Blood

Functions
Blood composition
Types of blood cells
Hematopoeisis/Erythropoeisis
Hemostasis
Cool links

- http://anthro.palomar.edu/blood/default.htm
- http://nobelprize.org/educational_games/medicine/landsteiner/readmore.html (blood types)
Blood: Overview

Blood is a fluid connective tissue composed of fluid (plasma) plus cells and cell fragments (formed elements).

We have about 5-6 Liters of blood.

- Men have a little more than women and kids a little less than adults.
- About 8% of body weight.
- 5x Thicker than water
- Slightly alkaline (pH 7.4)
Blood: Functions

1. Transport (nutrients, wastes, immune cells, gases - oxygen and carbon dioxide, hormones and more)
2. Regulation
   - pH (keeps interstitial fluid = 7.35)
   - Temperature
   - Ion composition/fluid balance
3. Protection
   - White blood cells fight infection
   - Prevents blood loss at injury sites (clotting proteins)
Transport

- Oxygen from lungs to tissues
- Metabolic waste from tissues to
  - Lungs (carbon dioxide exhaled)
  - Liver (lactic acid converted to glucose)
  - Kidneys (excretion of waste)
- Digested nutrients from intestine to liver to tissues
- Hormones: from endocrine glands to targets
Regulation

• Temperature: Absorb and distribute heat by variable skin blood flow
• pH: blood proteins regulate acid/base balance

\[
\begin{align*}
H^+ (aq) + HCO_3^- (aq) & \leftrightarrow H_2CO_3(aq) & \leftrightarrow H_2O (l) + CO_2(g)
\end{align*}
\]

• Fluid Volume: ions and blood proteins regulate capillary fluid dynamics (how much fluid leaves/enters capillary)
Protection

• Clot formation
  – Platelets (thrombocytes) and blood proteins initiate clot formation to prevent blood loss

• Prevent bacterial, viral and other infections
  – Antibodies
  – Complement proteins
  – White blood cells
Blood Composition

Blood is collected from superficial vein (easy to locate, thinner walled than artery, blood pressure is low so puncture wound seals easily).

Centrifuge separates blood into 3 layers

1. Plasma (55% of whole blood)
2. Buffy coat: leukocytes and platelets (<1% of whole blood)
3. Erythrocytes (44% of whole blood)

2. Place the tube into a centrifuge and spin for about 10 minutes.
3. Components of blood separate during centrifugation to reveal plasma, buffy coat, and erythrocytes.
Blood Analysis

**CBC:** Complete blood count (count of formed elements.)

**Blood Chemistry:** general function of body

**Cholesterol:** LDL/HDL predict atherosclerosis

**Blood typing:** ABO and Rh factor for transfusion and pregnancy
Diagnostic Blood Tests

**Type and Crossmatch**: determination of ABO and Rh blood types.
Red cells tested against antibodies

**Complete Blood Count**
- **Red Blood Count**: number of RBCs/ microliter of blood
- **Hemoglobin Measurement**: grams of hemoglobin/100 mL of blood. For a male, 14-18, female 12-16 g/100 mL
- **Hematocrit Measurement**: percent of blood that is RBCs
- **White Blood Cell Count**: 5,000-10,000 /microliter of blood

**Differential White Blood Count**: determines percentage of each of the five types of WBC
- Neutrophils: 60-70%
- Lymphocytes: 20-30%
- Monocytes: 2-8%
- Eosinophils: 1-4%
- Basophils: 0.5-1%

**Clotting**
- **Platelet Count**: 250,000- 400,000/microliter
- **Prothrombin Time Measurement**: measures how long it takes for blood to start clotting. 9-12 seconds. To test, thromboplastin is added to whole plasma

**Blood Chemistry**: composition of materials dissolved or suspended in the plasma. Used to assess functioning of many body systems
Composition of Blood

Sample of whole blood consists of:

- Plasma (46–63%)
- Formed elements (37–54%)
Composition of Blood

PLASMA
Water - 92%
Ions - 1%
Proteins - 7%
  • Albumins - 60%
  • Globulins - 35%
  • Fibrinogen: clot formation

CELLS
Red Blood Cells = 99.9%
White blood cells - .1%
Platelets - cell fragments
(b) Components of plasma

**PLASMA COMPOSITION**

- Plasma proteins: 7%
- Other solutes: 1%

**OTHER SOLUTES**

- Electrolytes: Normal extracellular fluid ion composition essential for vital cellular activities. Examples: Na⁺, K⁺, Ca²⁺, Cl⁻, HCO₃⁻
- Organic nutrients: Used for ATP production, growth, and maintenance of cells. Examples: Fatty acids, glucose, amino acids
- Organic wastes: Carried to sites of breakdown or excretion. Examples: Urea, bilirubin

**PLASMA PROTEINS**

- Albumins (60%): Major contributors to osmotic pressure of plasma; transport lipids, steroid hormones
- Globulins (35%): Transport ions, hormones, lipids; immune function
- Fibrinogen (4%): Essential component of clotting system; can be converted to insoluble fibrin
- Regulatory proteins (<1%): Enzymes, proenzymes, hormones

Sample of whole blood consists of

Plasma (55%)
**CELLS**

Red Blood Cells (erythrocytes) = 99.9 %

White blood cells (leukocytes) = .1%

Platelets (cell fragments)

WBC: Never Let Monkeys Eat Bananas

Hematocrit = % RBC in whole blood.
Question to check understanding

Albumin, globulins, and fibrinogen are examples of
A. formed elements.
B. platelets.
C. plasma proteins.
D. granulocytes.
E. agranulocytes.
Question to check understanding

Albumin, globulins, and fibrinogen are examples of
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B. platelets.
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E. agranulocytes.

Answer: C. plasma proteins.
Hematopoiesis: Blood cell production

Precursor cell for all blood cells is hemocytoblast.

In fetus, blood cell formation occurs in many tissues: spleen, thymus, lymph nodes, red bone marrow.

After birth - mainly in red marrow.

Type and number of different blood cells is determined by growth factors (chemicals).
The bone marrow, hidden within the bones of the skeleton, is easily overlooked as a tissue, although collectively, it is nearly the size and weight of the liver!
Bone marrow consists of blood cells in different stages of development and supporting tissue known as the **stroma** (mattress).

Mature blood cells squeeze through the endothelium to reach the circulation.

Fragments of megakaryocyte break off to become platelets.

The stroma is composed of fibroblast-like reticular cells, collagenous fibers, and extracellular matrix.
Red Bone Marrow:

- trabecular bone
- granulocytes
- megakaryocyte
- erythroid island
Red Blood Cells

- Respiratory gas transporter: Transport oxygen from lungs to tissue and carbon dioxide from tissue to lungs.
- Most abundant cell type in blood
- Travel round-trip to heart in 1 minute
- Live for about 120 days
- Biconcave shape increases surface area for gas exchange and promotes easy passage through small capillaries
**RBC Development**

**Erythropoiesis**: 3 phases, takes 3-5 days

1. Immature RBC prepares to synthesize Hb by producing large numbers of ribosomes = proerythroblast (cells may continue to divide)

2. Hb is synthesized and accumulates in the cytoplasm = early erythroblast (cells may continue to divide) near end = late erythroblast, end = normoblast w/34% Hb in cytoplasm

3. RBC ejects nucleus and most of its organelles, causes cell to collapse inward - producing cell shape = reticulocyte - young RBC’s, still have clumped rough ER. Reticulocytes released into bloodstream where they finish maturing into RBC’s within 2-3 days
Hemoglobin reversibly binds oxygen and carbon dioxide
4 Heme molecules with each containing Fe (iron).
Fe required for oxygen transport (needs vitamin C and acid for intestinal absorption, lost in urine, menses, feces). 2/3 of body Fe inside RBC's.
Each RBC has 280 million hemoglobin which can bind billions of oxygen (4/hb)
Transport $CO_2$

$\text{H}_2\text{O} + CO_2 \iff H_2CO_3 \iff HCO_3^- + H^+$

- 23% of is transported bound to hemoglobin – not the Fe but an amino group of Hb
- 70% transported as bicarbonate ions ($HCO_3^-$) carbonic anhydrase
- 7% dissolved in plasma
- Increases $CO_2$ transport to the lungs
Erythropoiesis

Depends upon age, sex, altitude

Production is controlled by the hormone erythropoietin made by the kidney. There is a basal rate of Epo secretion/RBC production that is increased in response to low oxygen in the blood.

Factors that stimulate RBC formation include:
- Hemorrhage
- less O2 available (high altitude to pneumonia)
- increased tissue demands (aerobic exercise)
- Testosterone also aids in production so men have more RBC's

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Recycling: Summary movie

Globin: aa used for protein synthesis
Heme: converted to bilirubin>
> released in bile for excretion AND to kidney for elimination via urine
Iron: returns to red marrow for use in Hb synthesis

**HEME degraded to bilirubin: poop/urine color**
Blood doping involves using a transfusion of either the athlete's own blood or, more commonly, someone else's, to temporarily increase the quantity of red blood cells in the body and therefore the oxygen-carrying capacity of the blood. It's a startlingly crude but extremely effective performance-enhancer. Unfortunately, it's also beset with serious health risks.

Tyler Hamilton, pictured in the 2004 Olympic time trial, is the first rider to be accused of blood doping under the new test.

http://www.faqis.org/sports-science/Ba-Ca/Blood-Doping.html

www.cyclingnews.com/.../2004/sep04/sep23news2
Training Techniques: High Altitude

![Graph showing the percentage of red blood cells over days at Pikes Peak. The Y-axis indicates Male % and Female %, with data points showing an increase in both over time.](image)

![Graph showing relative viscosity vs. hematocrit. The viscosity of blood increases with hematocrit, while plasma remains relatively constant.](image)
RBC's Disease

Jaundice: Problems with Hb recycling - increased bilirubin in blood

RBC in urine

Anemia = lacking blood (not enough O2 in the blood)

1. Insufficient RBC's:
   - **Hemorrhagic**: blood loss (stab wound, bleeding ulcer of hemorrhoids)
   - **Hemolytic**: RBC plasma membrane ruptures (genetic, viruses, bacteria, mismatched transfusion)
   - **Aplastic**: disease that destroys red bone marrow (toxins, drugs, radiation), also affects other BC's production

2. Decrease in Hb count:
   - **Iron deficiency** (http://ods.od.nih.gov/factsheets/iron.asp)
   - **Pernicious Anemia**: insufficient hemopoiesis due to lack of vitamin B12

4. Abnormal Hb: usually genetic
   - **Sickle Cell Anemia** - RBC shape changes, cells more fragile though some advantages: better chance of surviving malaria because lose K+ that parasite needs to survive
Two copies of the sickle-cell allele

All hemoglobin is the sickle-cell (abnormal) variety

Abnormal hemoglobin crystallizes when oxygen content of blood is low, causing red blood cells to become sickle-shaped

Normal cells

Sickled cells

Breakdown of red blood cells

Clumping of cells and clogging of small blood vessels

Accumulation of sickled cells in spleen

Physical weakness

Anemia

Heart failure

Pain and fever

Brain damage

Damage to other organs

Spleen damage

Impaired mental function

Paralysis

Pneumonia and other infections

Rheumatism

Kidney failure

Symptoms of Anemia:

Central
- Fatigue
- Dizziness
- Fainting

Blood vessels
- Low blood pressure

Heart
- Palpitations
- Rapid heart rate
- Chest pain
- Angina
- Heart attack

Spleen
- Enlargement

Respiratory
- Shortness of breath

Muscular
- Weakness

Intestinal
- Changed stool color

Skin
- Paleness
- Coldness
- Yellowing

Eyes
- Yellowing

Red = In severe anemia
Never let monkeys eat bananas
Never = neutrophils
Let = leukocytes
Monkeys = monocytes
Eat = eosinophils
Bananas = basophils

http://www.wisc-online.com/objects/index_tj.asp?objID=AP14704
White Blood Cells = Leukocytes

WBC:
1. about 1% of blood
2. have 2 main functions:
   • Protect body against microorganisms
   • Remove dead cells and debris by phagocytosis
3. Use the blood stream to “travel” to tissues where they leave blood and crawl around:
   • Diapedesis
   • Ameboid movement
   • chemotaxis
5. Structure: Large cells with nuclei
   • Granular: Lobed nuclei (neutrophils, eosinophils, basophils)
   • Agranular: No cytoplasmic granules: (lymphocytes, monocytes)
6. Life Span: up to years but many just a few days, many die combating invading microorganisms
7. Production controlled by hormones
8. Development: Hemocytoblasts into either myeloid or lymphoid stem cells
   myeloid make all WBC's except lymphocytes, become committed, develop distinctive granules
9. Stored in bone marrow (10 - 20 times more WBC's than in blood)
WBC

Structure:

**Granular:** (Lobed nuclei) neutrophils, eosinophils, basophils

**Agranular:** (No cytoplasmic granules) lymphocytes, monocytes
Blood Components

Platelets (Thrombocytes)
Structure:
• cytoplasmic granules from megakaryocytes
• no nucleus (but smooth ER and mitochondria)
• make chemicals that are important for clot formation
Life Span: 5-9 days
**WBC's (NEUTROPHILS)**

Neutrophils:
- Most numerous of WBC (50-70%)
- Stain with both acidic and basic dyes
- Nuclei are lobed
- Active in phagocytosis
- Live for a short time (6 hours)
- Dead neutrophils are components of pus (infection sites)
WBC'S (LEUKOCYTES)

BASOPHILS: 0.5% of WBC'S

• Function: secrete heparin to prevent clot formation, and histamines

• histamine is inflammatory chemical that vasodilates

• attract other WBC's to site of inflammation

• mast cells are tissue basophils found in CT
WBC'S (LEUKOCYTES)

**EOSINOPHILS**: 2-4% of WBC's

**Function**: Allergies, parasitic worms

- granules w/lysosomes and digestive enzymes (enzymes for bacteria)
- attack parasitic worms - release enzymes onto the worms
- lessen allergies by phagocytizing immune (Ab/antigen) complexes
- inactivate certain inflammatory chemicals
WBC'S (LEUKOCYTES)

**MONOCYTES**: 3-8% of WBC's
**Function**: phagocytosis
In tissues differentiates into macrophage.
Large numbers are found with chronic infections e.g. Tuberculosis
Lymphocytes: 30% of WBC's

Function: immune responses and memory, mainly found in lymph tissue

T cells - immune response to cells infected with virus and tumor cells

B cells - give rise to plasma cells which produce antibodies (more later)
Can you match these?

A. Produces antibodies and other chemicals responsible for destroying microorganisms
B. Releases histamine, which promotes inflammation and heparin, which prevents clot formation
C. Forms platelet plugs; releases chemicals necessary for blood clotting
D. Phagocytizes microorganisms and other substances
E. Transports $O_2$ and $CO_2$
F. Releases chemicals that reduce inflammation; attacks certain worm parasites
G. Phagocytic cell in the blood that leaves the blood and becomes a macrophage
<table>
<thead>
<tr>
<th>Cell Type</th>
<th>Illustration</th>
<th>Description</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red blood cell</td>
<td><img src="image1.png" alt="Image" /></td>
<td>Biconcave disk; no nucleus; contains hemoglobin, which colors the cell red; 7.5 μm in diameter</td>
<td>Transports oxygen and carbon dioxide</td>
</tr>
<tr>
<td>White blood cells</td>
<td><img src="image2.png" alt="Image" /></td>
<td>Spherical cells with a nucleus; white in color because they lack hemoglobin</td>
<td>Five types of white blood cells, each with specific functions</td>
</tr>
<tr>
<td>Granulocytes</td>
<td><img src="image3.png" alt="Image" /></td>
<td>Nucleus with two to four lobes connected by thin filaments; cytoplasmic granules stain a light pink or reddish purple; 10–12 μm in diameter</td>
<td>Phagocytizes microorganisms and other substances</td>
</tr>
<tr>
<td>Neutrophil</td>
<td><img src="image4.png" alt="Image" /></td>
<td>Nucleus with two indistinct lobes; cytoplasmic granules stain blue-purple; 10–12 μm in diameter</td>
<td>Releases histamine, which promotes inflammation, and heparin, which prevents clot formation</td>
</tr>
<tr>
<td>Basophil</td>
<td><img src="image5.png" alt="Image" /></td>
<td>Nucleus often bilobed; cytoplasmic granules stain orange-red or bright red; 11–14 μm in diameter</td>
<td>Releases chemicals that reduce inflammation; attacks certain worm parasites</td>
</tr>
<tr>
<td>Eosinophil</td>
<td><img src="image6.png" alt="Image" /></td>
<td>Round nucleus; cytoplasm forms a thin ring around the nucleus; 6–14 μm in diameter</td>
<td></td>
</tr>
<tr>
<td>Agranulocytes</td>
<td><img src="image7.png" alt="Image" /></td>
<td>Nucleus round, kidney-shaped, or horseshoe-shaped; contains more cytoplasm than does lymphocyte; 12–20 μm in diameter</td>
<td>Produces antibodies and other chemicals responsible for destroying microorganisms; contributes to allergic reactions, graft rejection, tumor control, and regulation of the immune system</td>
</tr>
<tr>
<td>Lymphocyte</td>
<td><img src="image8.png" alt="Image" /></td>
<td></td>
<td>Phagocytic cell in the blood; leaves the blood and becomes a macrophage, which phagocytizes bacteria, dead cells, cell fragments, and other debris within tissues</td>
</tr>
<tr>
<td>Monocyte</td>
<td><img src="image9.png" alt="Image" /></td>
<td>Cell fragment surrounded by a plasma membrane and containing granules; 2–4 μm in diameter</td>
<td>Forms platelet plugs; releases chemicals necessary for blood clotting</td>
</tr>
<tr>
<td>Platelet</td>
<td><img src="image10.png" alt="Image" /></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Can you identify these blood cells?
Can you identify these cells?
Question to check understanding

___________ are phagocytic, have a trilobed nucleus, and make up the largest percentage of leukocytes.

A. Basophils
B. Eosinophils
C. Lymphocytes
D. Monocytes
E. Neutrophils
Question to check understanding

___________ are phagocytic, have a trilobed nucleus, and make up the largest percentage of leukocytes.

A. Basophils
B. Eosinophils
C. Lymphocytes
D. Monocytes
E. Neutrophils
Question to check understanding

Erythrocytes
A. are biconcave disks.
B. transport less than half of the oxygen in the blood.
C. transport most of the carbon dioxide in the blood.
D. can rupture and release hemoglobin in a process called erythrophoiesis.
E. are the least numerous formed elements.
Question to check understanding

Erythrocytes

A. are biconcave disks.
B. transport less than half of the oxygen in the blood.
C. transport most of the carbon dioxide in the blood.
D. can rupture and release hemoglobin in a process called erythropoiesis.
E. are the least numerous formed elements.
Question to check understanding

Each hemoglobin molecule has
__________ heme group(s) and
__________ globin molecule(s).

A. 1,2
B. 1,4
C. 2,4
D. 4,2
E. 4,4
Question to check understanding

Each hemoglobin molecule has

_____________ heme group(s) and

_____________ globin molecule(s).

A. 1,2
B. 1,4
C. 2,4
D. 4,2
E. 4,4
Hematopoiesis Summary Movie

• What is the name of the undifferentiated cells that begin hemopoiesis?
• Which cell line forms erythrocytes, platelets, and leukocytes (but not lymphocytes)?
• What is produced by erythropoiesis?
• What is produced by thrombopoiesis?
• What happens to the megakaryocyte to form platelets?
• Which cell line produces granulocytes (eosinophils, basophils, and neutrophils) and monocytes?
• Which cell line produces lymphocytes?
Hematopoiesis animation

- What is the name of the undifferentiated cells that begin hemopoeisis? **hemocytoblasts**
- Which cell line forms erythrocytes, platelets, and leukocytes (but not lymphocytes)? **myeloid**
- What is produced by erythropoiesis? **Red blood cells**
- What is produced by thrombopoiesis? **platelets**
- What happens to the megakaryocyte to form platelets? **It fractures into pieces**
- Which cell line produces granulocytes (eosinophils, basophils, and neutrophils) and monocytes? **Myeloid**
- Which cell line produces lymphocytes? **Lymphoid**
Hemostasis = stopping bleeding

3 strategies:
- 1. Vascular spasm
- 2. Platelet plug formation
- 3. Coagulation

(a) Vascular spasm
(b) Platelet plug formation
(c) Coagulation

FIGURE 18.21 Hemostasis. (a) Vasoconstriction of a broken vessel reduces bleeding. (b) A platelet plug forms as platelets adhere to exposed collagen fibers of the vessel wall. The platelet plug temporarily seals the break. (c) A blood clot forms as platelets become enmeshed in fibrin threads. This forms a longer-lasting seal and gives the vessel a chance to repair itself.

How does a blood clot differ from a platelet plug?
Preventing Blood Loss

Vasospasm: Contraction of smooth muscle in blood vessel wall

- Endothelial cells contract & expose basal lamina to bloodstream
- Endothelial cells begin to release chemical factors & hormones
- Endothelial plasma membranes become “sticky”

Platelet plug formation

- Adhesion of platelets near exposed collagen
- Platelet release reaction (ADP and thromboxanes that stimulate more platelets)
- More platelets adhere (+ feedback)
- Form fibrinogen bridges to bind more platelets
Hemostasis strategy

1. Platelet adhesion occurs when von Willebrand factor connects collagen and platelets.

2. The platelet release reaction results in the release of ADP, thromboxanes, and other chemicals that activate other platelets.

3. Platelet aggregation occurs when fibrinogen receptors on activated platelets bind to fibrinogen, connecting the platelets to one another. A platelet plug is formed by the accumulating mass of platelets.
Coagulation

Goal: to convert fibrinogen into sticky fibrin to close a big gap in endothelium via a series of enzymatic reactions called a cascade.

- Many clotting factors made in the liver
- Enzymes require cofactors (Calcium and vitamin K made by bacteria in gut make about 50%)

Activation of clot formation:

- Extrinsic: clotting factors are released directly by damaged blood vessel and tissue
- Intrinsic: inactive clotting factors within the blood are activated in response to contact with CT (damaged tissue)

Clotting:

1. Activation leads to formation of prothrombin activator
2. Prothrombin converted to thrombin
3. Fibrinogen converted to fibrin
Blood Clotting

1. Stage 1. Inactive clotting factors are activated by exposure to connective tissue or by chemicals released from tissues.

2. Stage 1. Through a series of reactions, the activated clotting factors form prothrombinase.

3. Stage 2. Prothrombin is converted to thrombin by prothrombinase.

4. Stage 3. Fibrinogen is converted to fibrin (the clot) by thrombin.
Extrinsic Mechanism

Intrinsic Mechanism

Thromboplastin

Common Pathway

FYI: DETAILS

Factor 8 mutations are the most common that lead to hemophilia
FYI: COMMON PATHWAY: prothrombin $\rightarrow$ thrombin $\rightarrow$ Fibrin
Control of Clot Formation

• Nutrition is important!
  – Calcium is needed for all three pathways
  – Vitamin K is needed for four clotting factors, so problems can occur if insufficient fat or problems with bacteria in large intestine

• Anticoagulants: prevent factors from initiating clot formation
  – Heparin made by basophils inactivates thrombin
  – Antithrombin made by liver inactivates thrombin
  – Prostacyclin: prostaglandin derivative from endothelial cell inhibits release of coagulating factors from platelets

Drugs: Warfarin (aka Coumadin) suppresses liver production of vitamin K dependent clotting factors
Extrinsic Clotting Pathway

Begins with chemicals outside of blood

Stage 1
- Damaged tissues release tissue factor (TF; factor III)
- When Ca\(^{2+}\) is present, forms complex with factor VII, activating factor X
- Prothrombinase is formed

Stage 2: prothrombinase converts prothrombin into thrombin

Stage 3
- Thrombin converts fibrinogen to fibrin
- Thrombin activates factor XIII, which stabilizes clot
Intrinsic Clotting Pathway

Begins with chemicals that are part of the blood

Stage 1

In damaged blood vessels, factor XII comes in contact with exposed collagen, activating factor XII

Stimulates factor XI, activates factor IX. PF-3 (platelet factor 3) is also involved.

Activated factor IX joins with factor VIII, platelet phospholipids and Ca\(^{2+}\) to activate factor X

Prothrombinase is formed

Stages 2 and 3 progress to clot formation
Fibrinolysis:

Clot retraction: Clot pulls vessel walls together, platelets use actin and myosin extensions to grab to fibrin

Fibrin is digested by plasmin
ABO Blood Groups

http://nobelprize.org/educational_games/medicine/landstein
er/readmore.html
Agglutination Reaction

(a) Type A blood of donor + Anti-B antibody in type A blood of recipient → No agglutination

(b) Type A blood of donor + Anti-A antibody in type B blood of recipient → Agglutination
Blood type A

Blood from type B = Anti-A antibody

Blood type A

Anti-B antibody

agglutinate
B-Type

Overall in the world, B is the rarest of the blood types; only about 16% of the world have it.
A-Type:
A is somewhat more common; about 21% of the world have the A allele; highest frequency is among the Blackfoot Indians of Montana, the Aborigines, & the Lapps

Seems to be linked with higher risk of smallpox, cancer of the esophagus/pancreas/stomach
O is very common; ~63% people have O. particularly high in Central and South America; lowest frequency is found in Easter Europe and Central Asia (where B is common)
Higher risk of cholera/plague; Dueodenal ulcers; more tasty to mosquitoes???
In the Modern US

<table>
<thead>
<tr>
<th>ABO Type</th>
<th>Rh Type</th>
<th>How Many Have It</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>positive</td>
<td>38%</td>
</tr>
<tr>
<td>O</td>
<td>negative</td>
<td>7%</td>
</tr>
<tr>
<td>A</td>
<td>positive</td>
<td>34%</td>
</tr>
<tr>
<td>A</td>
<td>negative</td>
<td>6%</td>
</tr>
<tr>
<td>B</td>
<td>positive</td>
<td>9%</td>
</tr>
<tr>
<td>B</td>
<td>negative</td>
<td>2%</td>
</tr>
<tr>
<td>AB</td>
<td>positive</td>
<td>3%</td>
</tr>
<tr>
<td>AB</td>
<td>negative</td>
<td>1%</td>
</tr>
</tbody>
</table>
Erythroblastosis Fetalis

Rh+ antigen on RBC
Rh- no antigen on RBC
<table>
<thead>
<tr>
<th>Rh Blood Types</th>
<th>Antigen D</th>
<th>No antigen D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RBCs</strong></td>
<td>Rh positive</td>
<td>Rh negative</td>
</tr>
<tr>
<td><strong>Plasma</strong></td>
<td>No anti-D antibodies</td>
<td>Anti-D antibodies (after prior exposure)</td>
</tr>
</tbody>
</table>
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**Type and Crossmatch**: determination of ABO and Rh blood types. Red cells tested against antibodies.

**Complete Blood Count**

- **Red Blood Count**: number of RBCs/ microliter of blood
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- Monocytes: 2-8%
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- Basophils: 0.5-1%

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