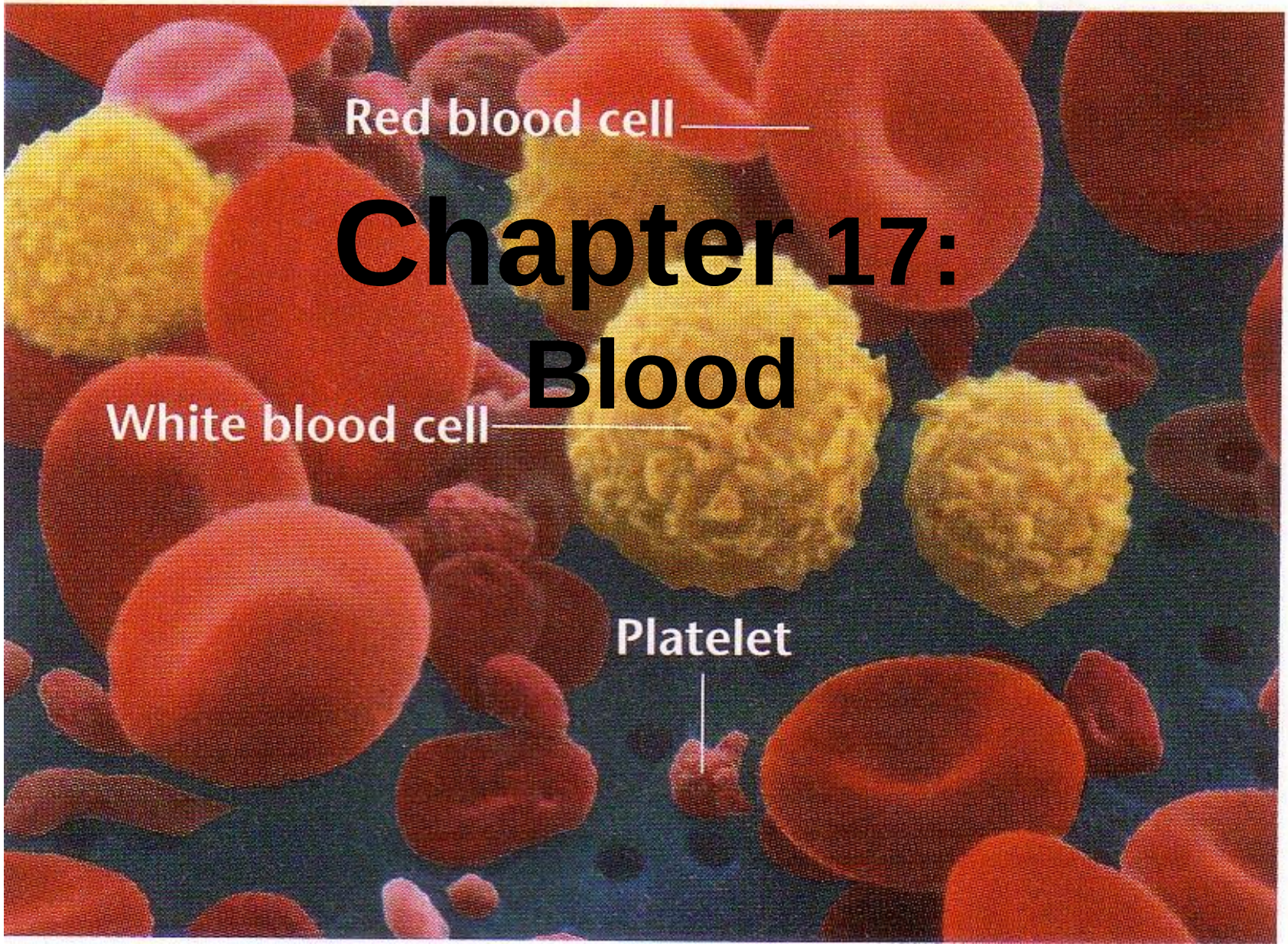
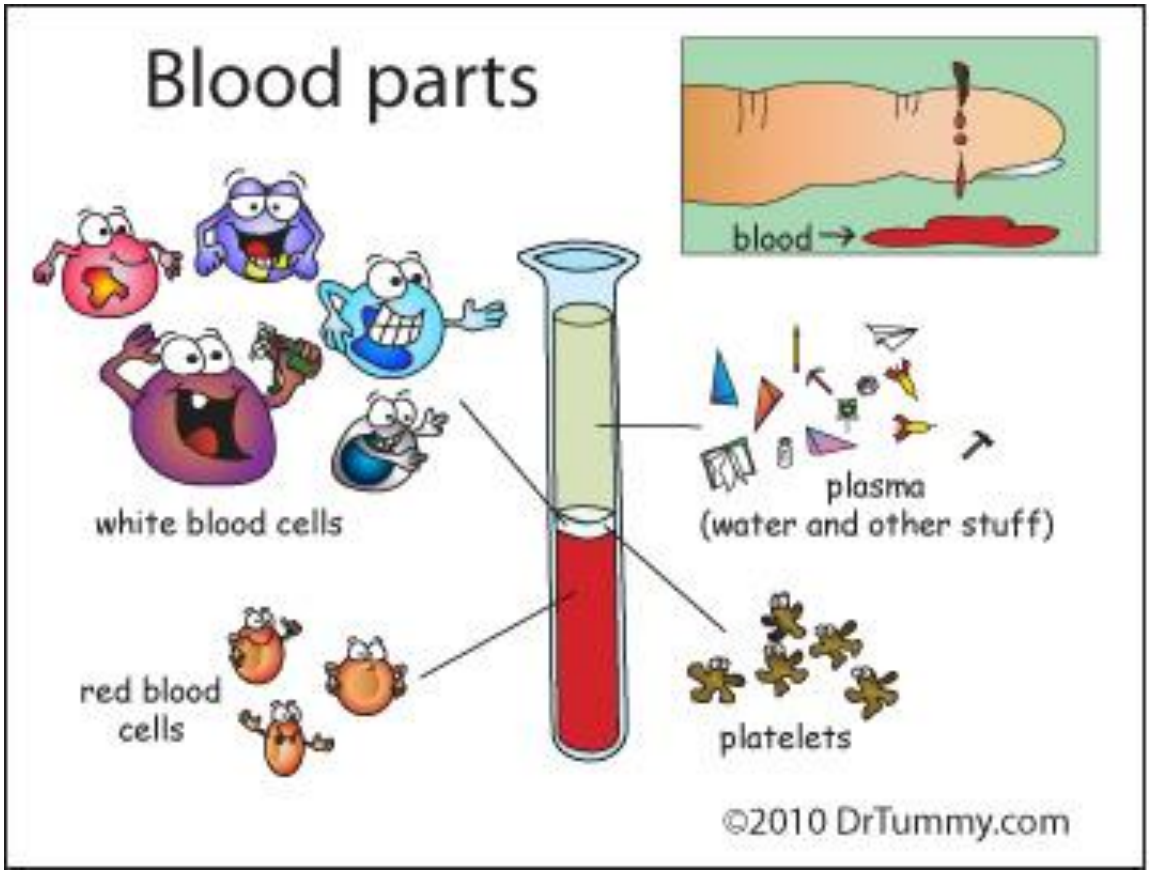


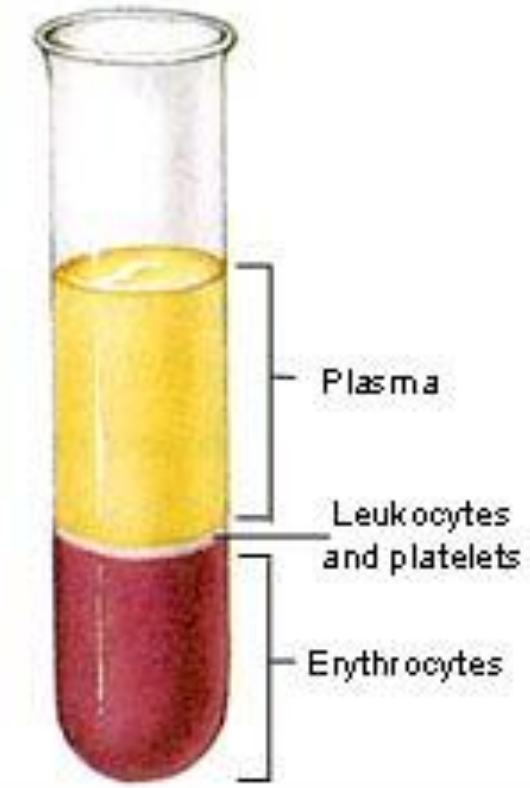
Chapter 17: Blood

Overview:
Blood Composition and Function



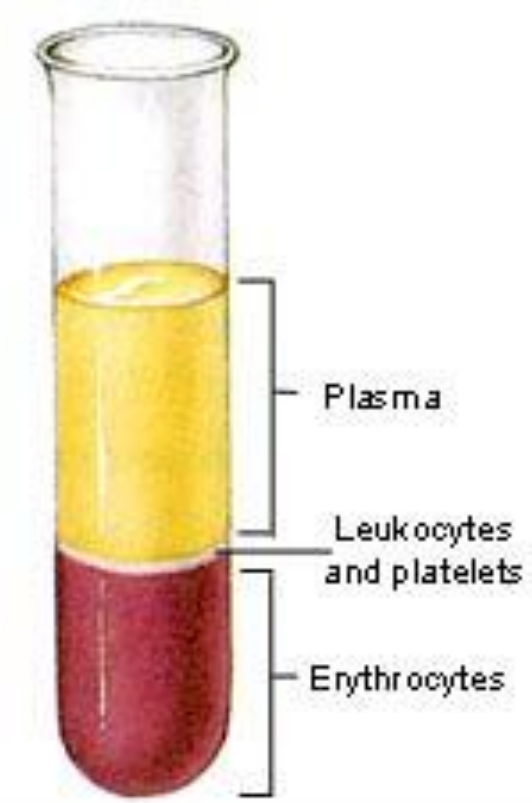
Overview: Blood Composition and Function

- Formed elements – 45% of whole blood
  - Blood cells and cell fragments
    - Erythrocytes – Red blood cells (99.9%)
    - Leukocytes – White blood cells (Buffy coat <1%)
    - Thrombocytes – platelets (Buffy coat <1%)



Overview: Blood Composition and Function

- Plasma – 55% of whole blood
  - The nonliving fluid matrix in which the formed elements are suspended
  - Plasma proteins are also suspended in solution



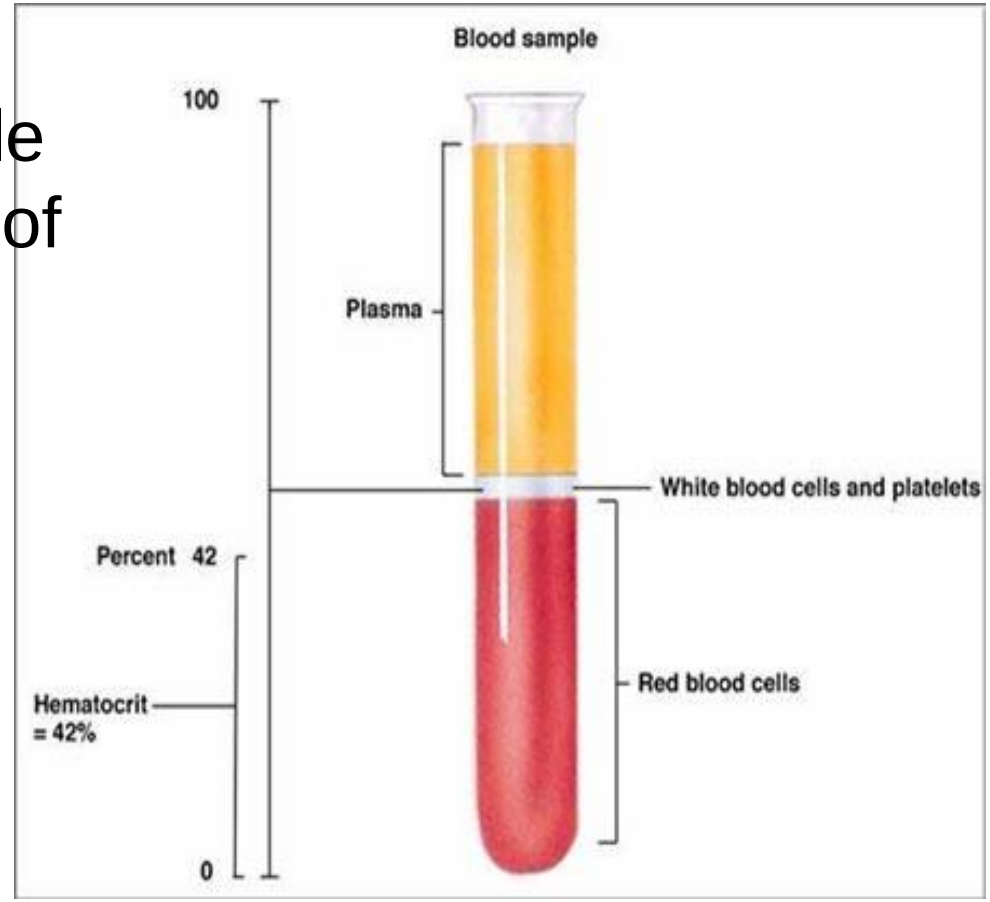
Components of Blood

1. Plasma – 55% total volume of blood
   - → mostly liquid water (91%)
   - → soluble blood proteins (7%)
   - → hormones
   - → electrolytes } (2%)
   - → nutrients

2. Cellular Component – 45% total volume of blood
   - → White blood cells
   - → Platelets
   - → Red blood cells

Overview: Blood Composition and Function

- Hematocrit – "blood fraction"
  - The % volume of whole blood that is made up of RBCs
  - Values may vary:
    - Males 47% $\pm$ 5%
    - Females 42% $\pm$ 5%
  - Values are differ b/t males and females because of hormones (m) and blood loss (f)



Physical Characteristics and Volume

- Sticky, opaque fluid with a metallic taste

- Only fluid tissue in the body
  - Formed elements and Plasma
- Color varies depending on the amount of oxygen blood carries

Physical Characteristics and Volume

- Temperature is slightly higher than our body temp (100.4^{o}F)
- pH ~7.4
- Accounts for approximately 8% of our weight

- Average volume:
  - Males 5-6 liters (1.5 gallons)
  - Females 4-5 liters (1.2 gallons)

Functions

- Transports dissolved gases, nutrients, hormones and metabolic wastes
- Stabilizes body temperature
- Maintains normal pH in body tissues
- Maintains adequate fluid volume in the circulatory system
- Prevents blood loss
- Prevents infection

Blood Plasma

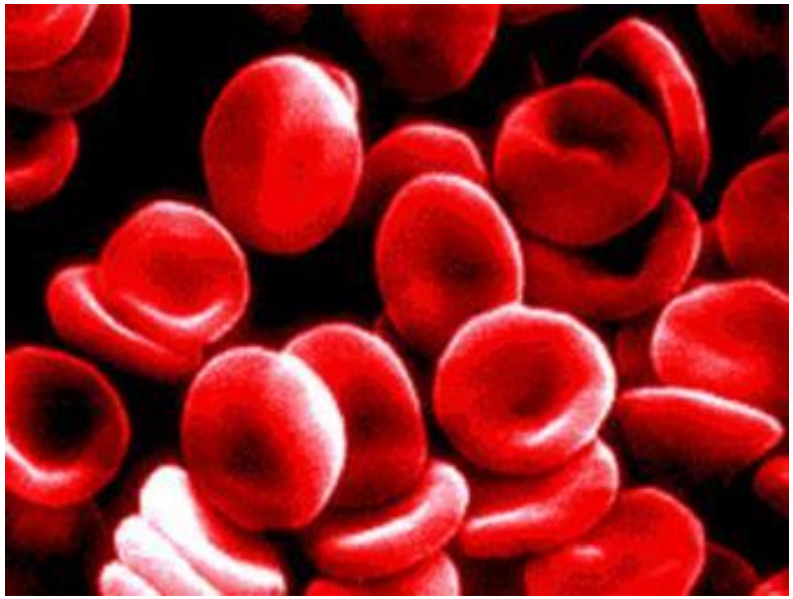
- Fluid Matrix
- Accounts for 55% of total blood volume
- Straw-colored, sticky fluid

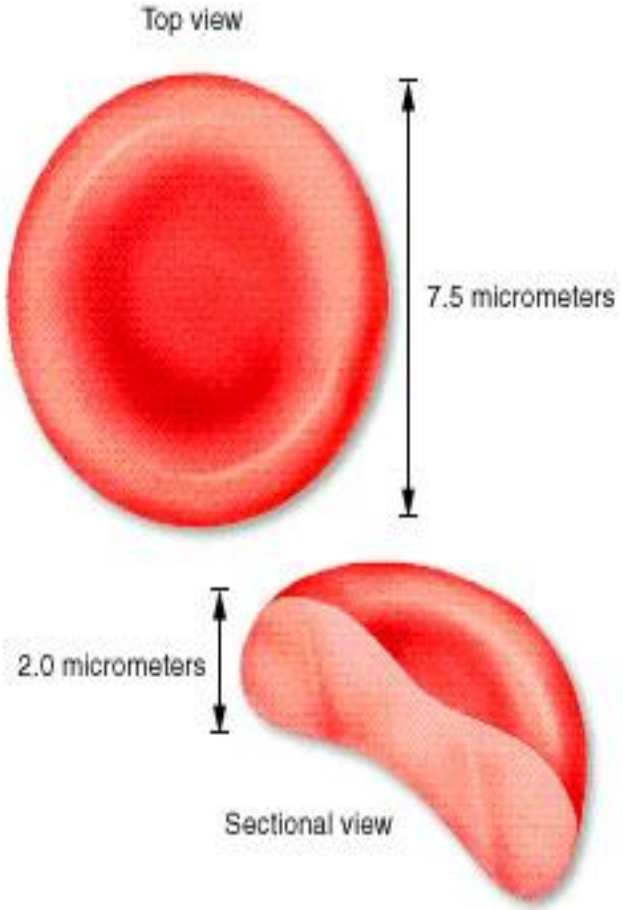
Blood Plasma

- Composition
  - 90% Water
  - 10% 100 different solutes (nutrients, gases, hormones, wastes, and products of cell activity, ions, and proteins.
- Transports solutes around the body and distributes heat (a byproduct of metabolism) throughout the body.

Formed Elements - Erythrocytes

- Red Blood Cells
  - Among most specialized cells in the body
  - Account for 99.9% of formed elements

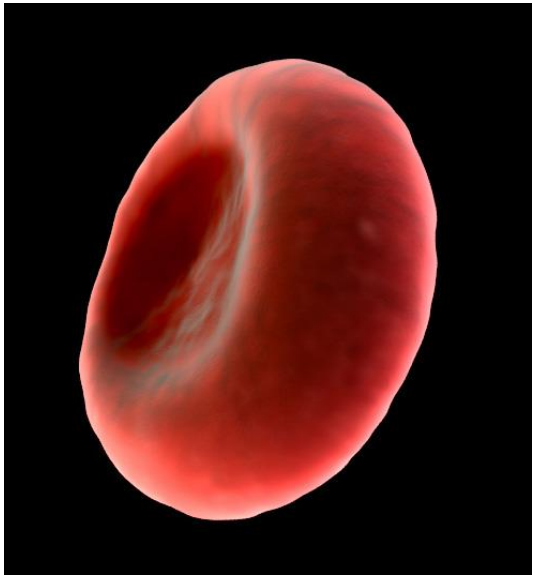




Formed Elements - Erythrocytes

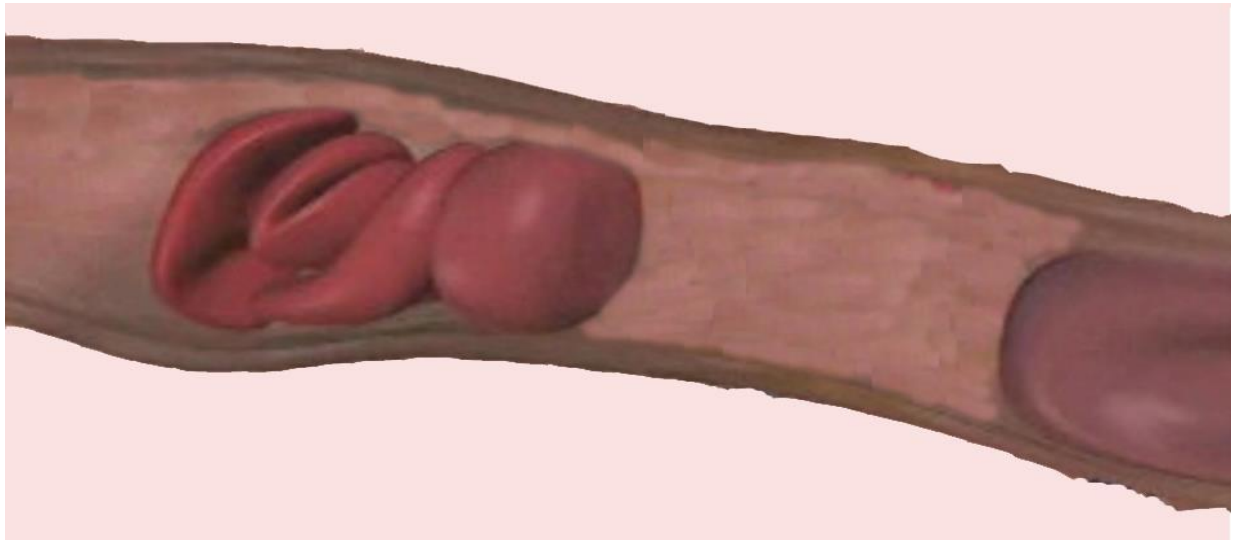
- Each RBC is a biconcave disc with a thin central region and a thicker outer margin
  - Looks like a miniature doughnut when viewed with a microscope

- Stackable – like dinner plates – allows the RBCs to flow smoothly through narrow blood vessels



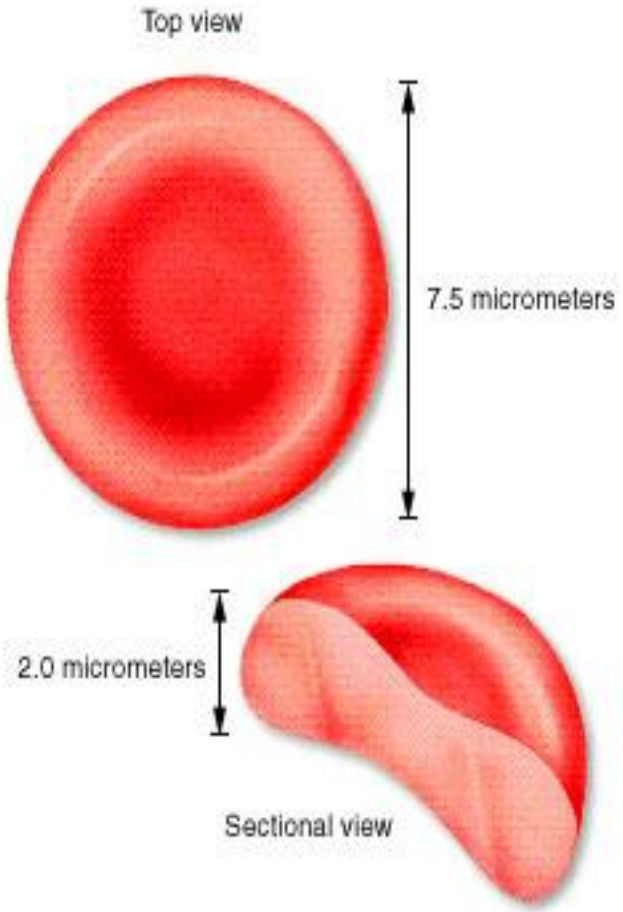
Formed Elements - Erythrocytes

- Bendable & flexible (protein *spectrin*) → able to change shape to fit through small capillaries then “spring” back to its original shape



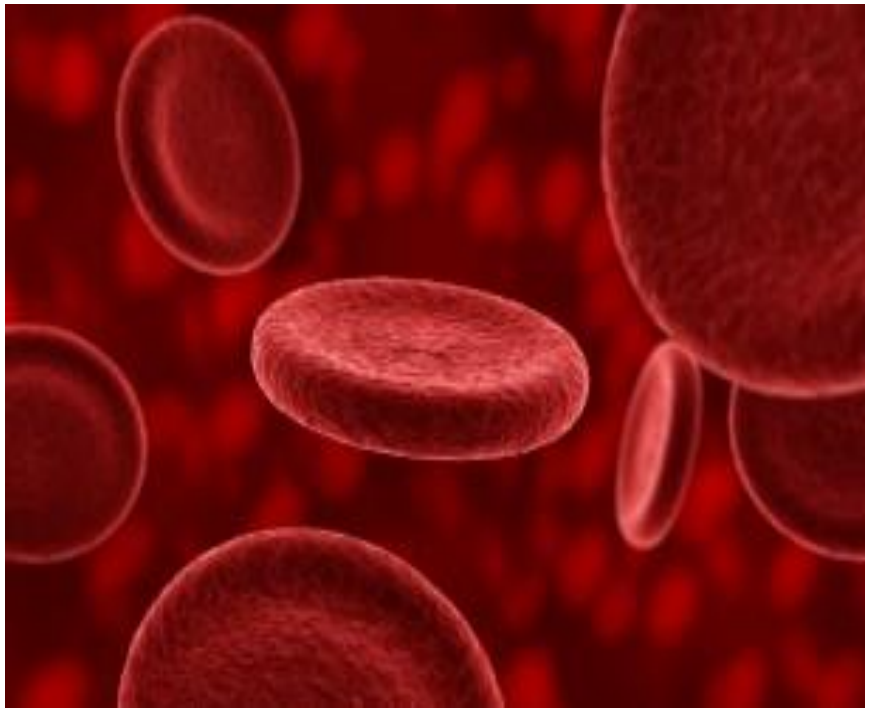
Formed Elements - Erythrocytes

- Bound by a plasma membrane. Lack a nucleus (anucleate), essentially no organelles
  - Lose most of organelles and nuclei during development – retain only cytoskeletal elements
- Little more than “bags” of hemoglobin (Hb), the protein responsible for gas transport.



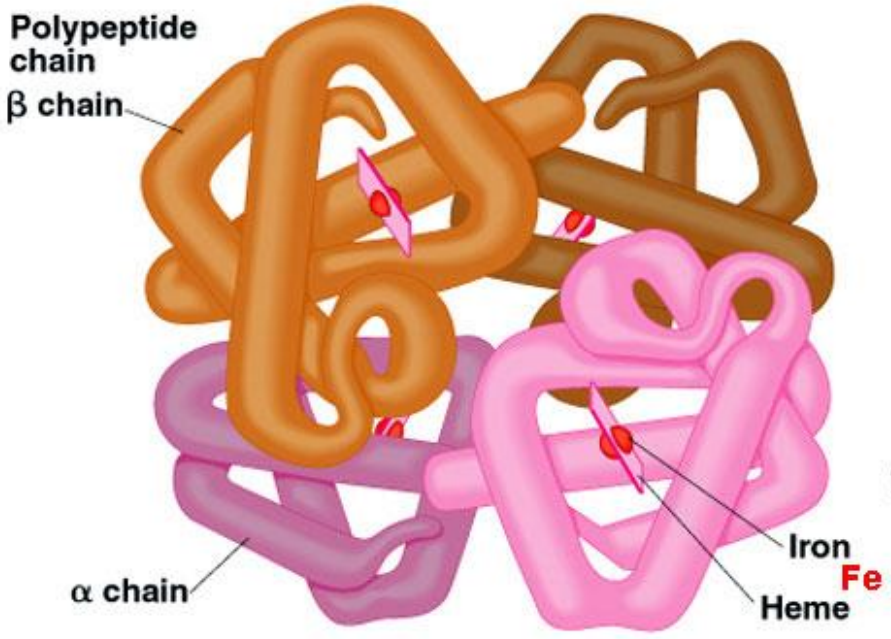
Formed Elements - Erythrocytes

- Contains the red pigment **<u>hemoglobin (Hb)</u>**
  - Gives blood its deep red color
  - Binds and transports oxygen and carbon dioxide
  - Oxyhemoglobin →Oxygen rich → Bright red
  - Deoxyhemoglobin → Oxygen Poor → Dark red

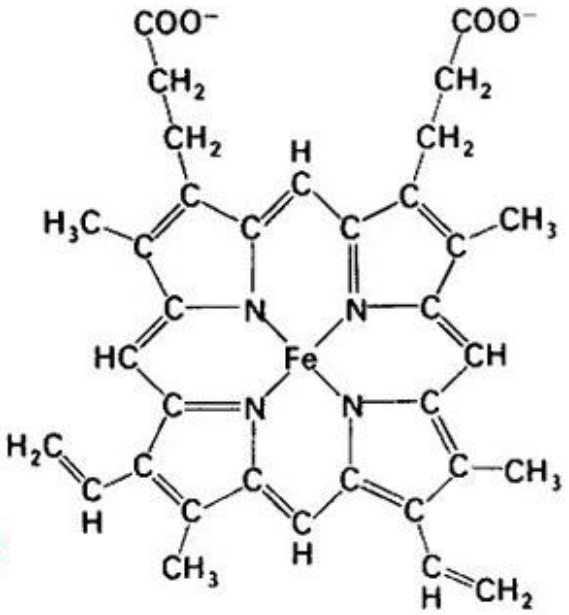


Formed Elements - Erythrocytes

- Hemoglobin is made up of protein **globin** bound to the red **heme** pigment.



Hemoglobin



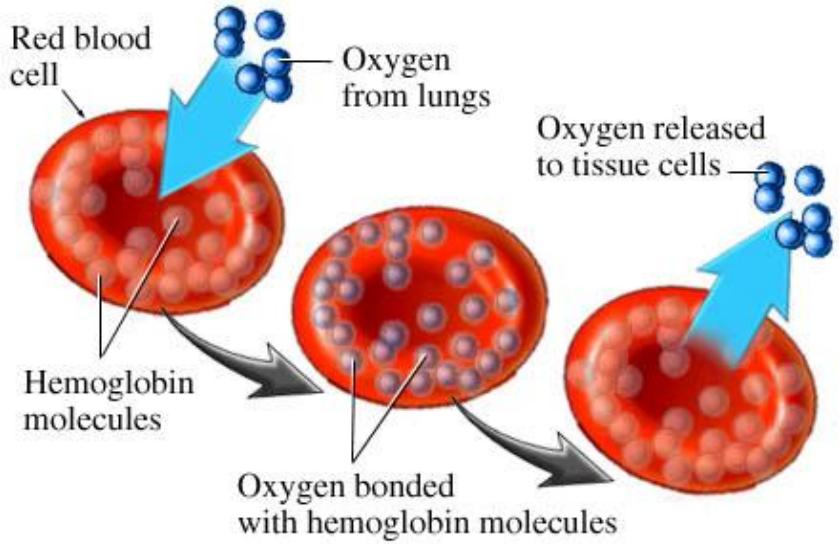
Heme
(Fe-protoporphyrin IX)

Formed Elements - Erythrocytes

- Globin consists of **4 polypeptide chains**, each bound to a heme group. Each heme group has **1 iron atom** bound to it. Each iron can bind with 1 molecule of oxygen (O_2). Each hemoglobin molecule can carry up to **4 O_2**.
- One RBC can have up to **250 million hemoglobin** molecules → able to carry ~ **1 billion O_2**!

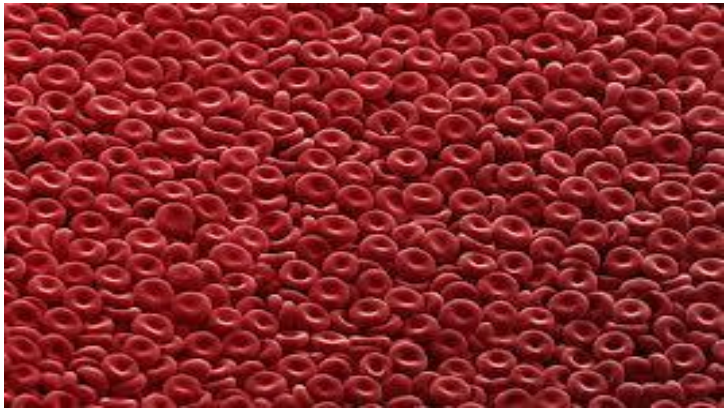
Formed Elements - Erythrocytes

- Complementarity of structure and function:
  - Small size and biconcave shape provide a huge surface area relative to volume. No point in the cytoplasm is far from the surface, the RBC is ideally suited for fast and efficient gas exchange



Formed Elements - Erythrocytes

- Complementarity of structure and function:
  - The RBC is over 97% hemoglobin → can carry **a lot** of oxygen.
  - Erythrocytes lack mitochondria and generate ATP by anaerobic means, they don't consume any of the oxygen that they are transporting, making them very efficient oxygen transporters.



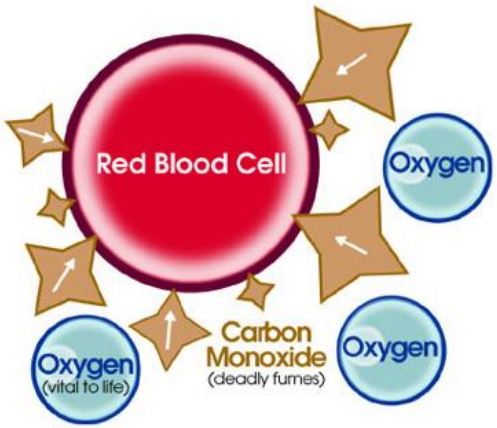
Composition of Blood – Formed Elements

- Hematopoiesis
  - Formation of BCs
- Erythropoiesis
  - Formation of RBCs
- Lifespan
  - About 120 days
- Broken down in spleen.
  - Most of the iron is recycled to the bone marrow

- Circulation
  - A single round-trip from the heart, through the tissues and back to the heart takes less than a minute!
  - Travels about 700 miles during its lifespan

Carbon Monoxide Poisoning

- CO is a colorless, odorless, and tasteless gas.
- Too much CO in the air your breathe can greatly diminsish your ability to absorb oxygen, leading to serious tissue damage. Can lead to death.
- Produced by devices that generate combustion flames.
- RBC pick up CO quicker than they pick up O_2 → Oxygen is blocked from getting into the body



Sickle Cell Anemia

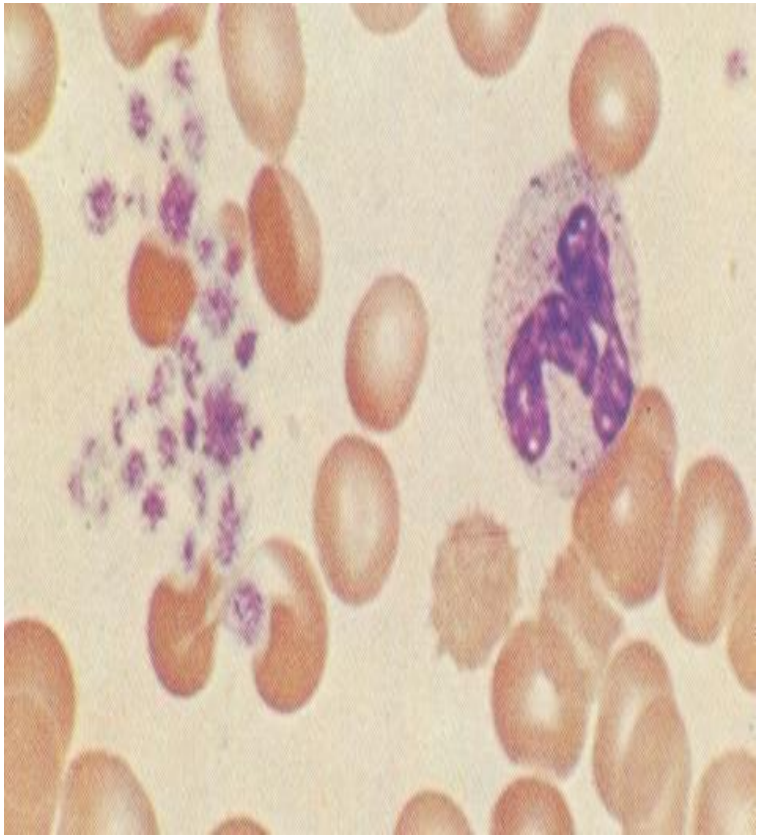
- An inherited form of anemia. Caused by a mutation in the gene that tells your body to make hemoglobin
  - Normally RBC are flexible and round, moving easily through your blood vessels. In sickle cell anemia, the RBC become rigid and sticky and are shaped like sickles or crescent moons. These irregularly shaped cells can get stuck in small blood vessels, which can slow or block flow and oxygen to parts of the body.

Anemia

- Condition in which you don't have enough healthy RBC to carry adequate oxygen to your tissues.
  - Your body doesn't make enough
  - Bleeding causes you to lose RBC more quickly than can be replaced
  - Body destroys RBCs

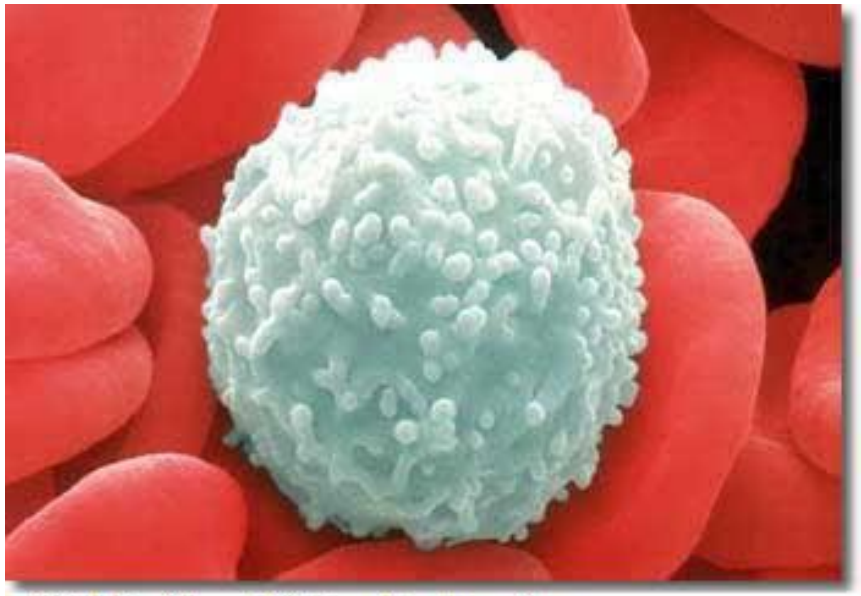
Formed Elements - Leukocytes

- White Blood Cells
- Only formed element that is a complete cell. Larger than a RBC
- Accounts for less than 1% of our total blood volume



Formed Elements - Leukocytes

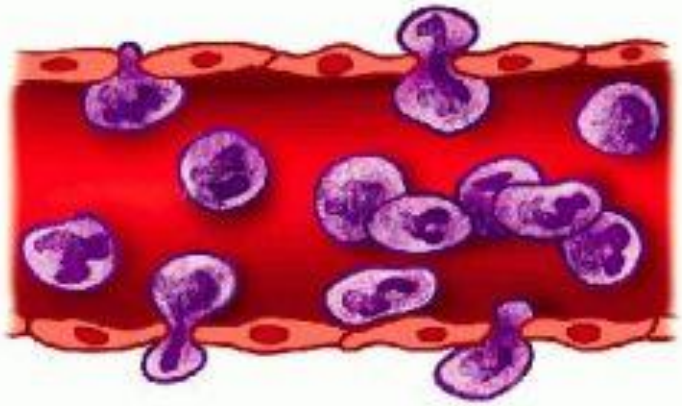
- Produced in bone marrow
- Crucial to our defense against disease. Protect the body from damage by bacteria, viruses, parasites, toxins, and tumor cells



A White Blood Cell or Leukocyte

Formed Elements - Leukocytes

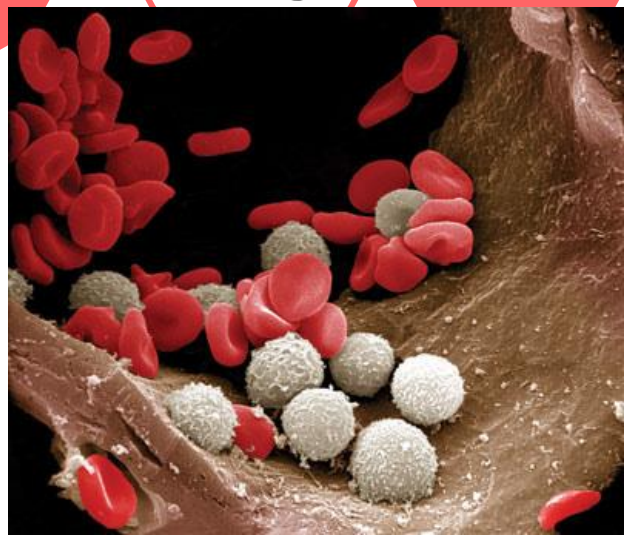
- RBC are contained to the blood vessels.
- For the WBC, the blood vessels are a means to transport them to different areas of the body. They are able to slip out of the capillaries by a process called **diapedesis**, to get to the areas of the body that need "help."



Formed Elements - Leukocytes

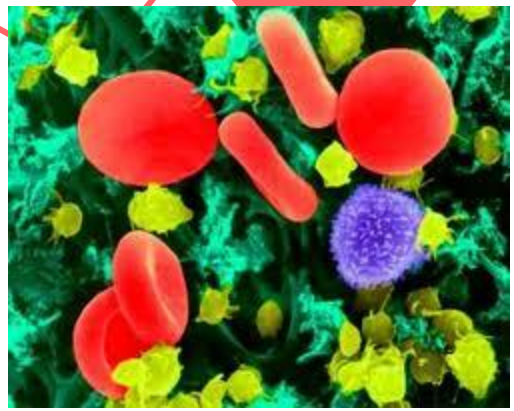
- Leukocytes – White Blood Cells
  - 5 different kinds
  - Can live from hours to years
  - Can see a serious infection by counting WBC in blood

Formed Elements - Leukocytes



- **N**eutrophils
  - Phagocytize bacteria
- **L**ymphocytes
  - Immune response (antibodies)
- **M**onocytes
  - Phagocytize develop into macrophages in tissues
- **E**osinophil
  - Kill parasitic worms; inactivate some inflammatory chemicals of allergy
- **B**asophils
  - Release histamine and other mediators of inflammation; contain heparin (anticoagulant)

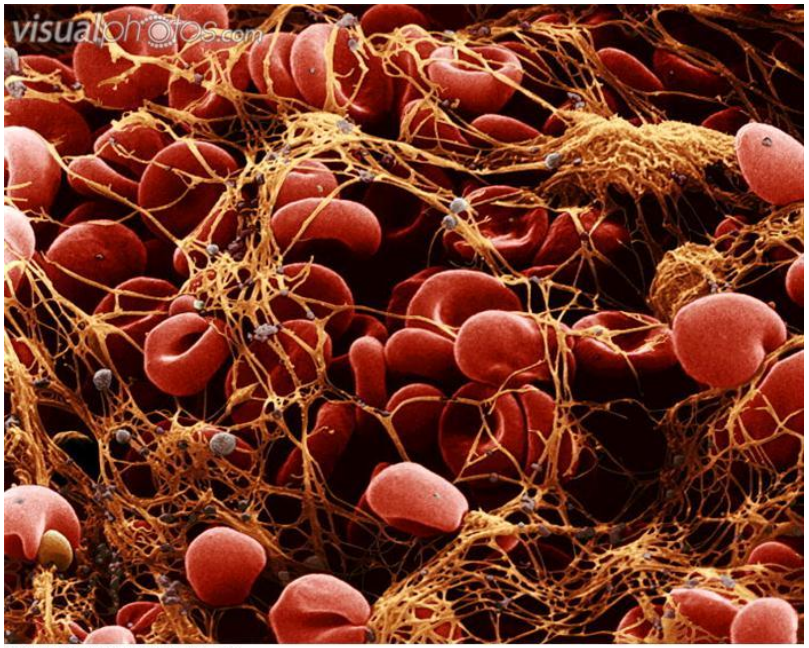
Formed Elements - Thrombocytes



- Platelets
  - Not cells in the strict sense → Cell fragments
  - They are cytoplasmic fragments from large cells called **megakaryocytes**
  - “live” about 5 – 10 days
  - Essential for the clotting process that occurs in plasma when blood vessels are ruptured.

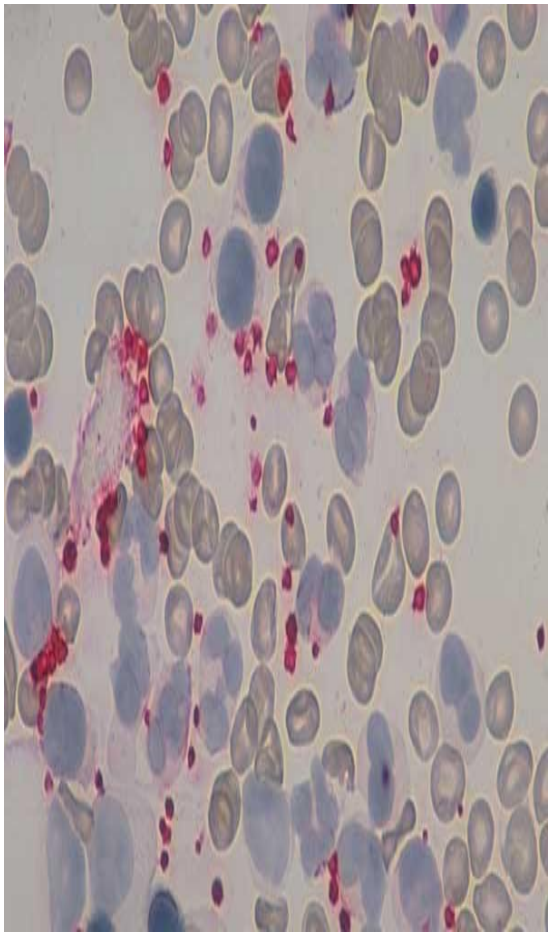
Formed Elements - Thrombocytes

- Stick to the damaged site to form a temporary plug that helps seal the break.
- Begins the chain reaction that results in blood clotting
  - Release proteins called clotting factors that clot the blood → turn it from a liquid to a solid



Formed Elements - Thrombocytes

- Thrombocytes - Platelets
  - Cell fragments
  - Aid in blood clotting
    - Hemophilia is when someone is lacking a clotting factor
    - Like dominos – take out the middle chunk – wont continue to fall from beginning to end



Blood Types

- Blood type is determined by the presence or absence of specific surface antigens (agglutinogens) in the RBC cell membrane
  - Antigens are materials that can trigger an immune response – a defense mechanism that protects you from infection
  - Our cell membranes contain surface antigens that our immune system recognize as “normal.”
  - There are at lest 24 different blood groups, and more than 100 antigens that can be detected on RBCs!

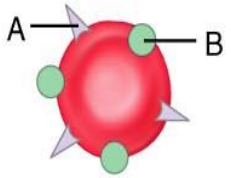
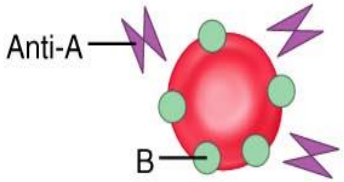
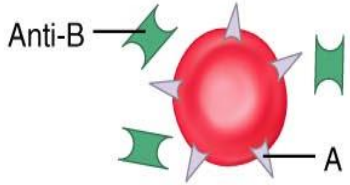
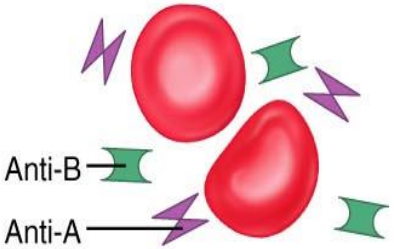
Blood Types

- Antigen (agglutinogen)
  - **A protein on the cell** that triggers an immune response
- Antibody (agglutinins)
  - Causes the immune response
  - Found in the plasma
  - React with the antigen

Blood Types

- Three main surface antigens:
  - A
  - B
  - Rh (D)
- Red blood cells of individuals may have:
  - A surface antigens – Type A
  - B surface antigens – Type B
  - Both A and B surface antigens – Type AB
    - Universal Reciever
  - Neither A nor B surface antigens – Type O
    - Universal Donor

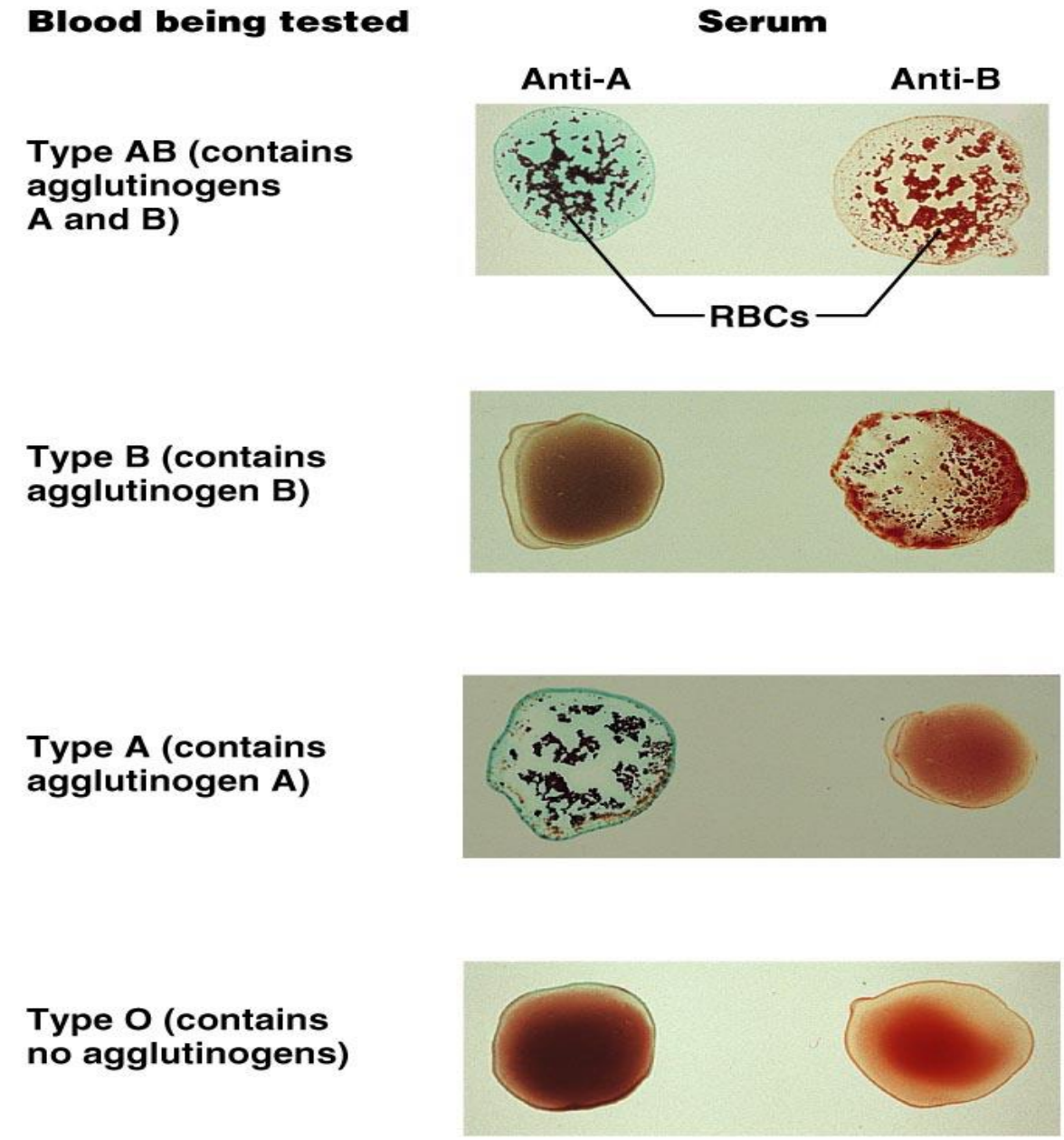
TABLE 17.4 ABO Blood Groups

BLOOD GROUP	FREQUENCY (% U.S. POPULATION) WHITE	BLACK	ASIAN	NATIVE AMERICAN	RBC ANTIGENS (AGGLUTINOGENS)	ILLUSTRATION	PLASMA ANTIBODIES (AGGLUTININS)	BLOOD THAT CAN BE RECEIVED
AB	4	4	5	<1	A B		None	A, B, AB, O (Universal recipient)
B	11	20	27	4	B		Anti-A (a)	B, O
A	40	27	28	16	A		Anti-B (b)	A, O
O	45	49	40	79	None		Anti-A (a) Anti-B (b)	O (Universal donor)

Blood Types

- In the plasma
  - Type A
    - Anti-B antibodies → will attack blood cells with B surface antigens
  - Type B
    - Anti-A antibodies → will attack blood cells with A surface antigens
  - Type AB
    - Neither anti-A nor anti-B antibodies
  - Type O
    - Both anti-A & anti-B antibodies → will attack blood cells with A or B surface antigens

y



Blood Types

- Rh Factor
- Discovered in the blood of the *Rheuses* monkey
  - Presence of Rh surface antigens – Rh positive
  - Absence of Rh surface antigens – Rh negative

Blood Types

- Rh Factor
  - Anti-Rh antibodies are not spontaneously formed in the blood of Rh- individuals
    - First exposure → no problem
    - Second exposure → immune response
- Especially important in pregnant Rh- women who carry Rh+ babies
  - First pregnancy → healthy baby
    - During birth some of the Rh+ antigens transferred into mom's blood stream → Now sensitive to Rh+
    - Mother can be given RhoGAM – a serum that blocks the mother's immune response
  - Second pregnancy if no RhoGAM→ activated immune response (body sees the baby as a disease and attacks the baby)

Differences in Blood Group Distributions

Population	O	A	B	AB	Rh^+
U.S. (average)	46	40	10	4	85
Caucasian	45	40	11	4	85
African American	49	27	20	4	95
Chinese American	42	27	25	6	100
Japanese American	31	38	21	10	100
Korean American	32	28	30	10	100
Filipino American	44	22	29	6	100
Hawaiian	46	46	5	3	100
Native North American	79	16	4	<1	100
Native South American	100	0	0	0	100
Australian Aborigines	44	56	0	0	100

Transfusion and Blood Types

- The transfer of whole blood or blood components (RBC only or plasma only) into the blood stream

- Transfusion of incompatible blood can be fatal!!
  - If you get an incompatible blood transfusion, the blood will cause an agglutination which is a clumping of foreign cells
  - Within a few hours the cells begin to rupture → hemoglobin in bloodstream → enters kidneys and causes blockages → kidney shutdown (most severe)
  - Less severe → fever, chills, low bp, rapid heartbeat, nausea, vomiting.