Hematopoietic and Lymphoid Systems
Blood

- Provides the major transport system of the body for essentials
  - Oxygen (primary function)
  - Glucose
  - Other nutrients
    - Hormones
    - Electrolytes
    - Cell wastes
Blood

- Adults
  - 5-6 liters
    - 55% plasma
      - Water and dissolved solutes
    - 45% cells or formed elements
      - Erythrocytes
      - Leukocytes
      - Thrombocytes or platelets
Blood

- Plasma Proteins (7% of plasma)
  - Albumin
    - Maintains osmotic pressure in blood
  - Globulins
    - Antibodies
  - Fibrinogen
    - Essential to the formation of blood clots
Blood Cells

- Originate from red bone marrow
  - In the adult
    - Flat and irregular bones
      - Ribs
      - Vertebrae
      - Sternum
      - Pelvis (iliac crest)
        - Common donor site
Blood Cells

- Red Blood Cells (erythrocytes)
- White Blood Cells (leukocytes)
  - Neutrophils
  - Eosinophils
  - Basophils
  - Monocytes
  - Lymphocytes
- Platelets
Erythrocytes

- Red Blood Cells – RBCs
  - Bi-concave discs
  - Non-nucleated when mature
  - Contain hemoglobin
  - Live in circulation approx 120 days
  - Primary function: transport of oxygen
Hemoglobin

- Iron containing pigment
- Complex molecule containing 4 heme groups and 4 globins
- Synthesis requires iron, vitamin B12, vitamin B6, and folic acid
Blood

- **Lifespan**
  - 120 days
    - Fragile as it ages
    - Succumbs to phagocytosis in the spleen or liver
      - Recycled in the amino acid pool
      - Iron can be stored
      - Heme component is converted to bilirubin and may form bile
        - Elevated serum bilirubin = jaundice
          - Yellow sclera and skin
Leukocytes (WBCs)

- Participate in body’s defense against infection

- Lymphocytes
  - 40% of WBCs
  - T & B lymphocytes - immunity
WBC

- Neutrophils
  - Most common but have short lifespan
    - 4 days
  - First responders to tissue damage
    - phagocytosis
WBC

- Basophils
  - Migrate from the blood and enter tissue to become mast cells
    - Can release
      - Histamine
      - Heparin
  - May be fixed or wandering
WBC

- Eosinophils
  - Control the effects of histamine
  - Increased by allergic reactions
WBC

- Monocytes
  - Enter the tissue to become macrophages
  - Act as phagocytes when tissue damage occurs
Complete Blood Count (CBC)

- Test provides results regarding the concentration of WBC, RBC, platelets
  - WBC- tells whether level is normal, decreased, elevated
    - Elevated- infection or inflammatory response
    - Decreased- bone marrow disease or chemotherapy
  - RBC- assessing body’s ability to carry oxygen
Blood tests of RBC

- Hematocrit
  - Volume of packed RBC, expressed as a % of total peripheral blood
    - Quick screen for anemia
    - Adults: 37-52%

- Hemoglobin
  - Total RBC mass
    - Also screen for anemia
    - Adults: 12-18 g/dl
Platelets

- Essential to clotting process
  - Hemostasis
- NOT Cells, small irregularly shaped, non-nucleated fragments
  - Stick to damaged tissue as well as to each other to form a platelet plug
    - Sealing small breaks in blood vessels
Platelets

- Able to adhere to
  - Rough surfaces
  - Foreign material

- Aspirin prevents this adhesion and can lead to an increased bleeding tendency.
Blood Clotting

- 3 steps in hemostasis
  - ONE
    - Immediate response of a blood vessel to injury
      - Vasoconstriction
        - May allow a plug to form
Blood Clotting

- 3 steps in hemostasis
  - TWO
    - Thrombocytes (platelets) tend to adhere to the underlying tissue at the site of injury
      - A clot can form
Blood Clotting

- 3 steps in hemostasis
  - THREE
  - Blood clotting mechanism is required in larger vessels, by which the clotting factors that are present in inactive forms in the circulating blood are activated through a sequence of reactions.
Blood Clotting

- Damaged tissue and platelets release factors that stimulate a cascade of reactions involving numerous clotting factors
  - Prothrombin activator
Blood Clotting

- Prothrombin
  - Inactive in the plasma
  - Is converted into thrombin
Blood Clotting

- **Fibrinogen**
  - Is converted into fibrin threads
  - Results in the formation of a fibrin mesh that traps cells
    - Makes up a solid clot
    - Thrombus
      - Stops the flow of blood

Blood Clotting

- The clot gradually shrinks or retracts
- Pulling the edges of damaged tissue closer together and sealing the site
Blood Clotting

- Circulating clotting factors are produced primarily in the liver
- **Vitamin K** (*fat soluble vitamin*)
  - Required for the synthesis of most clotting factors
- **Calcium ions**
  - Essential for many steps in the process
Blood Clotting

- Facilitating a clot
  - Apply pressure
  - Apply cold
    - Vasoconstrictor
- These reduce blood flow in the area
  - Thrombin solution can be applied directly to speed up clotting
Fibrinolysis

- Balance
  - Between clotting tendency and blood loss
  - Formations of clots unnecessarily and cause infarctions
    - Coagulation inhibitors
      - Antithrombin
      - Prostaglandin prevents platelets from sticking
      - Heparin
      - Released from basophils
Disorders of RBC

- Anemia
  - Reduction of hemoglobin in the blood to below normal levels
    - Male: below 14 g/dl
    - Female: below 12 g/dl
  - Reduction in oxygen-carrying capacity in the blood
    - hypoxia
Anemia

- Results from:
  - Excessive blood loss
    - GI bleeding
  - Increased destruction of RBC
    - Autoimmune hemolytic anemia
  - Decreased production of RBC
    - Aplastic anemia
Anemia

- Clinical manifestations:
  - Mild: fatigue
  - As anemia progresses: weakness, dyspnea on exertion, easy fatigue

- Treatment
  - Directed towards cause
Sickle Cell Disease

- Autosomal recessive disorder
- Shape changes from biconcave disk to crescent (or sickle) shape once the oxygen is released
- Resumes normal shape once re-oxygenated
- Repeated cycles leave RBC permanently damaged and hemolyzes
Sickle Cell Disease

- Average sickle RBC lifetime only 10-20 days
- Cells cannot be replaced fast enough and anemia is the result
Sickle Cell Disease

- Clinical manifestations:
  - Pain
  - Vascular complications
  - Pulmonary episodes
  - Neurologic manifestations
  - Renal complications
Sickle Cell Disease

- Marked by periodic exacerbations... sickling crisis

- Sickling crisis caused by
  - Infection
  - Emotional problems
  - Extreme temperatures
  - Fatigue
  - Pregnancy
  - Dehydration
  - Alcohol
Disorders of RBC

- Polycythemia
  - Increased amount of RBC
  - Increases viscosity of the blood that can lead to thrombosis or embolism

Causes:
- Types of lung and heart disease
- Living in high altitude
- Dehydration
Polycythemia

- Symptoms:
  - Increased risk of clot
  - HTN
  - Appear red or flushed in face
  - Headaches
  - Visual problems
Disorders of WBC

- Leukopenia
  - Reduction in WBC
  - Neutropenia: low # of neutrophils
  - Lymphopenia: reduction in # of lymphocytes
- Causes:
  - Radiation therapy
  - Chemotherapy
  - Chronic diseases that damage bone marrow
- Leads to reduction in ability of immune system to fight off disease
Malignant diseases of WBC

- Leukemias
  - Neoplasm of blood forming cells
- Lymphomas
  - Cells develop in lymphoid system
Replaces normal bone marrow with malignant clone

- 4 major types:
  - Acute lymphocytic
  - Chronic lymphocytic
  - Acute myeloid
  - Chronic myeloid
Leukemia

- Symptoms:
  - Anemia
  - Infection
  - Bleeding tendencies
Lymphoma

- Malignant cells infiltrate the lymph nodes, spleen, thymus, bone marrow
- 2 types
  - Hodgkin’s
  - Non-Hodgkins
Multiple myeloma

- Neoplasm of plasma cells arising in the bone marrow
- Initially affects bones
- Progression to damage of kidney, nervous system
- Prognosis: median survival is 3 yrs
Bleeding Disorders

- Vascular disorders
  - Mechanical trauma
  - Vessel wall weakness
  - Immune mechanisms
Bleeding disorders

- Platelet disorders
  - Decreased #
    - Thrombocytopenia
      - decreased production of platelets
        - Aplastic anemia
        - Leukemia
        - Drugs
      - Increased destruction of platelets
        - SLE
        - Hemolytic anemia
Platelet disorders

- Thrombocytopenia
  - Increased removal of platelets
    - Hypersplenism
  - Consumption of platelets
    - DIC
Clotting Factor Deficiencies

- Congenital- hemophilia
  - Sex linked autosomal recessive trait
  - Affected males
  - Severe:
    - bleed spontaneously or with only slight trauma (particularly into joints and deep muscle)
  - Moderate:
    - Major bleeding episodes can occur with minor trauma
Clotting Factor Deficiencies

- Acquired:
  - Chronic liver disease
  - Anticoagulant use