Discuss the composition of blood including the functions of the various components.

Explain the anatomy and functions of the red blood cells, including a description of blood typing.

Discuss the types of white blood cells found in the blood and give the functions of each.

Give a brief accounting of platelets.

Review hemopoiesis, including RBC and leukocyte formation.

Developed by John Gallagher, MS, DVM.
Functions of Blood

- Distribution/transport - nutrients, wastes, gases, etc.
- Communication, i.e., hormones
- Prevention of fluid loss – hemostasis, osmosis
- Maintenance of pH
- Disease/ infection fighting
- Heating/Cooling
Classification of Connective Tissue (Review: Chapt 4)
Blood = connective tissue

Extracellular fluid matrix:
- Plasma

Cells: (= Formed elements)
- RBCs
- WBCs
- Platelets

Hematocrit (centrifuge)
Plasma Composition

- Water ~92%
- Plasma proteins ~7%
- Other solutes ~1%

Transports organic and inorganic molecules, formed elements, and heat

Lavender Top Tube
Plasma Proteins (90% from liver)

- **Albumin (60%)** Major contributor to osmotic concentration of plasma. Transport of lipids and steroid hormones

- **Globulins (35%)** Transport ions, hormones, lipids; immune function

- **Fibrinogen (4%)** Essential component of clotting system (conversion to insoluble fibrin) **NOT IN SERUM**
  - Anticoagulants (blood thinner), e.g. coumadin

- **Regulatory proteins (< 1%)** Protein-based hormones

- **Lipoproteins** = particles containing lipids (cholesterol & triglycerides) and proteins (albumins & globulins)
Plasma Solutes

- **Electrolytes**: Normal extracellular fluid ion composition
- Organic nutrients: glucose, FA, AA
- Organic wastes: urea, bilirubin
- Dissolved gases
- Nonprotein-based hormones
  - E.g., steroids
Plasma vs. Interstitial Fluid:

Plasma has more:

- Dissolved $O_2$ $O_2$ diffuses out into tissue
- Dissolved proteins (too big to cross caps.)
  - Albumins
  - Globulins
    - $\gamma$ globulins
    - $\alpha$ and $\beta$ globulins
  - Fibrinogen

Similar concentration: Salts & small molecules
Plasma vs. Serum:

Difference between plasma and serum?

serum = plasma – clotting factors
Formed Elements (Cells)

1. Red Blood Cells (> 99%)
2. White Blood Cells
3. Platelets

PCV = Hematocrit = % of the blood sample that is Formed Elements

Man: 46%
Woman: 42%
FORMED ELEMENTS

<table>
<thead>
<tr>
<th>Element</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platelets</td>
<td>0.1%</td>
</tr>
<tr>
<td>White blood cells</td>
<td>99.9%</td>
</tr>
<tr>
<td>Red blood cells</td>
<td></td>
</tr>
</tbody>
</table>

Why white blood cells???
1. **RBCs = Erythrocytes**

Measured by hematocrit (PCV)

Most **abundant** blood cell: 1000 RBCs/1 WBC

Contain **hemoglobin** (Hb), carry oxygen

No organelles, just Hb

Lifespan ~ 120 days replacement rate ~ $3 \times 10^6$ RBCs / sec
RBC Shape

**Biconcave Disc**, $7 \mu$ (good measuring device)

1) Larger surface area
2) Flexible
Structure of Hemoglobin (Hb)

Fe ion in heme group reversibly binds $O_2$

How many oxygen molecules can 1 Hb molecule carry? Four!
Clinical Brief

Anemia:
Reduced oxygen carrying ability of blood. Causes??

Polycythemia:
Erythrocytosis: excessive increase in RBCs
Polycythemia vera:

Blood Doping:
Via direct transfusion, or
EPO use
2. WBCs = Leukocytes

- Quantity and type determined by differential WBC count
- Circulating WBCs are only a small fraction of total WBCs. Most are located in interstitial tissues
  - Diapedesis
  - Chemotaxis
- Five different kinds:
  - Three Granulocytes
  - Two Agranulocytes

Granulocytes and Agranulocytes
WBCs = Leukocytes

- Neutrophil
- Eosinophil
- Basophil
- Lymphocyte
- Monocyte
Neutrophil (= PMN)

PMN = polymorphonuclear leukocyte = poly = seg

- ~ 60-70% (~ 2/3) of circulating WBCs
- Cytoplasm packed with pale granules containing lysosomal enzymes
- Phagocytic
Eosinophil

- ~ 2% - 4% of circulating WBCs
- Granules stain with acidic dyes (eosin), look reddish
- Increased in allergies and parasitic infections
Basophil

- < 1% of circulating WBCs
- Granules stain with basic dyes (hematoxylin) and contain histamine
- Discharge of histamine promotes inflammation at site of injury
Lymphocyte (chap 21)

- ~ 20% - 30% of circulating WBCs
- Relatively small (slightly larger than RBCs, smaller than PMNs)
- Large round nucleus, not much cytoplasm
- Mostly found in tissues
- Types
  - B lymphs become plasma cells
  - T lymphs attack directly
  - NK recognize “lack of self.”
Monocyte

- ~ 2% - 8% of circulating WBCs
- Large kidney (or U) shaped nucleus
- In tissue, called **Macrophage**
3. Platelets = Thrombocytes

Cell fragments of megakaryocytes of bone marrow
(~ 4,000 thrombocytes per megakaryocyte)

Lifespan ~ 12 days

Clotting mechanism
3. Platelets = Thrombocytes
Clotting Mechanism
Abnormal White Blood Cell Counts

Leukopenia < 2,500/µL (normal 6000 – 9000)
Leukocytosis > 30,000/µL

Thrombocytopenia: < 80,000/µL (normal ~ 350,000)
Thrombocytosis: > 1,000,000/µL

Also
Lymphopenia vs. lymphocytosis
Neutropenia vs. Neutrophilia
Leukemia
Hemopoiesis

= Blood Cell Formation (Red marrow)

Hemocytoblasts: Stem cell for all blood cells

... then differentiation into 4 types of progenitor stem cells:

- Erythroblast
- Myeloblast
- Monoblast
- Lymphoblast
Hemopoiesis

Pluripotent Stem Cell
-blast Cells