Blood = Fluid connective tissue

- Formed elements in plasma.
Blood – Physical Characteristics

- Color
- Viscosity
- Volume
- Temperature
Blood pH

- pH = \log \left( \frac{1}{[H^+]} \right)
- 7
- >7
- <7
Blood - Functions

- Transportation
- Regulation
- Protection
John has been feeling so tired.

He feels like his muscles lack energy.

What’s the basic cellular form of energy?

He decides to go see the doctor.

What do you need to make it?
1. Withdraw blood into a syringe and place it into a glass centrifuge tube.

2. Place the tube into a centrifuge and spin for about 10 minutes.
Plasma (liquid)

Buffy Coat (WBCs + Platelets)

RBCs

Which of these is problematic for John?
What's great about this?

90%

What's dissolved in here??

What's great about this?

90%
Plasma Proteins: Albumin

- Most abundant.
- Maintains plasma osmotic pressure
- Transports
2 solutions separated by a semi-permeable barrier.

Water can pass thru the barrier, but red particles cannot.

- *Which direction will water flow?*

- *Which side (A or B) has the higher osmotic pressure?*
Osmotic Pressure vs Hydrostatic Pressure

Arteriolar End → CAPILLARY → Venular End

Filtration: Arterial end net filtration pressure = +10 mm Hg
No net movement: Mid capillary net filtration pressure = 0 mm Hg
Reabsorption: Venous end net filtration pressure = -7 mm Hg
Kwashiorkor

What’s wrong with their blood plasma?

Blood osmotic pressure is _________ Interstitial Fluid osmotic pressure.

Why?
Plasma Proteins: Globulins

• Transport (α and β)
  – Metal ions
  – Lipids
  – Fat-soluble vitamins.

• Antibodies (γ)
  – Made by plasma cells during the immune response.
Buffers

- Resist changes in...

- *Why are they necessary?*

- *Albumin & Bicarbonate (HCO$_3^-$)*

10mL of HCl were added to A and its pH dropped by 4 units.
10mL of HCl were added to B and its pH dropped by 1 unit.

*Which solution is the better buffer?*
Erythrocytes
What are these cells lacking?

What’s the advantage?

Would you hire this guy to move your heroin supply?
Hemoglobin

- 2 alpha chains/2 beta chains
- 4 heme groups
- 4 irons

- Oxyhemoglobin
- Deoxyhemoglobin
- Carbaminohemoglobin
Hemopoiesis = Blood Cell Production

Multipotent hematopoietic stem cell (Hemocytoblast)

Common myeloid progenitor
- Erythrocyte
- Mast cell
- Myeloblast
- Megakaryocyte
- Thrombocytes
- Basophil
- Neutrophil
- Eosinophil
- Monocyte
- Plasma cell
- Macrophage

Common lymphoid progenitor
- Small lymphocyte
- B lymphocyte
- T lymphocyte
- Natural killer cell (Large granular lymphocyte)
Suppose you followed his advice and started a new “healthy” habit.

Then what would happen to...

1. Plasma EPO levels
2. Red blood cell count
3. Blood viscosity
4. % of blood occupied by RBCs
5. Hematocrit
6. % of blood occupied by plasma
RBC Graveyard
Heme

Globin

Hemoglobin

Amino acids

Back into the plasma for reuse/recycling
Heme is carried by transferrin.

Iron is stored with ferritin or hemosiderin.

Bilirubin is carried by albumin.

Stored with ferritin or hemosiderin.
Modified and secreted into SI as part of bile

Metabolized by bacteria and excreted in feces and urine
Problems Getting Rid of Bilirubin
Leukocytes (WBCs)

4,500-11,000 per µL of blood
Where Are Most Leukocytes?
Leukocytosis vs Leukopenia
Leukopoiesis
Diapedesis, Migration, & Positive Chemotaxis
2 Classes of Leukocytes (WBCs)

1. Granulocytes.
   • Contain…
   • Examples?

2. Agranulocytes.
   • Lack…
   • Examples?
Anaphylactic Reaction

Plasma cell

IgE - receptors

Granules

Mast cells

Nucleus

Histamine

Lymphokines

Eicosanoids

Antigens

Single binding antigens

Multiple binding antigen

PAF

Serotonin
Acute viral infection
Platelets

- Cell fragments filled with chemicals necessary for coagulation
- Thrombocytes
- 150,000 – 400,000 per μL of blood
Thrombopoiesis = Platelet Production
Hemostasis

1. Vessel injury
2. Vessel spasm
3. Platelets adhere to injury site and aggregate to form plug
4. Formation of insoluble fibrin strands and coagulation

Ruptured epithelium
Spasm
Platelets
Fibrin
Vascular Spasm

Blood vessel constricts to limit blood escape.
Platelet Plug Formation (and Prevention)

1. Exposed collagen binds and activates platelets
2. Release of platelet factors
3. Attracts more platelets
4. Aggregate into platelet plug

- Lumen of blood vessel
- Intact endothelium
- Prevents platelet adhesion
- Releases prostacyclin
- Collagenin subendothelial layer
- Smooth muscle cells

ECF
What’s a blood clot made out of?

- Fibrin
- Platelets
- Erythrocytes
To make a clot, we need fibrin!

Active plasma protein

Inactive plasma protein

Fibrinogen

Thrombin

Fibrin

Active plasma protein
To make fibrin, we need thrombin!

Prothrombin Activator

Prothrombin

Inactive plasma protein

Thrombin

Active plasma protein
To make thrombin, we need prothrombin activator!

2 mechanisms for making PTA

- Intrinsic Path – initiated by platelets activated by BV damage.
- Extrinsic Path – initiated by perivascular damage.
• Many steps.
  – Slow
  – Makes lots of PTA
Extrinsic Path

- Few steps
  - Fast
  - Doesn’t make a lot of PTA
Koagulation

Intrinsic pathway:
- Vessel endothelium ruptures, exposing underlying tissues (e.g., collagen)
- Platelets cling and their surfaces provide sites for mobilization of factors
- XII, XI, IX, Ca²⁺, IXa, VIII, VIIIa, IXa/VIIIa complex
- PF₃ released by aggregated platelets

Extrinsic pathway:
- Tissue cell trauma causes release of Tissue factor (TF)
- Ca²⁺, VII, VIIa, TF/VIIa complex
- X, Ca²⁺, PF₃, V, Vₐ, Prothrombin activator
- Prothrombin (II), Thrombin (IIa)
- Fibrinogen (I), Fibrin
- Cross-linked fibrin polymer

Note: The diagram illustrates the mechanisms of blood coagulation, including both intrinsic and extrinsic pathways.
Clot Retraction

- Platelet contractile proteins
- Squeezes serum out
- Draws edges together.
- Sets the stage for repair.
Fibrinolysis

When?

Tissue plasminogen activator

Plasminogen → Plasmin

Inactive plasma protein → Active plasma protein

When?
Things that promote abnormal coagulation:

- Rough blood vessel lining
- Pooling of blood
Things that impair coagulation:
Mosquito saliva contains an enzyme called apyrase. Which of the following is it most likely to do?

a. Inhibit fibrinolysis
b. Promote thrombin production
c. Inhibit platelet aggregation
d. Promote fibrin production

Individuals with atrial fibrillation (uncoordinated contraction) can be at risk for clot formation.

Why?
Blood Pressure

Response to Blood Loss

>10% of Blood Vol.