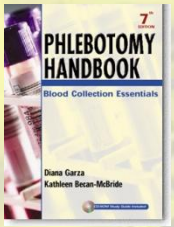
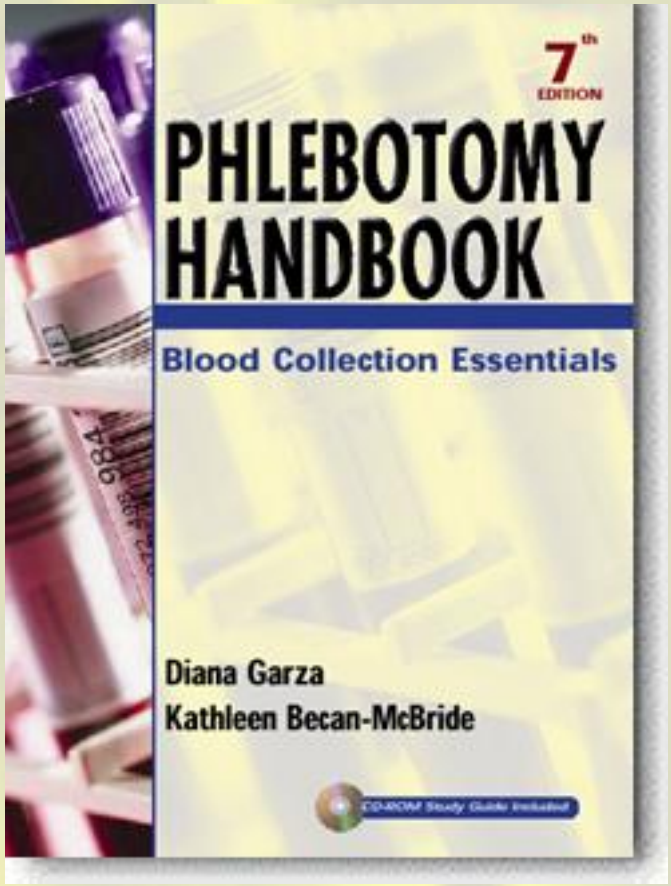


Phlebotomy Handbook

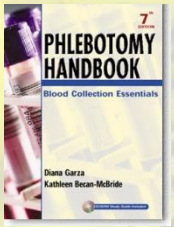
Blood Collection Essentials

Seventh Edition

Diana Garza
Kathleen Becan-McBride

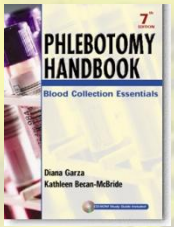


Chapter Four
The Cardiovascular System



Introduction

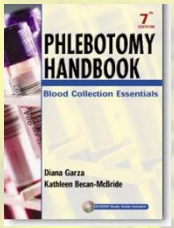
- Circulatory system is a transport system.
- Contributes to body defenses and the coagulation process and controls body temperature.
- The lymphatic system is considered to be part of the circulatory system, the primary purpose of which is to circulate lymph fluid



The Blood

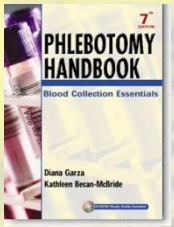
Box 4–1	Functions of the Blood
Transportation	Carry gases
	Carry oxygen from the lungs to the tissues
	Carry carbon dioxide from the tissues to the lungs
	Transport waste products to sites such as the kidneys for excretion
	Transport antibodies and white blood cells to defend against pathogenic microbes and viruses
Disbursement of nutrients	Distribute nutrients absorbed in the digestive tract to all organs of the body
	Take nutrients released from fat, muscle, and tissues for use in other parts of the body
Regulation	Regulate the blood pH in all parts of the body
	Regulate electrolyte balance to maintain a “steady state” condition
	Control body temperature by redistribution of heat
Hemostasis	Restrict fluid loss when blood vessels are damaged
	Formation of blood clots to prevent bleeding

Box 4.1: Functions of the blood



Blood

- All blood cells develop from undifferentiated stem cells
  - Stem cells are considered immature cells
  - As they mature, they differentiate into erythrocytes (red blood cells or RBCs), leukocytes (white blood cells or WBCs) and thrombocytes (platelets).
  - undergo changes in the nucleus and cytoplasm so that when they reach the circulating blood, they become fully mature and functional



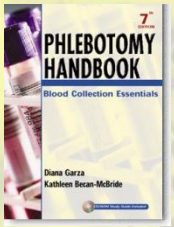
The Blood

TABLE 4–1. Blood Cells

CELLS	NUMBER/ SIZE	FUNCTION	FORMATION	DESTRUCTION
Erythrocytes (RBCs)	4.5–5.5 million/mm^3; size 6–7 m	Transport O_2 and CO_2	Bone marrow	Fragmentation and removal in spleen, liver, and bone marrow; life span—120 days
Leukocytes (WBCs)	5000–9000/mm^3; size 9–16 m	Defense	Granulocytes in bone marrow; nongranular WBCs in all lymphatic tissue	Removed in spleen, liver, bone marrow; life span—1 day to 1 year
Thrombocytes (platelets)	250,000–450,000/mm^3; size 1–4 m	Clotting	Bone marrow	Removed in spleen; life span—9 to 12 days

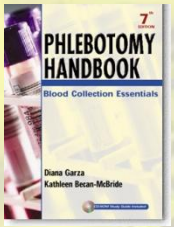
Abbreviations: RBCs, red blood cells; WBCs, white blood cells.

Table 4.1: Blood Cells



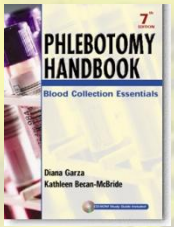
Erythrocytes

- Red blood cells measure about 7 mm in diameter with a thickness of 2 mm
- During maturation in the bone marrow the RBCs lose their nucleus
- Unique and flexible shape (biconcave disc) enables them to pass through very narrow capillaries and provides for maximum surface area to transfer oxygen and carbon dioxide.
- Normal blood has approximately 4.5 to 5 million cells per cubic milliliter.
- The life-span of RBCs is approximately 120 days in the circulating bloodstream.



Erythrocytes

- The main component of the RBC is ***hemoglobin*** which binds to oxygen for transport to the tissues, then binds to CO2 to be delivered to the lungs as a waste product.
- Hemoglobin gives blood its red color.
- Millions of RBCs are continually being formed and destroy daily
- Deficiencies may result in anemia.
- The surface membrane of RBCs contain structures called antigens that designate the individuals blood type



The Blood

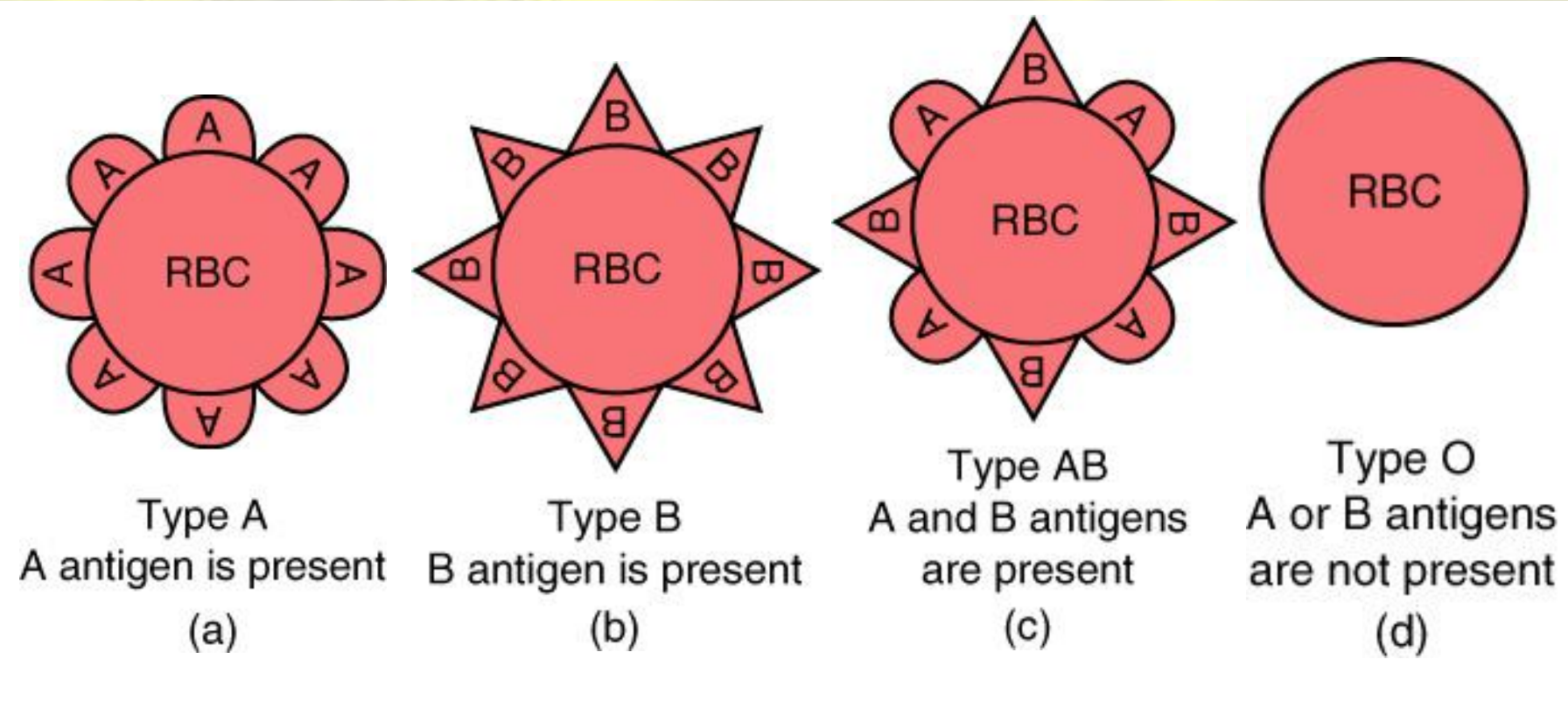
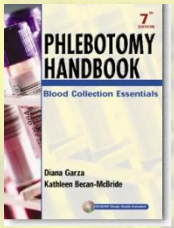
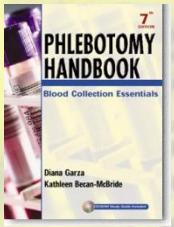


Figure 4.5 Human Blood Types



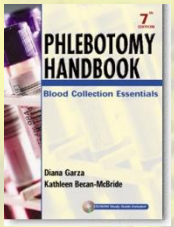
Leukocytes

- WBCs number about 5,000 to 10,000 and are classified into cell lines which differ in color size, shape, nuclear formation and function.
- White cells are further divided into cell lines , one of which is the ***granulocytes*** which contain cytoplasmic granules .
  - *Segmented neutrophils*
  - *Eosinophils*
  - *Basophils*



Leukocytes

- Monocytes and lymphocytes are agranular cells.
  - *Monocytes*
  - *Lymphocytes*
- A commonly performed laboratory test is the "*differential*"
  - A high WBC count with an increase in granulocytes indicates a bacterial infection
  - A high WBC count with predominantly immature WBCs present indicates leukemia
  - A low WBC count with an increase in the lymphocytes indicates a viral infection.



The Blood

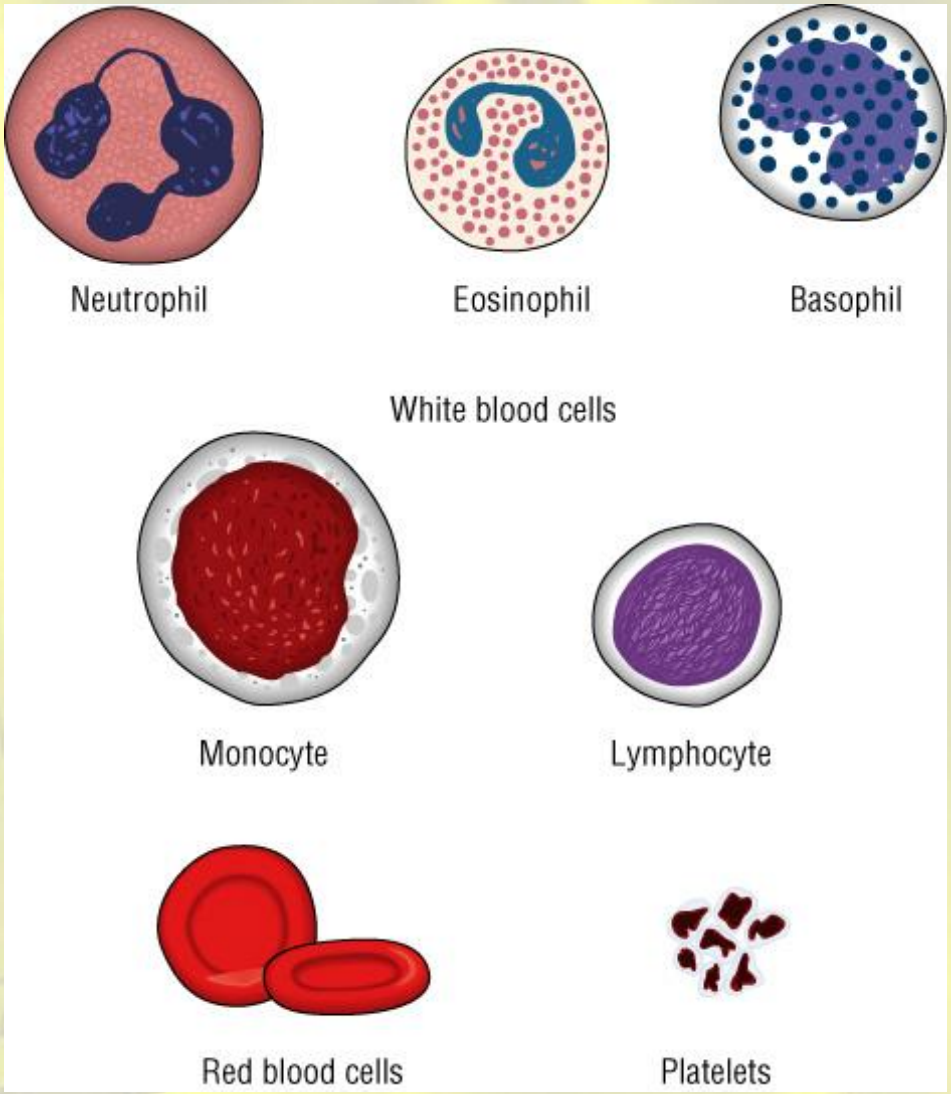
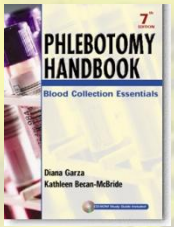
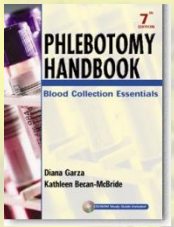


Figure 4.6 Human Blood Cells



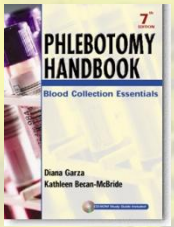
Platelets

- *Thrombocytes*, commonly called *platelets*, are much smaller than other blood cells and are actually fragments of megakaryocytes.
- Normally there are 250,000 to 450,000 platelets/mm3.
- Life span is 9–12 days.
- Thrombocytes participate in blood clotting.
- When vessels are damaged, the platelets release factors that are needed for the clotting reaction
- Blood clotting, or coagulation, is the final step in hemostasis, the prevention of blood loss.
- Low platelets may cause a patient to have excessive bleeding or uncontrolled bleeding after an injury.



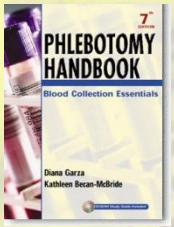
Plasma

- Plasma
  - If a chemical agent or anticoagulant is added to prevent clotting, a blood sample can be separated by centrifugation into the cells and plasma.
  - *Plasma cannot clot* due to inactivation of certain vital necessary elements and *will contain all coagulation factors*.
  - Anticoagulated whole blood is required for all tests performed in the hematology department
  - Plasma is required for all coagulation tests



Serum

- *Serum is produced when blood is drawn into a non-additive tube and allowed to clot.*
  - The blood cells become meshed in a fibrin clot.
  - Serum contains essentially the same chemical constituents as plasma except that clotting factors have been used up to form the clot so *will have NO coagulation factors.*



The Blood

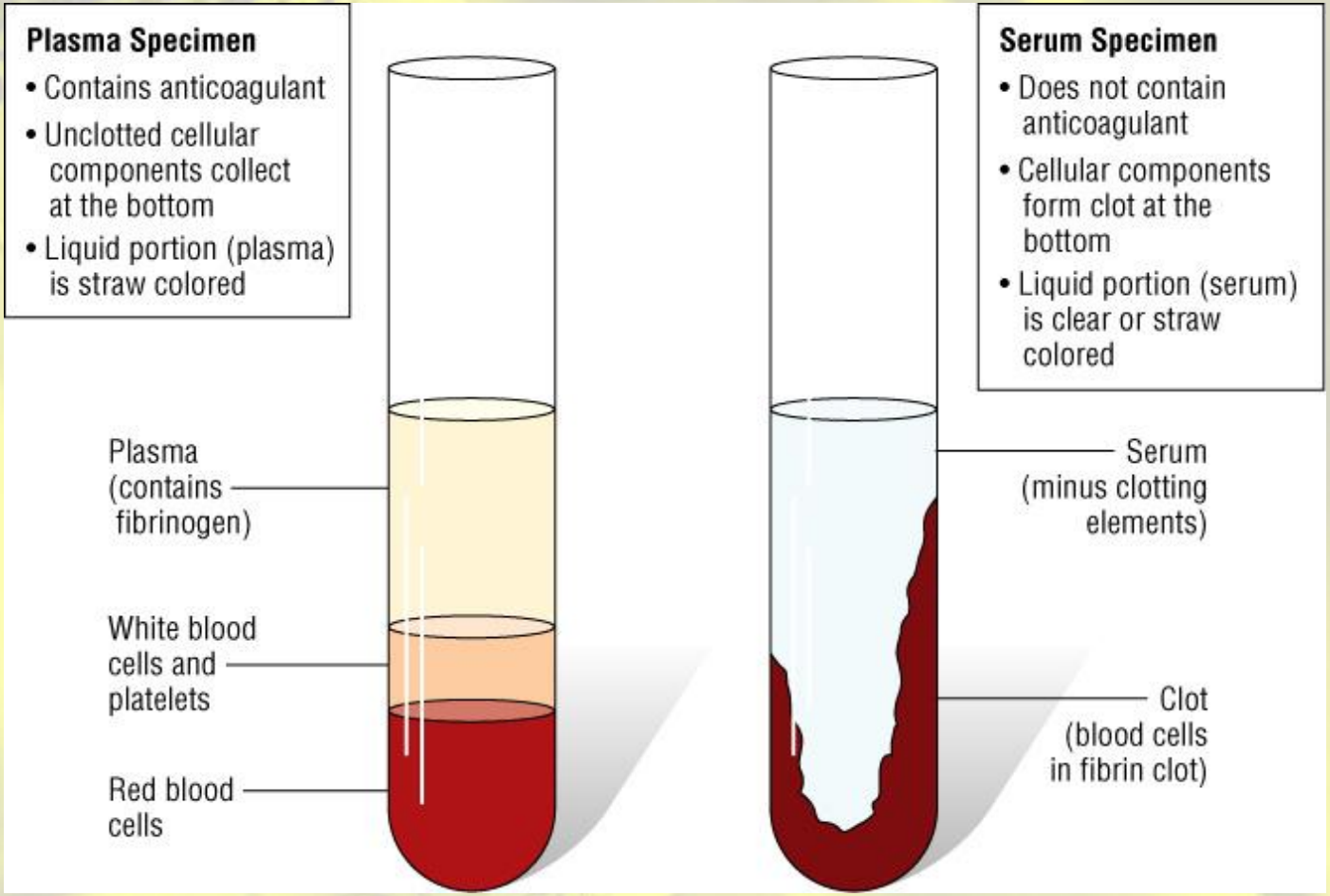
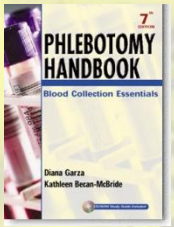


Figure 4.7 Centrifuged Blood Specimens With and Without Anticoagulant, Respectively



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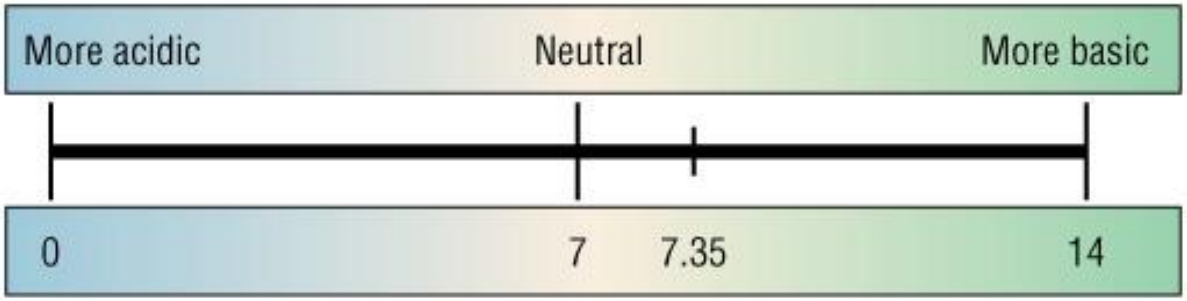
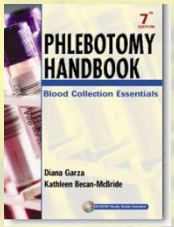


Note: Examples of acidic substances (low pH) are acetic acid (vinegar), citric acid (juices from oranges, lemons), or lactic acid (produced in muscles). Examples of basic substances (high pH) are sodium bicarbonate (baking soda) and milk of magnesia.

Figure 4.8 Blood is slightly basic with a pH of 7.35



The Heart

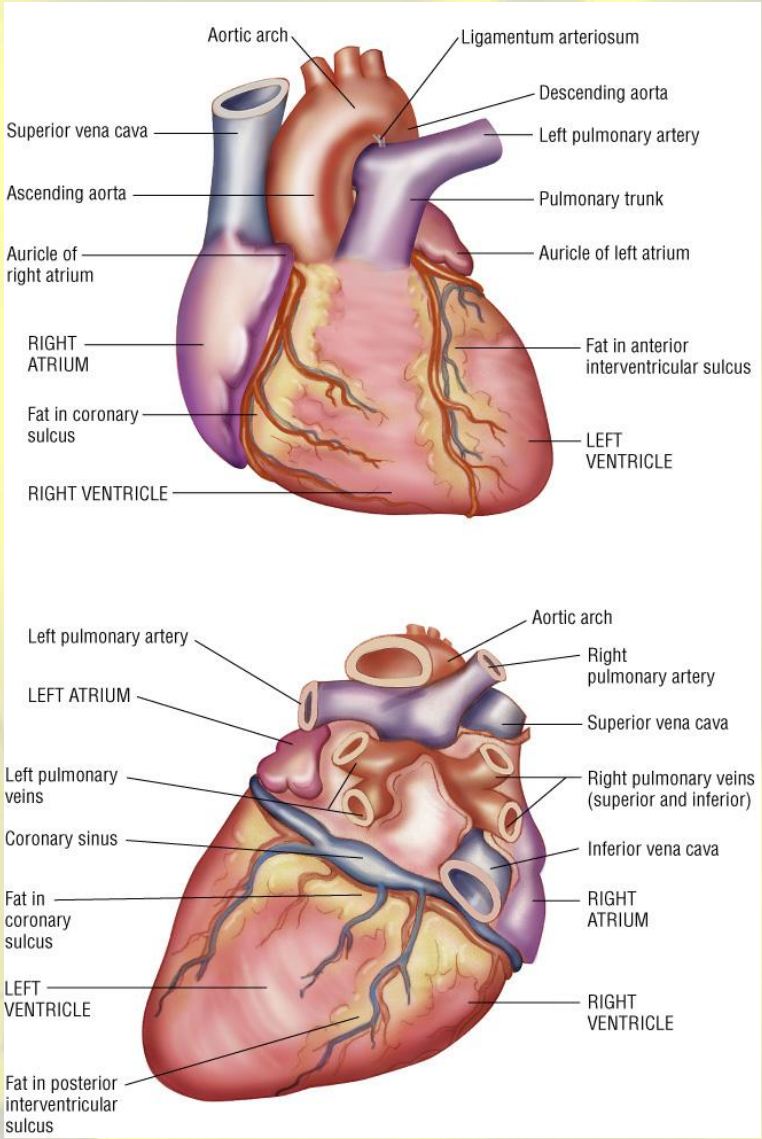
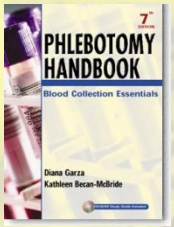
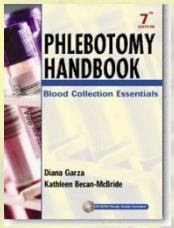


Figure 4.1 Superficial Anatomy of the Heart



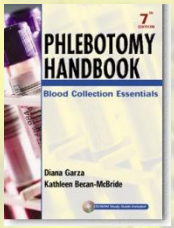
The Heart

- The human heart is a muscular organ about the size of a man's closed fist.
- The heart contains four chambers and is located slightly left of the midline in the thoracic cavity.
- The two atria are separated by the interatrial septum (wall), and the interventricular septum divides the two ventricles.
- Heart valves are positioned between each atrium and ventricle so that blood can flow in one direction only, thereby preventing backflow.
- Blood flow through the heart



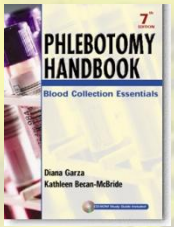
The Heart

- The heart is a muscular organ responsible for the continuous pumping of blood through the vascular system
- It is about the size of a man's closed fist.
- It contains four chambers: the right and left atrium, and the right and left ventricle



The Heart

- Blood enters the heart through the right atrium and left atrium and leaves by way of the right and left ventricles.
  - Right atrium receives blood from superior vena cava and inferior vena cava.
  - Blood exits through the right ventricle to begin pulmonary circuit.



The Heart

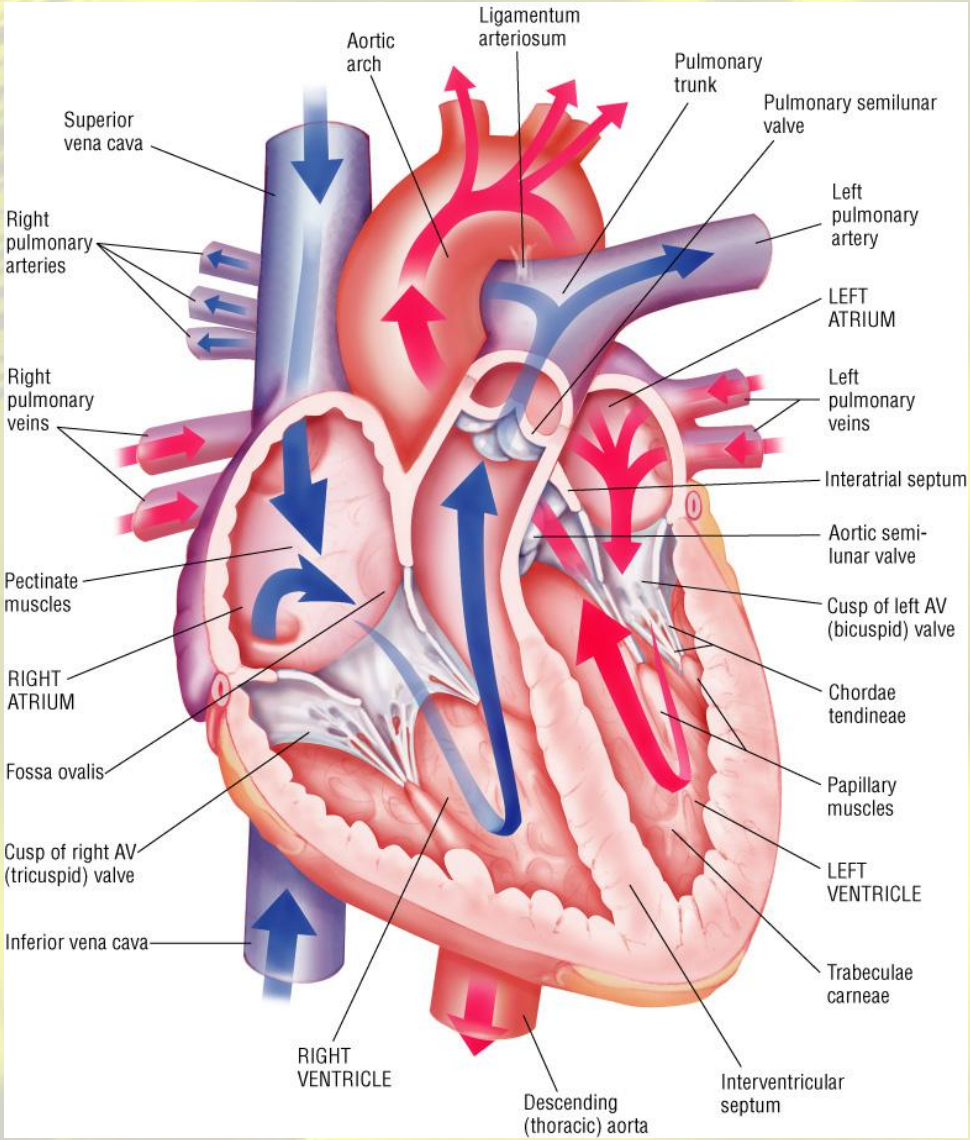
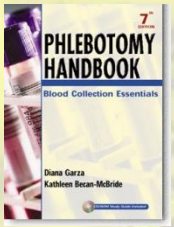
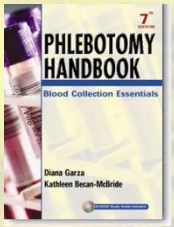


Figure 4.2 Sectional Anatomy of the Heart



The Heart

- *The right side of the heart is responsible for pumping* ***oxygen poor*** *blood* ***to the lungs*** *to pick up oxygen.*
- *The left side of the heart is responsible for pumping the* ***oxygen rich*** *blood* ***to all parts of the body.***
- A muscular wall called the septum divides the right and left sides of the heart.



The Heart

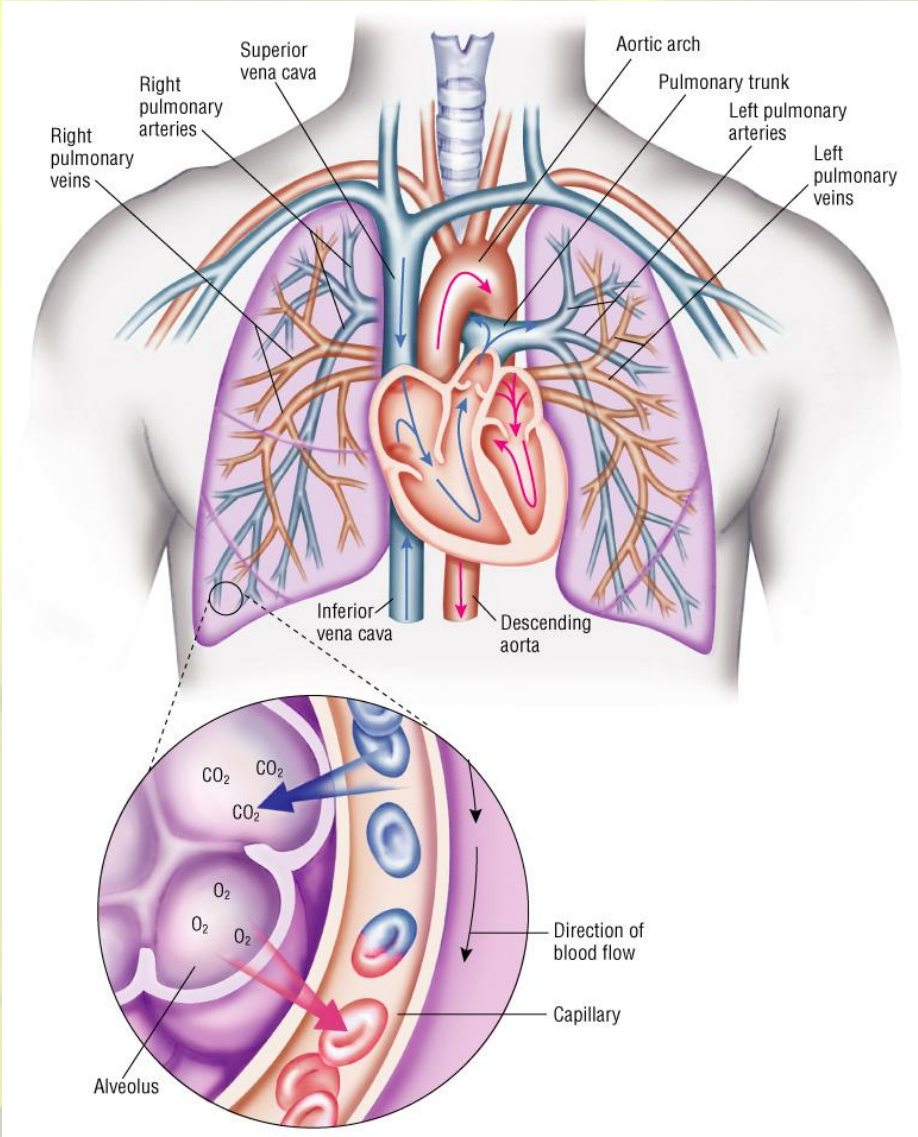
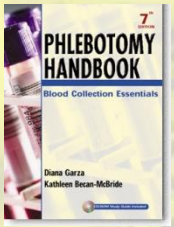
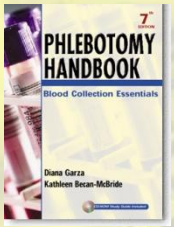


Figure 4.3 The Pulmonary Circuit



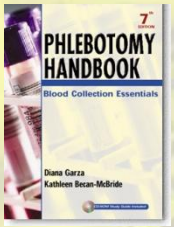
The Heart

- The pulmonary veins bring oxygen rich blood and the vena cava brings oxygen poor blood
- Valves in the heart control the flow, if a valve malfunctions, blood flows backwards causing a heart murmur.
- The heart beats about 60 to 80 times per minute and is measured by feeling the pulse.



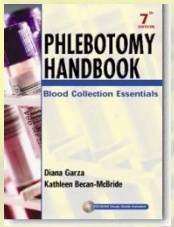
The Vessels and Circulation

- Blood circulates throughout the body within a closed system through blood vessels.
- Blood vessels are tube-like structures capable of expanding and contracting and consist of three types: arteries, veins and capillaries.



Arteries

- ***Arteries*** carry highly oxygenated blood away from the heart.
  - Arteries branch into smaller vessels called ***arterioles***.
  - Arteries have thick walls composed of three layers because the blood is under pressure
  - The only artery that is ***not oxygenated*** is the ***pulmonary artery***, which carry blood from the right side of the heart to the lungs for oxygenation.



The Vessels and Circulation

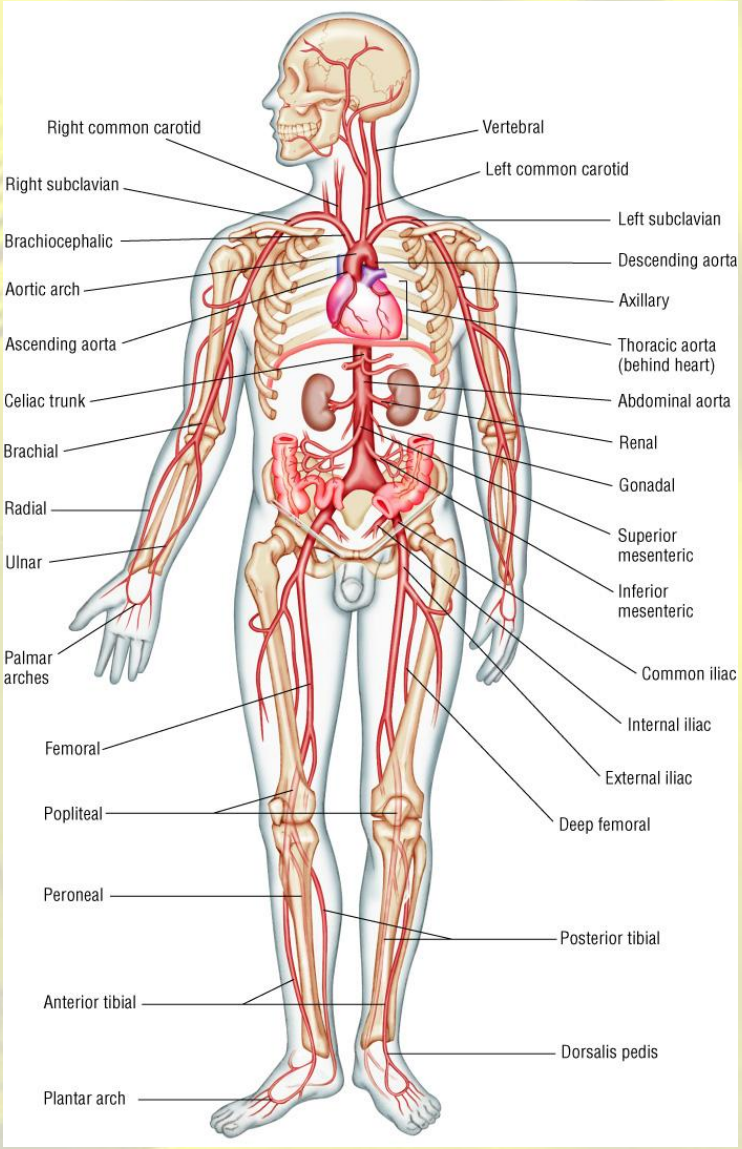
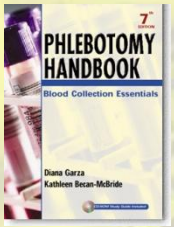
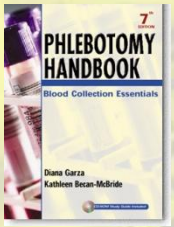


Figure 4.9 The Arterial System



Arteries

- The only artery that is ***not oxygenated*** is the ***pulmonary artery***, which carry blood from the right side of the heart to the lungs for oxygenation.
- Full of oxygen, normal arterial blood is bright, cherry red in color.
- The largest artery in the body is the ***aorta***.
- ***Arteries have a pulse.***



The Vessels and Circulation

Capillaries: Thin walls permit exchange of blood and fluids from surrounding tissues. They are so small in diameter that only one RBC can pass through at a time.

Veins: Thinner walls than arteries so they are more likely to collapse when blood is withdrawn.

Arteries: Thicker walls (Tonica externa) than veins; resist the strong pressure of blood being pushed through.

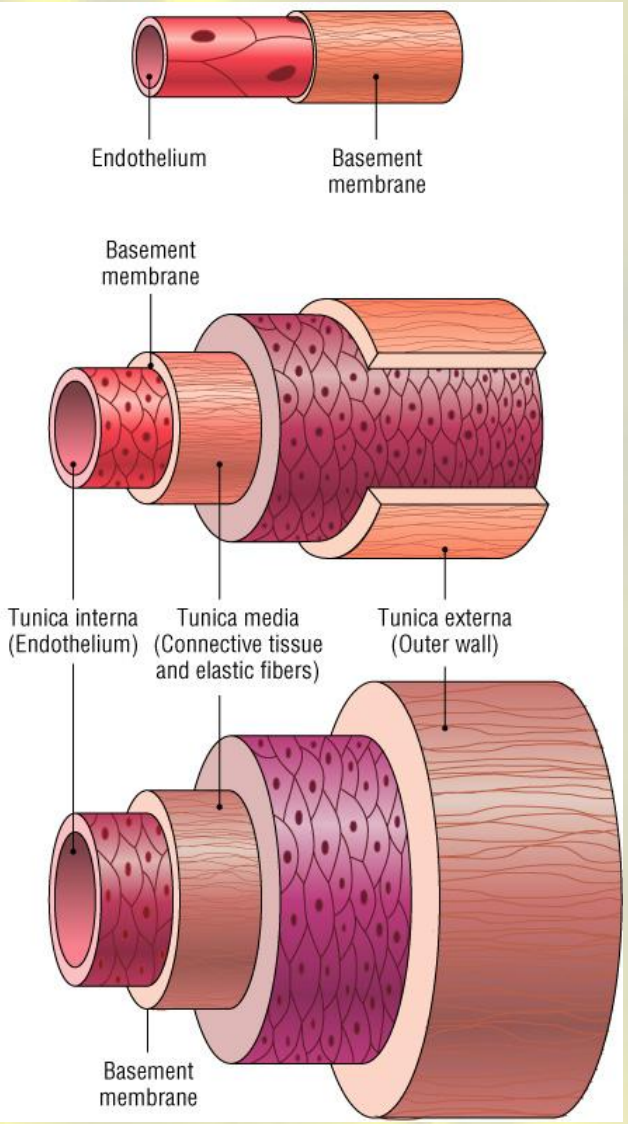
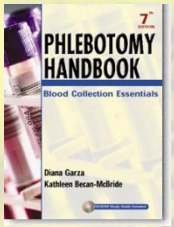
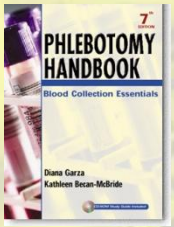


Figure 4.11 Comparison of Arteries, Veins, and Capillaries



Capillaries

- Blood flows from the arterial system into the smallest of the blood vessels, the ***capillaries***.
  - Capillaries are microscopic vessels composed of a single layer of endothelial cells
  - oxygen is released and carbon dioxide is absorbed by the blood.
  - Capillaries return the oxygen poor blood to the smallest of the veins, ***venules***
  - Blood in the capillaries is a mixture of both venous and arterial blood.



The Blood

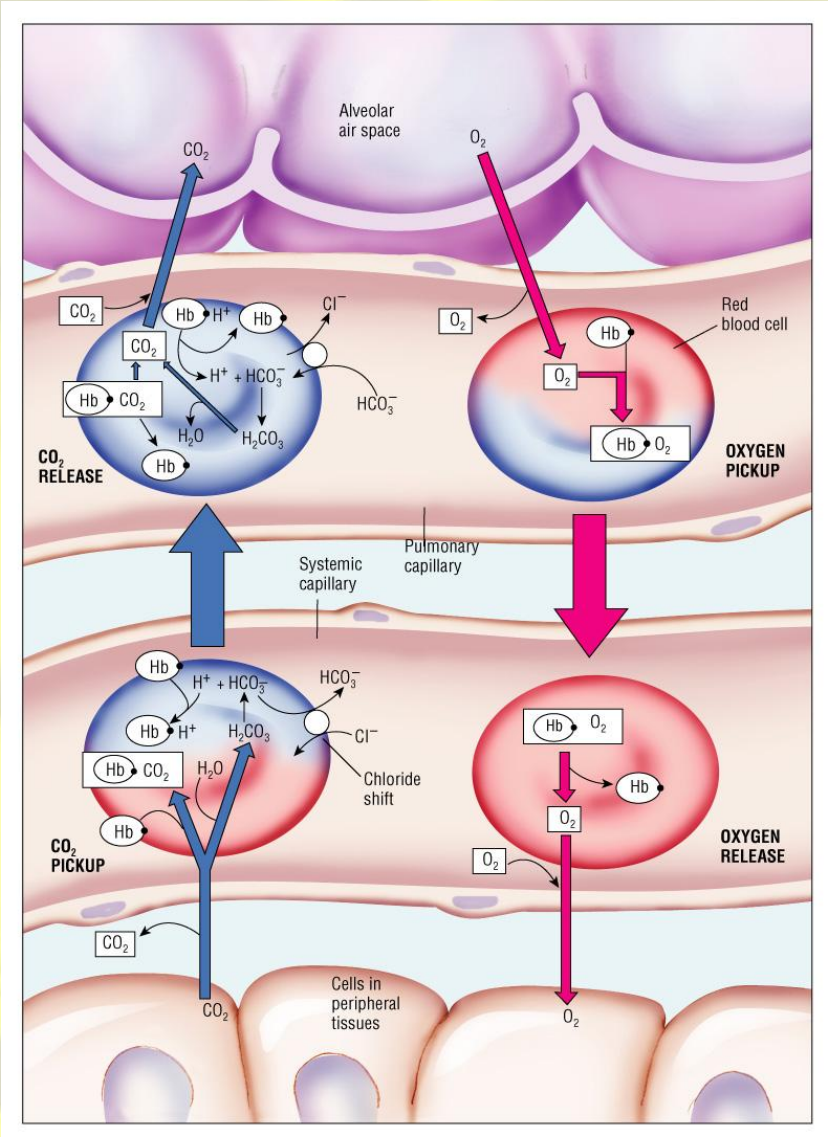
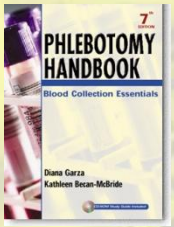


Figure 4.4 Exchange of gases in Systemic and Pulmonary Capillaries



The Vessels and Circulation

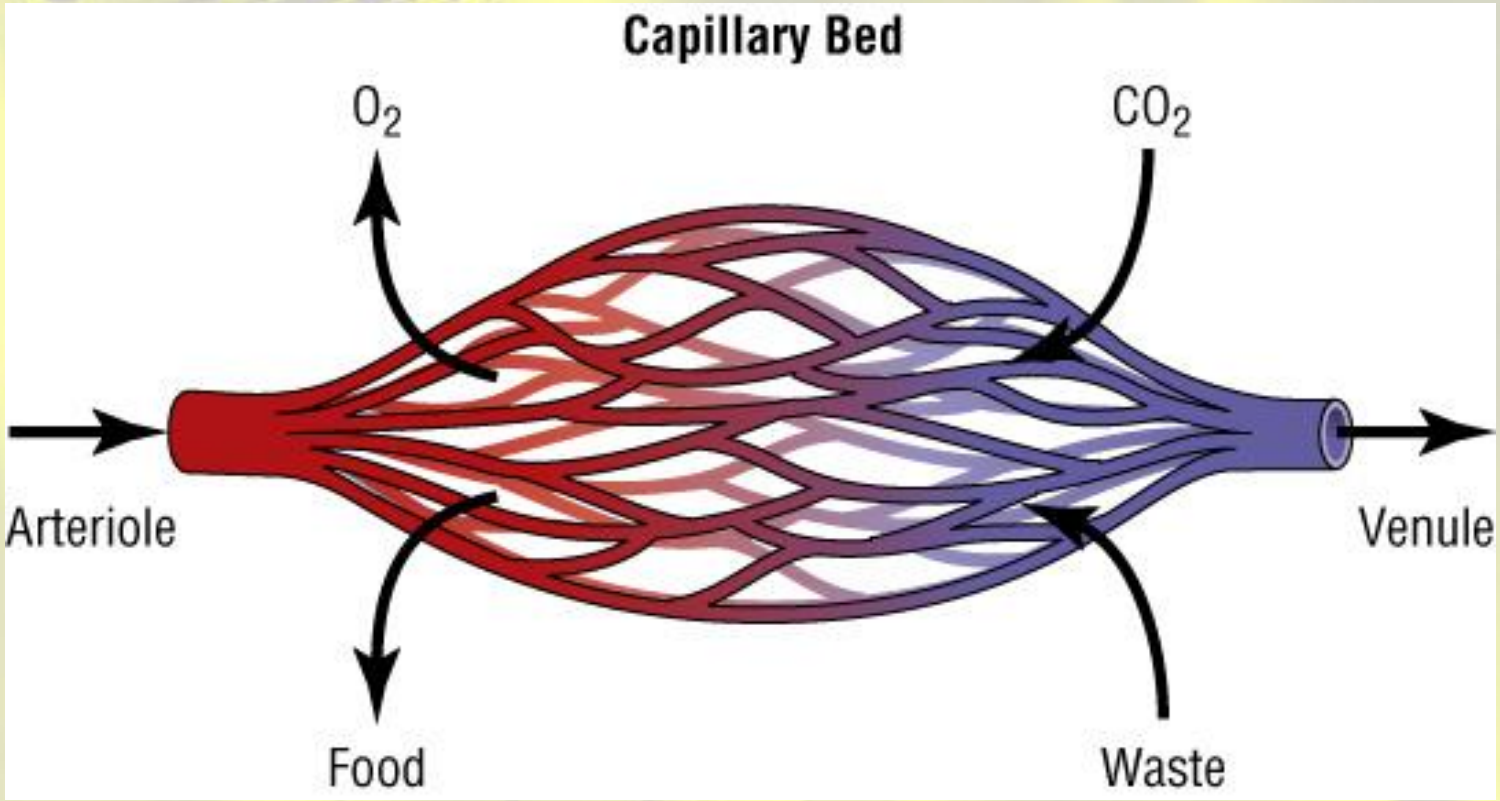
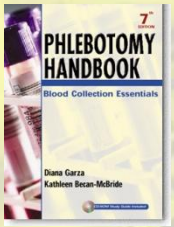
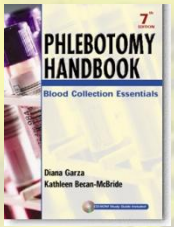


Figure 4.17 Capillary Bed

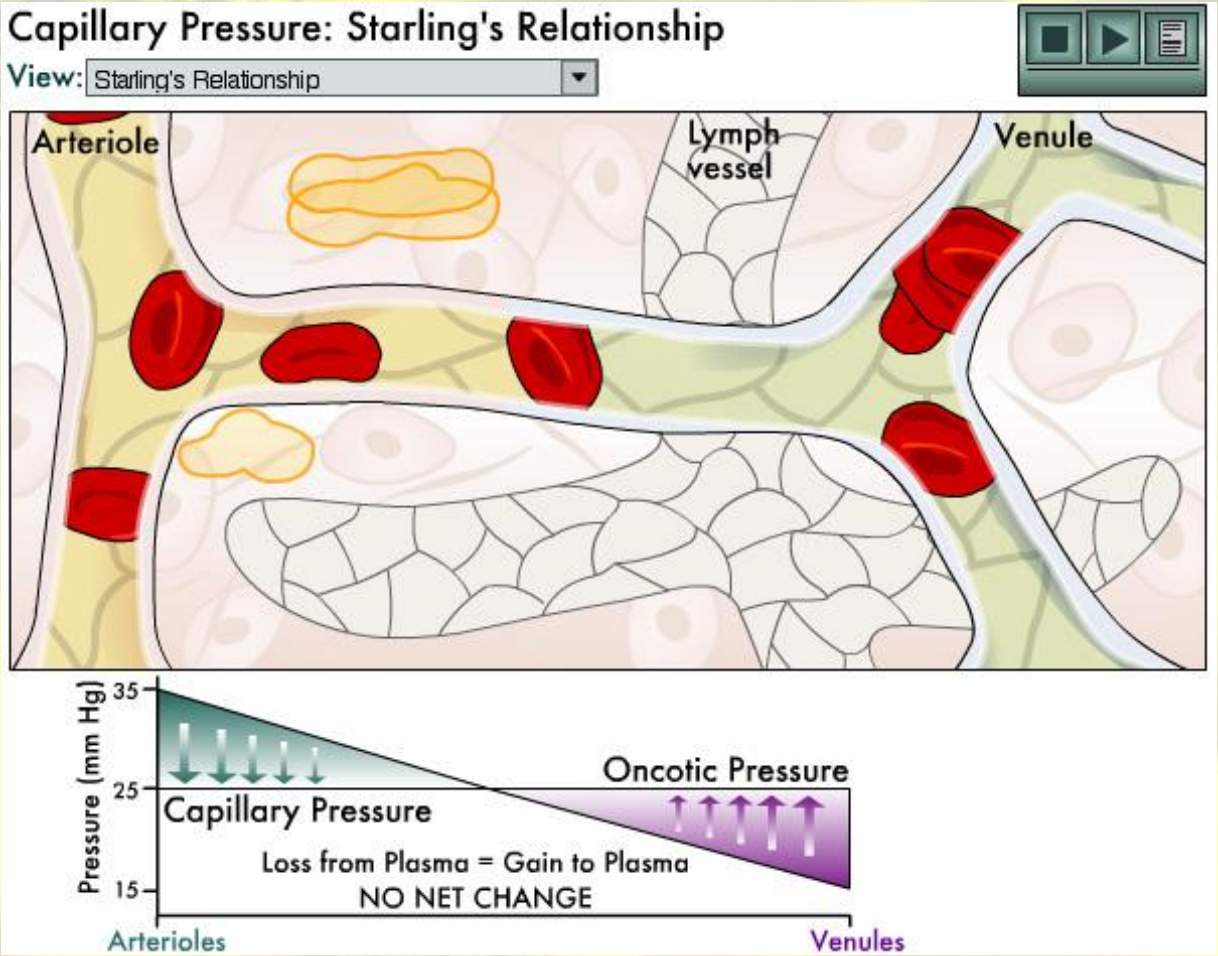


Capillaries

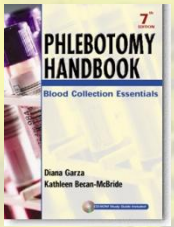
- Capillary bleeding is occurs slowly and evenly because of the smaller size of the vessels and the low pressure within the vessels.
- Capillary bleeding is usually considered minor and is easily controlled with slight pressure or sometimes bleeding stops without intervention.



The Vessels and Circulation



Click on the image above to see an animation showing capillary pressure.



The Vessels and Circulation

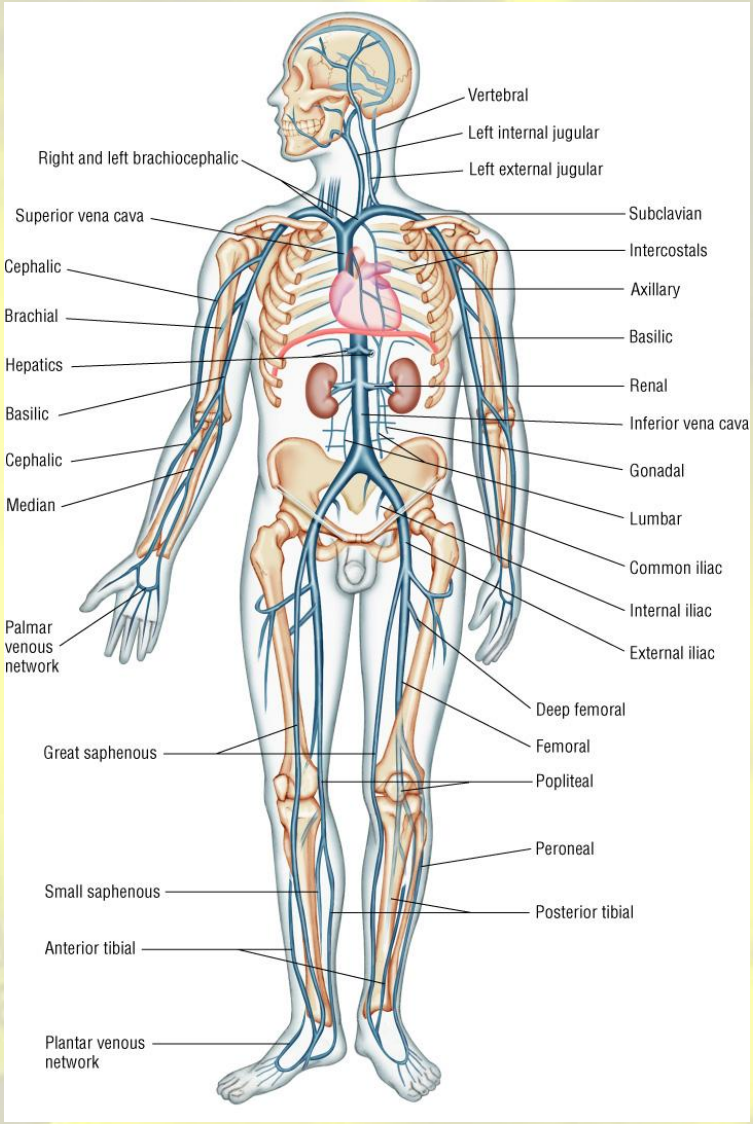
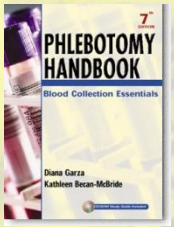
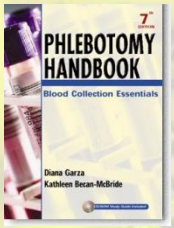


Figure 4.10 Venous System



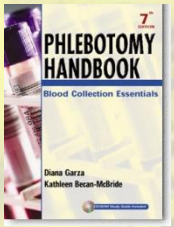
Veins

- ***Veins*** are responsible for returning blood to the heart.
  - Veins carry deoxygenated blood
  - The only vein that ***carries oxygenated*** blood is the ***pulmonary vein***, which carries oxygenated blood from the lungs back to the heart.
  - The walls composed of three layers but are thinner than arteries because the blood is under less pressure.



Veins

- Because venous blood is oxygen poor, it is much darker in color than normal arterial blood.
- The largest vein in the body is the *vena cava*.
- The longest vein in the body is the *great saphenous* vein in the leg.



The Vessels and Circulation

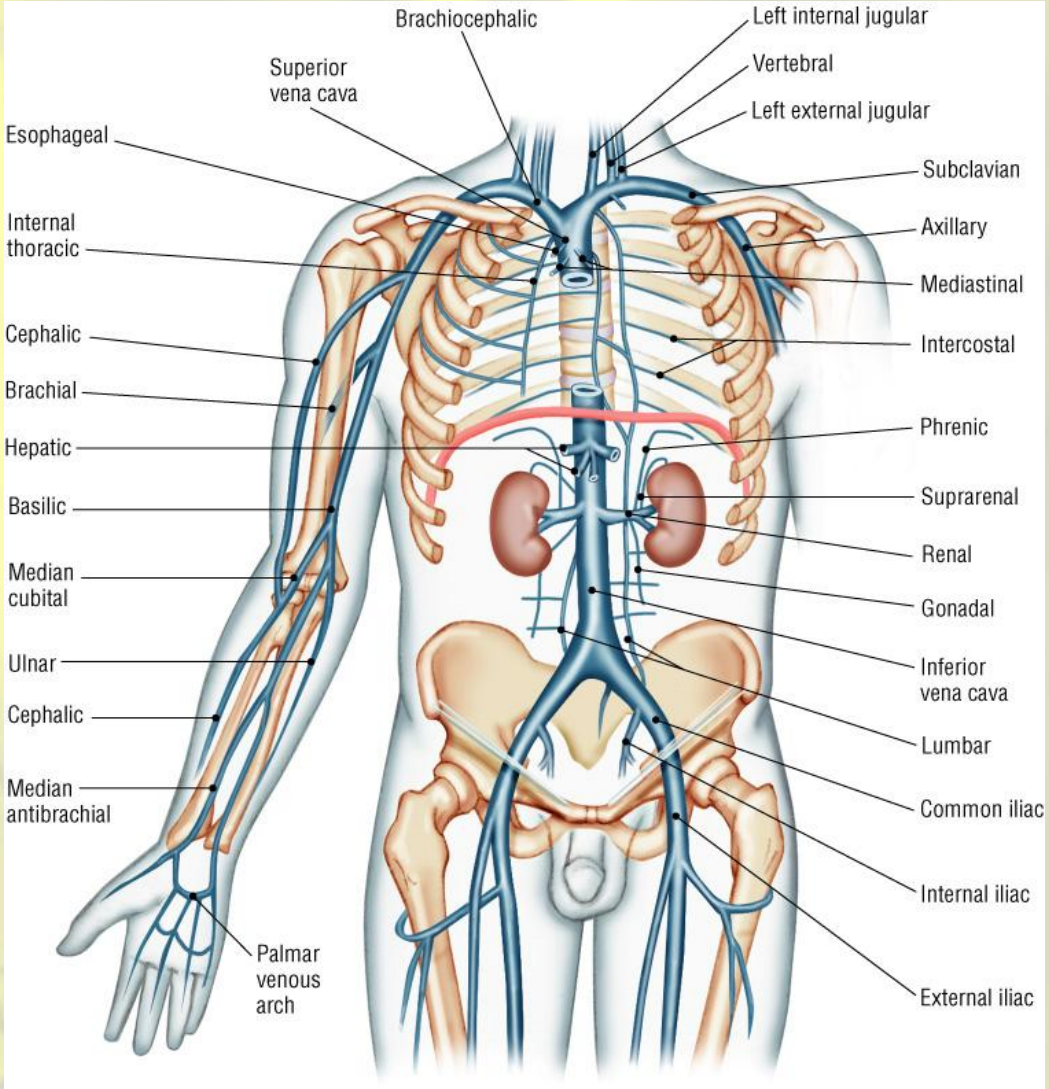
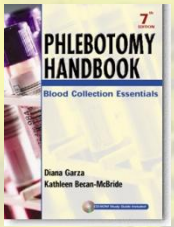


Figure 4.13 Venous System of the Upper Torso and Arm



The Vessels and Circulation

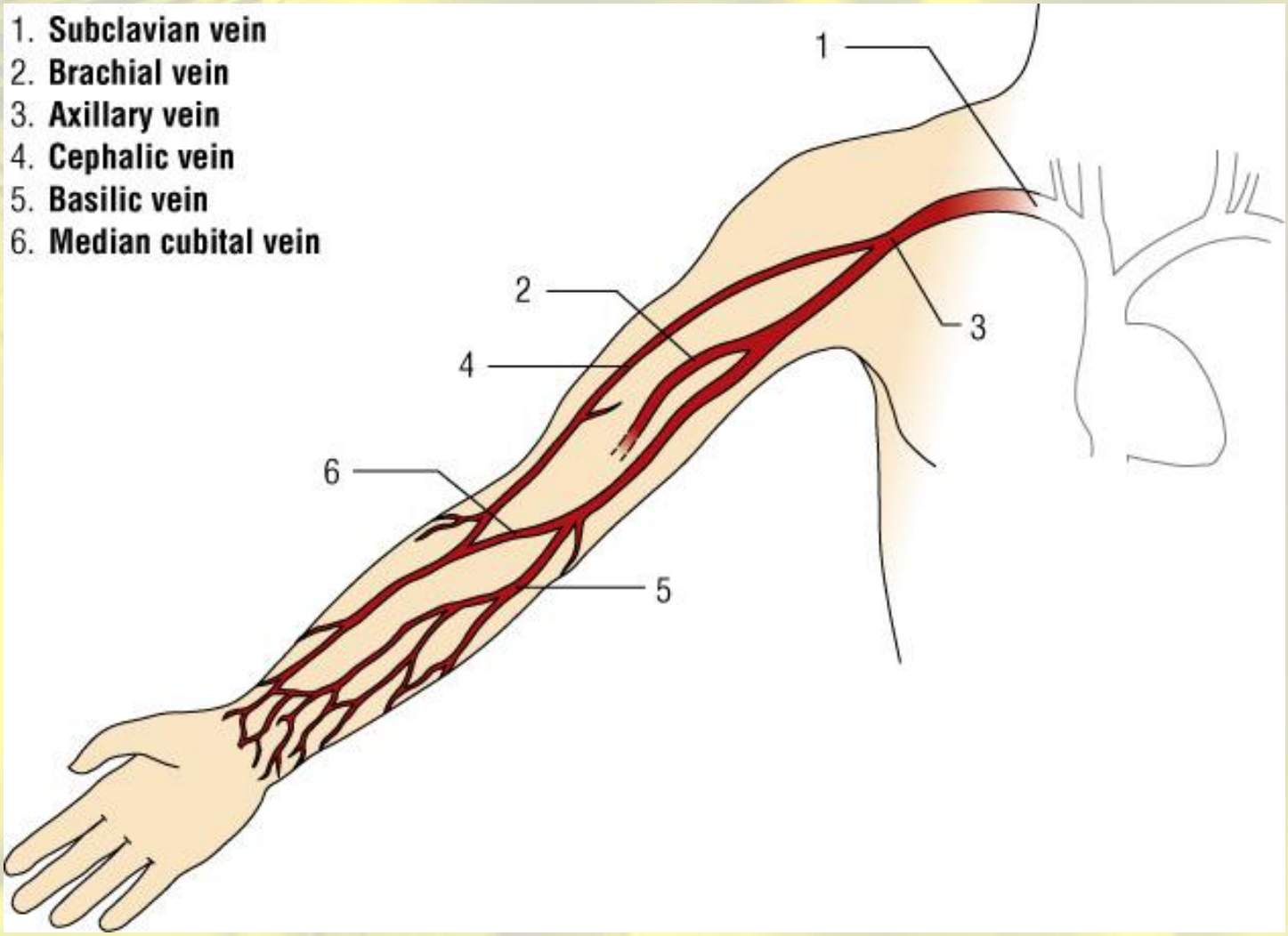
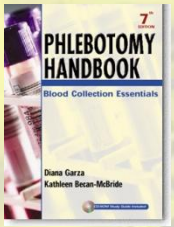


Figure 4.14 Major Arm Veins



The Vessels and Circulation

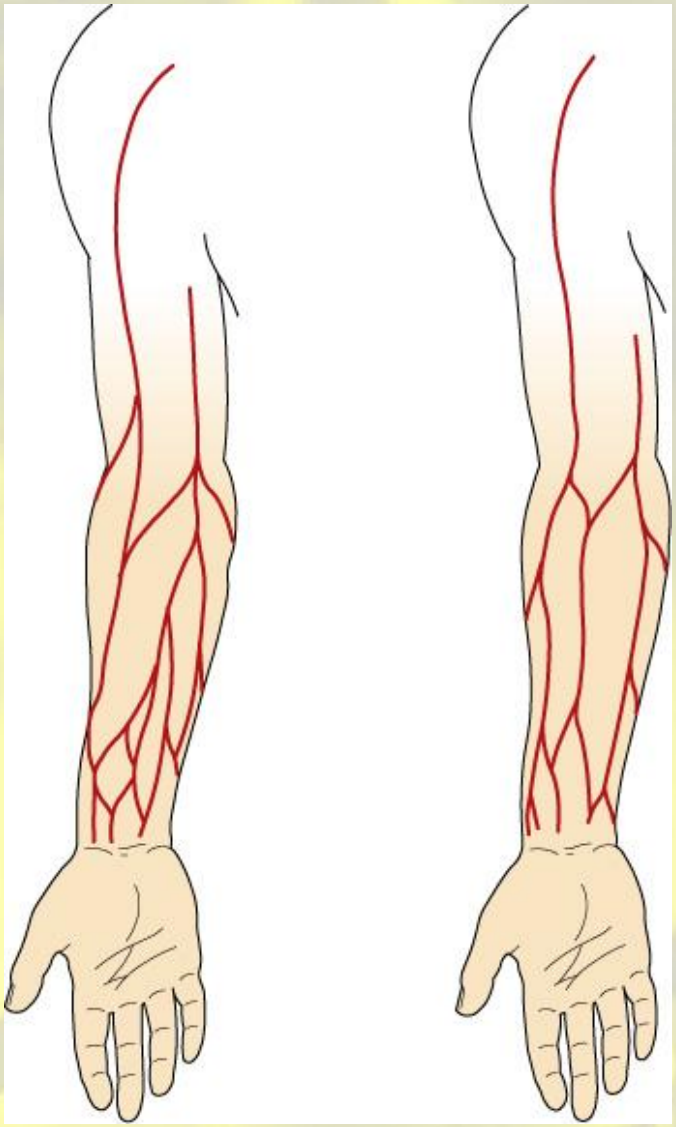
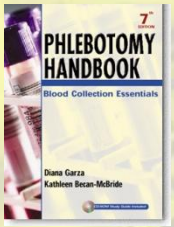


Figure 4.15 Variations in Venous Patterns



The Vessels and Circulation

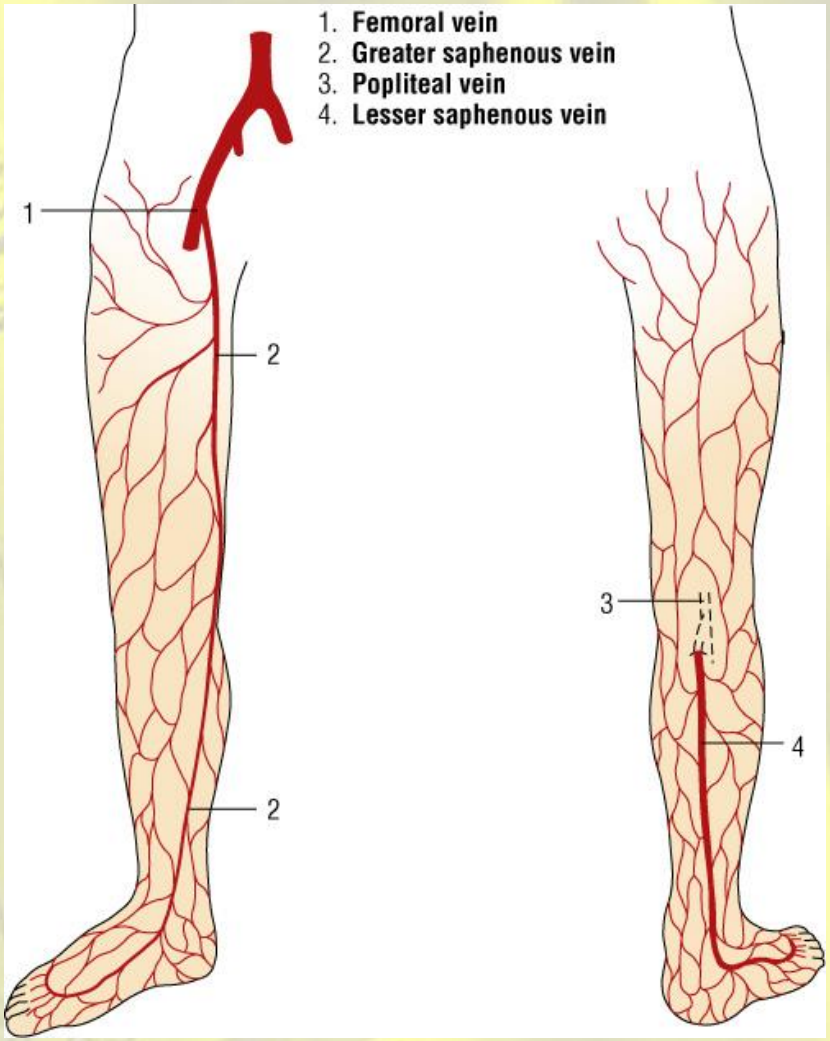
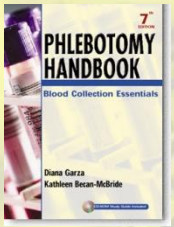


Figure 4.16 Major Leg Veins



The Vessels and Circulation

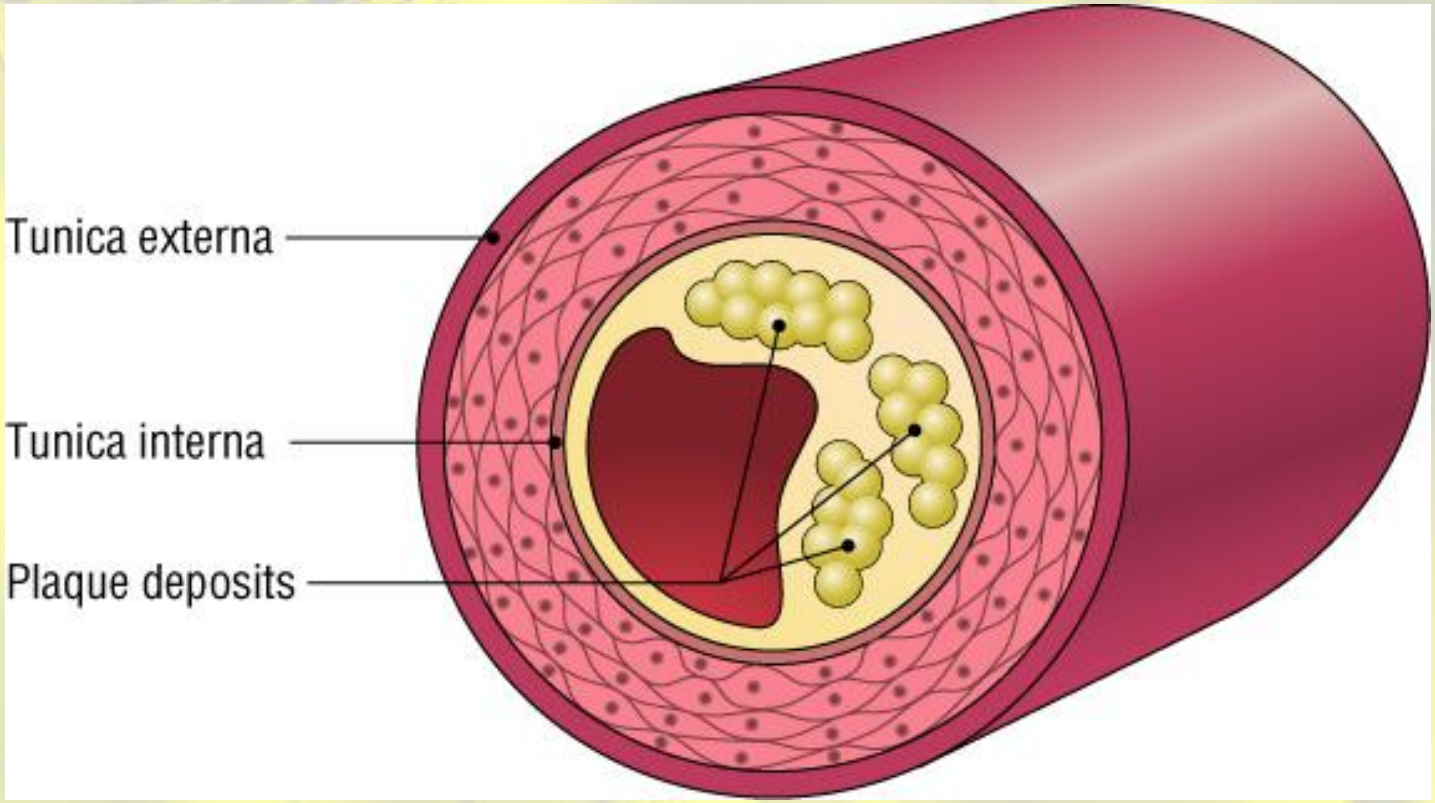
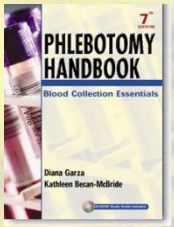
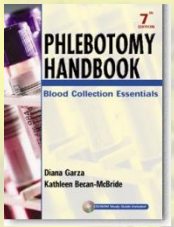


Figure 4.12 Plaque Build-Up Causing Partial Blockage of the Artery



Summary

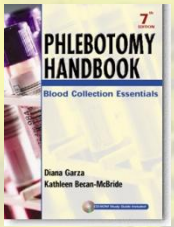
- In summary, blood is oxygenated in the lungs, the arteries carry the oxygen rich blood through arterioles then to the smallest branches called capillaries. Blood goes from the capillaries into the venules to the veins to be returned back to the heart.



Hemostasis and Coagulation

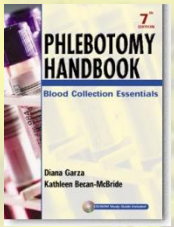
Hemostasis

- Hemostasis is the maintenance of circulating blood in the liquid state and retention of blood in the vascular system by preventing blood loss.



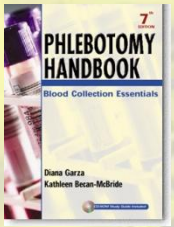
Hemostasis and Coagulation

- Hemostasis is the process by which the body stops the leakage of blood from the vascular system after an injury.
  - It includes the process that leads to clot formation as well as clot dissolution.
  - If an injury occurs to a blood vessel, the hemostatic process is set in motion to repair the injury.



Hemostasis and Coagulation

- This *hemostatic process*, also called *coagulation*, proceeds in four steps – MEMORIZE.
  - *Vasoconstriction*
  - *Platelet plug formation*
  - *Fibrin clot formation*
  - *Fibrinolysis*



Hemostasis and Coagulation

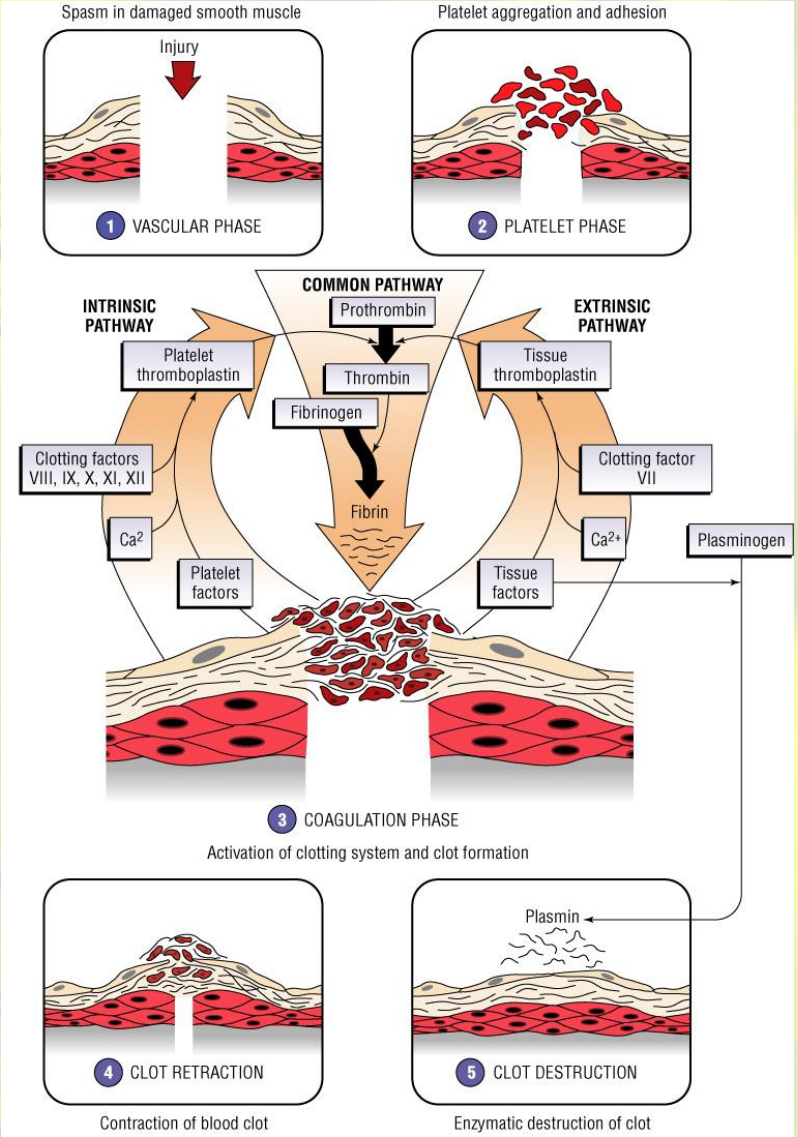
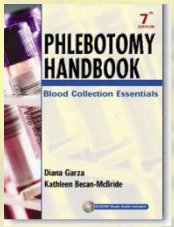


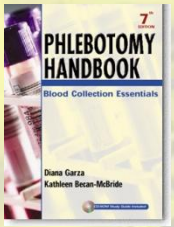
Figure 4.18 Steps in the clotting response



Hemostasis and Coagulation

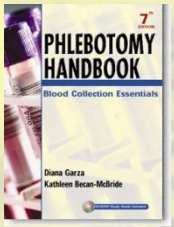
Coagulation Issues that Impact Phlebotomy

- Divided into two systems: intrinsic and extrinsic.
- When a phlebotomist discovers or anticipates bleeding, it is important to use standard precautions, including gloves, to avoid exposure of the skin and mucous membranes.
- Drugs such as heparin and Coumadin (warfarin), suppress clotting factors.
- Clotting factors are not produced by the body.
- Disseminated intravascular coagulation (DIC), emboli, thrombi, etc.



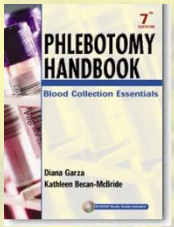
Laboratory Tests of the Cardiovascular System

- The number of RBCs, their morphological traits, and their hemoglobin content can be determined from an anticoagulated blood specimen in the clinical hematology laboratory.
- Platelets and WBCs can be assessed on the basis of number and morphological features.
- Platelet function, as well as each coagulation factor, can be measured from anticoagulated blood specimens in the coagulation section of the clinical hematology laboratory.



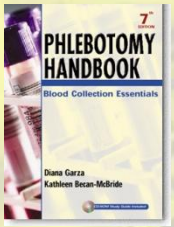
Diagnostic Assessment of the Circulatory System

- Blood
  - CBC including indices (MCV, MCH, MCHC) – lavender
  - Hemoglobin and/or Hematocrit (H&H) –lavender
  - differential – lavender
  - eosinophil count – lavender
  - ESR–lavender or black
  - Ferritin – red
  - Iron and total iron binding capacity (TIBC) – red
  - bone marrow



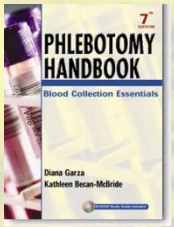
Diagnostic Assessment of the Circulatory System

- Heart
  - ABG
  - AST
  - CK and CK isoenzymes
  - Electrolytes –Na, K, CO2 and Cl
  - LDH
  - Triglycerides
  - cholesterol



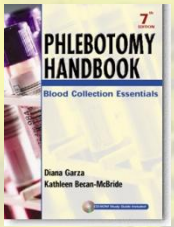
Diagnostic Assessment of the Circulatory System

- Blood Vessels
  - Cholesterol
  - Triglycerides
  - coagulation tests (see next)



Diagnostic Assessment of the Circulatory System

- Coagulation
  - Prothrombin time (PT)
  - Partial thromboplastin time (PTT)
  - Fibrinogen
  - Fibrin degradation products (FDP)
  - Platelet count
  - Factor assays
  - Bleeding time



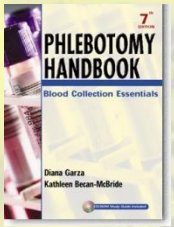
Laboratory Tests of the Cardiovascular System

TABLE 4–3. Common Blood Chemistries and Examples of Disorders Associated with Abnormal Results

Test	Abbreviation	Normal Range	EXAMPLES OF POSSIBLE DIAGNOSIS: Results Increased	EXAMPLES OF POSSIBLE DIAGNOSIS: Results Decreased
Alkaline phosphate	ALP	30–115 mU/mL	Liver disease, bone disease, mononucleosis	Malnutrition, hypothyroidism, chronic nephritis
Blood urea nitrogen	BUN	8–25 mg/dL	Kidney disease, dehydration, GI bleeding	Liver failure, malnutrition
Calcium	CA	8.5–10.5 mg/dL	Hypercalcemia, bone metastases, Hodgkin's disease	Hypocalcemia, renal failure, pancreatitis
Chloride	Cl	96–10 mEq/L	Dehydration, eclampsia, anemia	Ulcerative colitis, burns, heat exhaustion
Cholesterol	CHOL	120–200 mg/dL	Atherosclerosis, nephrosis, obstructive jaundice	Malabsorption, liver disease, hyperthyroidism
Creatinine	Creat	0.4–1.5 mg/dL	Chronic nephritis, muscle disease, obstruction of urinary tract	Muscular dystrophy
Globulin	Glob	1.0–3.5 g/dL	Brucellosis, rheumatoid arthritis, hepatic carcinoma	Severe burns
Glucose fasting blood sugar	FBS	70–110 mg/100 mL	Diabetes mellitus	Excess insulin
Two-hour postprandial	2-hr PPBS	< 140 mg/dL	Cushing syndrome, brain damage	Addison's disease, CA of pancreas
Lactic acid	LDH	100–225 mU/mL	Acute MI, acute leukemia, hepatic disease	
Potassium	K	3.5–5.5 mEq/L	Renal failure, acidosis, cell damage	Malabsorption, severe burn, diarrhea
Serum glutamicoxaloacetic	SGOT	0–41 mU/mL	MI, liver disease, pancreatitis	Uncontrolled diabetes mellitus with acidosis
Serum glutamicpyruvic transaminase	SGPT	0–45 mU/mL	Active cirrhosis, pancreatitis, obstructive jaundice	
Sodium	NA	135–145 mEq/L	Diabetes insipitus, coma, Cushing syndrome	Severe diarrhea, severe nephritis, vomiting
Free thyroxine	T4	1–2.3 mg/dL	Thyroiditis, hyperthyroidism, Graves disease	Goiter, myeledema, hypothyroidism
Total bilirubin	TB	0.1–1.2 mg/dL	Liver disease, hemolytic anemia, lupus erythemia	
Triglycerides	TRIG	40–170 mg/dL	Liver disease, atherosclerosis, pancreatitis	Malnutrition
Uric acid	UA	2.2–9.0 mg/dL	Renal failure, gout, leukemia, eclampsia	

GI = gastrointestinal; CA = carcinoma, malignant tumor; MI = myocardial infarction

Table 4.3 Common Blood Chemistries and Examples of Disorders Associated with Abnormal Results



Laboratory Tests of the Cardiovascular System

- Bone marrow can be stained and studied microscopically in the hematology laboratory for the detection of abnormal numbers and morphological characteristics of blood cells.
- Tests for blood types and cross-matches for donor blood are done in an immunohematology, a transfusion, or a blood banking laboratory