

Cardiovascular System Blood

William T. Budd
Virginia Commonwealth University
Center for the Study of Biological Complexity
Medical Careers College

Objectives

- What is blood?
- Review metabolism
- Functions of blood
- Components of blood
- Regulation of blood constituents

What do you need to keep cells alive?

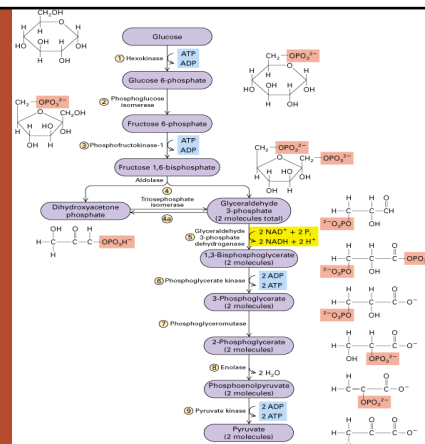
- Functioning Heart
- Intact vasculature
- Adequate blood volume
- Adequate red blood cells
- Adequate hemoglobin
- Proper shape of hemoglobin molecule
- Oxygen

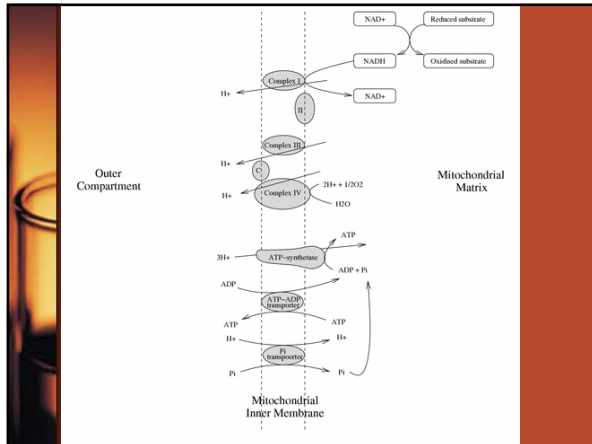
What is blood?

- Blood is a connective tissue
- Humans contain 5 liters on average
- 8% of body weight is blood
- Terminology
 - Heme, Hemato = blood
 - Emia = blood condition

Metabolism

- Metabolism is series of chemical reactions that maintain life
- Primary reaction glucose converted into adenosine triphosphate (ATP)
 - Glycolysis
 - Oxidative phosphorylation





Glycolysis

- First step of glucose metabolism
- Occurs in cytosol of cell
- Doesn't require oxygen
- Yields 2 molecules of ATP
- Waste products are pyruvic acid which changes into lactic acid

Oxidative Phosphorylation

- Occurs in mitochondria of cells
- Requires oxygen
- Total of 32 ATP molecules produced per glucose molecule
- Waste products are water and carbon dioxide

<http://giantsoulders.files.wordpress.com/2007/10/mitochondria.jpg>

Functions of Blood

- Transportation
- Regulation
- Protection

<http://180.photobucket.com/albums/x6/me/atbagman/finish.jpg>

Functions of Blood Transportation

- Carries Oxygen to tissues
- Carries Carbon Dioxide from tissues
- Delivers Nutrients
- Removes Heat
- Removes Waste
- Delivers Hormones

<http://180.photobucket.com/albums/x6/me/atbagman/finish.jpg>


Functions of Blood Regulation

- Acid/ base balance of body fluids
- Temperature Maintenance

<http://180.photobucket.com/albums/x6/me/atbagman/finish.jpg>

Functions of Blood Protection

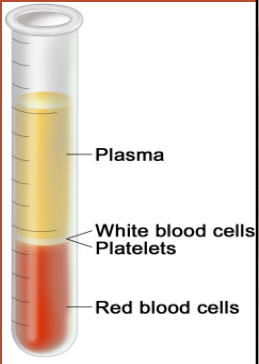
- Hemostasis
- Fighting off infection and disease



<http://1180.photobucket.com/albums/x6/meatbagman/finish.jpg>

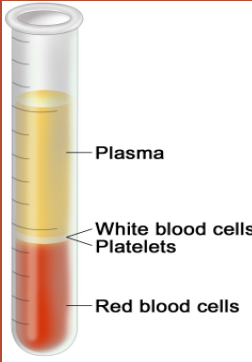
Blood Components

- Plasma
- Formed Elements



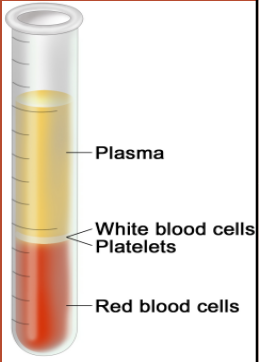
Blood Components Plasma

- Accounts for 55% of circulating volume
 - 91% Water
 - 2% Solutes
 - 7% Proteins



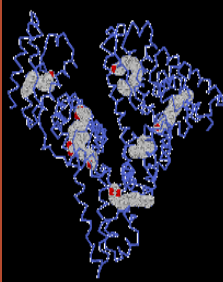
Blood Components Plasma

- Solute in plasma
 - Nutrients
 - Gases
 - Ions
 - Amino Acids
 - Glucose
 - Hormones



Blood Components Plasma Proteins

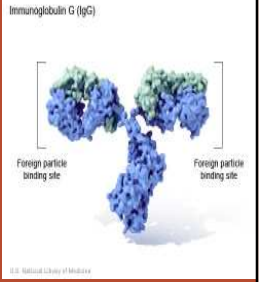
- Serum albumin
 - Maintains osmotic pressure
 - Keeps fluid in vascular space
 - 60% of serum protein



http://upload.wikimedia.org/wikipedia/commons/d/d8/Serum_Albumin_@RasMol.png

Blood Components Plasma Proteins

- Globulins
 - Produced during an immune response
 - Prothrombin A
 - Involved in clotting
 - Fibrinogen
 - Involved in clotting
 - Gamma Globulins
 - Form anti-bodies



<http://ghr.nlm.nih.gov/handbook/illustrations/igg.jpg>

Blood Components Formed Elements

- Erythrocytes
- Leukocytes
- Thrombocytes
- Stem Cells

Plasma
White blood cells
Platelets
Red blood cells

Erythrocytes (Red Blood Cells)

- Men = 4.6 - 6.2 million/ mm³
- Women = 4.2 - 5.4 million/ mm³
- Flexible, biconcave disk
- Anucleate, without organelles
- Contain hemoglobin
- Why doesn't a RBC contain mitochondria?

<http://www.academic.marist.edu/~jz/mz/Hematology/Intro8.jpg>

Production of RBC Erythropoiesis

- Process begins in the kidneys
- Kidneys constantly produce erythropoietin
- Renal cells are sensitive to hypoxia
- Hypoxia caused by several conditions
 - Reduced number of RBCs
 - Reduced availability of O₂
 - Increased tissue demands of O₂
- Requires iron, B12, and folic acid

Production of RBC Erythropoiesis

- Because of hypoxia, kidneys increase production of erythropoietin
- Erythropoietin travels to red bone marrow

Bone Marrow

<http://www.besthealth.com/besthealth/bodyguide/reftext/images/Marrow.jpg>

Production of RBC Erythropoiesis

Stem cell
Committed cell
Developmental pathway
Phase 1 Ribosome synthesis
Phase 2 Hemoglobin accumulation
Phase 3 Ejection of nucleus and organelles, like mitochondria
Hematocytoblast
Proerythroblast
Early erythroblast
Late erythroblast
Normoblast
Reticulocyte
Erythrocyte

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<http://pimm.files.wordpress.com/2007/01/picture-88.png?w=561&h=156>

- Process begins with stem cells (hematocytoblasts)
- Takes 3-5 days for maturation
- Reticulocytes leave bone marrow and enter blood

Production of RBC Erythropoiesis

- Reticulocyte count provides information about rate of RBC production
 - Low = Not producing a normal number of RBCs
 - Bone marrow disease (cancer)
 - Low intake of vitamin B12, iron, or folic acid
 - High = Response to blood loss or anemia

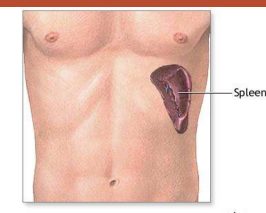
Destruction of RBCs



http://www.lifeforcehospitals.com/images/LF_images/sidecell.jpg

Destruction of RBCs

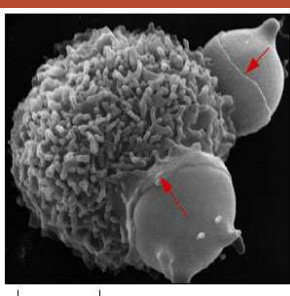
- Abuse of RBCs cause them to wear out
- Unable to repair damage that occurs
- Life span = 120 days average
- Worn out RBCs are destroyed in spleen, liver, and red bone marrow by macrophages



<http://www.clarian.org/ADAM/doc/graphics/images/en/7173.jpg>

Destruction of RBCs

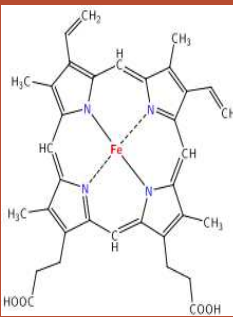
- Spleen is a series of ducts with macrophages



http://www.zoology.ubc.ca/~berger/B200/sample/unit_8_protein_processing/images_unit8/14_28.jpg

Hemoglobin

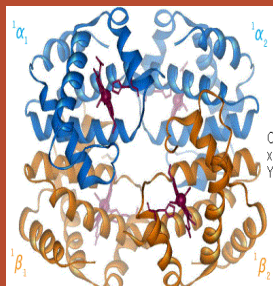
- Oxygen reversibly binds to heme group (oxyhemoglobin)
- Composed of 4 subunits each capable of binding an oxygen
- Each RBC carries 250 million Hgb molecules



<http://en.wikipedia.org/wiki/Image:Heme.svg>

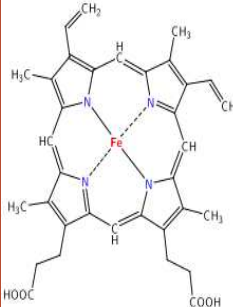
Hemoglobin Carbon Dioxide

- CO₂ binds to the globin portion (carbaminohemoglobin)
- Small amount of CO₂ binds to Hgb
- Will discuss in more detail with respiratory chapter



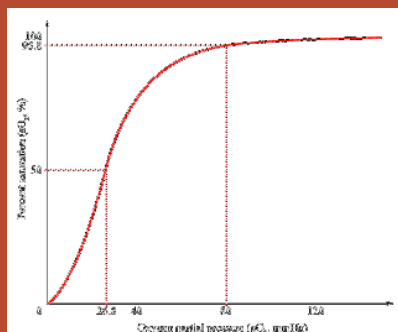
Hemoglobin

- Normal level of Hgb is 12 – 18 g / 100 ml
- The color of blood comes from the state of iron in Hgb
 - With O₂
 - Without O₂



<http://en.wikipedia.org/wiki/Image:Heme.svg>

Saturation Curve of Hgb



Recycling of Hgb

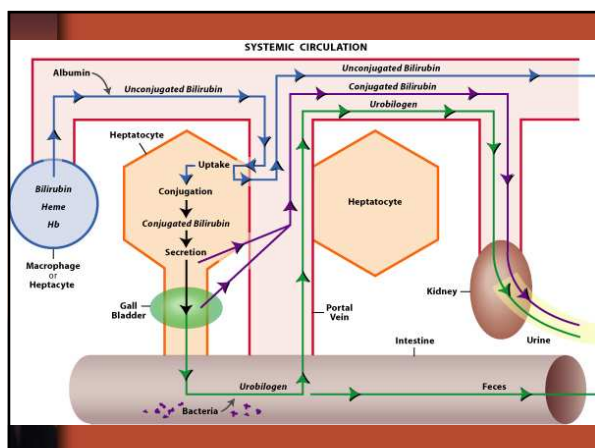
- Globin and heme are separated from each other
- Globin is broken into individual amino acids
- Heme is broken into iron and biliverdin
- Iron is taken to liver attached to transferrin (plasma protein)
- When iron is needed, it is transported to bone marrow

Recycling of Hgb

- Biliverdin (greenish pigment) is converted into bilirubin (yellowish pigment)
- Bilirubin enters blood stream and binds to albumin for transport to the liver
- In liver, bilirubin is made water soluble by conjugation with glucuronic acid
- Conjugated bilirubin is transported into bile and into small intestine

Recycling of Hgb

- In small intestine, conjugated bilirubin is converted into urobilinogen by bacteria
- Three paths for urobilinogen
 - Reabsorption back into bile
 - Renal excretion as urobilin (yellow color)
 - Oxidized in intestines into stercobilin (brown color) and excreted in feces



Pathologies of erythrocytes

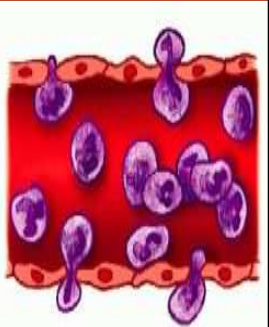
- Polycythemia – too many RBCs
- Anemia – too few RBCs
 - There are many causes of anemias

Leukocytes White blood cells

- WBC's are short lived
 - Hours
 - Days
- Nucleated cells without hemoglobin
- Two categories
 - Granulocytes
 - Agranulocytes
- General function is to combat infection and inflammation

Leukocytes White blood cells

- WBCs can leave the blood vessel by diapedesis
- Allows them to move to site of injury
- Cells at injury site release a chemical that attracts WBCs (chemotaxis)



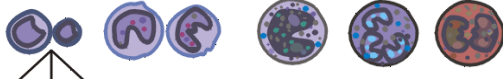
The diagram shows a cross-section of a blood vessel with red blood cells. White blood cells are shown moving from the vessel through the endothelial lining (diapedesis) towards an injury site. A chemical signal is shown attracting the white blood cells.

<http://img.tfd.com/dorland/thumbs/diapedesis.jpg>

Types of WBCs Leukocytes

white blood cells ~ WBC

agranular		granular		
lymphocytes	monocytes	basophils	neutrophils	eosinophils
20 - 25 %	3 - 8%	.5 - 1%	60 - 70%	2 - 4%

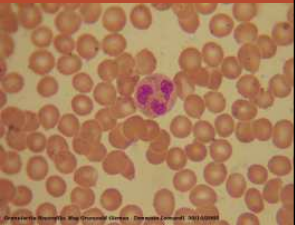


The images show various types of white blood cells: lymphocytes (T-cell, B-cell, NK Cell), monocytes, basophils, neutrophils, and eosinophils.

<http://www.lymphomation.org/images/leukocytes-normal.gif>

Neutrophils

- 54- 62% of total WBCs
- Characteristic multi-lobed nucleus
- Role is to phagocytize bacteria and destroy with lysosomes in granules
- Increased during bacterial infection

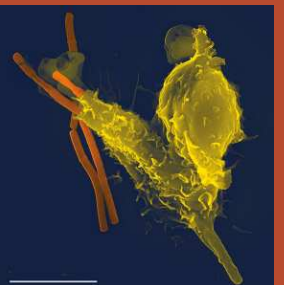


The image shows a microscopic view of neutrophils, characterized by their multi-lobed nuclei and granules.

<http://en.wikipedia.org/wiki/Image:Neutrophil.jpg>

Neutrophils

- SEM of neutrophil attacking anthrax bacteria

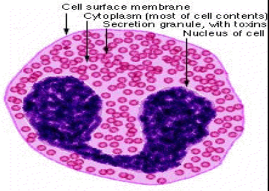


The scanning electron micrograph shows a neutrophil attacking anthrax bacteria.

http://en.wikipedia.org/wiki/Image:Neutrophil_with_anthrax_copy.jpg

Eosinophils

- 1- 3% of total WBC count
- Bi-lobed nucleus
- Primary job is to combat parasitic worms

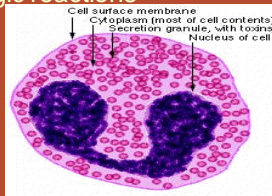


The image shows a microscopic view of eosinophils, characterized by their bi-lobed nuclei and granules. Labels include: Cell surface membrane, Cytoplasm (most of cell content), Secretion granule, with toxins, and Nucleus of cell.

http://www.users.globalnet.co.uk/~asr/Eo_0_2_GIF

Eosinophils

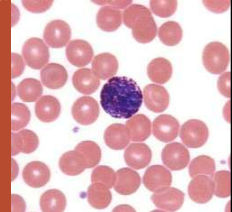
- During allergic reactions, they lessen the severity of reaction by inactivating inflammatory mediators
- They release anti-histamines
- Increase during allergic reactions



<http://www.users.globenet.co.uk/~sali/Eo.02.GF>

Basophils

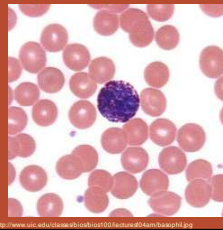
- Less than 1% of total WBC count
- Granules contain histamine and heparin
- Histamine causes vasodilation and attracts other WBCs to area



<http://www.uc.edu/~lase/bio/bio000/bio000/lecture/44m/basophil.jpg>

Basophils

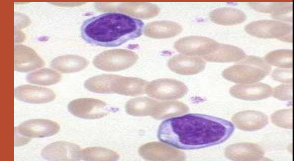
- If there in tissue, they are called MAST cells
- Involved in severe allergic reactions



<http://www.uc.edu/~lase/bio/bio000/bio000/lecture/44m/basophil.jpg>

Lymphocytes

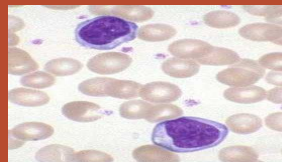
- 25- 33% of total WBC count
- Large dark nucleus, small cytoplasm
- Most are found in lymphatic system
- Responsible for immune response



http://www.aamds Glossary.co.uk/ict/2_lymphocytes.jpg

Lymphocytes

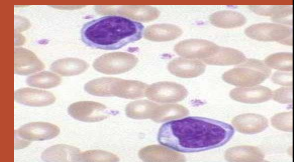
- Can differentiate into two types
 - B-Cells- made in bone marrow
 - Found in blood and produce antibodies that attack bacteria and toxins



http://www.aamds Glossary.co.uk/ict/2_lymphocytes.jpg

Lymphocytes

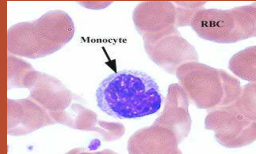
- T-cells- Made in thymus
 - T8 cells- destroy body's cells that are infected with virus and kills tumor cells
 - T4 cells- enhance immune response by releasing chemotaxis agents



http://www.aamds Glossary.co.uk/ict/2_lymphocytes.jpg

Monocytes

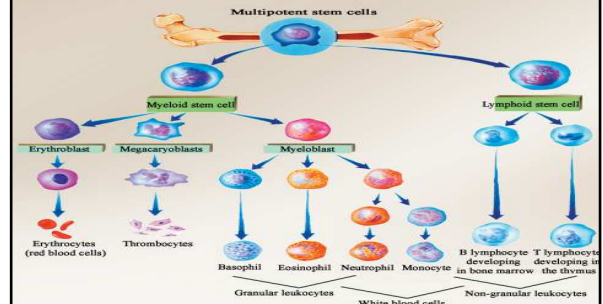
- 3- 7% of total WBC count
- Largest WBC
- Large horseshoe shaped nucleus
- Leave blood and become macrophages
- Able to phagocytize bacteria



<http://faculty.smc.edu/comibell/histo/monocyte.pg>

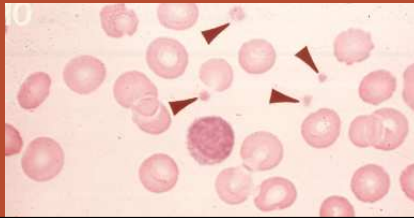
Formation of WBCs

FROM STEM CELL TO BLOOD CELL



Thrombocytes

- 150,000 – 350,000 mm³
- Fragments of cells with membrane
- Form a plug in damaged vessels
- Contain granules with clotting chemicals



<http://images.google.com/imgres?imgref>

Hemostasis

- Series of reactions to stop bleeding
- Blood Vessel Spasm
- Platelet Plug Formation
- Blood Coagulation

Blood Vessel Spasm

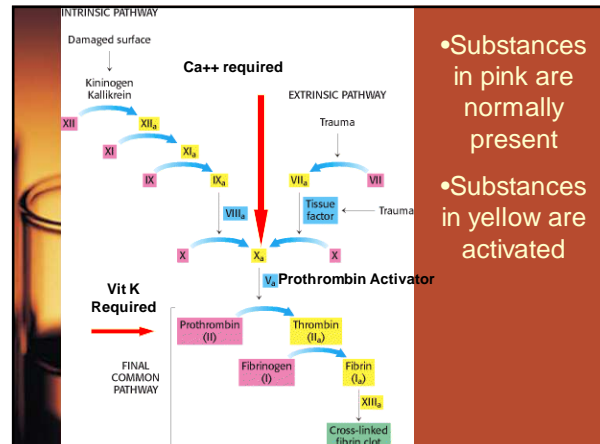
- Immediate response and continues for 30 minutes
- Triggered by pain, endothelial cell damage causes release of factor III, or platelet aggregation releases serotonin
- All cause vasospasm of nearby vessels to diminish blood loss

Platelet Plug Formation

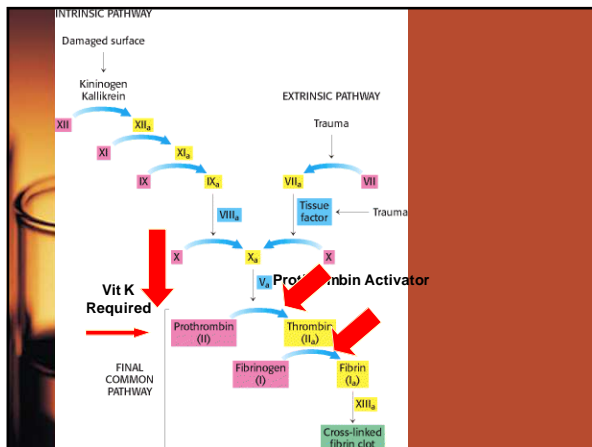
- Platelets adhere to rough surfaces
- Damaged vessels contain exposed collage fibers that attract platelets
- Attached platelets extend projections to attach to other platelets
- Further increases release of serotonin
- Release ADP; attracts more platelets
- Positive feedback loop

Blood Coagulation

- Complex cascade that involves 30 substances
- Final step is to convert circulating fibrinogen into fibrin
- Involves ionic calcium and 14 clotting factors
- Need to know the last few steps!



- Substances in pink are normally present
- Substances in yellow are activated



Blood Coagulation

- Fibrin entraps RBCs, platelets, and plasma to create a clot



<http://media-2.web.britannica.com/eb-media/28/98328-004-5514AFAC.jpg>

Blood Coagulation Clot Retraction

- Contractile proteins in platelets contract and pull the fibrin strands
- Closes the proximity of the ruptured endothelium
- Fibroblasts divide and form connective tissue patch
- Endothelial cells restore lining








Fibrinolysis

- When clot is no longer needed, it is broken down
- Plasminogen is converted into plasmin
- Plasmin breaks down fibrin strands

ABO Blood Typing

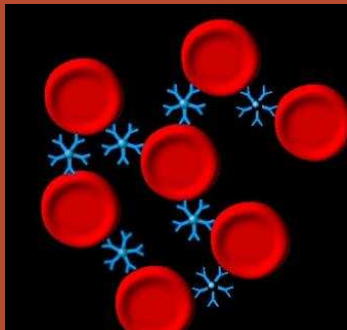
- Erythrocytes contain genetically determined surface antigens (agglutinogens/ isoantigens)
- Blood plasma contains antibodies that react with specific antigens (agglutinins)
- Blood is named according to surface antigens that are present

The ABO Blood System

Blood Type (genotype)	Type A (AA, AO)	Type B (BB, BO)	Type AB (AB)	Type O (OO)
Red Blood Cell Surface Proteins (phenotype)	 A agglutinogens only	 B agglutinogens only	 A and B agglutinogens	 No agglutinogens
Plasma Antibodies (phenotype)	 b agglutinin only	 a agglutinin only	NONE No agglutinin	 a and b agglutinin

http://faculty.weber.edu/nokazaki/Human_Biology/Chp%207-blood_files/image016.gif

What happens if wrong blood is given to a patient?



http://www.biopro.de/Imperia/nd/imaget/artikelgebunden/nd/ign_agglutineri_338x338.jpg

Rh Blood Type

- In addition to surface antigens, RBC may carry Rh (Rhesus D) antigen
- If present, Rh positive
- If not present, Rh negative
- Also causes agglutination if unmatched blood is given
- The cause of hemolytic disease of the newborn (erythroblastosis fetalis)

Erythroblastosis fetalis

- Rh negative mom gives birth to a Rh positive baby
- During pregnancy, mom develops antibodies against Rh antigen
- Subsequent pregnancy is a problem
- Can be treated with Rho(D) immunoglobulin

Hematology

- Complete Blood Count (CBC)
 - Numbers of RBCs, WBCs, and platelets
 - Amount of Hgb
 - Hct (percentage of formed elements)
 - MCV- mean corpuscular volume (average volume of RBC)
 - MCH- mean corpuscular hemoglobin (average Hgb per RBC)
 - MCHC- mean corpuscular hemoglobin concentration

Hematology

- Leukocyte Differential
 - Lists the different percentages of leukocytes

Increased WBC	Causes
Neutrophils	Bacterial Infection
Lymphocytes	Viral Infection
Monocytes	Chronic Infection
Basophils	Allergic Rxn
Eosinophils	Allergic Rxn and parasitic infections