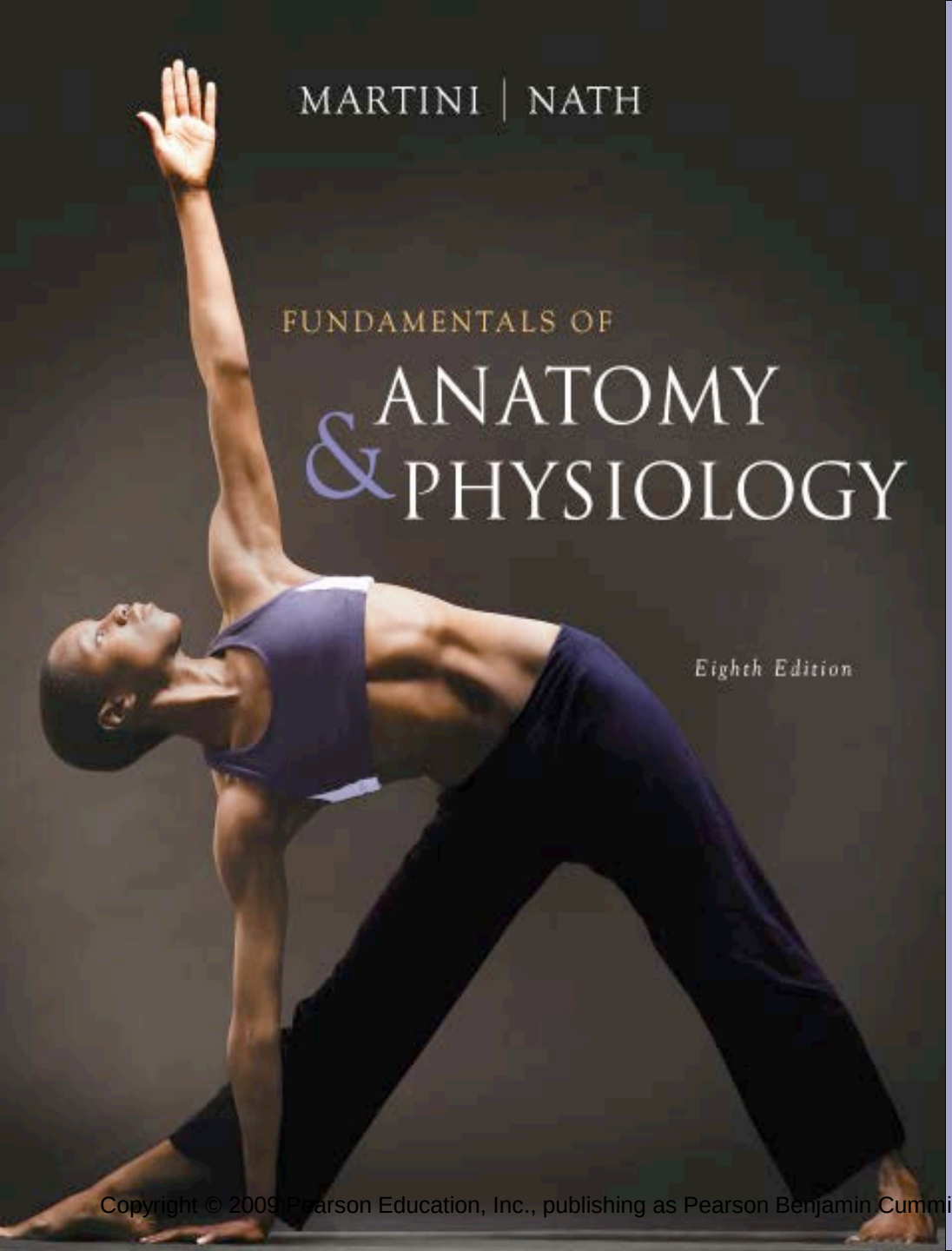

Chapter

19

Blood

PowerPoint® Lecture Slides
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Introduction to the Cardiovascular System

- To transport materials to and from cells
  - Oxygen and carbon dioxide
  - Nutrients
  - Hormones
  - Immune system components
  - Waste products

Functions of Blood

- Transport of dissolved substances
- Regulation of pH and ions
- Restriction of fluid losses at injury sites
- Defense against toxins and pathogens
- Stabilization of body temperature

Physical Characteristics of Blood

- Whole Blood
  - Plasma
    - Fluid consisting of:
      - water
      - dissolved plasma proteins
      - other solutes
  - Formed elements
    - All cells and solids

Physical Characteristics of Blood

- Three Types of Formed Elements
  - **Red blood cells (RBCs)** or **erythrocytes**
    - Transport oxygen
  - **White blood cells (WBCs)** or **leukocytes**
    - Part of the immune system
  - **Platelets**
    - Cell fragments involved in clotting

Physical Characteristics of Blood

- Hemopoiesis
  - Process of producing formed elements
  - By myeloid and lymphoid stem cells
- Fractionation
  - Process of separating whole blood for clinical analysis
    - Into plasma and formed elements

Physical Characteristics of Blood

- Three General Characteristics of Blood
  - 38°C (100.4°F) is normal temperature
  - High viscosity
  - Slightly alkaline pH (7.35–7.45)

Physical Characteristics of Blood

- Blood volume (liters) = 7% of body weight (kilograms)
  - Adult male: 5 to 6 liters
  - Adult female: 4 to 5 liters

Plasma

- Makes up 50–60% of blood volume
- More than 90% of plasma is water
  - Materials plasma exchanges across capillary walls
    - Water
    - Ions
    - Small solutes

Plasma

- Plasma Proteins
  - **Albumins** (60%)
    - Transport substances such as fatty acids, thyroid hormones, and steroid hormones
  - **Globulins** (35%)
    - Antibodies, also called immunoglobulins
    - Transport globulins (small molecules): hormone-binding proteins, metalloproteins, apolipoproteins (**lipoproteins**), and steroid-binding proteins
  - **Fibrinogen** (4%)
    - Molecules that form clots and produce long, insoluble strands of fibrin

Plasma

- Serum
  - Liquid part of a blood sample
    - In which dissolved fibrinogen has converted to solid fibrin
- Other Plasma Proteins
  - 1% of plasma
    - Changing quantities of specialized plasma proteins
    - Enzymes, hormones, and prohormones

Red Blood Cells

- Red blood cells (RBCs) make up 99.9% of blood's formed elements
- Hemoglobin
  - The red pigment that gives whole blood its color
  - Binds and transports oxygen and carbon dioxide

Red Blood Cells

- Structure of RBCs
  - Small and highly specialized discs
  - Thin in middle and thicker at edge
  - Quickly absorbs and releases oxygen

Red Blood Cells

- Lifespan of RBCs
  - Lack nuclei, mitochondria, and ribosomes
    - Means no repair and *anaerobic* metabolism
    - Live about 120 days

Red Blood Cells

- Hemoglobin (Hb)
  - Protein molecule, that transports respiratory gases

Red Blood Cells

- Hemoglobin Structure
  - Complex quaternary structure
  - Four globular protein subunits:
    - Each with one molecule of **heme**
    - Each heme contains one iron ion
  - Iron ions
    - Associate easily with oxygen (**oxyhemoglobin**)
      - » OR
    - Dissociate easily from oxygen (**deoxyhemoglobin**)

Red Blood Cells

- Hemoglobin Function
  - Carries oxygen
  - With low oxygen (peripheral capillaries)
    - Hemoglobin releases oxygen
    - Binds carbon dioxide and carries it to lungs
      - Forms **carbaminohemoglobin**

Red Blood Cells

- RBC Formation and Turnover
  - 1% of circulating RBCs wear out per day
    - About 3 million RBCs per second
  - Macrophages of liver, spleen, and bone marrow
    - Monitor RBCs
    - Engulf RBCs before membranes rupture (**hemolyze**)

Red Blood Cells

- RBC Production
  - Erythropoiesis
    - Occurs only in red bone marrow in adults
    - Stem cells (Hemocytoblasts) mature to become RBCs
    - **Myeloid stem cells**: become RBCs, some WBCs
    - **Lymphoid stem cells**: become lymphocytes

Blood Typing

- Are cell surface proteins that identify cells to immune system
- Normal cells are ignored and foreign cells attacked
- Blood types
  - Are genetically determined
  - By presence or absence of RBC surface antigens **A, B, Rh (or D)**

Blood Typing

- Four Basic Blood Types
  - A (surface antigen A)
  - B (surface antigen B)
  - AB (antigens A and B)
  - O (neither A nor B)

Blood Typing

- Agglutinogens
  - Antigens on surface of RBCs
  - Screened by immune system
  - Plasma antibodies attack and **agglutinate** (clump) foreign antigens

Blood Typing

- Blood Plasma Antibodies
  - Type A
    - Type B antibodies
  - Type B
    - Type A antibodies
  - Type O
    - Both A and B antibodies
  - Type AB
    - Neither A nor B antibodies

Blood Typing

- The Rh Factor
  - Also called D antigen
  - Either Rh positive (Rh^+) or Rh negative (Rh^-)
    - Only **sensitized** Rh^- blood has anti-Rh antibodies

Blood Typing

- Cross-Reactions in Transfusions
  - Also called transfusion reaction
  - Plasma antibody meets its specific surface antigen
  - Blood will agglutinate and hemolyze
  - Occur if donor and recipient blood types not **compatible**

Blood Typing

- Cross-Match Testing for Transfusion Compatibility
  - Performed on donor and recipient blood for compatibility
  - Without cross-match, type O^- is universal donor

White Blood Cells

- Also called leukocytes
- Do not have hemoglobin
- Have nuclei and other organelles
- WBC functions
  - Defend against pathogens
  - Remove toxins and wastes
  - Attack abnormal cells

White Blood Cells

- WBC Circulation and Movement
  - Most WBCs in
    - Connective tissue proper
    - Lymphoid system organs
  - Small numbers in blood

White Blood Cells

- WBC Circulation and Movement
  - Characteristics of circulating WBCs
    - Can migrate out of bloodstream
    - Have amoeboid movement
    - Attracted to chemical stimuli (**positive chemotaxis**)
    - Some are phagocytic:
      - neutrophils, eosinophils, and monocytes

White Blood Cells

- Types of WBCs

1. Granulocytes – contain tiny granules
    - Neutrophils
    - Eosinophils
    - Basophils

White Blood Cells

- Types of WBCs

  2. Agranulocytes – don’t contain tiny granules

     - Monocytes
     - Lymphocytes
       - T cells
       - B cells
       - NK (natural killer) cells

White Blood Cells

- Neutrophils
  - 50–70% of circulating WBCs
  - Pale cytoplasm granules with
    - Lysosomal enzymes
    - Bactericides (hydrogen peroxide and superoxide)

White Blood Cells

- Neutrophil Action
  - Very active, first to attack bacteria
  - Engulf pathogens
  - Digest pathogens
    - Degranulation:
      - removing granules from cytoplasm
      - **defensins** (peptides from lysosomes) attack pathogen membranes
  - Release prostaglandins and leukotrienes
  - Form pus

White Blood Cells

- Eosinophils
  - 2–4% of circulating WBCs
  - Attack large parasites
  - Excrete toxic compounds
    - Nitric oxide
    - Cytotoxic enzymes
  - Are sensitive to allergens
  - Control inflammation with enzymes that counteract inflammatory effects of neutrophils and mast cells

White Blood Cells

- Basophils
  - Are less than 1% of circulating WBCs
  - Are small
  - Accumulate in damaged tissue
  - Release histamine
    - Dilates blood vessels
  - Release heparin
    - Prevents blood clotting

White Blood Cells

- Monocytes
  - 2–8% of circulating WBCs
  - Are large and spherical
  - Enter peripheral tissues and become macrophages
  - Engulf large particles and pathogens
  - Secrete substances that attract immune system cells and fibrocytes to injured area

White Blood Cells

- Lymphocytes
  - 20–30% of circulating WBCs
  - Are larger than RBCs
  - Migrate in and out of blood
  - Mostly in connective tissues and lymphoid organs
  - Are part of the body’s specific defense system

White Blood Cells

- Three Classes of Lymphocytes
  - T cells
    - Cell-mediated immunity
    - Attack foreign cells directly
  - B cells
    - Humoral immunity
    - Differentiate into **plasma cells**
    - Synthesize antibodies
  - Natural killer (NK) cells
    - Detect and destroy abnormal tissue cells (cancers)

White Blood Cells

- WBC Disorders
  - Leukopenia
    - Abnormally low WBC count
  - Leukocytosis
    - Abnormally high WBC count
  - Leukemia
    - Extremely high WBC count

Platelets

- Cell fragments involved in human clotting system
  - Nonmammalian vertebrates have thrombocytes (nucleated cells)
- Circulate for 9–12 days
- Are removed by spleen
- 2/3 are reserved for emergencies

Platelets

- Platelet Counts
  - Thrombocytopenia
    - Abnormally low platelet count
  - Thrombocytosis
    - Abnormally high platelet count

Platelets

- Three Functions of Platelets:
  1. Release important clotting chemicals
  2. Temporarily patch damaged vessel walls
  3. Actively contract tissue after clot formation

Platelets

- Platelet Production
  - Also called **thrombocytopoiesis**
    - Occurs in bone marrow
  - Megakaryocytes
    - Giant cells in bone marrow
    - Manufacture platelets from cytoplasm