BLOOD

Chapter 14

Karen Webb Smith

BLOOD

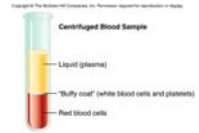
Blood
- connective tissue
- transports vital substances
- maintains stability of interstitial fluid
- distributes heat

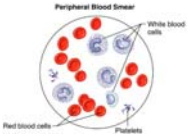
Blood Cells
- form mostly in red bone marrow
- red blood cells
- white blood cells
- platelets (cell fragments)

Blood Volume

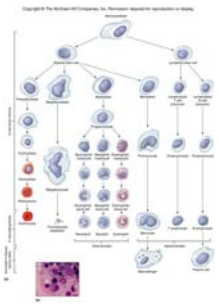
- varies with
  - body size
  - changes in fluid concentration
  - changes in electrolyte concentration
  - amount of adipose tissue
- about 8% of body weight
- about 5 liters

Blood Composition



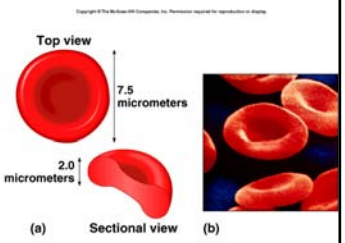


Origin of Blood Cells



Characteristics of Red Blood Cells

- erythrocytes
- biconcave discs
- one-third hemoglobin
  - oxyhemoglobin
  - deoxyhemoglobin
- can readily squeeze through capillaries
- lack nuclei and mitochondria

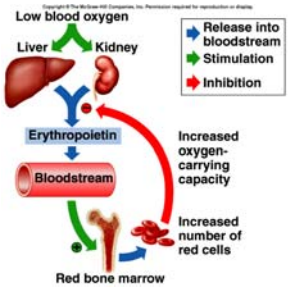


Red Blood Cell Counts

- number of RBCs in a cubic millimeter of blood
- 4,600,000 – 6,200,000 in males
- 4,200,000 – 5,400,000 in adult females
- 4,500,000 – 5,100,000 in children
- reflects blood's oxygen carrying capacity

Red Blood Cell Production

- low blood oxygen causes kidneys and liver to release erythropoietin which stimulates RBC production
- vitamin B_{12}, folic acid and iron necessary



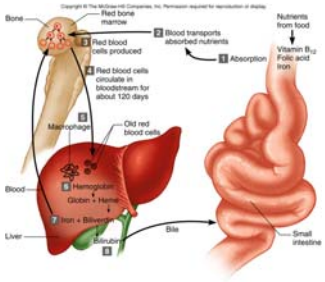
Dietary Factors Affecting Red Blood Cell Production

TABLE 14.1 Dietary Factors Affecting Red Blood Cell Production

Substance	Source	Function
Vitamin B_{12} (requires intrinsic factor for absorption via small intestine)	Absorbed from small intestine	DNA synthesis
Iron	Absorbed from small intestine; conserved during red blood cell destruction and made available for reuse	Hemoglobin synthesis
Folic acid	Absorbed from small intestine	DNA synthesis

Life Cycle of Red Blood Cell

- circulate for about 120 days
- macrophages in spleen and liver destroy worn out RBCs
- hemoglobin is broken down into heme and globin
- iron from heme returns to red bone marrow
- bilirubin and biliverdin excreted in bile



Types of Anemia

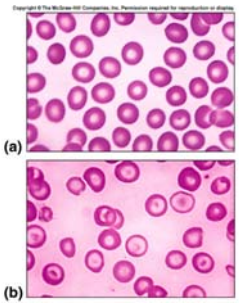
TABLE 14.2 Types of Anemia

Type	Cause	Defect
Aplastic anemia	Toxic chemicals, radiation	Damaged bone marrow
Hemolytic anemia	Toxic chemicals	Red blood cells destroyed
Iron deficiency anemia	Dietary lack of iron	Hemoglobin deficient
Pernicious anemia	Inability to absorb vitamin B_{12}	Excess of immature cells
Sickle cell disease	Defective gene	Red blood cells abnormally shaped
Thalassemia	Defective gene	Hemoglobin deficient; red blood cells short-lived

Anemia

Normal RBCs

RBCs of person with hypochromic anemia



Destruction of Red Blood Cells

TABLE 14.3 Major Events in Red Blood Cell Destruction

1. Squeezing through the capillaries of active tissues damages red blood cells.
2. Macrophages in the spleen and liver phagocytize damaged red blood cells.
3. Hemoglobin from the red blood cells is decomposed into heme and globin.
4. Heme is decomposed into iron and biliverdin.
5. Iron is made available for reuse in the synthesis of new hemoglobin or is stored in the liver as ferritin.
6. Some biliverdin is converted into bilirubin.
7. Biliverdin and bilirubin are excreted in bile as bile pigments.
8. The globin is broken down into amino acids that are metabolized by macrophages or released into the blood.

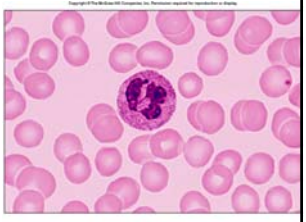
White Blood Cells

- leukocytes
- protect against disease
- interleukins and colony-stimulating factors stimulate development

- granulocytes
  - neutrophils
  - eosinophils
  - basophils
- agranulocytes
  - lymphocytes
  - monocytes

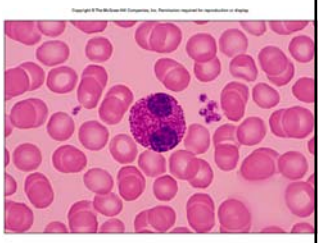
Neutrophils

- light purple granules in acid-base stain
- lobed nucleus
- other names
  - segs
  - polymorphonuclear leukocyte
  - bands (young neutrophils)
- first to arrive at infections
- phagocytic
- 54% - 62% of leukocytes
- elevated in bacterial infections



Eosinophils

- deep red granules in acid stain
- bilobed nucleus
- moderate allergic reactions
- defend against parasitic worm infestations
- 1% - 3% of leukocytes
- elevated in parasitic worm infestations and allergic reactions

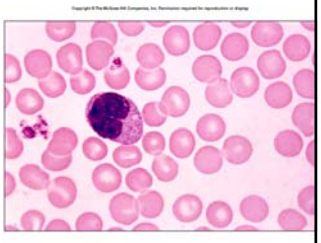


Basophils

- deep blue granules in basic stain
- release histamine
- release heparin
- less than 1% of leukocytes
- similar to eosinophils in size and shape of nuclei

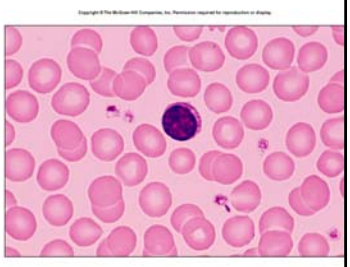
Monocytes

- largest blood cell
- spherical, kidney-shaped, oval or lobed nuclei
- leave bloodstream to become macrophages
- 3% - 9% of leukocytes
- phagocytize bacteria, dead cells, and other debris



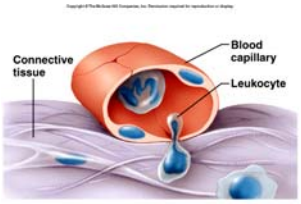
Lymphocytes

- slightly larger than RBC
- large spherical nucleus surrounded by thin rim of cytoplasm
- T cells and B cells
  - important in immunity
- B cells produce antibodies
- 25% - 33% of leukocytes



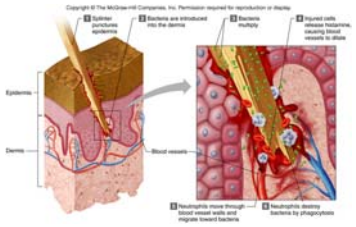
Diapadesis

- leukocytes squeeze between the cells of a capillary wall and enter the tissue space outside the blood vessel



Positive Chemotaxis

- movement of leukocytes toward the damaged tissue region because of the chemicals that were released by damaged cells



White Blood Cell Counts

- procedure used to count number of WBCs per cubic millimeter of blood
  - 5,000 – 10,000 per cubic millimeter of blood
- leukopenia
  - low WBC count (below 5,000)
  - typhoid fever, flu, measles, mumps, chicken pox, AIDS
- leukocytosis
  - high WBC count (above 10,000)
  - acute infections, vigorous exercise, great loss of body fluids
- differential WBC count
  - lists percentages of types of leukocytes
  - may change in particular diseases

White Blood Cell Counts

TABLE 14.4 White Blood Cell Alterations

White Blood Cell Population Change	Illness
Elevated lymphocytes	Hairy cell leukemia, whooping cough, mononucleosis
Elevated eosinophils	Tapeworm infestation, hookworm infestation, allergic reactions
Elevated monocytes	Typhoid fever, malaria, tuberculosis
Elevated neutrophils	Bacterial infections
Too few helper T cells (lymphocytes)	AIDS

Blood Platelets

- thrombocytes
- cell fragments of megakaryocytes
- 130,000 – 360,000 per cubic millimeter of blood
- helps control blood loss from broken vessels

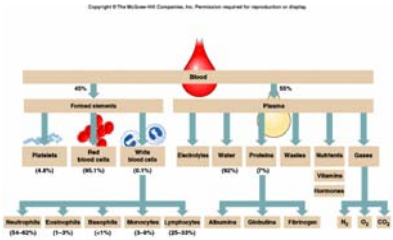
Blood Platelets

TABLE 14.5 Cellular Components of Blood

Component	Description	Number Present	Function
Red blood cell (erythrocyte)	Biconcave disc without a nucleus, about one-third hemoglobin	4,200,000 to 6,200,000 per mm^3	Transports oxygen and carbon dioxide
White blood cell (leukocyte)		5,000 to 10,000 per mm^3	Destroys pathogenic microorganisms and parasites and removes worn cells
Granulocytes	About twice the size of red blood cells; cytoplasmic granules are present		
1. Neutrophil	Nucleus with two to five lobes; cytoplasmic granules stain light purple in combined acid and base stains	54%–62% of white blood cells present	Phagocytizes small particles
2. Eosinophil	Nucleus bilobed; cytoplasmic granules stain red in acid stain	1%–3% of white blood cells present	Kills parasites and helps control inflammation and allergic reactions
3. Basophil	Nucleus lobed; cytoplasmic granules stain blue in basic stain	Less than 1% of white blood cells present	Releases heparin and histamine
Agranulocytes	Cytoplasmic granules are absent		
1. Monocyte	Two to three times larger than a red blood cell; nuclear shape varies from spherical to lobed	3%–9% of white blood cells present	Phagocytizes large particles
2. Lymphocyte	Only slightly larger than a red blood cell; its nucleus nearly fills cell	25%–33% of white blood cells present	Provides immunity
Platelet (thrombocyte)	Cytoplasmic fragment	130,000 to 360,000 per mm^3	Helps control blood loss from broken vessels

Blood Plasma

- straw colored
- liquid portion of blood
- 55% of blood
- 92% water



Plasma Proteins

TABLE 14.6 Plasma Proteins

Protein	Percentage of Total	Origin	Function
Albumin	60%	Liver	Helps maintain colloid osmotic pressure
Globulin	36%		
Alpha globulins		Liver	Transport lipids and fat-soluble vitamins
Beta globulins		Liver	Transport lipids and fat-soluble vitamins
Gamma globulins		Lymphatic tissues	Constitute the antibodies of immunity
Fibrinogen	4%	Liver	Plays a key role in blood coagulation

Gases and Nutrients

Gases
- oxygen
- carbon dioxide

Nutrients
- amino acids
- simple sugars
- nucleotides
- lipids

Nonprotein Nitrogenous Substances

- molecules containing nitrogen but are not proteins
- **urea** – product of protein catabolism; about 50% of NPN substances
- **uric acid** – product of nucleic acid catabolism
- amino acids – product of protein catabolism
- **creatine** – stores phosphates
- **creatinine** – product of creatine metabolism
- **BUN** – blood urea nitrogen; indicate health of kidney

Plasma Electrolytes

- absorbed from the intestine or released as by-products of cellular metabolism
  - sodium
  - potassium
  - calcium
  - magnesium
  - chloride
  - bicarbonate
  - phosphate
  - sulfate
  - sodium and chloride are most abundant

Hemostasis

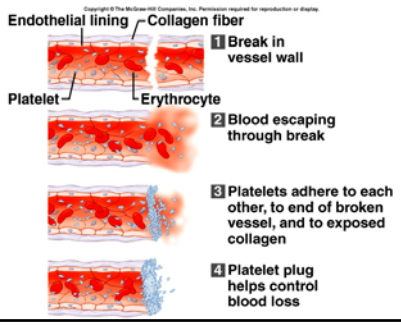
• stoppage of bleeding

Blood Vessel Spasm
- triggered by pain receptors, platelet release, or serotonin
- smooth muscle in vessel contracts

Platelet Plug Formation
- triggered by exposure of platelets to collagen
- platelets adhere to rough surface to form a plug

Blood Coagulation
- triggered by cellular damage and blood contact with foreign surfaces
- blood clot forms

Platelet Plug Formation



Blood Coagulation

Coagulation
- hemostatic mechanism
- causes the formation of a blot clot via a series of reactions which activates the next in a cascade
- occurs extrinsically or intrinsically

Blood Coagulation

Extrinsic Clotting Mechanism
- chemical outside of blood triggers blood coagulation
- triggered by thromboplastin (not found in blood)
- triggered when blood contacts damaged tissue

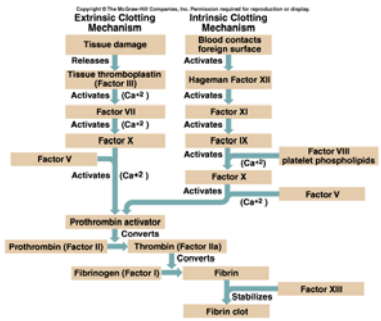
Intrinsic Clotting Mechanism
- chemical inside blood triggers blood coagulation
- triggered by Hageman factor (found inside blood)
- triggered when blood contacts a foreign surface

Blood Coagulation

TABLE 14.8 Blood Coagulation

Steps	Extrinsic Clotting Mechanism	Intrinsic Clotting Mechanism
Trigger	Damage to vessel or tissue	Blood contacts foreign surface
Initiation	Tissue thromboplastin	Hageman factor
Series of reactions involving several clotting factors and calcium ions (Ca^{+2}) lead to the production of:	Prothrombin activator	Prothrombin activator
Prothrombin activator and calcium ions cause the conversion of:	Prothrombin to thrombin	Prothrombin to thrombin
Thrombin causes fragmentation, then joining of:	Fibrinogen to fibrin	Fibrinogen to fibrin

Blood Coagulation



Fate of Blood Clots

- After forming, a blood clot retracts and pulls the edges of a broken vessel together while squeezing the fluid **serum** from the clot
- **Platelet-derived growth factor** stimulates smooth muscle cells and fibroblasts to repair damaged blood vessel walls
- **Plasmin** digests blood clots
- **thrombus** – abnormal blood clot
- **embolus** – blood clot moving through blood

Prevention of Coagulation

- The smooth lining of blood vessels discourages the accumulation of platelets and clotting factors
- As a clot forms, fibrin adsorbs thrombin and prevents the clotting reaction from spreading
- Antithrombin inactivates additional thrombin by binding to it and blocking its action on fibrinogen
- Some cells, such as basophils and mast cells secrete heparin (an anticoagulant)

Prevention of Coagulation

TABLE 14.10 Factors That Inhibit Blood Clot Formation

Factor	Action	Factor	Action
Smooth lining of blood vessel	Prevents activation of intrinsic blood clotting mechanism	Antithrombin in plasma	Interferes with the action of thrombin
Prostacyclin	Inhibits adherence of platelets to blood vessel wall	Heparin from mast cells and basophils	Interferes with the formation of prothrombin activator
Fibrin threads	Adsorbs thrombin		

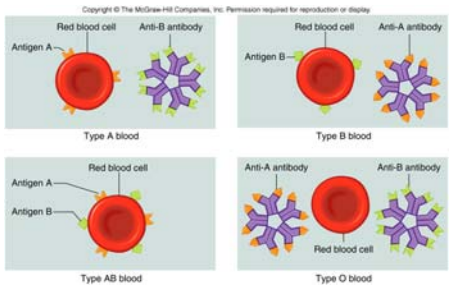
Antigens and Antibodies

Agglutination – clumping of red blood cells in response to a reaction between an antibody and an antigen

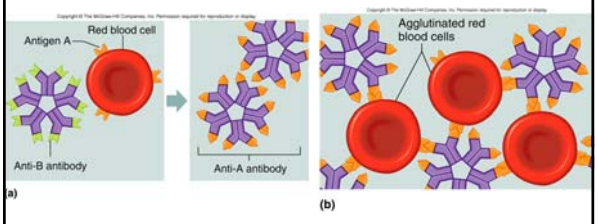
Antigens – a chemical that stimulates cells to produce antibodies

Antibodies – a protein that reacts against a specific antigen

Antigens and Antibodies



Agglutination



ABO Blood Group

Based on the presence or absence of two major antigens on red blood cell membranes

- **antigen A**
- **antigen B**

ABO Blood Group

TABLE 14.11 Antigens and Antibodies of the ABO Blood Group

Blood Type	Antigen	Antibody
A	A	anti-B
B	B	anti-A
AB	A and B	Neither anti-A nor anti-B
O	Neither A nor B	Both anti-A and anti-B

Blood Types for Transfusion

TABLE 14.12 Preferred and Permissible Blood Types for Transfusions

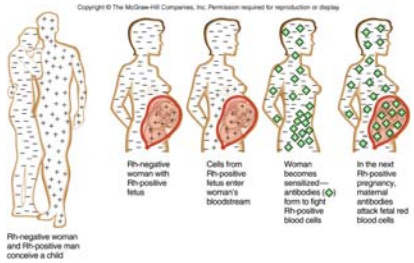
Blood Type of Recipient	Preferred Blood Type of Donor	Permissible Blood Type of Donor (In an Extreme Emergency)
A	A	A, O
B	B	B, O
AB	AB	AB, A, B, O
O	O	O

Rh Blood Group

Rh positive – presence of antigen D or and other Rh antigens on the red blood cell membranes

Rh negative – lack of these antigens

Rh Blood Group



Clinical Application

Leukemia

Myeloid Leukemia
- **bone marrow produces too many immature granulocytes**
- **leukemia cells crowd out other blood cells**
- **anemia**
- **bleeding**
- **susceptible to infections**

Lymphoid Leukemia
- **lymphocytes are cancerous**
- **symptoms similar to myeloid leukemia**

Treatments
- **drugs**
- **marrow and umbilical cord transplants**
- **chemotherapy regimens**