

Essentials of Human Anatomy & Physiology

Seventh Edition

Elaine N. Marieb

Adapted by H. Goon, North HS, Phoenix, AZ

Blood

Blood

1. Functions

- **Transports nutrients, O₂, wastes, hormones**
- **Maintains homeostasis; chemical levels of intracellular fluids**
- **distributes heat**

Blood

2. Tissue type

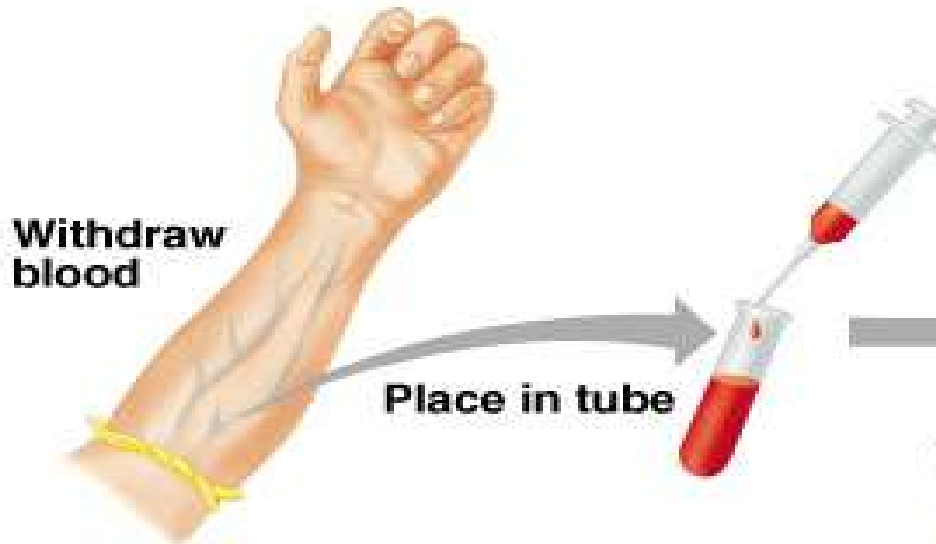
- classified as a connective tissue
 - living cells = formed elements
 - nonliving matrix = plasma (90% water)

3. Physical characteristics of blood:

- fluid, more viscous than water
- color range
 - Oxygen-rich blood is scarlet red
 - Oxygen-poor blood is dull red
- pH must remain between 7.35–7.45 (slightly alkaline)

- blood volume: 5-6 liters (~6 quarts)
- 8% of body weight

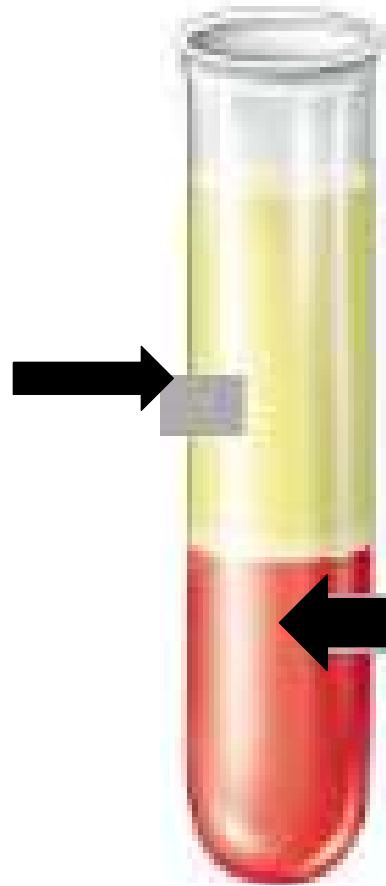
4. Composition of Blood



centrifuge
(spins the blood sample)

Figure 10.1

**55% plasma
(fluid)**



**45% formed
elements
(RBC, WBC,
platelets)**

A) Blood Plasma

- Composed of approximately 90 percent water
- Includes many dissolved substances
 - Nutrients, Salts (metal ions)
 - Respiratory gases
 - Hormones
 - Waste products

Plasma Proteins in the Blood

- I. Albumin – regulates osmotic pressure
- II. Fibrinogens (clotting proteins)—stop blood loss when a blood vessel is injured
- III. Globulins—transport lipids & fat-soluble vitamins
 - Antibodies – helps the body fight foreign antigens

B) Formed Elements (cells or cell fragments in the blood)

Erythrocytes

(red blood cells, or RBCs)



4–6 million

Salmon-colored biconcave disks; anucleate; literally, sacs of hemoglobin; most organelles have been ejected

Leukocytes

(white blood cells, or WBCs)

4000–11,000

Granulocytes

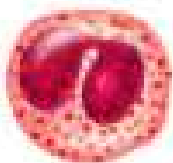
- Neutrophils



3000–7000
(40–70%
of WBCs)

Cytoplasm stains pale pink and contains fine granules, which are difficult to see; deep purple nucleus consists of three to seven lobes connected by thin strands of nucleoplasm

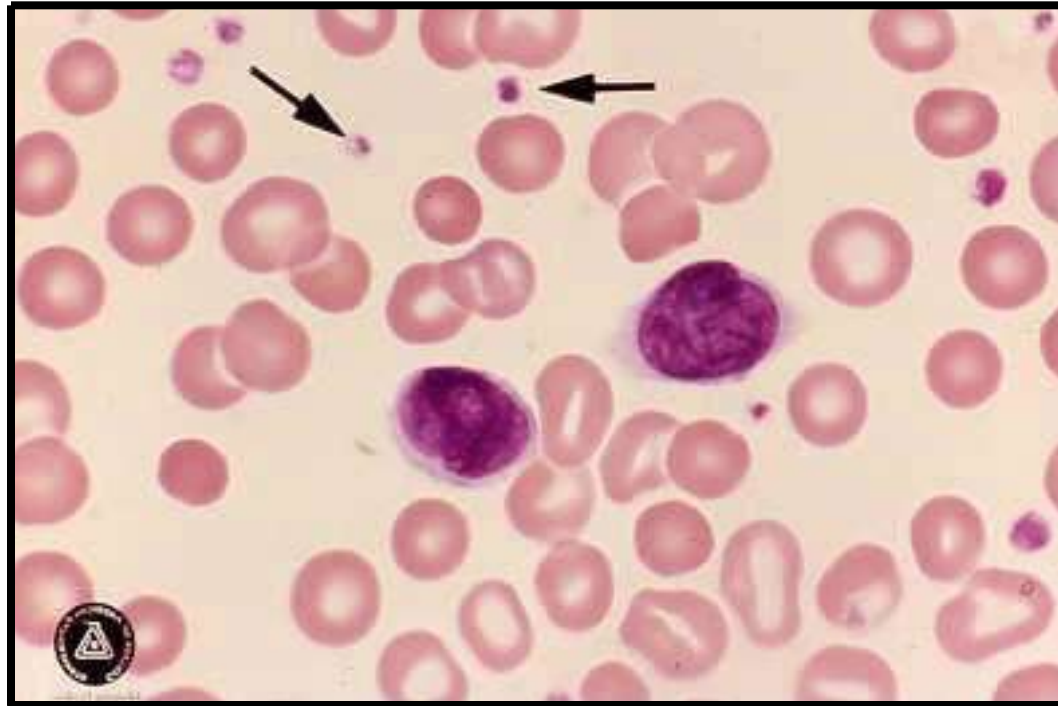
- Eosinophils



100–400
(1–4% of
WBCs)

Red coarse cytoplasmic granules; figure-8 or bilobed nucleus stains blue-red

Platelets



Functions of Blood Cell Types

- 1) Erythrocytes: transport oxygen
- 2) Leukocytes: defend the body against pathogens
- 3) Platelets: help blood clotting to occur

- Basophils



20–50
(0–1% of
WBCs)

Cytoplasm has a few large blue-purple granules; U- or S-shaped nucleus with constrictions, stains dark blue

Agranulocytes

- Lymphocytes



1500–3000
(20–45% of
WBCs)

Cytoplasm pale blue and appears as thin rim around nucleus; spherical (or slightly indented) dark purple-blue nucleus

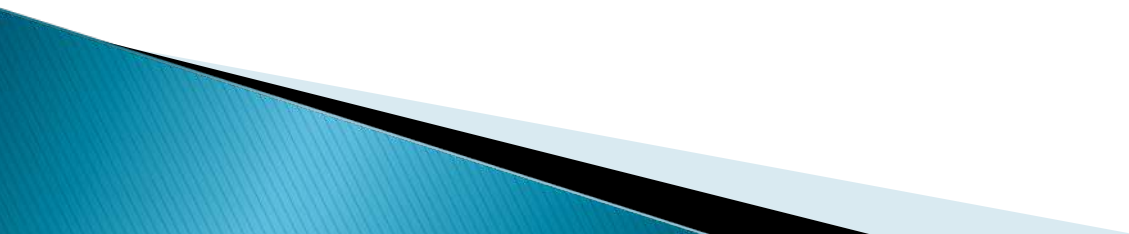
- Monocytes









100–700
(4–8% of
WBCs)

Abundant gray-blue cytoplasm; dark blue-purple nucleus often kidney-shaped

Composition of Blood, Part 2



Cell type	Occurrence in blood (per mm ³)	Cell anatomy*	Function
Erythrocytes (red blood cells, or RBCs) 	4–6 million	Salmon-colored biconcave disks; anucleate; literally, sacs of hemoglobin; most organelles have been ejected	Transport oxygen bound to hemoglobin molecules; also transport small amount of carbon dioxide
Leukocytes (white blood cells, or WBCs)	4000–11,000		
<i>Granulocytes</i>			
<ul style="list-style-type: none"> • Neutrophils  	3000–7000 (40–70% of WBCs)	Cytoplasm stains pale pink and contains fine granules, which are difficult to see; deep purple nucleus consists of three to seven lobes connected by thin strands of nucleoplasm	Active phagocytes; number increases rapidly during short-term or acute infections
<ul style="list-style-type: none"> • Eosinophils  	100–400 (1–4% of WBCs)	Red coarse cytoplasmic granules; figure-8 or bilobed nucleus stains blue-red	Kill parasitic worms; increase during allergy attacks; might phagocytize antigen-antibody complexes and inactivate some inflammatory chemicals

Cell type	Occurrence in blood (per mm ³)	Cell anatomy*	Function
<ul style="list-style-type: none"> Basophils 	20–50 (0–1% of WBCs)	Cytoplasm has a few large blue-purple granules; U- or S-shaped nucleus with constrictions, stains dark blue	Granules contain histamine (vasodilator chemical), which is discharged at sites of inflammation
<i>Agranulocytes</i>			
<ul style="list-style-type: none"> lymphocytes 	1500–3000 (20–45% of WBCs)	Cytoplasm pale blue and appears as thin rim around nucleus; spherical (or slightly indented) dark purple-blue nucleus	Part of immune system; one group (B lymphocytes) produces antibodies; other group (T lymphocytes) involved in graft rejection, fighting tumors and viruses, and activating B lymphocytes
<ul style="list-style-type: none"> Monocytes 	100–700 (4–8% of WBCs)	Abundant gray-blue cytoplasm; dark blue-purple nucleus often kidney-shaped	Active phagocytes that become macrophages in the tissues; long-term “clean-up team”; increase in number during chronic infections such as tuberculosis
Platelets	250,000– 500,000	Essentially irregularly shaped cell fragments; stain deep purple	Needed for normal blood clotting; initiate clotting cascade by clinging to broken area; help to control blood loss from broken blood vessels

1. Erythrocytes (Red Blood Cells)

- Outnumber white blood cells 1000:1
- The main function is to carry oxygen
- Anatomy of circulating erythrocytes
 - biconcave disks
 - anucleate (no nucleus)
 - contain very few organelles

Hemoglobin

- Iron-containing protein
- Each hemoglobin molecule has four oxygen binding sites
- Each erythrocyte has 250 million hemoglobin molecules

“Life as an erythrocyte”



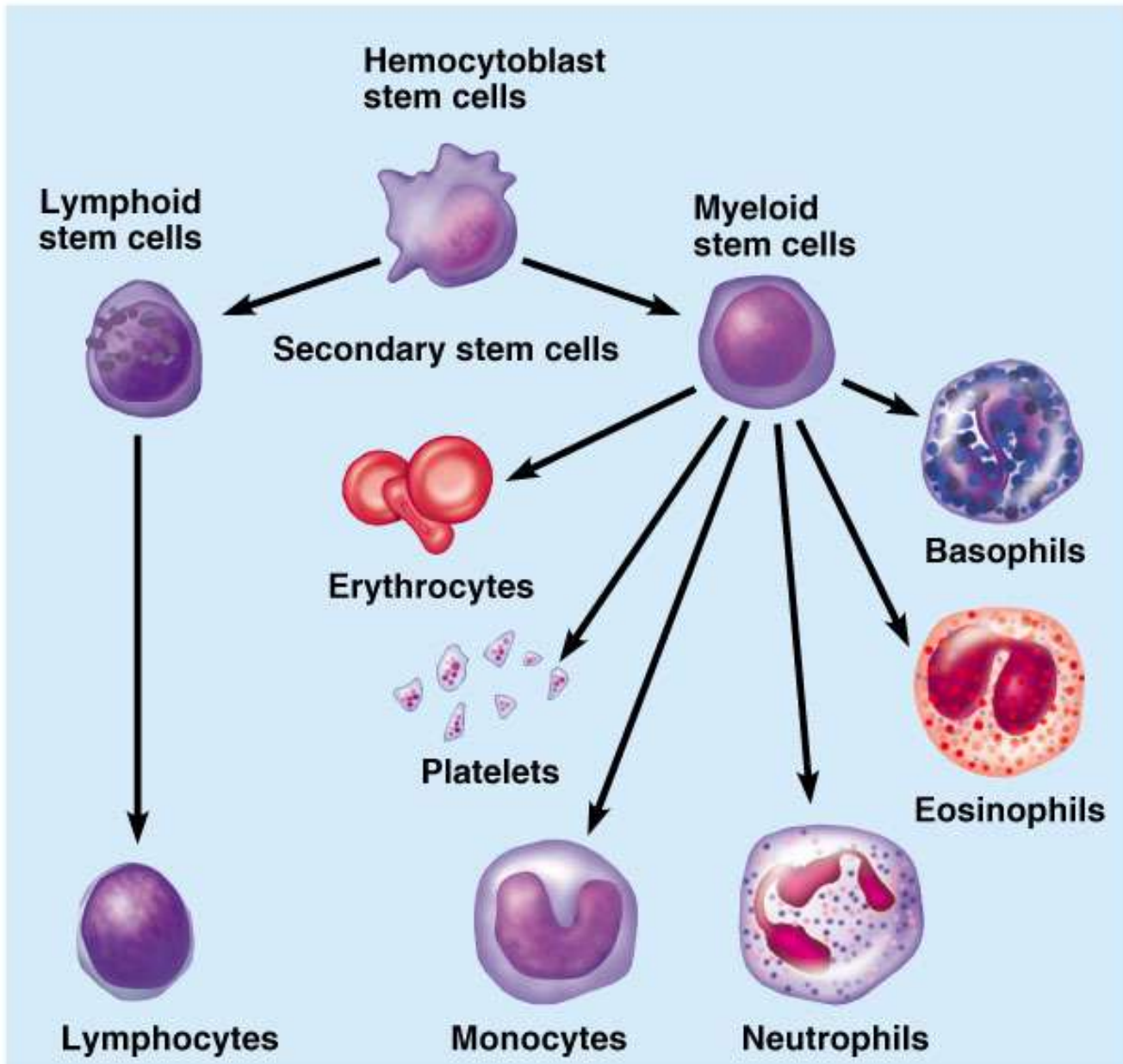
- does not divide, grow, or synthesize proteins
- life expectancy is 100 to 120 days; eliminated by phagocytes in the spleen or liver
- lost RBCs are replaced by division of stem cells

2. Leukocytes (White Blood Cells)

- Crucial in the body's defense against disease
- These are complete cells, with a nucleus and organelles
- Able to move into and out of blood vessels (diapedesis)
- Can respond to chemicals released by damaged tissues

Leukocyte Levels in the Blood

- Normal levels = 4,000 to 11,000 cells/ml
- Abnormal leukocyte levels
 - Leukocytosis
 - Above 11,000 leukocytes/ml
 - Generally indicates an infection
 - Leukopenia
 - Abnormally low leukocyte level
 - Commonly caused by certain drugs



Overview: Types of Leukocytes

A) Granulocytes

- Granules in their cytoplasm can be stained

B) Agranulocytes

- Lack visible cytoplasmic granules

Figure 10.4

A) Granulocytes

- Neutrophils

- Act as phagocytes at active sites of infection
- Multilobed nucleus with fine granules

- Eosinophils

- Found in response to allergies and parasitic worms
- Large brick-red cytoplasmic granules

- Basophils

- Initiate inflammation

- Have histamine-containing granules

B) Agranulocytes

- Lymphocytes
 - Nucleus fills most of the cell
 - Play an important role in the immune response
- Monocytes
 - Largest of the white blood cells
 - Function as macrophages
 - Important in fighting chronic infection

3. Platelets

- Derived from ruptured multinucleate cells called megakaryocytes
- Needed for the clotting process



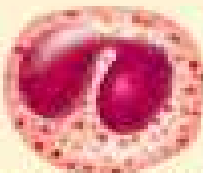




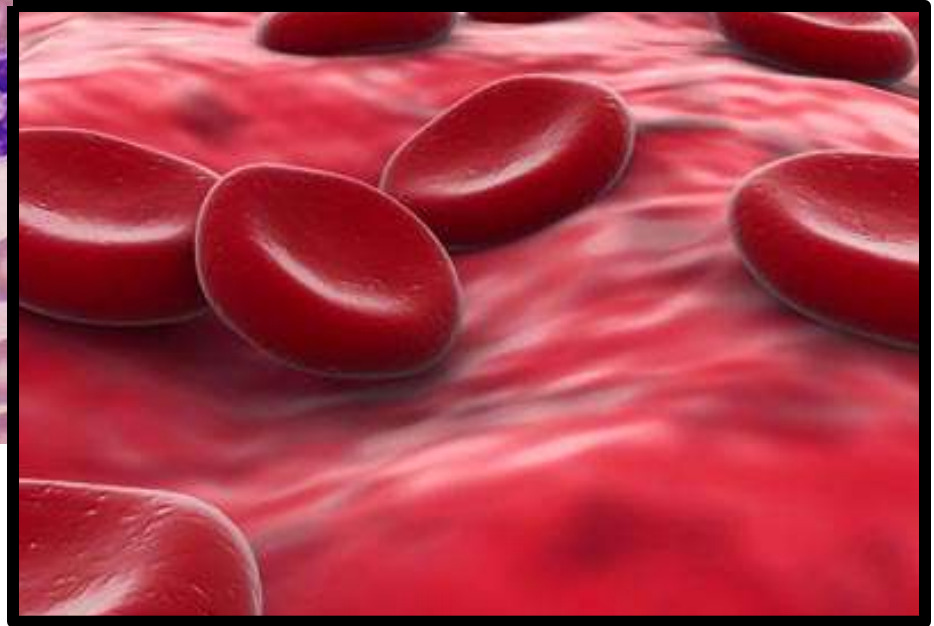
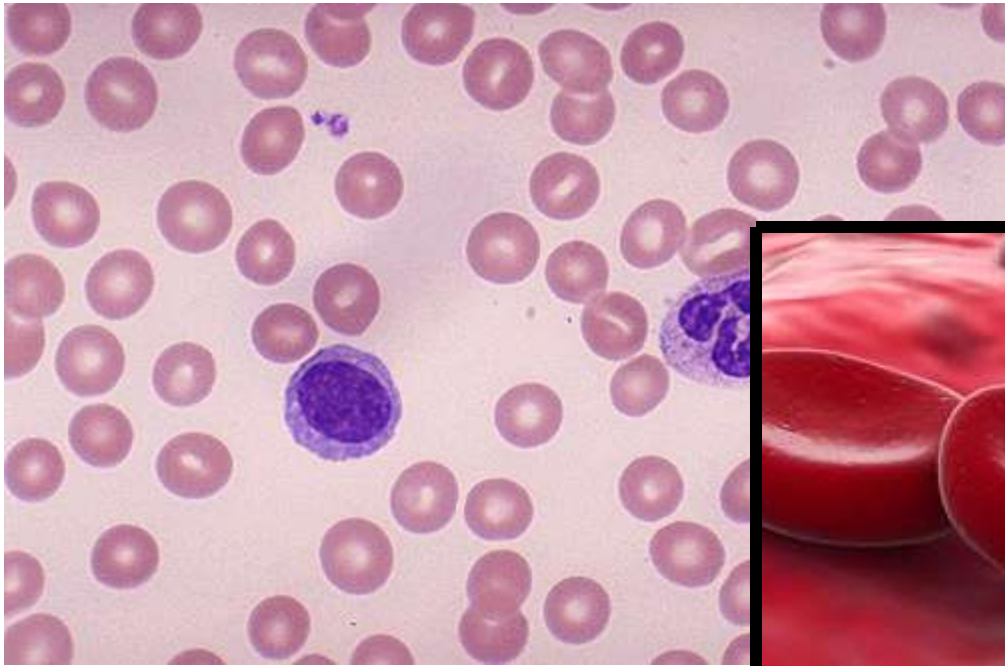
Formed Elements (cells) 45%		
Cell type	Number (per mm ³ of blood)	Functions
Erythrocytes (red blood cells) 	4–6 million	Transport oxygen and help transport carbon dioxide
Leukocytes (white blood cells)	4000–11,000	Defense and immunity
 Basophil	 Eosinophil	 Lymphocyte
 Neutrophil	 Monocyte	
Platelets 	250,000–500,000	Blood clotting

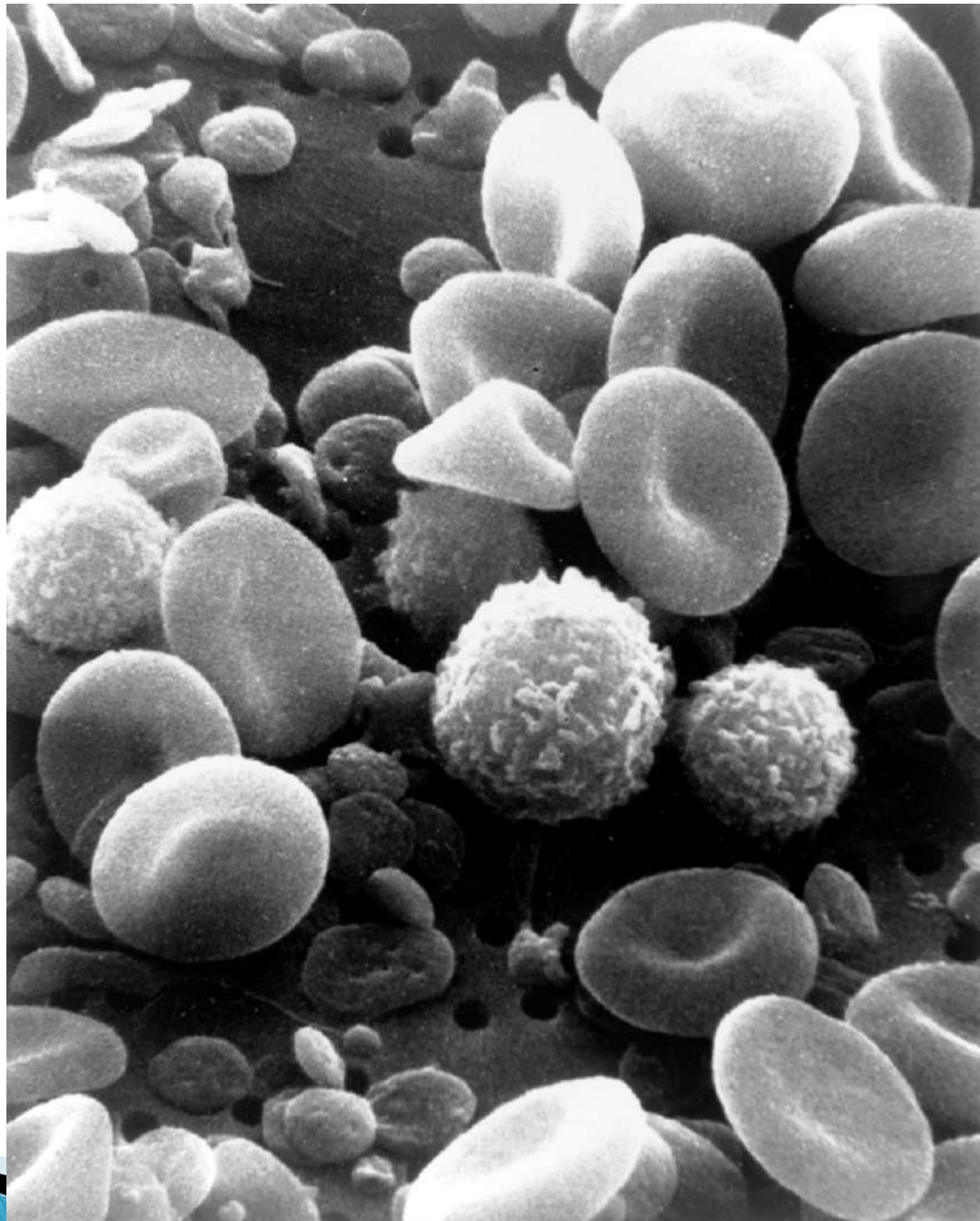
Figure 10.1

Hematopoiesis (Blood Cell Formation)



- Occurs in red bone marrow
- All blood cells are derived from a common stem cell (hemocytoblast)
- Negative feedback mechanism controls RBC production:
 - low O₂ levels
 - increase erythropoietin hormone (kidneys)
 - increase RBC production

RESULT: increase O₂ blood levels



Hemostasis

- is the stoppage of blood flow
- Result of a break in a blood vessel

http://mhhe.com/biosci/esp/2002_general/Esp/folder_structure/tr/m1/s7/trm1s7_3.htm

When vessel damage occurs . . .



STEP 1: Blood vessel spasm
(vascular spasm)

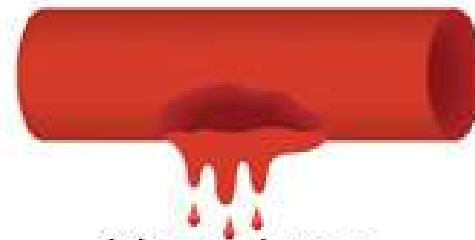


STEP 2: Platelet plug forms

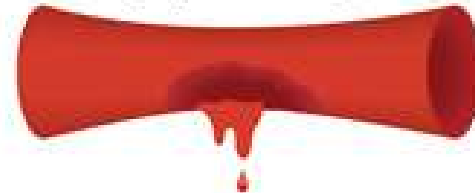


- collagen fibers are exposed by a break in a blood vessel
- platelets become “sticky” and cling to fibers, forming a platelet plug
- platelets release chemicals to attract more platelets and serotonin that causes blood vessel muscles to constrict, thereby decreasing blood loss

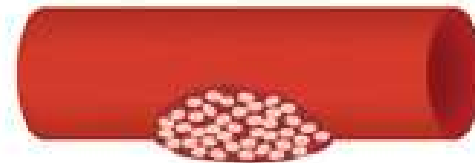
STEP 3: Blood coagulation (clotting)



Injury or damage



Vessel contracts



Platelet plug



Fibrin clot

- Thrombin joins fibrinogen proteins into insoluble hair-like fibrin
- Fibrin forms a meshwork (a clot)

Deficiencies of factor VIII and factor IX are known as **hemophilia A and B**, respectively.

Contact activation (intrinsic) pathway

Damaged surface

XII → XIIa

XI → XIa

IX → IXa

VIIIa

X

Xa

X

Va

Prothrombin (II)

Thrombin (IIa)

Fibrinogen (I)

Fibrin (Ia)

XIIIa

Cross-linked fibrin clot

Tissue factor (extrinsic) pathway

Trauma

VII → VIIa

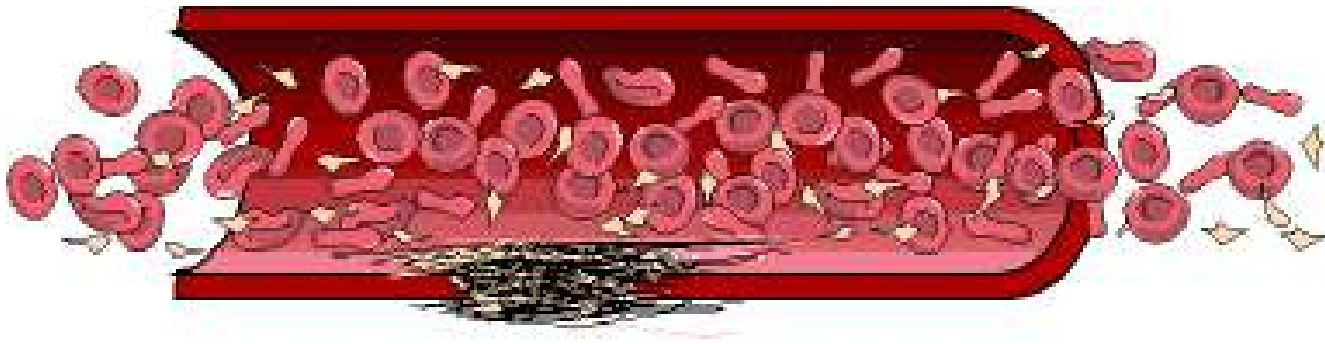
VIIIa

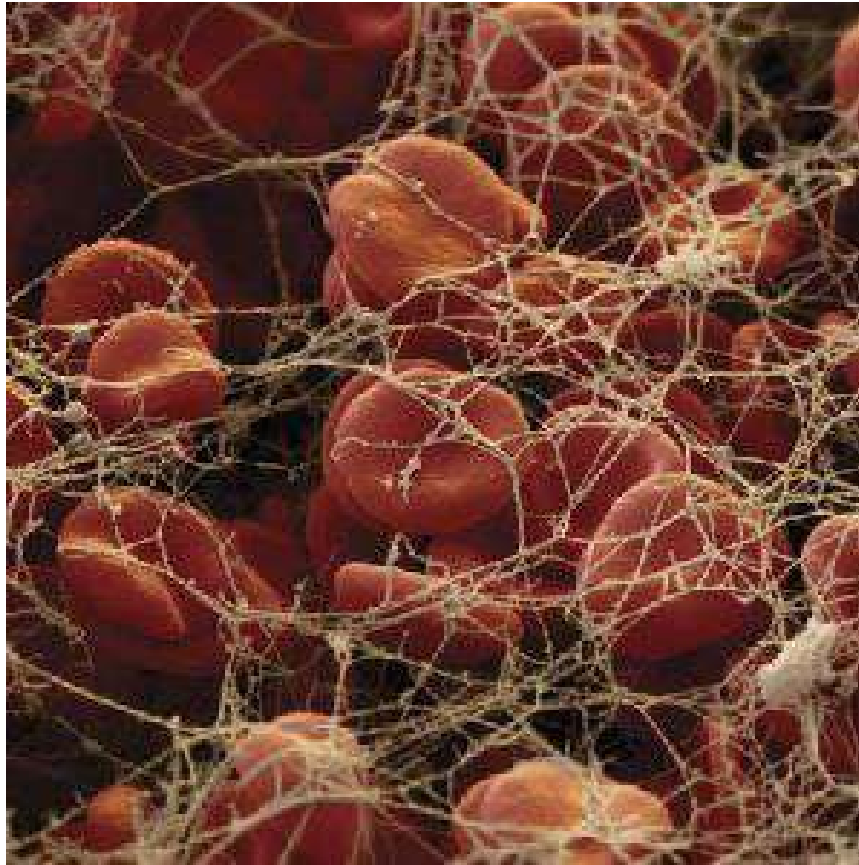
Tissue factor

← Trauma

Common pathway

The final key step in blood clot formation is the conversion of **fibrinogen into fibrin.**

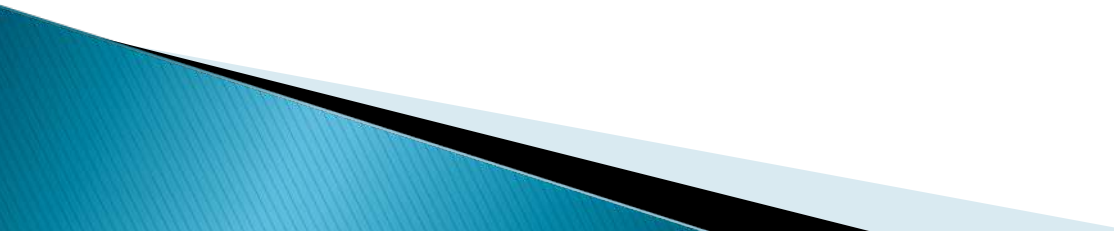




Blood Clotting (coagulation)

- usually occurs within 3 to 6 minutes
(and remains as endothelium regenerates)
- the clot is broken down after tissue repair

Summary: What did you learn today about the composition of blood that is different from yesterday's lesson?



Blood Drive on Halloween Day



"It's just a way of maintaining a sense of humor around here. Now if you'll just clench your fist ..."

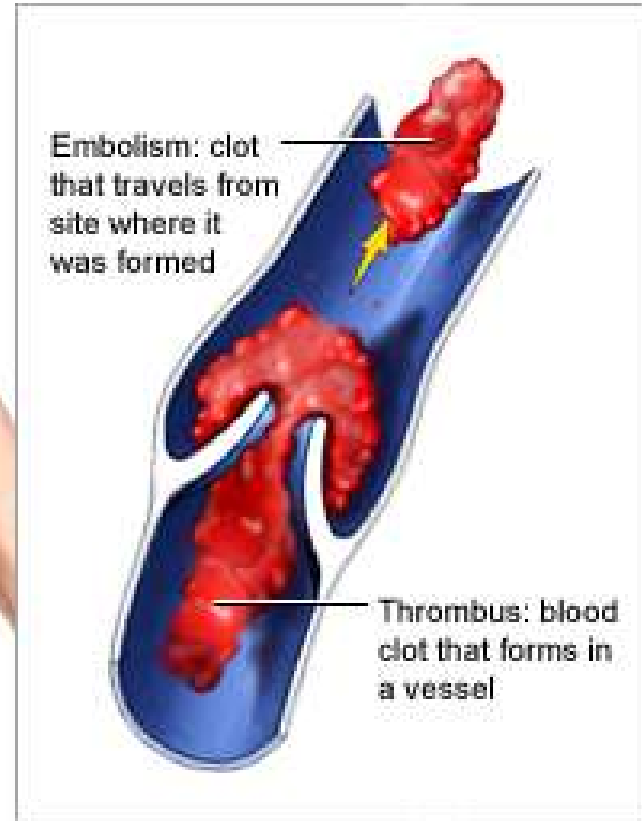
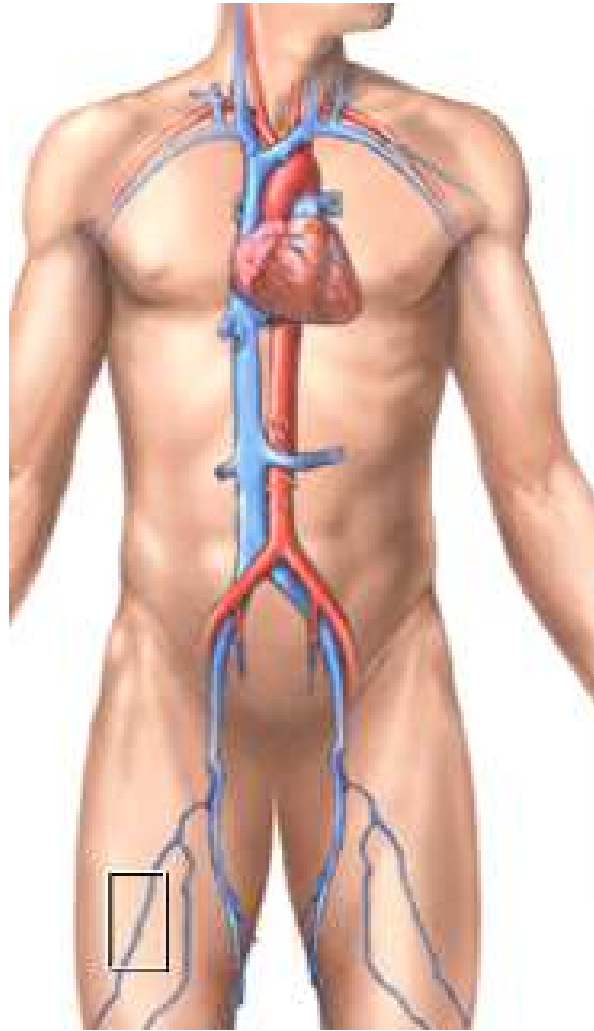
Undesirable Clotting

Thrombus

- A clot in an unbroken blood vessel
- Can be fatal in coronary (heart) arteries

Embolus

- A thrombus that breaks away and floats freely in the bloodstream
- Can later clog vessels in critical areas such as the brain, lungs

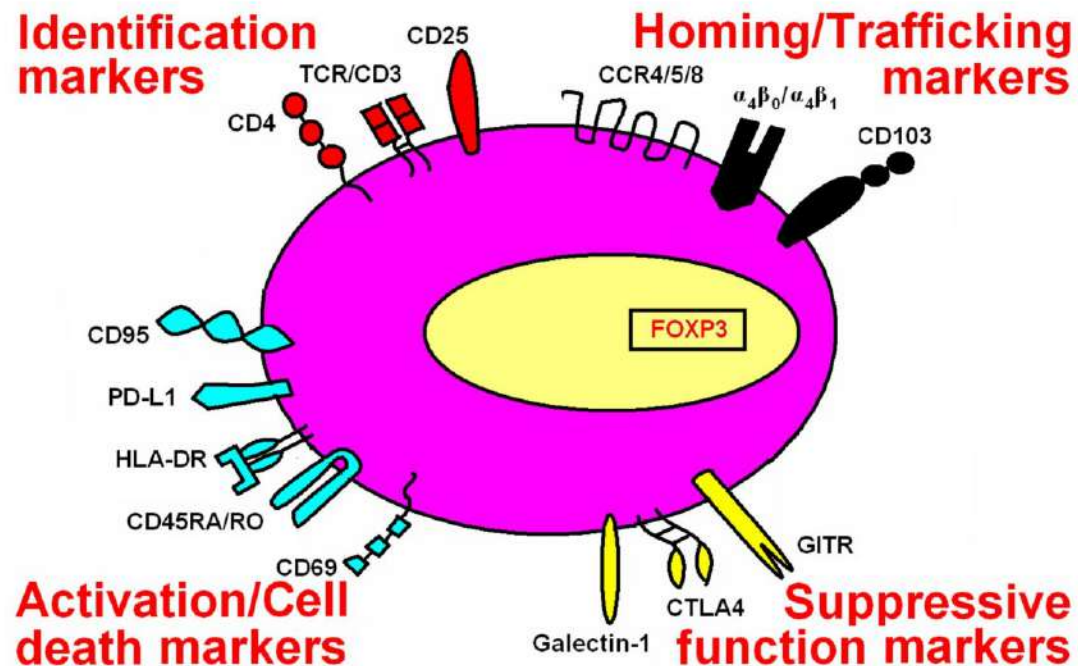


Human Blood Type



Human Blood Groups

- There are 20+ common red blood cell antigens



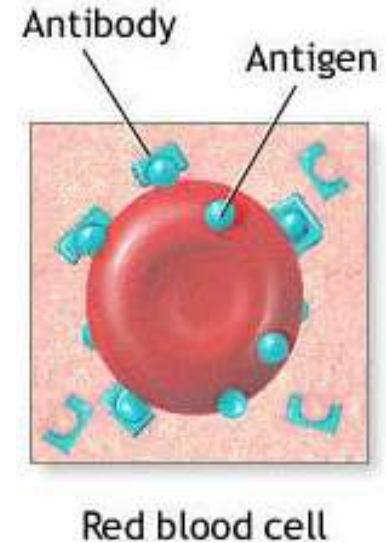
1. ABO Blood Groups

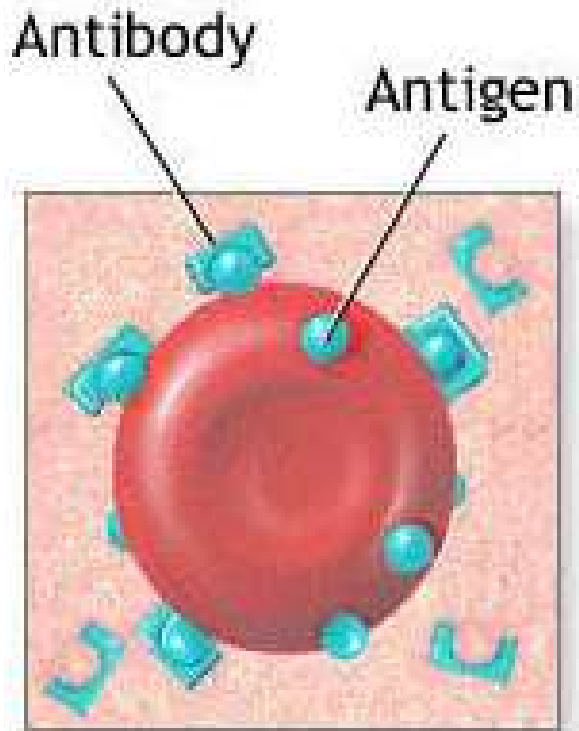
Type A: has antigen A

Type B: has antigen B

Type AB: has antigens A and B

Type O: lacks both antigen A and B

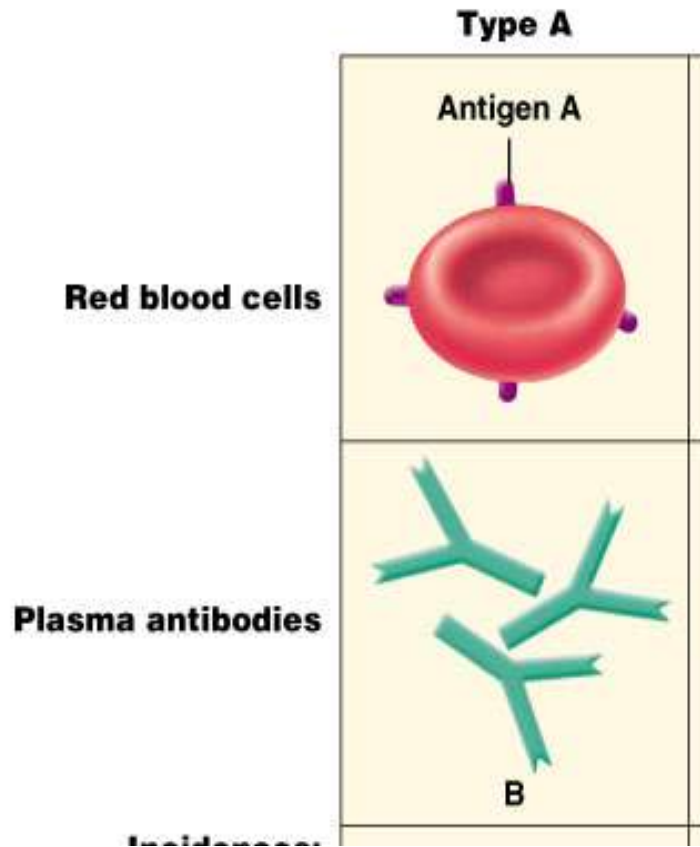




Red blood cell








An antibody is a protein produced by the immune system in response to the presence of an antigen

e.g.



2. Agglutination= clumping that occurs when the antibody attacks foreign proteins (antigens) in the blood

- The most vigorous transfusion reactions are caused by ABO and Rh antigens

	Type A	Type B	Type AB	Type O
Red blood cells	<p>Antigen A</p> 	<p>Antigen B</p> 	<p>Antigens A and B</p> 	<p>Neither A nor B antigens</p> 
Plasma antibodies	 <p>B</p>	 <p>A</p>	<p>Neither A nor B</p>	 <p>A and B</p>
Incidences:				
U.S. Caucasian	40%	10%	5%	45%
U.S. African-American	27%	20%	4%	49%
Native Americans	8%	1%	0%	91%

3. Blood Transfusions

- to replace blood quickly
- transfused blood must be of the “compatible” blood group



- Loss of 15 to 30 % of the blood volume causes significant weakness
- Loss of over 30% causes shock, which can be fatal

Shock is a life-threatening condition when the body is not getting enough blood flow.

- heart failure
- low blood volume (heavy bleeding, dehydration)
- drop in bp (anaphylaxis, septic shock)

Type A patients **cannot receive** blood that contains any B antigens!

Type A blood **can only be given to** someone whose blood contains A antigens.



Mismatched blood transfusions result in agglutination & hemolysis!

4. Rh Blood Groups

- due to presence or absence of one of eight Rh antigens
- most Americans are Rh⁺
- problems can occur giving Rh⁺ blood to a person who is Rh⁻

ABO and Rh Blood Type

Frequencies in the United States

ABO Type	Rh Type	How Many Have It	
 O	positive	37.4%	44%
O	negative	6.6%	
A	positive	35.7%	42%
A	negative	6.3%	
B	positive	8.5%	10%
B	negative	1.5%	
AB	positive	3.4%	4%
 AB	negative	.6%	

5. Rh Dangers During Pregnancy

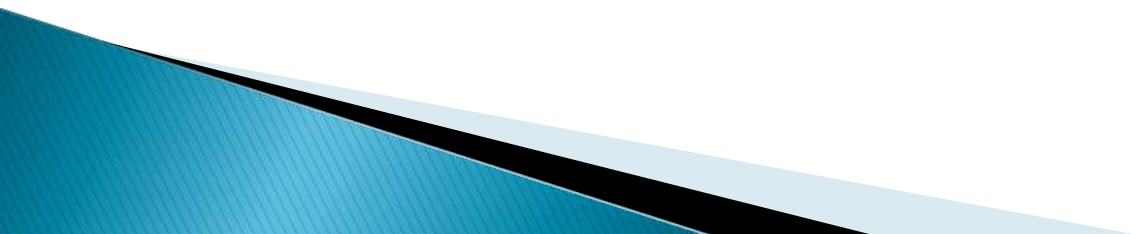
Rh⁻ mother carrying an Rh⁺ baby

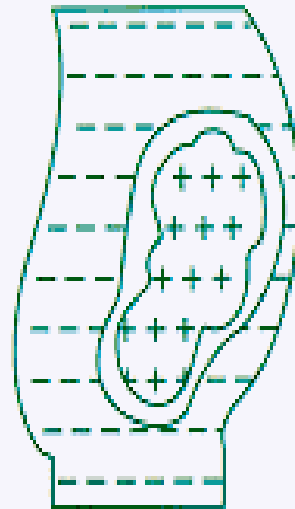
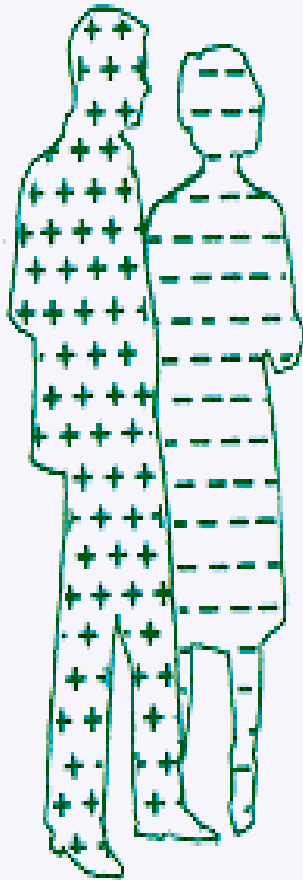
- The 1st pregnancy proceeds without problems
- But her immune system is sensitized after the first pregnancy
- In a 2nd pregnancy, the mother's antibodies attack the Rh⁺ blood of the fetus

Preventive measures:

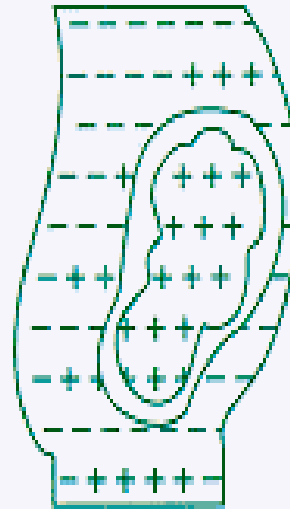
The Rh- woman is given anti-Rh immunoglobulin (aka RhoGAM) to suppress the woman's reaction to the baby's Rh+ by agglutinating the Rh antigens; this lasts about 12 weeks.

When the baby is born, the mother will be given another shot of RhoGAM to help avoid the possibility of her body becoming sensitized to the Rh+ factor in later pregnancies.

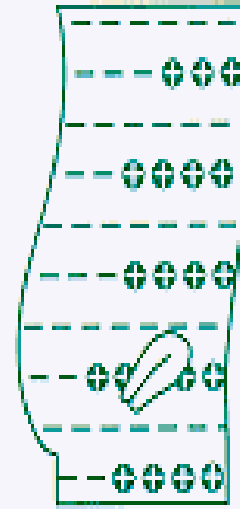




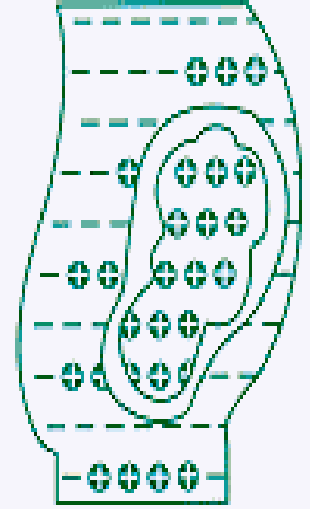
Rh-negative woman with Rh-positive fetus



Cells from Rh-positive fetus enter mother's bloodstream

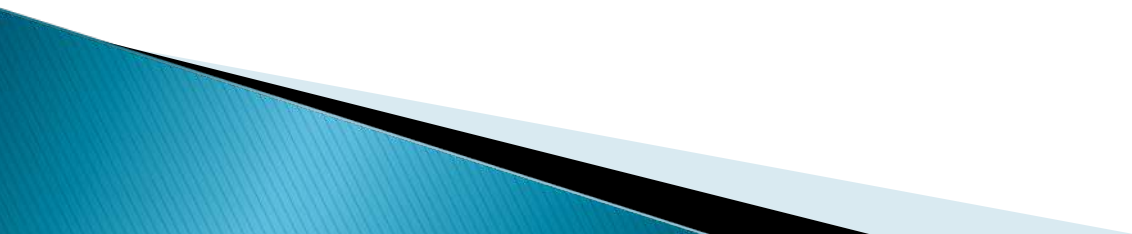


Woman becomes sensitized—antibodies (⊕) form to fight Rh-positive blood cells



In the next Rh-positive pregnancy, antibodies attack fetal blood cells

How Rh sensitization occurs.



Bleeding Disorders

- Thrombocytopenia (caused by viruses, medications or post-bone CA trtment)
 - Platelet deficiency
 - Even normal movements can cause bleeding from small blood vessels that require platelets for clotting
- Hemophilia
 - Hereditary bleeding disorder
 - Normal clotting factors are missing

Blood Typing

- Blood samples are mixed with anti-A and anti-B serum
- Coagulation or no coagulation leads to determining blood type
- Typing for ABO and Rh factors is done in the same manner
- Cross matching – testing for agglutination of donor RBCs by the recipient's serum, and vice versa

PLASMA 55%	
Constituent	Major functions
Water	Solvent for carrying other substances
Salts (electrolytes) Sodium Potassium Calcium Magnesium Chloride Bicarbonate	Osmotic balance, pH buffering, and regulation of membrane permeability
Plasma proteins Albumin Fibrinogen Globulins	Osmotic balance, pH buffering Clotting of blood. Defense (antibodies), and lipid transport
Substances transported by blood Nutrients (e.g., glucose, fatty acids, vitamins, amino acids) Waste products of metabolism (urea, uric acid) Respiratory gases (O ₂ and CO ₂) Hormones	

Figure 10.1

