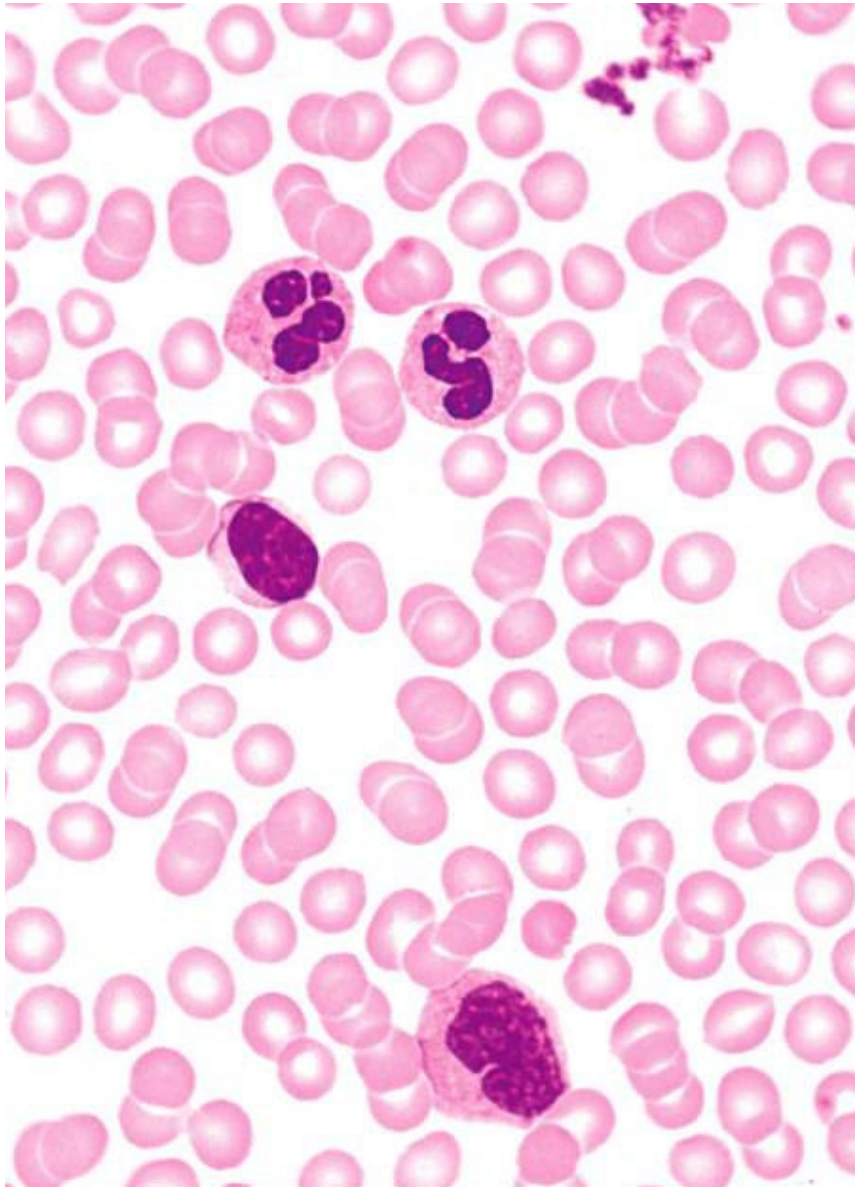
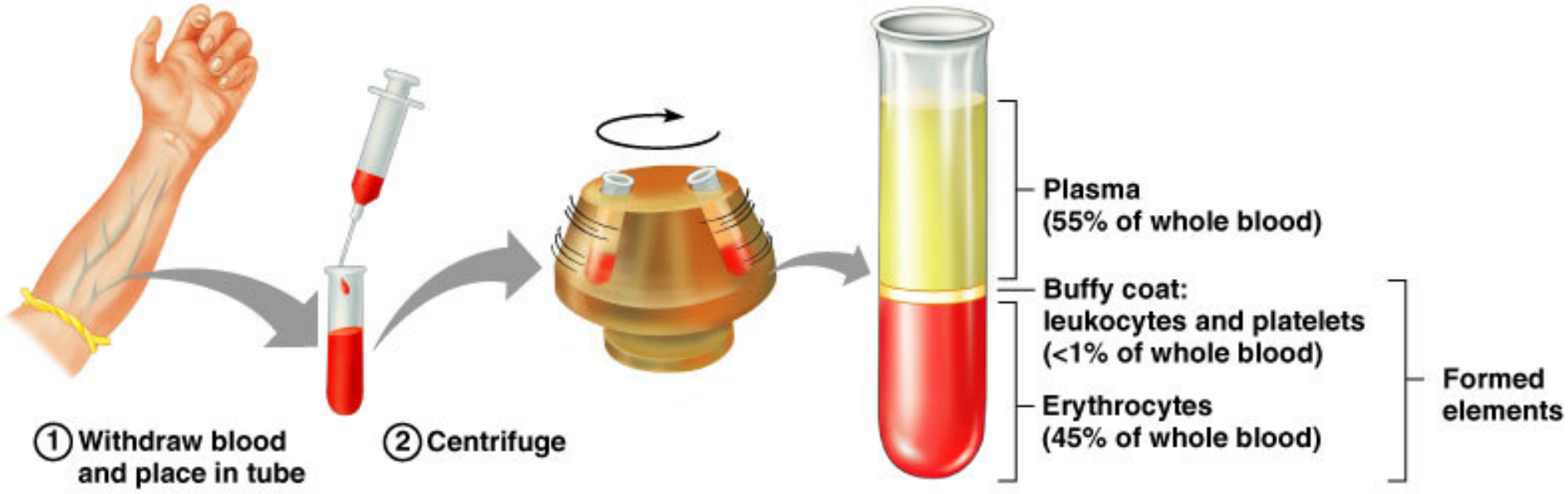
Blood

- Functions
  - Transport of Substances
    - Oxygen
    - Carbon Dioxide
    - Nutrients
    - Heat
    - Wastes
    - Hormones
  - Regulate
    - ph
    - Temperature
    - Hydration of cells
  - Defense Against
    - Blood loss
    - Microbes
    - Toxins



Blood Composition

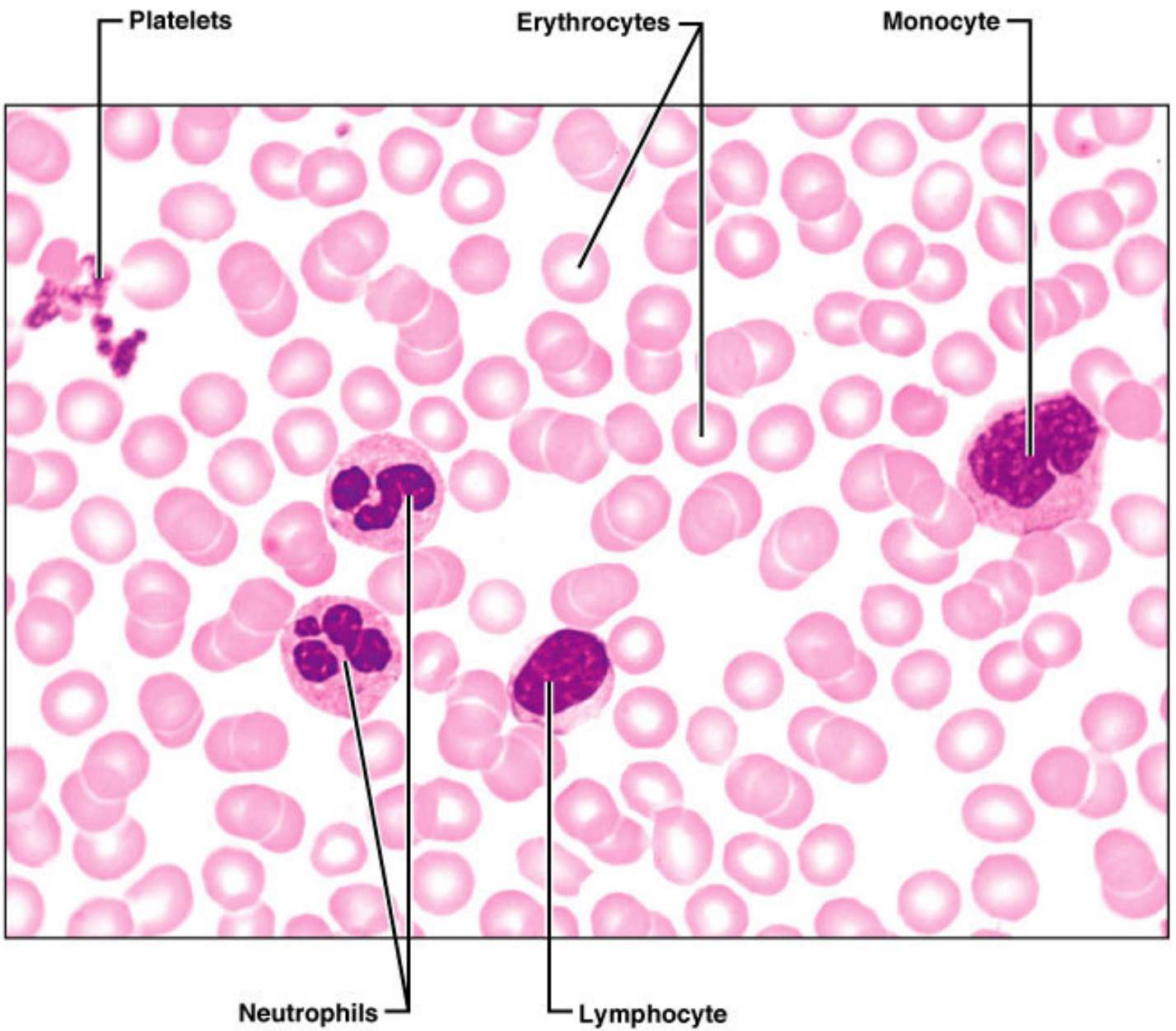
- Components



Blood Plasma

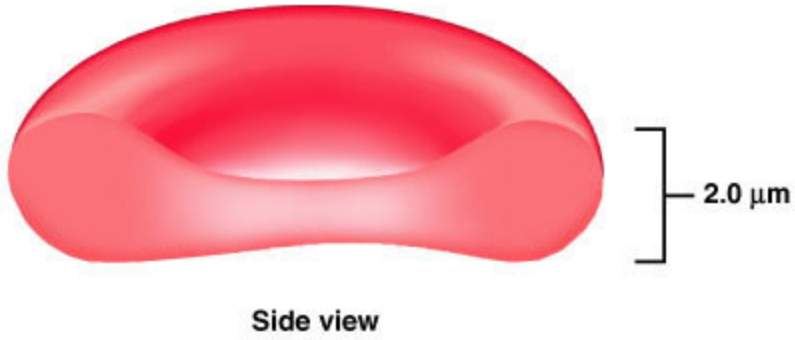
Constituent	Description and Importance
Water	90% of plasma volume; dissolving and suspending medium for solutes of blood; absorbs heat
Solutes	
Proteins	8% (by weight) of plasma volume
▪ Albumin	60% of plasma proteins; produced by liver; exerts osmotic pressure to maintain water balance between blood and tissues
▪ Globulins	36% of plasma proteins
alpha, beta	Produced by liver; transport proteins that bind to lipids, metal ions, and fat-soluble vitamins
Gamma	Antibodies released primarily by plasma cells during immune response
▪ Clotting proteins	4% of plasma proteins; include fibrinogen and prothrombin produced by liver; act in blood clotting
▪ Others	Metabolic enzymes, antibacterial proteins (such as complement), hormones
Nonprotein nitrogenous substances	By-products of cellular metabolism, such as urea, uric acid, creatinine, and ammonium salts
Nutrients (organic)	Materials absorbed from digestive tract and transported for use throughout body; include glucose and other simple carbohydrates, amino acids (digestion products of proteins), fatty acids, glycerol and triglycerides (fat products), cholesterol, and vitamins
Electrolytes	Cations include sodium, potassium, calcium, magnesium; anions include chloride, phosphate, sulfate, and bicarbonate; help to maintain plasma osmotic pressure and normal blood pH
Respiratory gases	Oxygen and carbon dioxide; some dissolved oxygen (most bound to hemoglobin inside RBCs); carbon dioxide transported bound to hemoglobin in RBCs and as bicarbonate ion dissolved in plasma

Formed Elements

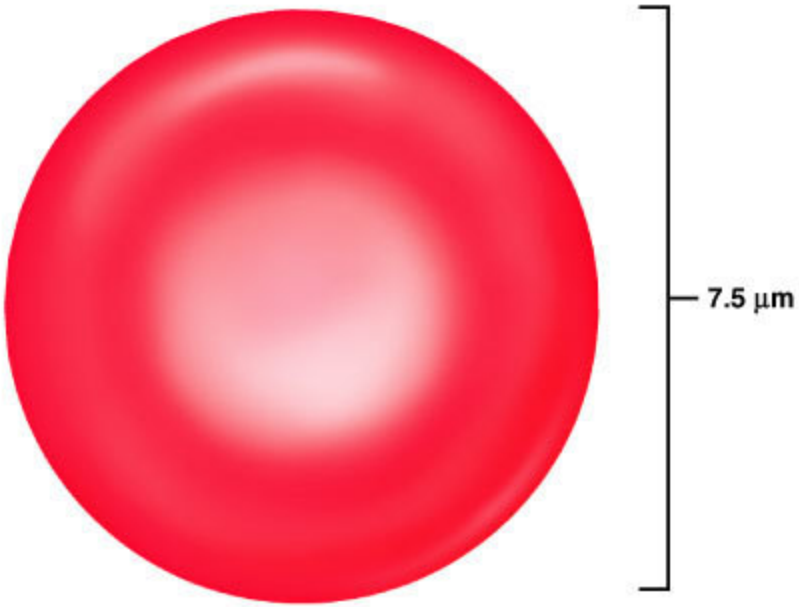


Formed Elements

- Erythrocytes
  - Biconcave discs
  - Anucleate
  - Life span – 120 days
  - Normal values
    - Male 5.4 million / mm^3
    - Female 4.8 million / mn



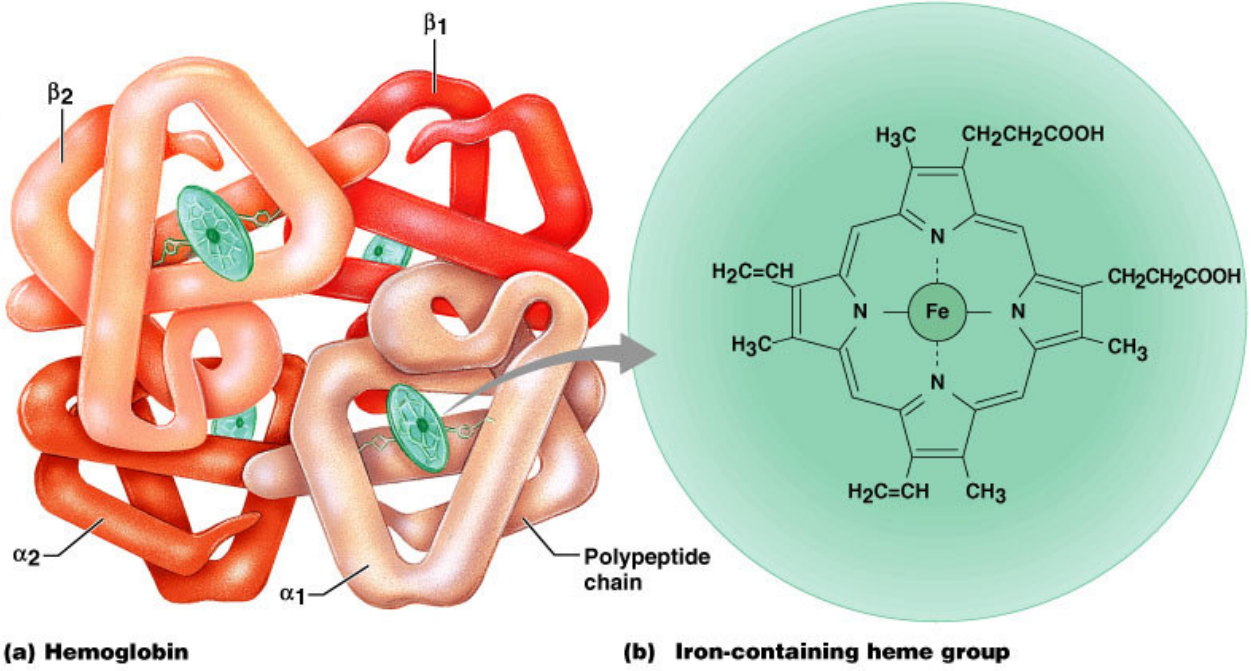
Side view



Top view

Formed Elements

- Contain Hemoglobin (Hb)

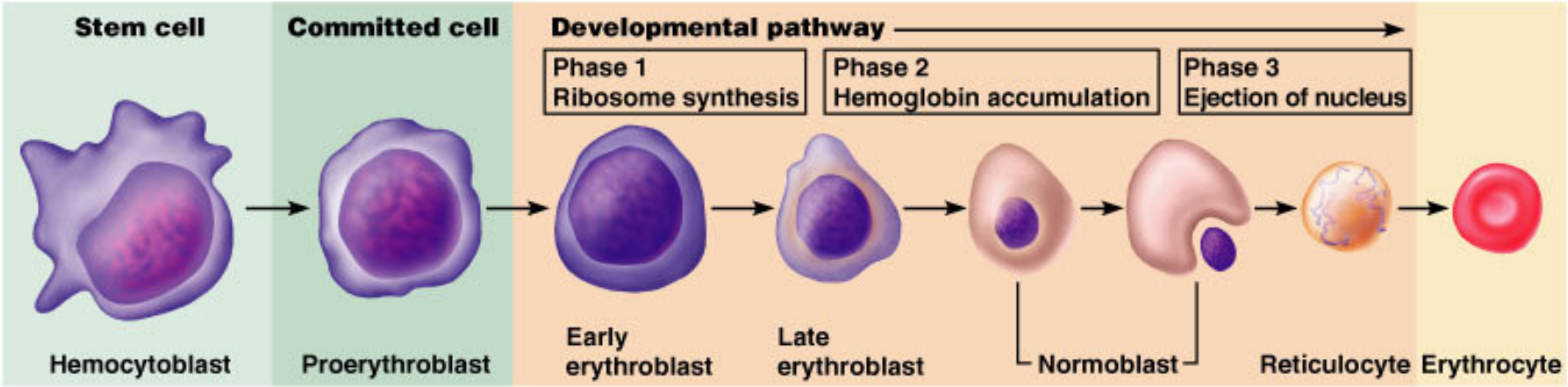


- Made up of four protein chains
- Possess and iron containing heme group
- Carries oxygen (oxyhemoglobin) and carbon dioxide (carbaminohemoglobin)
- Normal Values
  - Male 13 – 18 g/dl
  - Female 12 – 16 g/dl

Formed Elements

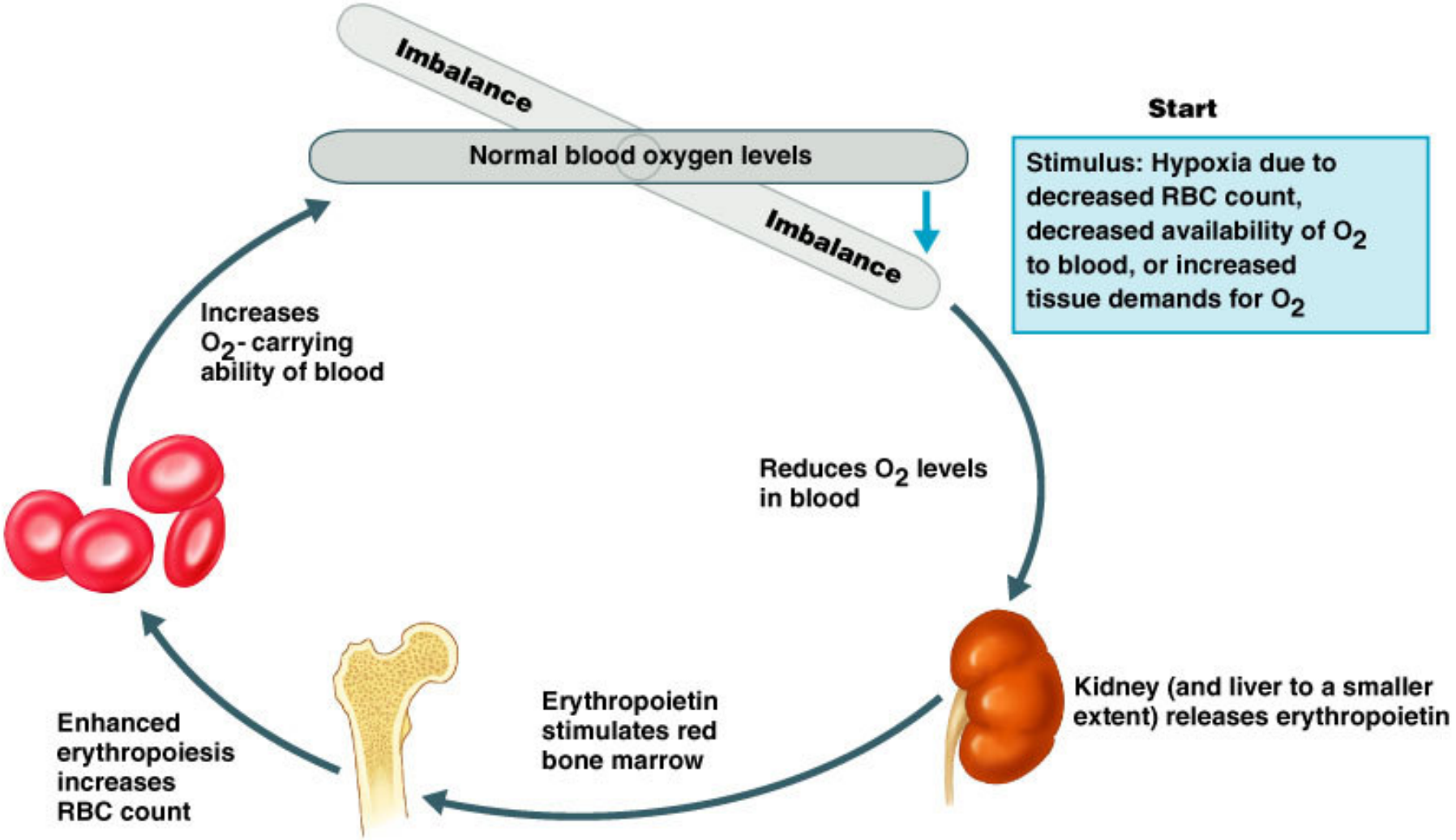
– Erythrocyte Production

- Hematopoiesis (hemopoiesis) – takes place where?
- Erythropoiesis



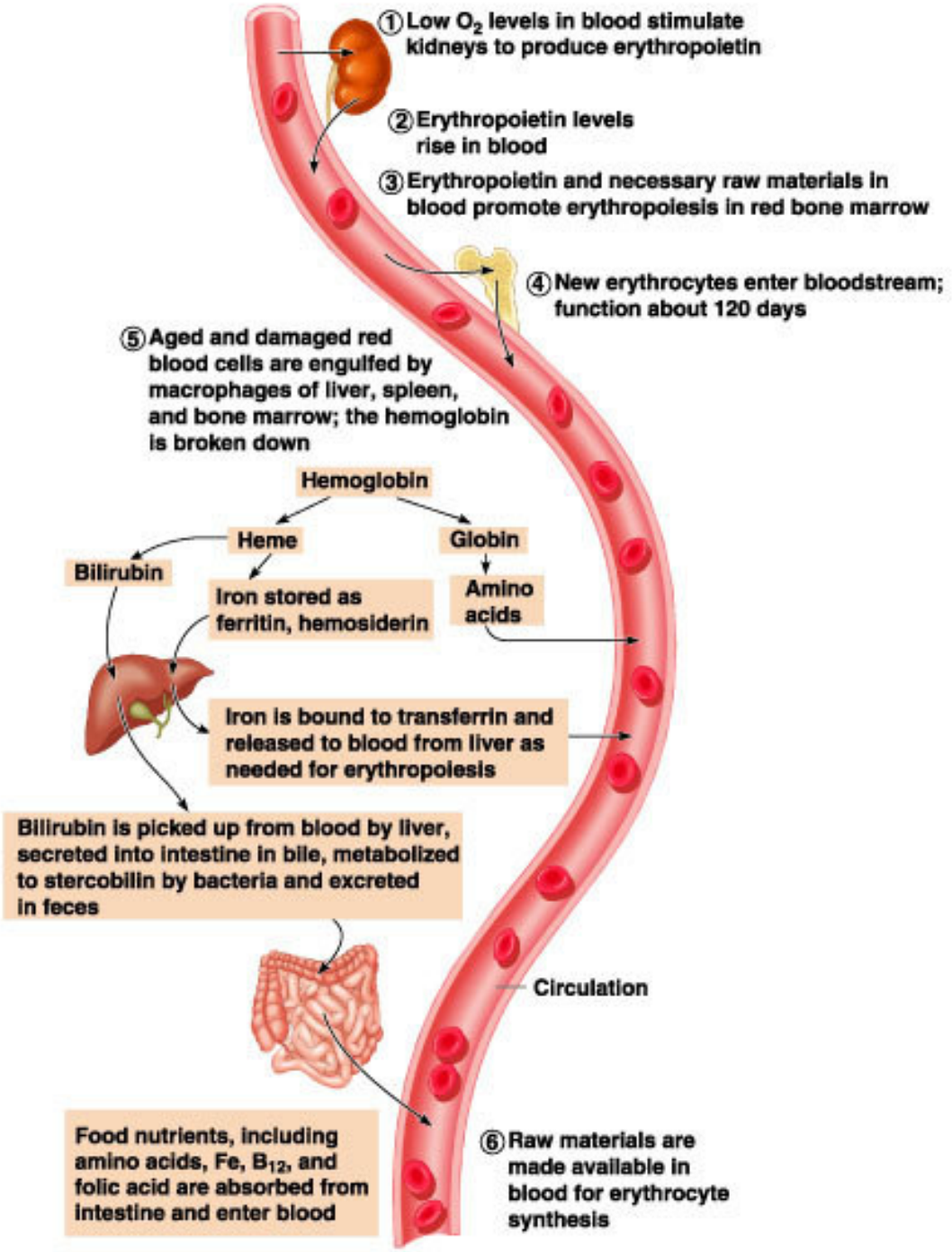
Formed Elements

– Regulation and Requirements for Erythorpoiesis



Formed Elements

- Dietary Requirements/Fate and Destruction of Erythrocytes
  - Typical nutrients
  - Iron
    - Stored in cells bound to proteins (ferritin and hemosiderin)
    - Small amounts lost daily in feces, urine, and perspiration (Women more, why?)
    - B12 and folic acid – needed for DNA synthesis



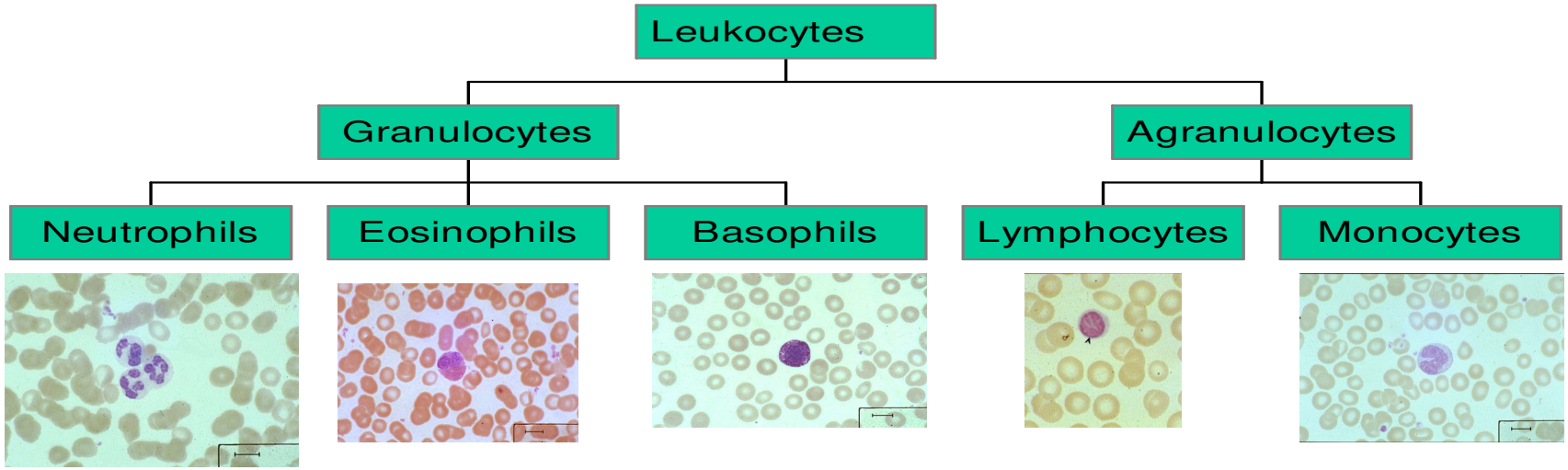
Formed Elements

- Erythrocyte Disorders
  - Anemias
    - Insufficient number of RBC's
      - » Hemorrhagic - The result of blood loss
      - » Pernicious - A deficiency of vitamin B12
      - » Aplastic - A disorder of the red bone marrow (x-rays, chemotherapy)
    - Low Hb - Iron deficient
    - Abnormal Hemoglobin
      - » Thalassemias
      - » Sickle-Cell Anemia
  - Polycythemias
    - Primary (Polycythemia vera)
    - Secondary

Formed Elements

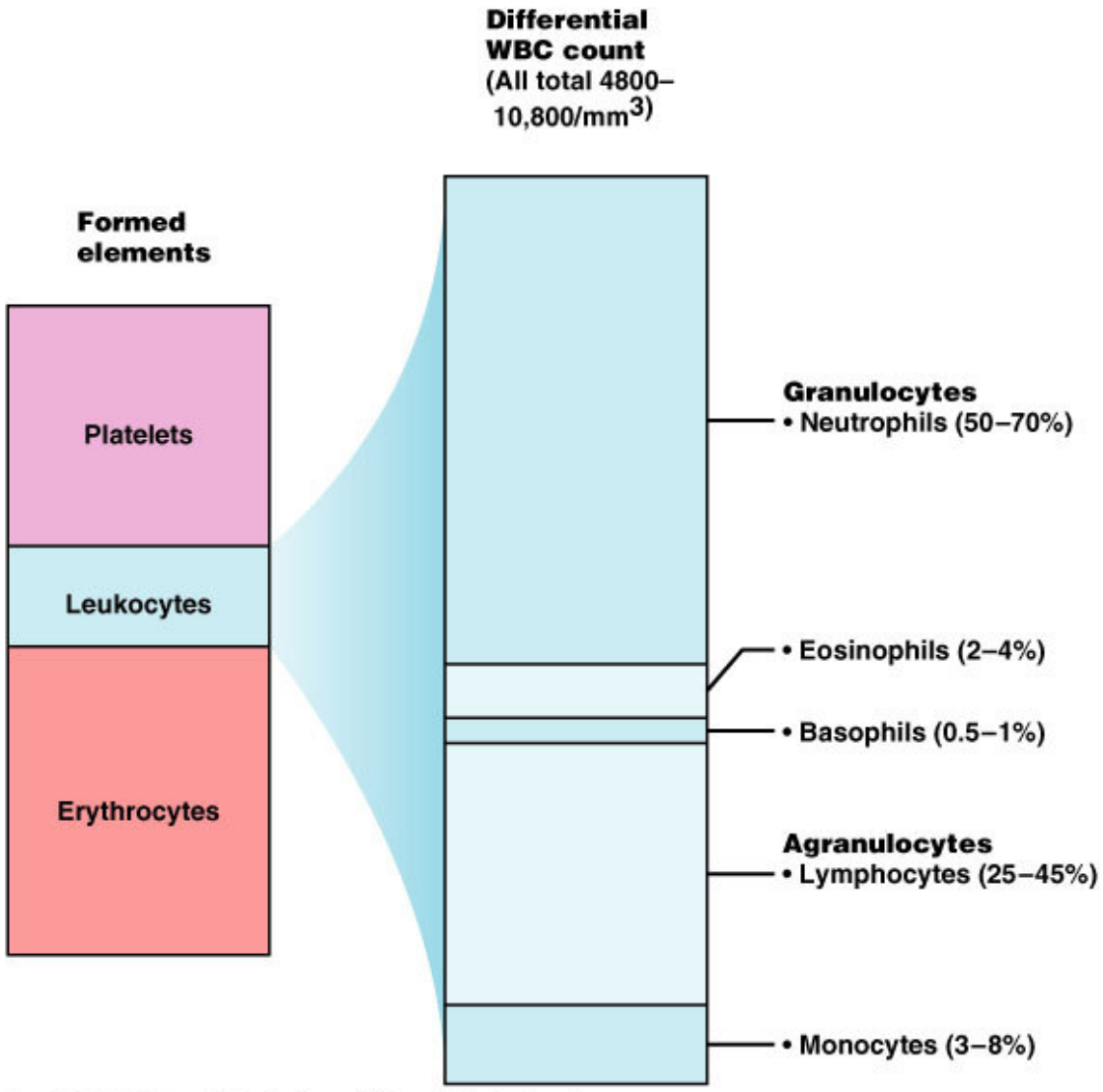
Formed Elements

- **Leukocytes (WBC's)**



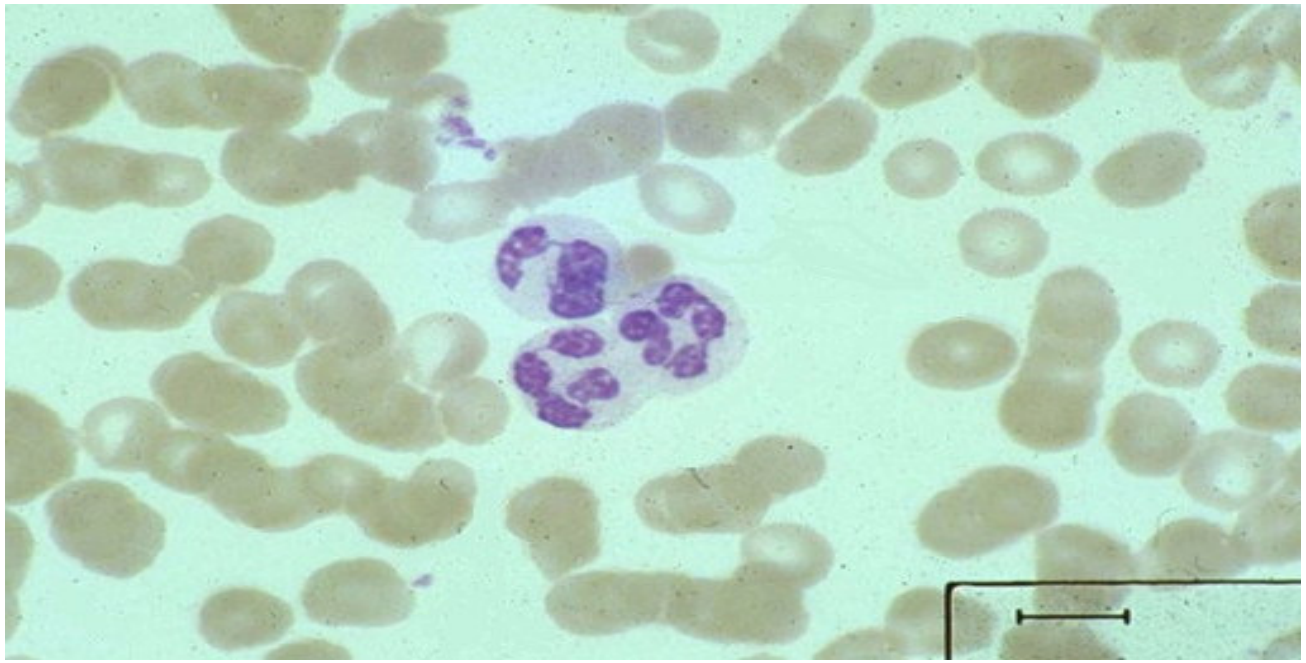
Formed Elements

- Differential WBC Count



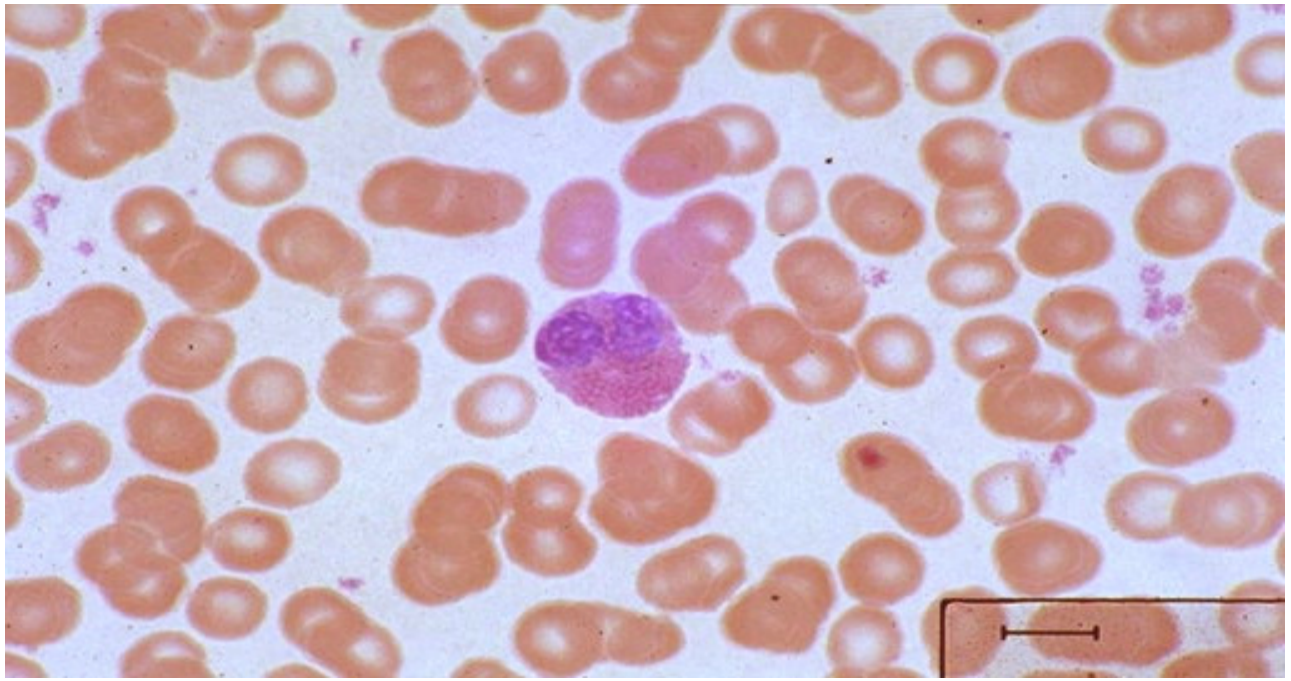
Granulocytes

- Neutrophils (Polymorphonuclear Lymphocytes [PMN's], polys
  - 50 – 70%
  - 2 – 5 lobes
  - Phagocytic – engulf bacteria



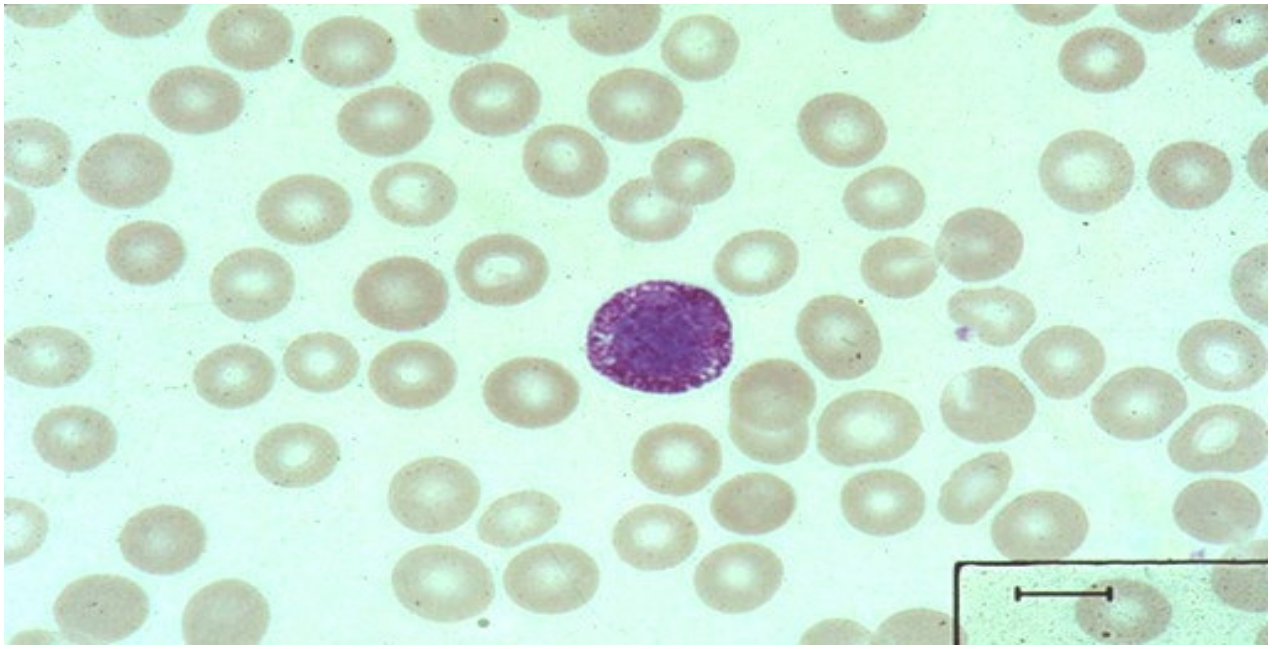
Granulocytes

- Eosinophils
  - 2 – 4%
  - 2 – 3 lobes
  - Red/orange granules
  - Associated with allergic reactions and parasitic infections



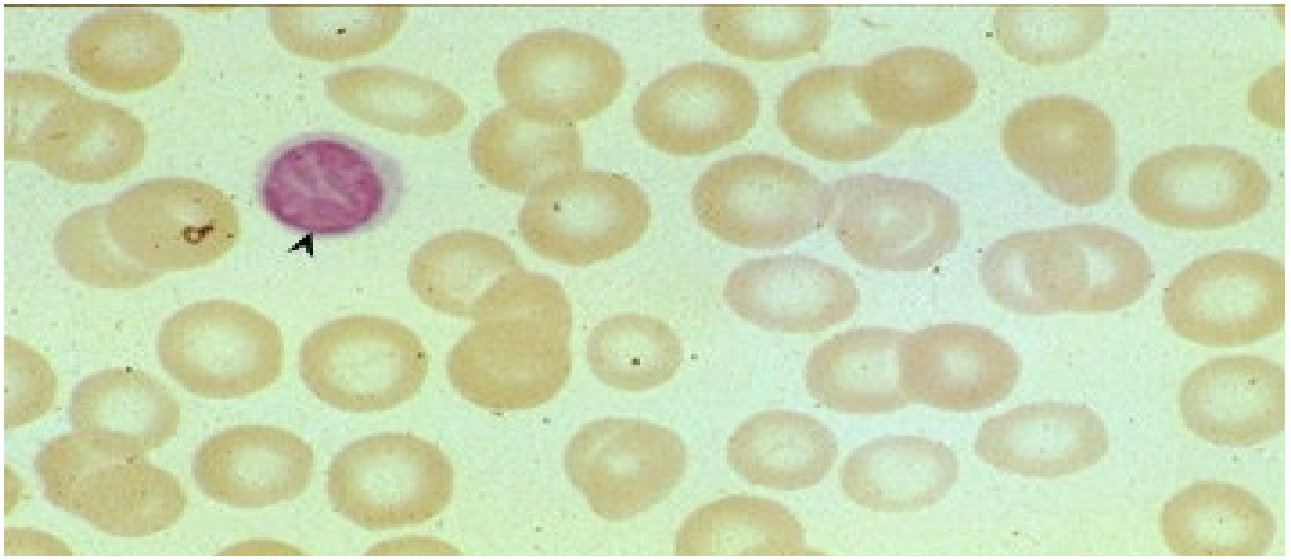
Granulocytes

- Basophils
  - < 1%
  - Dark blue granules, obscure the nucleus (heparin and histamine)
  - Associated with immediate immune response (asthma, hay fever and anaphylaxis)



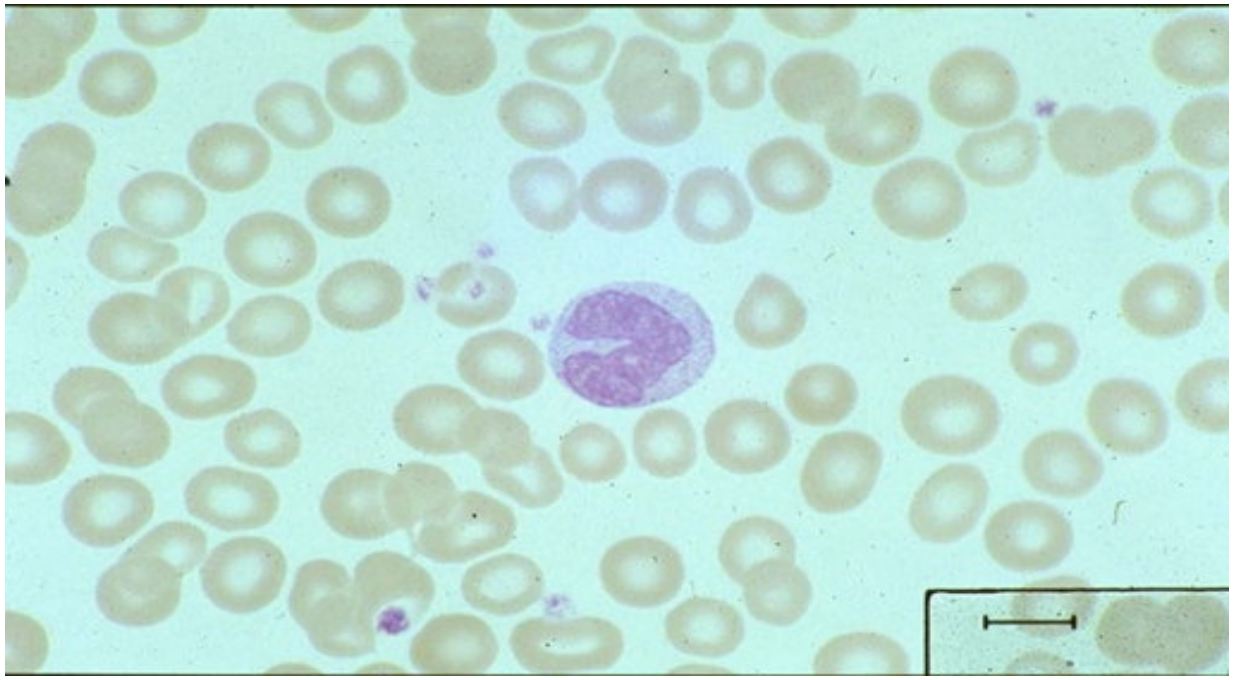
Agranulocytes

- Lymphocytes
  - 20 – 45%
  - Large nucleus with a small amount of cytoplasm
  - Two types
    - B cells - important in humoral immnity, they become plasma cells which produce antibodies [Ab's])
    - T cells – are important in cell mediated immunity



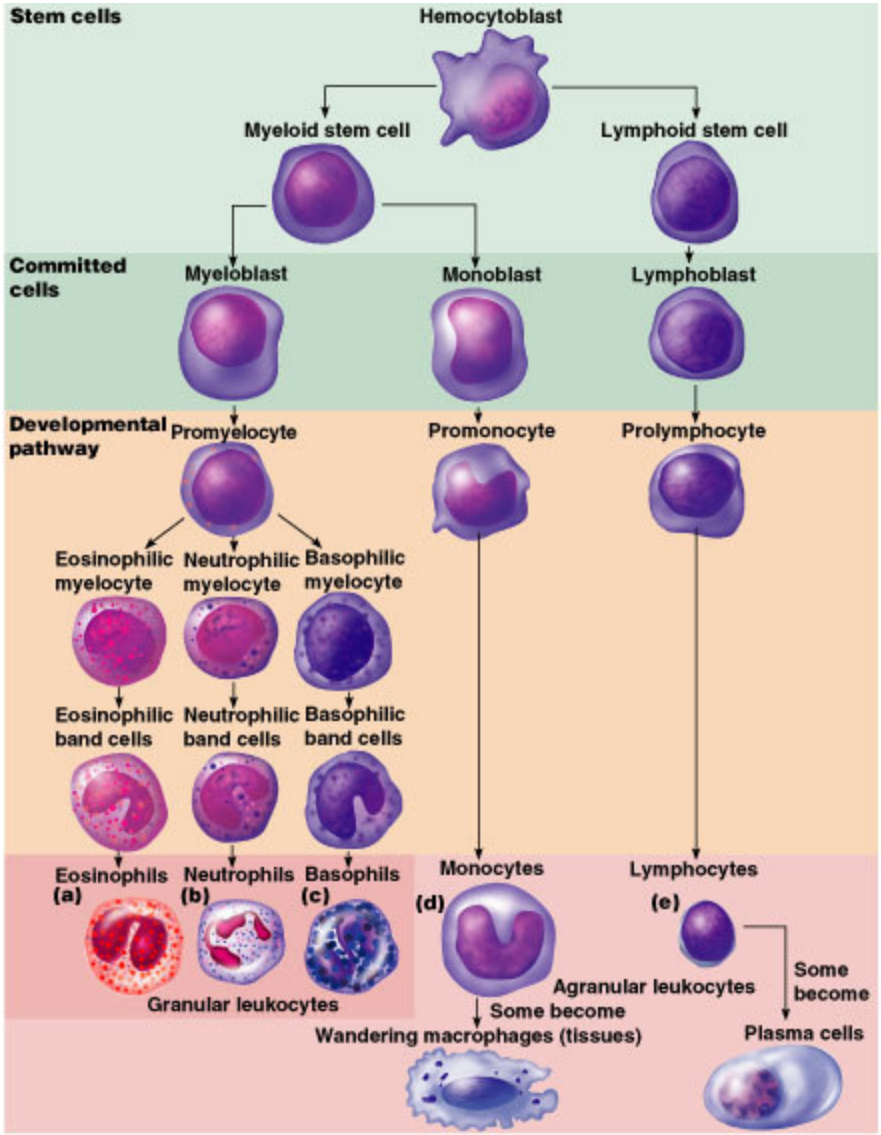
Agranulocytes

- Monocytes
  - 3 – 8%
  - "U" shaped nucleus
  - Are capable of leaving the blood stream where they become phagocytic macrophages



Formed Elements

- Production and Life Span of Leukocytes

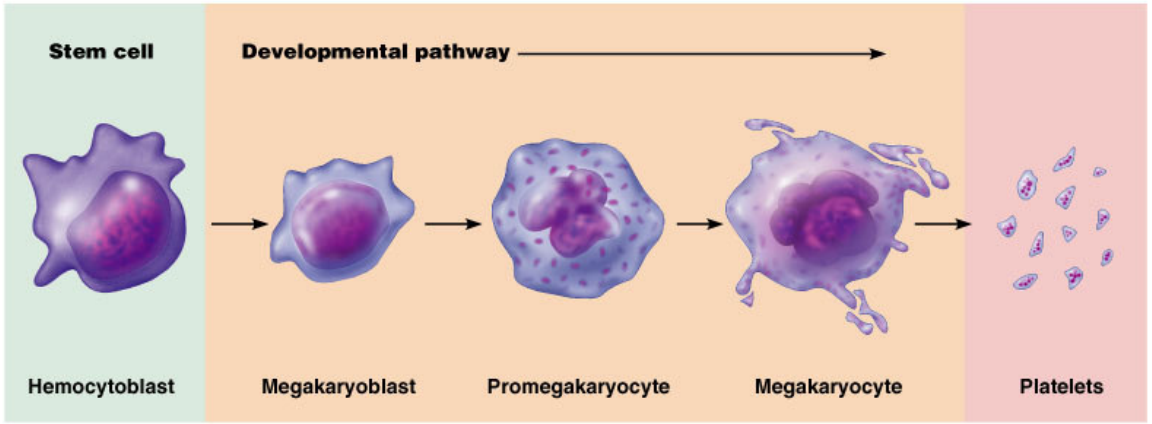


Formed Elements

- Leukocyte Disorders
  - Leukopenia – lower then normal numbers of WBC's – typically the result of certain drugs (glucocorticoids and anticancer agents)
  - Leukemias
    - Myelocytic Leukemias
    - Lymphocytic Leukemias
    - Acute or Chronic
  - Infectious Mononucleosis
    - Epstein Barr Virus
      - Lager than normal number of atypical agranulocytes

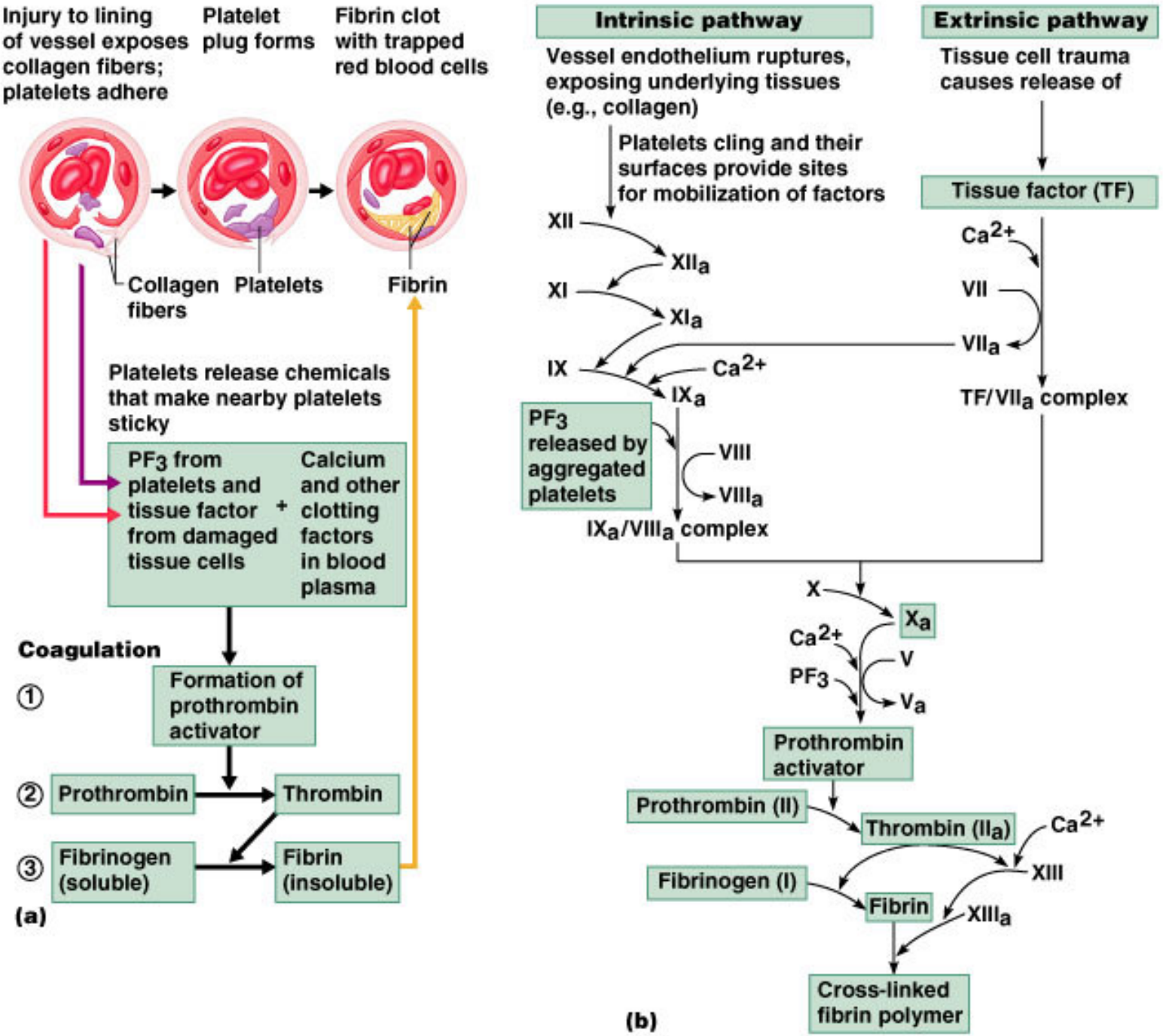
Formed Elements

- Platelets
  - Disc-shaped
  - Anucleate
  - Derived from megakaryocytes
  - Function in blood clotting
  - Life span 5-9 days, removed by macrophages in the liver and spleen
  - 250,000 – 400,000 / mm^3



Hemostasis

- Vascular spasm – contraction of smooth muscle, produced by the nervous system and chemicals (thromboxanes and endothelin)
- Platelet Plug Formation
  - Von Willebrand Factor – makes collagen fibers very sticky
  - Platelets release
    - Serotonin – enhances vascular spasm
    - ADP – attracts more platelets to the area, which release more of the same
- Coagulation – conversion of fibrinogen to fibrin


Injury to lining of vessel exposes collagen fibers; platelets adhere
Platelet plug forms
Fibrin clot with trapped red blood cells
Collagen fibers
Platelets
Fibrin
Platelets release chemicals that make nearby platelets sticky
PF3 from platelets and tissue factor from damaged tissue cells
+
Calcium and other clotting factors in blood plasma
Coagulation
①
Formation of prothrombin activator
②
Prothrombin
Thrombin
③
Fibrinogen (soluble)
Fibrin (insoluble)
(a)
Intrinsic pathway
Vessel endothelium ruptures, exposing underlying tissues (e.g., collagen)
Platelets cling and their surfaces provide sites for mobilization of factors
XII
XIIa
XI
XIa
IX
Ca2+
IXa
PF3 released by aggregated platelets
VIII
VIIIa
IXa/VIIIa complex
Extrinsic pathway
Tissue cell trauma causes release of
Tissue factor (TF)
Ca2+
VII
VIIa
TF/VIIa complex
X
Xa
Ca2+
V
PF3
Va
Prothrombin activator
Prothrombin (II)
Thrombin (IIa)
Ca2+
XIII
Fibrinogen (I)
Fibrin
XIIIa
Cross-linked fibrin polymer
(b)

Hemostasis

- Clot Retraction and Repair

- Fibrinolysis – involves the conversion of plasminogen to plasmin the result of tissue plasminogen activator (TPA)

Hemostasis Disorders

- Thrombocytopenia – a reduced number of platelets
- Hemophilia – genetic disorder resulting in absent or impaired clotting – typically the result of an inability to produce one or more clotting factors
- Von Willibrand's Disease – most common clotting disorder – a decrease in factor VIII (Von Willibrand's factor)
- Asprin/Warfarin/Heparin
- Impaired Liver Function
- Thrombus – a stationary blood clot within a blood vessle
- Embolus – a moving blood clot