Blood Composition

Objectives

- Explain how the properties of blood qualify it as a connective tissue
- Describe the various functions of blood
- Distinguish among the three major categories of formed elements
- Describe the shape, structure, and contents of an erythrocyte
- Know what hematocrit test determines, and what are the normal lab values
- Describe the differences between agranulocytes and granulocytes
- Visually differentiate each of the leukocytes on a normal blood smear
- Visually identify platelets, describe their function, and explain what coagulation tests are used to determine

The Cardiovascular System: An Introduction

The term "cardiovascular system" is broadly used to describe a body system that consists of tubular organs, called **vessels**, a fluid tissue, known as **blood**, and a muscular pump (the **heart**) that functions in driving the blood through those vessels. It is often more accurate to describe all of the above components as the **circulatory system**, reserving the term "cardiovascular" for the heart and vessels only.

Blood as Connective Tissue

[Section 18.1: An Overview of Blood]

What are the properties that are common to all connective tissues? (see Section 4.3 in your textbook for review)

Blood is considered to be a "liquid connective tissue." Describe the components of blood that fit the description of a connective tissue.

Functions of Blood

[Section 18.1.1: Functions of Blood]

List the various things that are transported by the blood.

List the many ways in which the blood serves a defensive, immune function for the body.

What homeostatic mechanisms are regulated and maintained by the blood?

Blood Composition

[Section 18.1.2: Composition of Blood]

[Figure 18.2: Composition of Blood]

- Define hematocrit
- 55% = *Plasma*
    - Proteins (for blood pressure, clotting, and immune functions)
    - Water (92% of plasma)
    - Electrolytes
    - Hormones
    - Nutrients
    - Blood gases
    - Waste
- 45% = *Formed Elements*
    - Red Blood Cells
    - Platelets
    - White Blood Cells

Erythrocytes

[Section 18.3.1: Shape and Structure of Erythrocytes]

[Section 18.3.2: Hemoglobin]

Primary function: transport respiratory gases to and from tissues

Lack a nucleus

Most abundant of all blood cells

Biconcave to increase surface area to allow for rapid gas exchange, allows for the cells to squeeze through vessels

Contains millions of Hemoglobin molecules: allow for binding of O_2 and CO_2

Hematocrit

[Figure 18.2: Composition of Blood]

- Determines the volume of packed elements (mainly RBCs) in a blood sample (reported as a percentage)
- Provides information about the oxygen-carrying capacity of blood. Low percentages mean less RBC's carrying O_2.

- Averages: males:_____%; females:_____%

Platelets

[Section 18.4.5: Platelets]

Produced by the fragmentation of cells in the bone marrow called **megakaryocytes**

Don't survive long

Involved in **coagulation**: the process of clot formation

During coagulation, molecules (fibrin) join to form long threads that form a net to trap platelets and plug the wound

Coagulation

[Section 18.5.3: Coagulation]

Also known as clotting

Happens when blood sits for 3-4 minutes outside of the body

Process of "closing" a wound:

- Person cuts themselves
- Enzymes activate circulating proteins
- Proteins convert fibrinogen to fibrin
- Fibrin joins together to form long threads that form a net that "traps" platelets
- These trapped platelets form a clot

A **coagulation test** determines how fast this occurs in your blood

- A clinical test used to detect bleeding disorders (missing clotting factors, low platelet counts, etc.)
- An unusual coagulation test can result from genetic disorders, or other underlying problems, such as cancer, vitamin deficiency, etc.

Leukocytes

[Section 18.4.2: Classification of Leukocytes]

[Figure 18.11: Granular Leukocytes]

[Figure 18.13: Leukocytes]

Only formed elements with a nucleus

lacks hemoglobin

travel between endothelial cells of capillaries and tissues

most are phagocytes

There are two types of WBC- *granular and agranular*

Granulocytes

All have granules in cytoplasm, these granules are secretory

- **Neutrophils** are the most common granulocytes (70% of total WBC count)
    - 1st to arrive at wound/infection site, release cytotoxins
    - phagocytize bacteria
    - release chemokines (attract other WBCs), and once activated
    - live only a day or two
- **Eosinophils** (3% of total WBC count)
    - phagocytize bacteria and microbes that the immune system has coated with antibodies (Abs)
    - decrease inflammatory response at site of wound
- **Basophil** (<1% of WBCs)
    - release histamines (cause vasodilation) and heparin (prevents clotting)
    - Important in allergies

Agranulocytes

- **Monocytes** (20-30% of total WBC count)
    - Wanderers, patrol body tissue for microbes and worn-out tissue cells, 2nd to arrive at wound site, phagocytize dead cells/debris that has accumulated at site of wound/infection
- **Lymphocytes** (2-8% of WBCs)
    - smallest leukocyte, abundant in bloodstream, occur in lymph nodes and glands
    - specialized lymphocytes:
        - *T-cells*: attach to and destroy infected or cancerous cells by releasing cytotoxic molecules and secreting antiviral/pro-inflammatory molecules
        - *B-cells*: manufacture antibodies that attach to foreign pathogens/cells and help destroy them
        - *Natural Killer cells*: can detect sick, cancerous, and infected cells and release cytotoxic molecules to destroy them

Blood Typing

Objectives

- Describe the antigen-antibody reactions of the ABO and Rh blood groups
- Be able to type a sample of unknown blood to determine the ABO and Rh blood types
- Explain the clinical importance of blood types on pregnancy and transfusions

Blood Typing

[Section 18.6.1: Blood Typing; Antigens, Antibodies, and Transfusion Reactions]

Each blood type is a function of the presence or absence of specific molecules, called antigens, on RBCs

Antigens are molecules that your body can use to differentiate self and non-self (virtually all proteins, carbohydrates, etc. are types of antigens). People with different blood types have RBCs with different antigens on them.

Antibodies are produced in response to some antigens (non-self), and are generally used by the immune system to recognize and remove foreign objects that don't belong.

Antibodies and antigens in an individuals blood do not interact with one another, but what happens when you mix blood/antibodies from different people?

More than 50 blood types in human population

The most clinically significant are the ABO and Rh(+/-) blood groups

The ABO Blood Group

[Section 18.6.2: The ABO Blood Group]

ABO typing does NOT affect a person's Rh designation

Type A blood= "A" antigens on cell, anti B antibodies

Type B blood= "B" antigens on cell, anti A antibodies

Type AB= "A" and "B" antigens on cell, no antibodies

Type O blood= no antigens on cell, anti A and B antibodies

If a different type of blood is put into your bloodstream, the blood will agglutinate (clump) and hemolysis (bursting) occurs within the foreign blood cells

Rh Blood Group

[Section 18.6.3: Rh Blood Groups]

Named after Rhesus monkey where it was first identified

Rh positive (+) contains a D-antigen

Rh negative (-) has no D-antigen, and unlike A/B/O, no anti-D-antibodies are present in Rh negative individuals

Grouped with ABO blood group to identify a blood type (example A+, B-, O-)

The Rh group only has ONE antigen (the D antigen) and ONE antibody (anti D) that could be present.

> If RBCs have a D antigen, the blood is positive
>
> If RBCs have no D antigen, the blood is negative
>
> Negative blood DOES NOT have anti D antibodies!

If positive and negative blood is mixed in an Rh(-) individual, anti D antibodies will be produced against the Rh(+) blood after a short while (a couple weeks)

Mixing of Rh positive and negative will result in production of anti D antibodies

You can get away with it once because anti-D antibodies don't exist beforehand, but a second time will cause a reaction

Importance of Rh during Pregnancy

[Section 18.6.3: Rh Blood Groups]

[Figure 18.15: Erythroblastosis Fetalis]

This is VERY important during childbirth. If the mother is Rh-negative, but her child is Rh-positive and any internal bleeding from the Rh(+) child occurs, the mothers blood will begin producing anti-D antibodies which will then hemolyze her babies blood (and any future Rh(+) fetuses). Exposure of the babies blood during childbirth can also be problematic for future Rh(+) fetuses

This is called hemolytic disease of the newborn or erythoblastosis fetalis

RhoGam a dosage of anti-D antibodies is given to the mother at 28 weeks and within 72 hours of giving birth in order to destroy any fetal blood cells in her blood so she will not produce her own anti-D antibodies. RhoGam antibody dosage is small enough not to hurt fetus, but strong enough to keep mom's immune system from attacking baby

Determining Blood Type

[Section 18.6.4: Determining ABO Blood Types]

[Figure 18.16: Cross Matching Blood Types]

To determine blood types, anti-serum is used.

The serum contains either anti-A antibodies or anti-B antibodies which react to the antigens on the RBC surface

If using anti A anti serum and the blood sample clumps:

then the blood could be Type A, or Type AB

You would then test with anti B anti serum

If it does clump, the blood is Type AB, if it doesn't then it is Type A.

Make sure to NEVER mix anti serums or blood samples!

Transfusions

[Section 18.6.5: ABO Transfusion Protocols]

[Figure 18.17: ABO Blood Group]

The first blood transfusions used animal blood as a source of blood

This often resulted in severe allergic reactions, and often death

In human transfusions, additional complications can arise when the donor's antibodies react with the recipient's RBCs, and vice versa

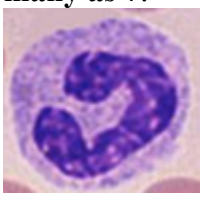
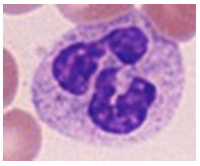
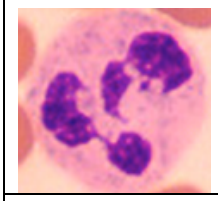
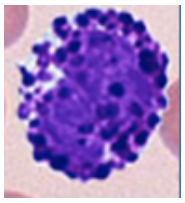
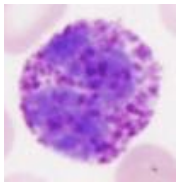
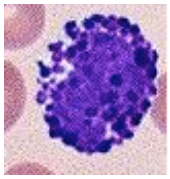
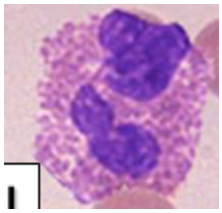
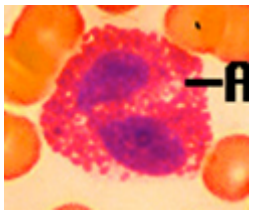
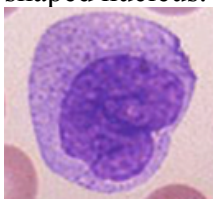
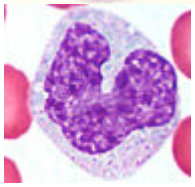
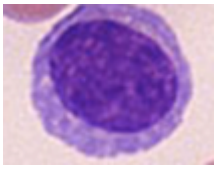
Thus, only donor RBCs are transferred, *no antibodies*

Type O- is considered the **universal donor**

Type AB+ is considered the **universal recipient**

An incorrect transfusion could cause blood to agglutinate within the recipient's blood vessels

Morphological Differences in Leukocytes

Neutrophil	Basophill	Eosinophil	Monocyte	Lymphocyte
Neutral	Basophilic = "Base Loving" Susceptible to stain by basic dyes	"Acid Loving"	**Largest of WBCs** Differentiate into macrophages after migration into tissues from blood.	Confer Adaptive Immunity
Granules do not stain darkly with eosin. They are a light neutral pink color.	When stained with haematoxylin, **granules are bluish/violet**. Granules are **distinct.**	Major Basic Protein Crystals in granules. **Eosin dyes stain bright pink/red**. Cell is crowed with a **mass of granules** that are **not distinctive** like basophils.	Cytoplasm stains lighter.	Both nucleus and cytoplasm stain blue.
3-5 Lobes but can have as many as 7.   	2-3 lobes   	2 lobes  	Large bilobate C-shaped nucleus.   	Round nucleus takes up almost the entire cytoplasm. 
Participate in acute an chronic infections of a bacterial origin. First responders to an inflammatory event. **12 hour life span.**	Fight parasites. Participate in allergic responses. Granules contain histamine which is vasoactive.	Participate in dampening over reactive allergic responses. Granules contain histaminase and arylsufatase.	Second responders to an inflammatory event. Phagocytose dead neutrophils, microbes, and tissue debris.	T-cells- responsible for "helping" other cells kill microbes. B-cells- produce antibodies with T-cell "help."

Red Blood Cells are biconcave, anuclear (no nucleus), and live for about 120 days.
All blood cells (erythrocytes and leukocytes) are born in the bone marrow.

TABLE 1: BLOOD, TESTS, AND TYPING (exercises 29 & 30)		
Term/Structure	**Definition/Location**	**Notes**
Connective Tissue		
Formed Element		
Erythrocytes (red blood cells)		
Leukocytes (white blood cells)		
Platelets (thrombocytes)		
Innate Immunity		
Adaptive Immunity		
Antibody-Mediated Immunity		
Cell-Mediated Immunity		

Leukopenia		
Erythrocytes (red blood cells)		
Hemoglobin		
Platelets		
Megakaryocytes		
Leukocytes		
Granular Leukocytes		
Neutrophils		
Eosinophils		
Basophils		

Agranular Leukocytes		
Lymphocytes		
B Cells		
T Cells		
Plasma Cells		
Antibodies		
Natural Killer (NK) Cells		
Macrophages		
Monocytes		
Antigens		

Type A		
Type B		
Type AB		
Type O		
Rh Factor		
Agglutinogens		
Agglutinins		
Transfusion Reaction		
Hemolytic Disease of the Newborn (HDN) (Erythroblastosis Fetalis)		
Hematocrit		

Polycythemia		
Anemia		
Heme Group		
Globin		
Hemoglobin		
Hemoglobinometer Method		
Tallquist Method		
Hemacytometer		

TABLE 2: FORMED ELEMENTS & THEIR CHARACTERISTICS

Formed Element	Size	Number	Granules	Shape of Nucles	Cause for Increase	Notes/Other
Erythrocyte						
Platelets						
Leukocytes						
Neutrophils						
Eosinophils						
Basophils						
Lymphocytes						
Monocytes						

TABLE 3: ABO BLOOD SYSTEM

Blood Type	Agglutinogens (Antigens)	Agglutinis (Antibodies)
A		
B		
AB		
O		

BLOOD TYPE PERCENTAGES AMONG AMERICANS

Caucasians	African Americans	Asian Americans	Native Americans

CBIO 2210L - Blood Lab

1. Formed elements have three main components. What are they?

2. What is the most common plasma protein?

3. What is another name for a platelet?

4. Which is the most common blood cell?

5. What is another name for a leukocyte?

6. What leukocyte is most numerous in a normal blood smear?

7. How many erythrocytes are normally found per cubic millimeter of blood?

8. What is an average number of leukocytes found per cubic millimeter of blood?

9. B cells and T cells belong to what class of agranular leukocytes?

10. How does a differential leukocyte count aid in medical diagnosis?

11. In counting 100 leukocytes you are accurately able to distinguish 15 basophils. Is this a normal number for the white blood cell count, and what possible health implications can you draw from this?

12. What is the function of platelets?

13. Label the blood cells in the following illustration.

CBIO 2210L - Blood Lab

1. What is the name of a surface membrane molecule that causes an immune reaction?

2. What is the average range of hemaotcrit for a normal female?

3. What is the average range of hemaotcrit for a normal male?

4. What percent of the blood volume consists of formed elements?

5. A person with blood type B has what kind of agglutinins (antibodies)?

6. A person has antibody A and antibody B in his or her blood with no Rh antibody. What blood type does this person have?

7. A total of 240 red blood cells are counted in the hemacytometer chamber. What is the red blood cell count of this person in terms of erythrocytes per cubic milliliter?

8. A person with blood type B negative is injected with type A positive blood. From an immunological (antigen/antibody) standpoint what would happen after the injection?

9. How might changes in the pipette technique alter the final determined value of erythrocytes? What type of errors might you expect?

10. Using the following illustration, calculate the hematocrit of the individual. Determine if it falls within normal limits.

11. Define anemia.