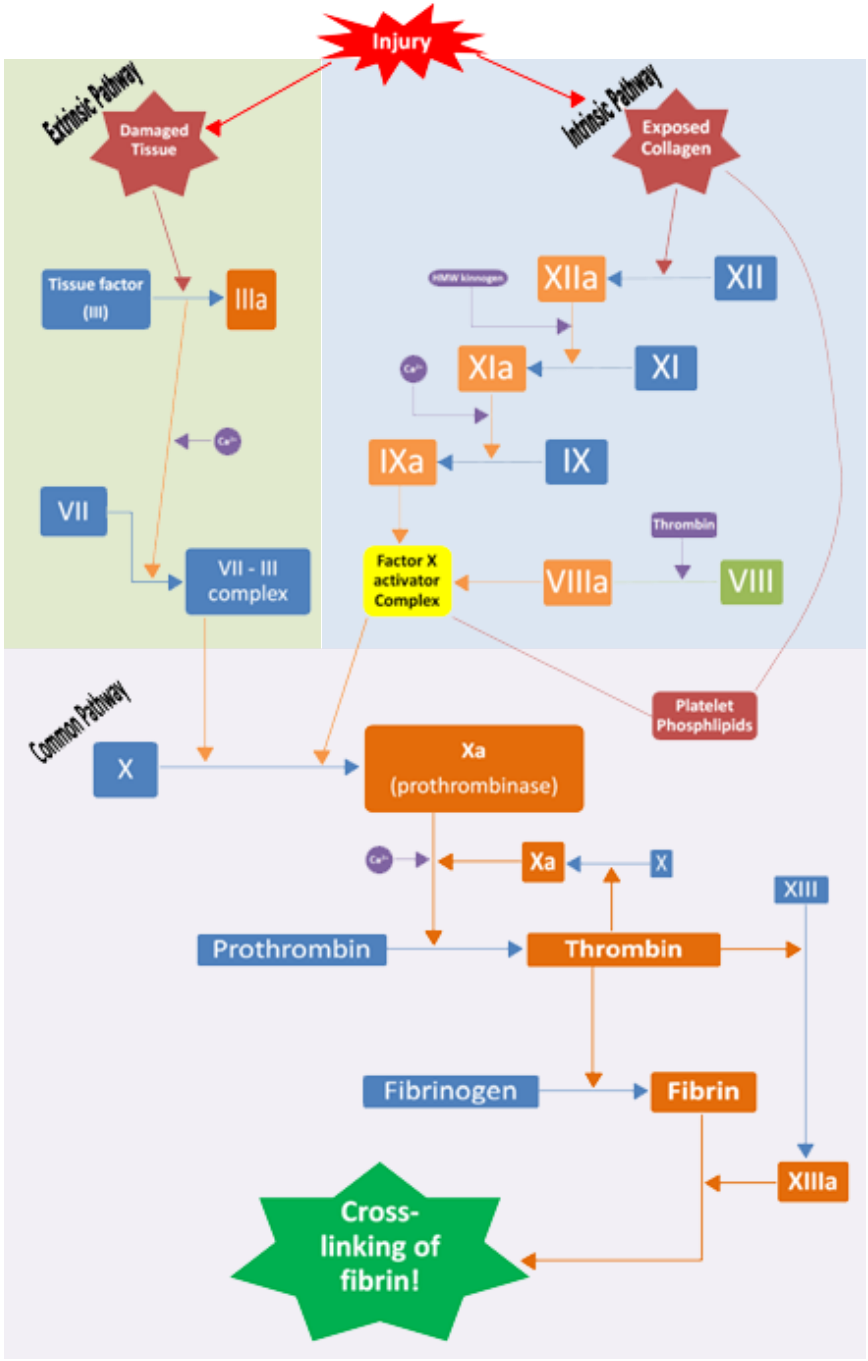
Hemostasis

- Coagulation
  - Blood contains procoagulants and anticoagulants
  - Anticoagulants predominate typically to maintain blood as a fluid
  - In an injury, procoagulants increase in activity
  - Chemical reactions and the use of clotting factors aid in the plug formation
  - Ca and Vitamin K are important in the process

Hemostasis

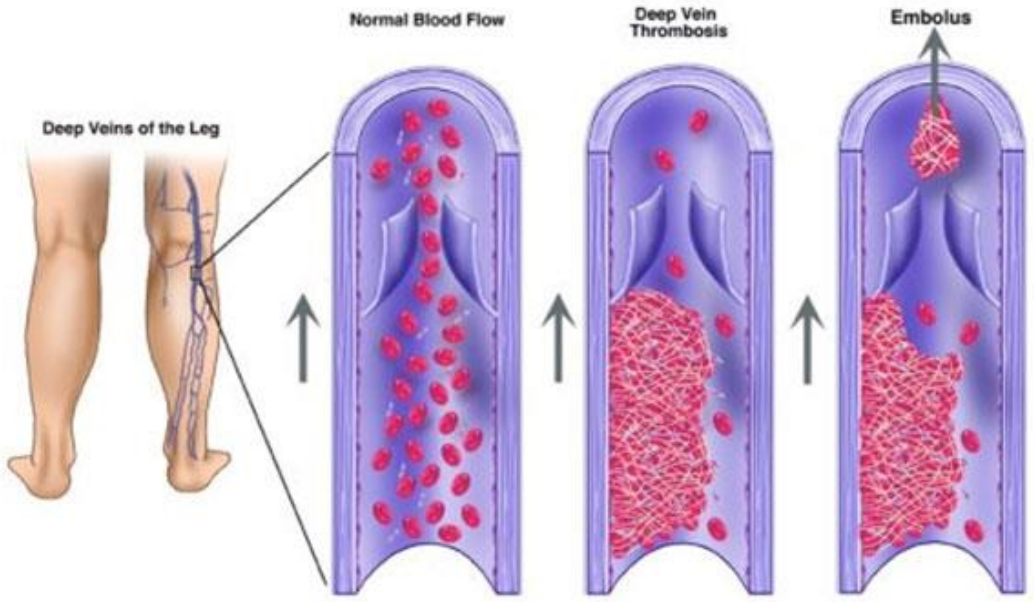
- Damaged tissue release chemicals
- This triggers a cascade of reactions involving Coagulation Factors that result in the formation of prothrombin activator (PA)
- With Ca and PA, prothrombin in the plasma is converted to active thrombin (which is normally inactive)
- Thrombin with Ca acts as an enzyme to convert inactive soluble fibrinogen into an active non-soluble fibrin
- This begins to form fibers to trap blood cells

Clotting Cascade



The Blood

- Embolus
  - The formation of a clot from platelets or leukocytes
- Thrombus
  - An aggregation of blood factors, primarily platelets and fibrin with entrapment of cellular elements



Hemostasis

- Increase Hemostasis
  - Apply rough surface (gauze)
  - Apply heat
  - Pinch the area around the wound (pressure)
- Decrease Hemostasis
  - Natural design of vessels
  - Presence of antithrombin (Heparin)
  - Coumarin compounds
    - Impair liver's ability to use Vitamin K which slows synthesis of prothrombin and other factors

Deteriorating the Clot

- Fibrin strands contract (clot retraction)
- Causes clot to shrink
- Pulls edges of damaged tissue together
- Reduces blood flow, reduces chances of infection and enhances healing
- Fibroblasts migrate to the clot and form fibrous connective tissue that repairs the damage
- Clot is dissolved by fibrinolysis

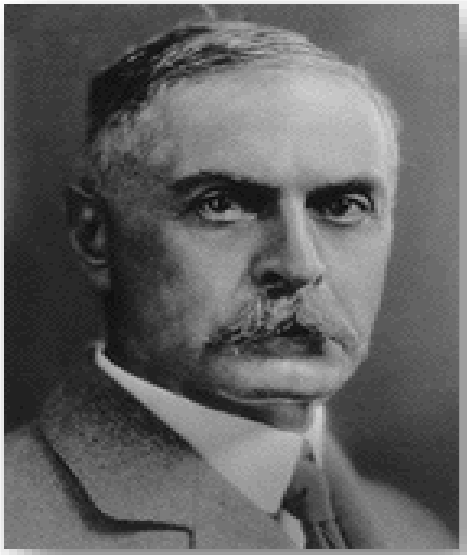
Vascular Anatomy

BLOOD TYPING

Blood Typing

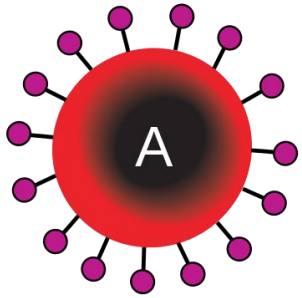
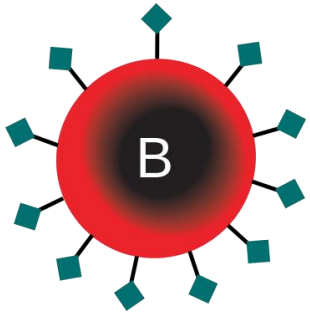
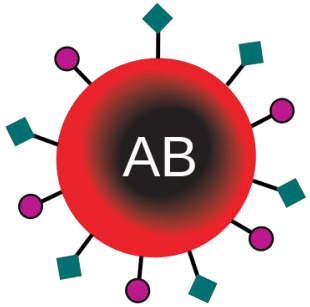
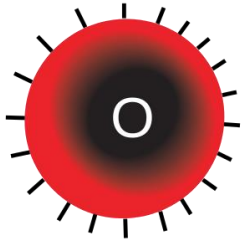
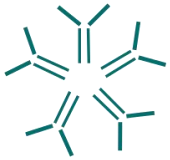
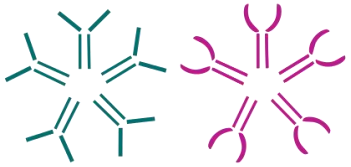
- Blood type is based on specific proteins (antigens) and antibodies related to RBC's
- Antigens (agglutinogens) for blood type are found in the cell membrane of the RBC
- Antibodies (agglutinins) are found in the plasma
- When they combine they result in agglutination
- Though there are many groups, ABO and Rh groups are the most important

ABO System



- Discovered by Dr. Karl Landsteiner in 1901
- His experiment involved mixing the serum and RBC's of patients and observing the reactions
- Noted 3 distinct groups
  - A, B and C (C was later changed to O)
- In 1902 Decastello and Sturli identified the fourth group which was labeled as AB

Blood Types

	Group A	Group B	Group AB	Group O
Red blood cell type				
Antibodies in Plasma	 Anti-B	 Anti-A	None	 Anti-A and Anti-B
Antigens in Red Blood Cell	 A antigen	 B antigen	 A and B antigens	None

ABO Group

- Based on certain aggultinogens (A & B antigens)
  - Type O has none, Type A has A, Type B has B
- Is inherited
- Develop anti-agglutinins based on the antigens
  - Type A has anti-B, Type B has anti-A, Type O has Anti-AB
- Type AB is known as the **Universal Recipient**
- Type O is known as the **Universal Donor**

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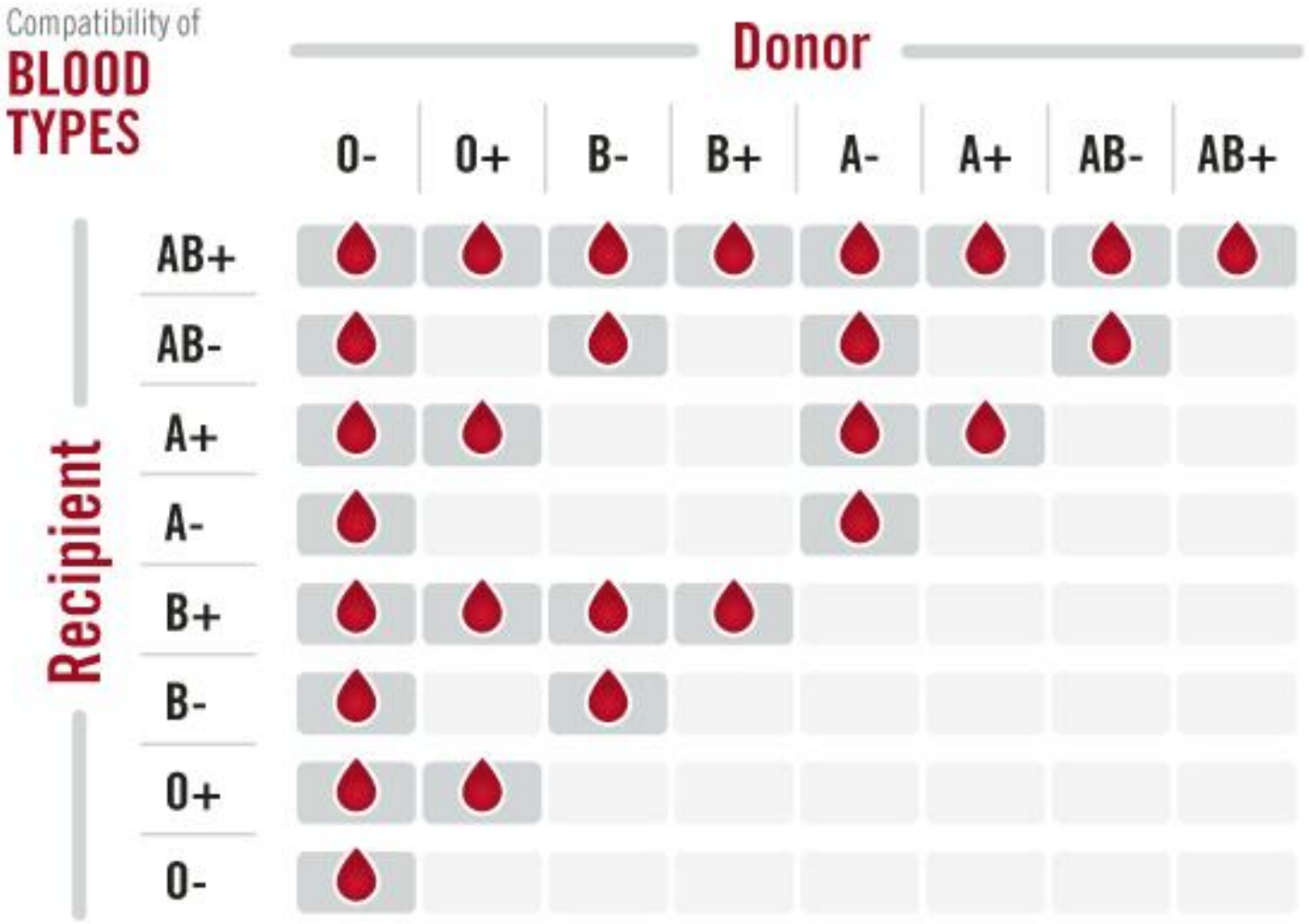
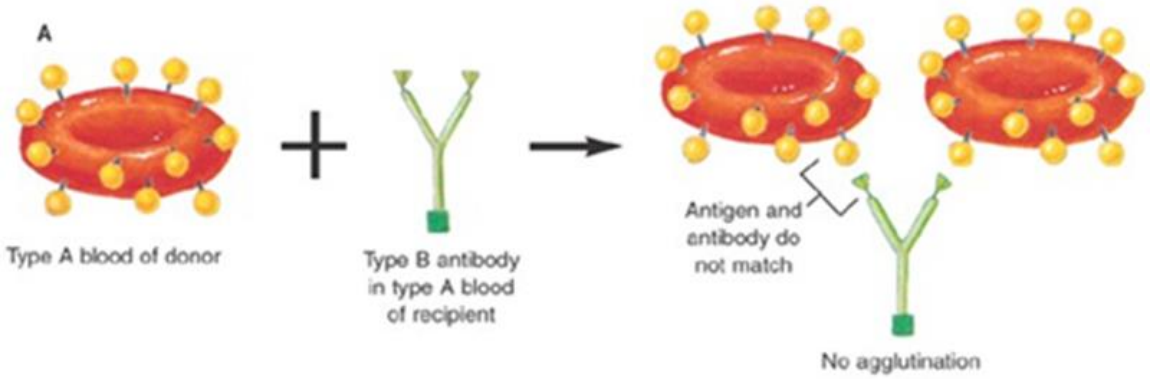
The Blood

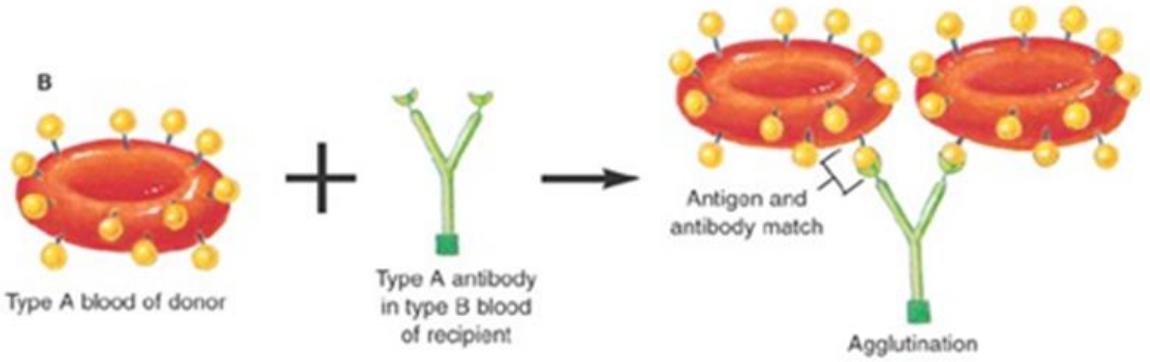


The Blood

- Blood Typing
  - A
    - Proper match of blood product results in no agglutination



  - B
    - Poor match, antigen-antibody complex formed and agglutination occurs



Rh Factor

- Rh Factor
  - Rh^+
    - Rh agglutinogens are on the surface of the RBC (85% of population)
  - Rh^-
    - Rh agglutinogens are not present
  - Also inherited
  - Normally no anti-Rh agglutinins found
    - If Rh^- is exposed to Rh^+ blood then anti-Rh agglutinins are formed
    - Reaction occurs with second exposure