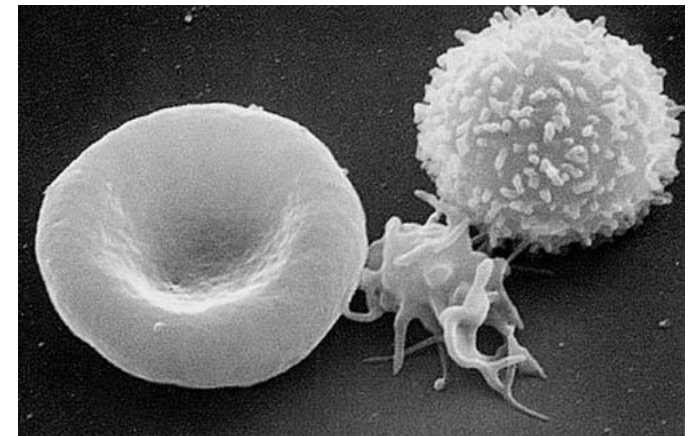
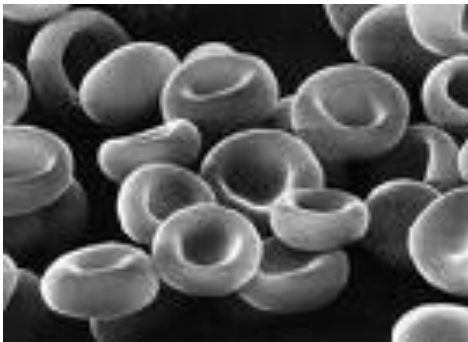
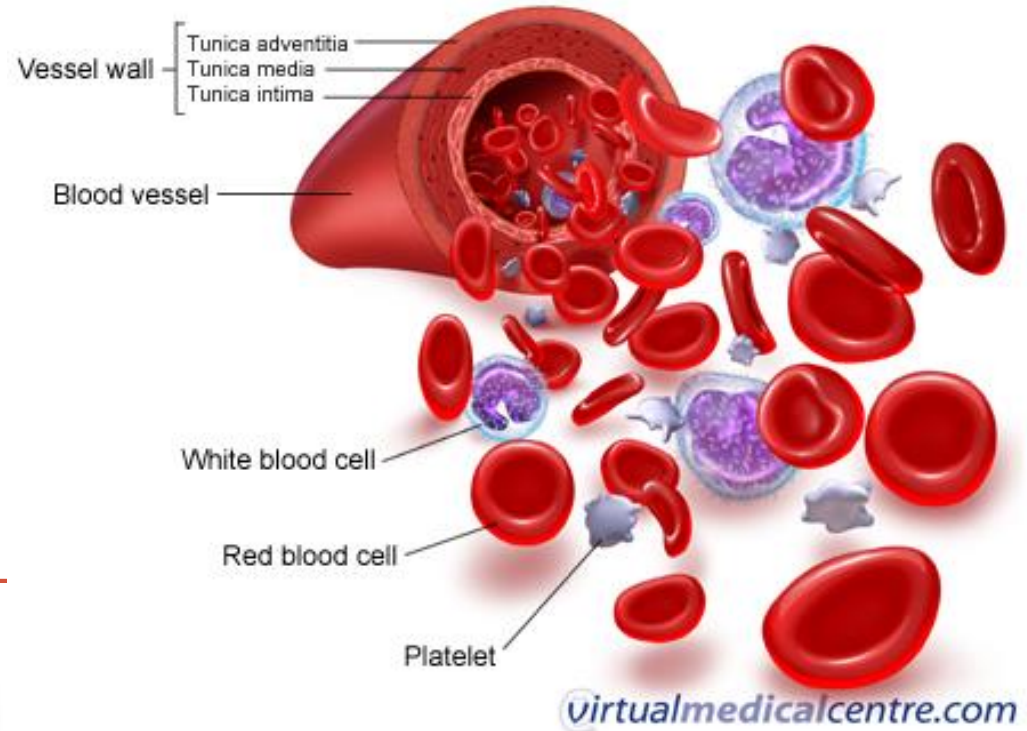


# LE SANG BLOOD

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# Essential Question

**Why is blood necessary for human life??**



# Cardiovascular system

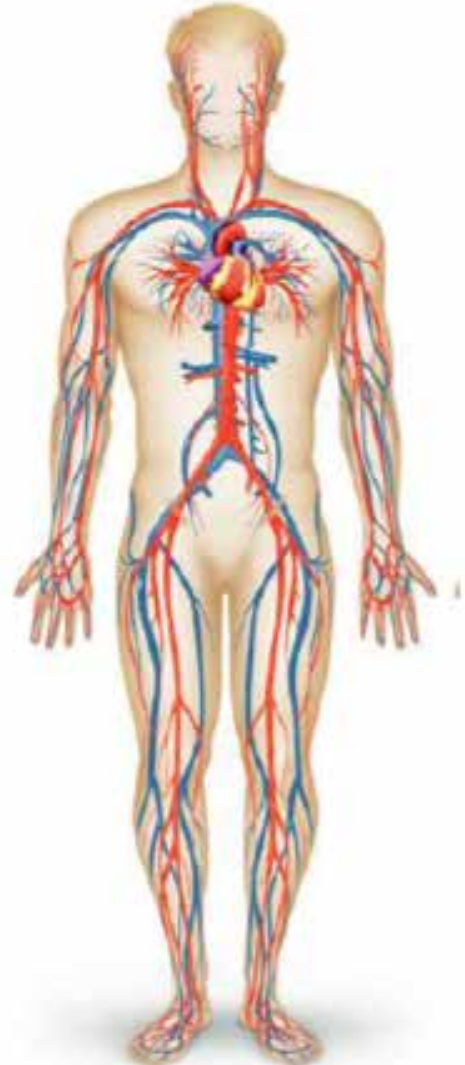
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- **Components**

- blood
- heart
- blood vessels

- **Functions**

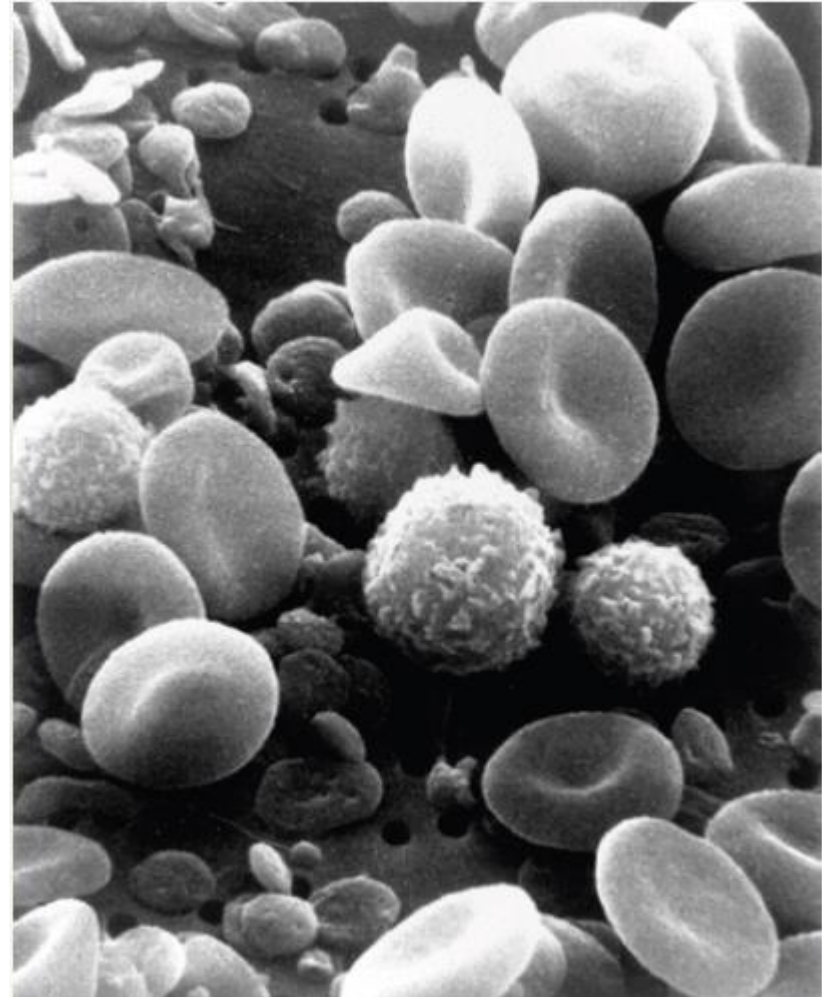
- pumps blood
- carries O<sub>2</sub> and nutrients to cells and wastes away
- regulates temperature, acid-base balance, and H<sub>2</sub>O





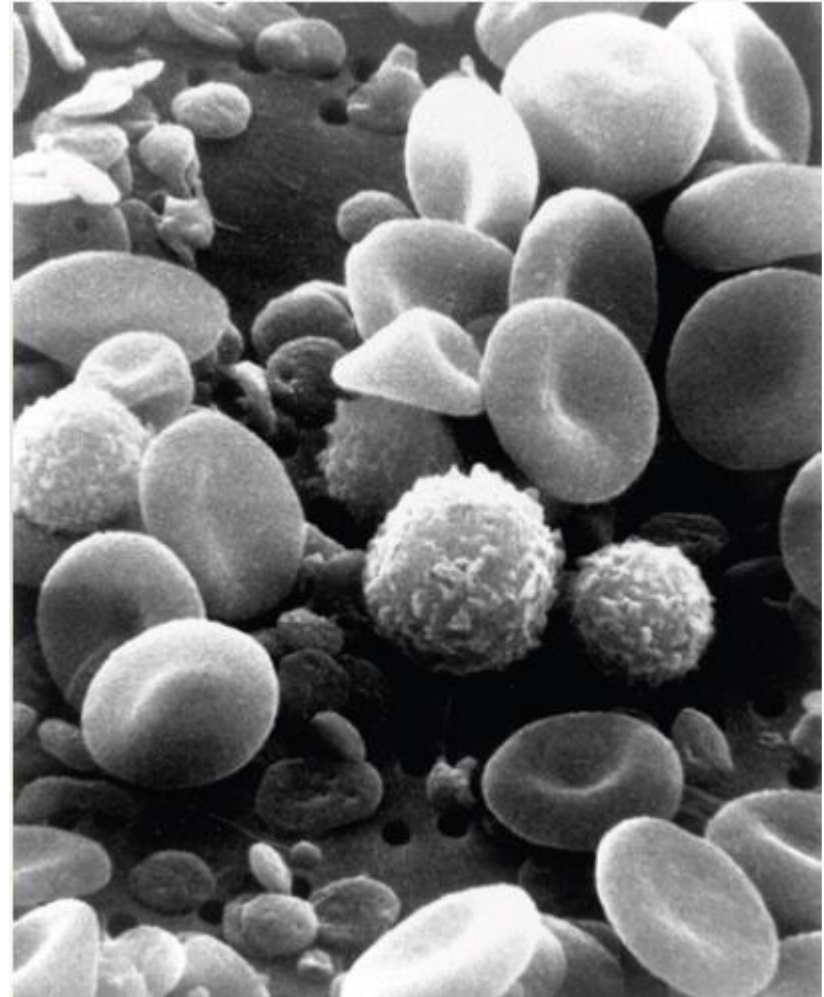
# Blood

- The only fluid tissue in the human body
- Transported in Closed System Throughout Body Through Blood Vessels
- Classified as a connective tissue=Cells + Matrix
  - Living cells = formed elements
  - Non-living matrix = plasma



# Blood

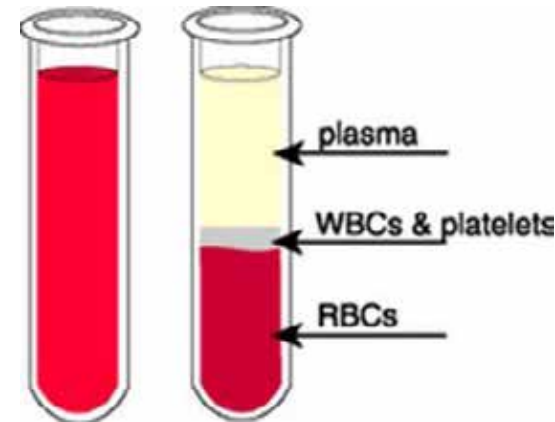
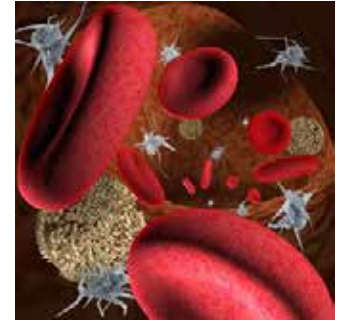
- Blood is a specialized fluid connective tissue comprising formed elements (red blood cells, white blood cells and platelets) and plasma.
- By comparison with the total extracellular fluid volume, the volume of blood is small: 70 ml/kg body weight
- Essential Life Supportive Fluid

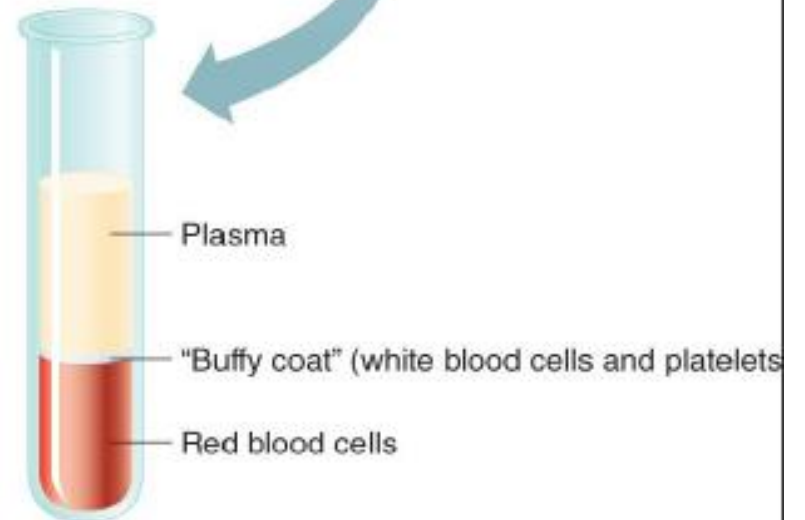
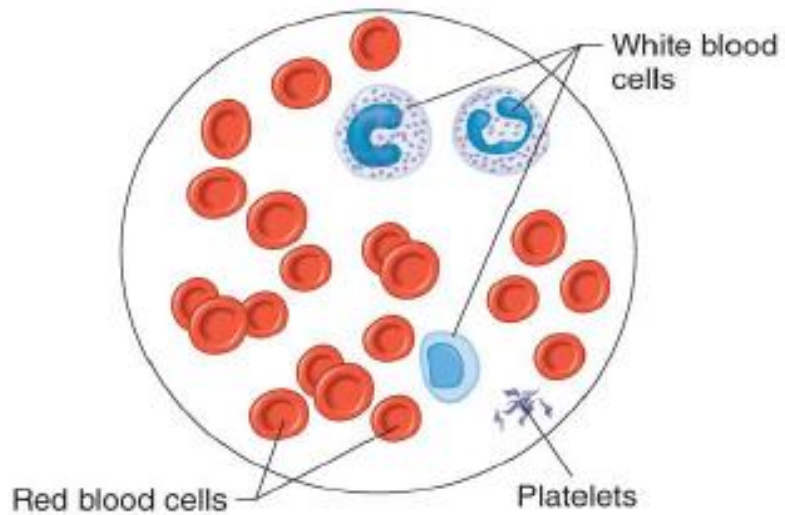


# Components of Blood

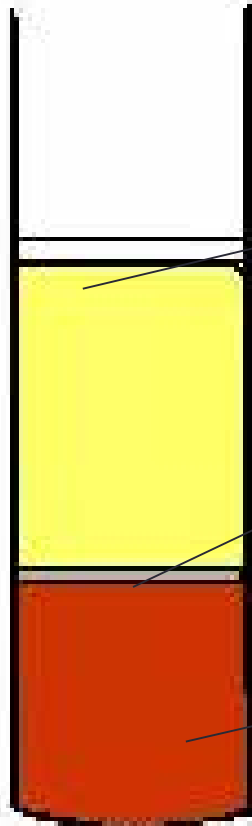
Each type of blood cell performs a different function.

- Red blood cells (Erythrocytes)
- White blood cells (Leukocytes)
- Platelets (Thrombocytes)





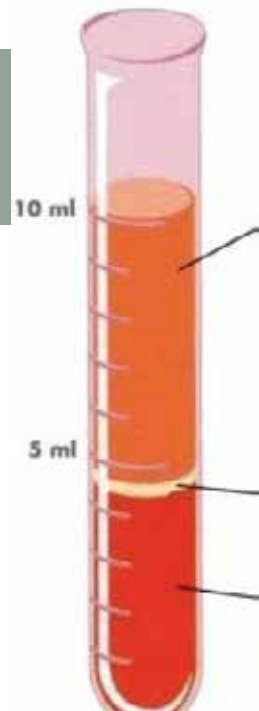
# Components of Blood



**Plasma 55%**

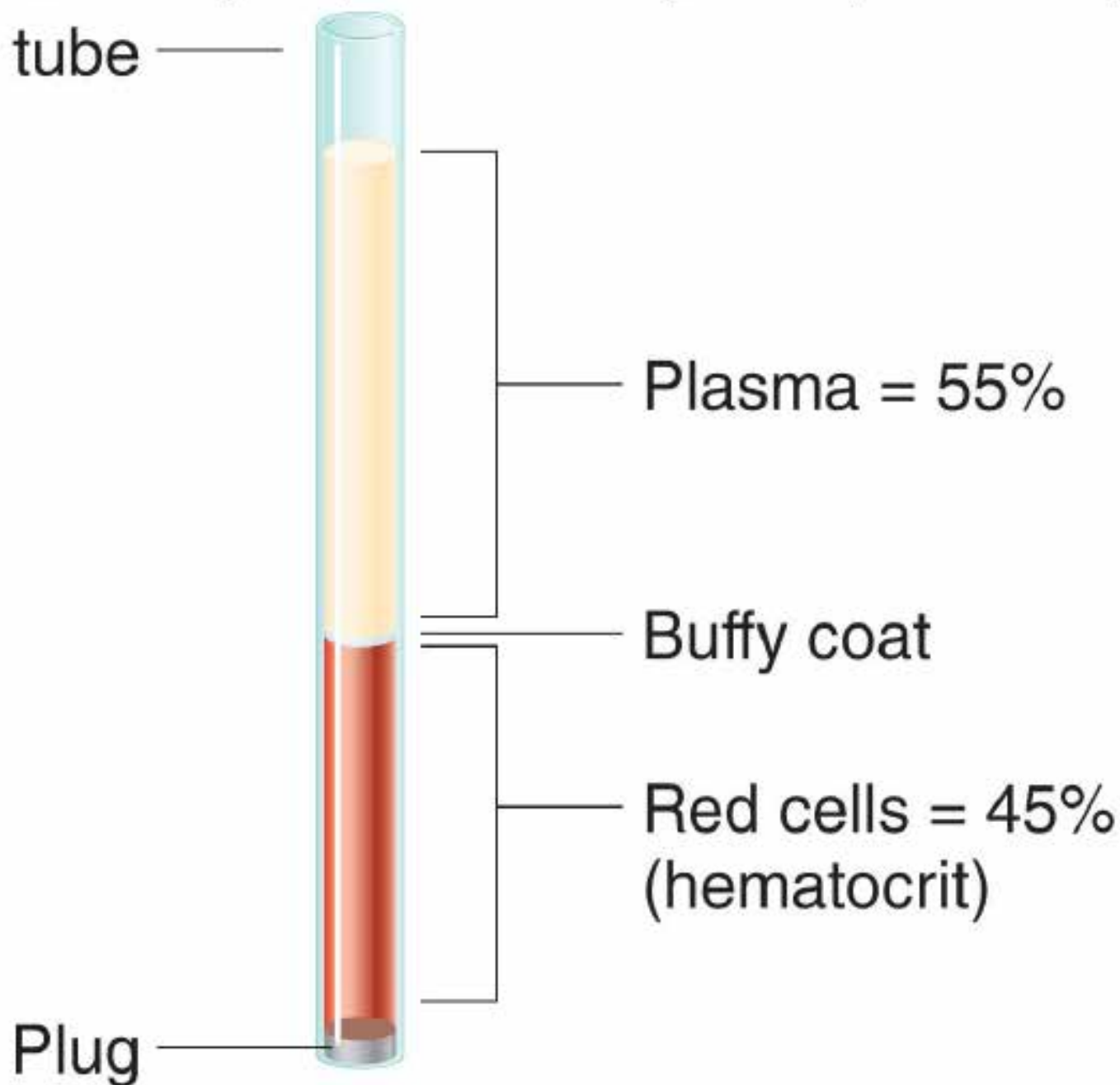
**Leukocytes and platelets:  
<1%**

**Erythrocytes:  
(hematocrit): 45%**





Capillary tube



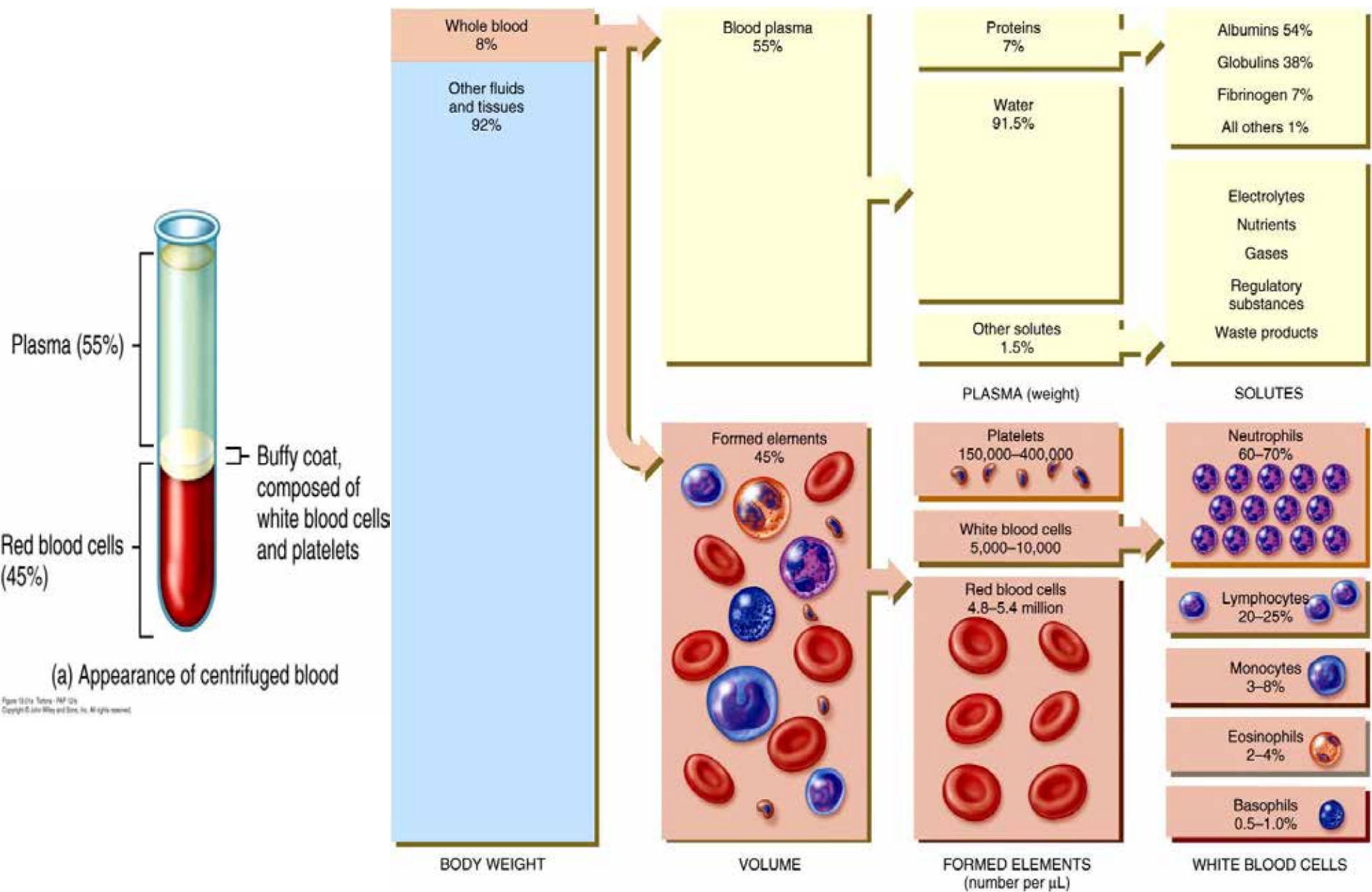
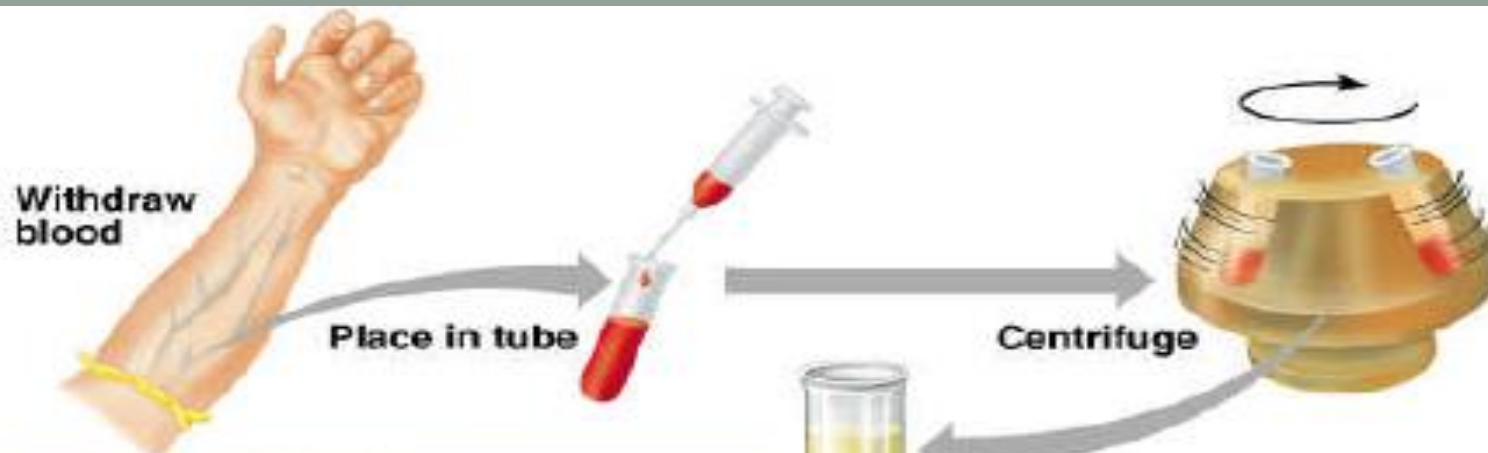









Figure 19.01b Tortora - PAP 12/e  
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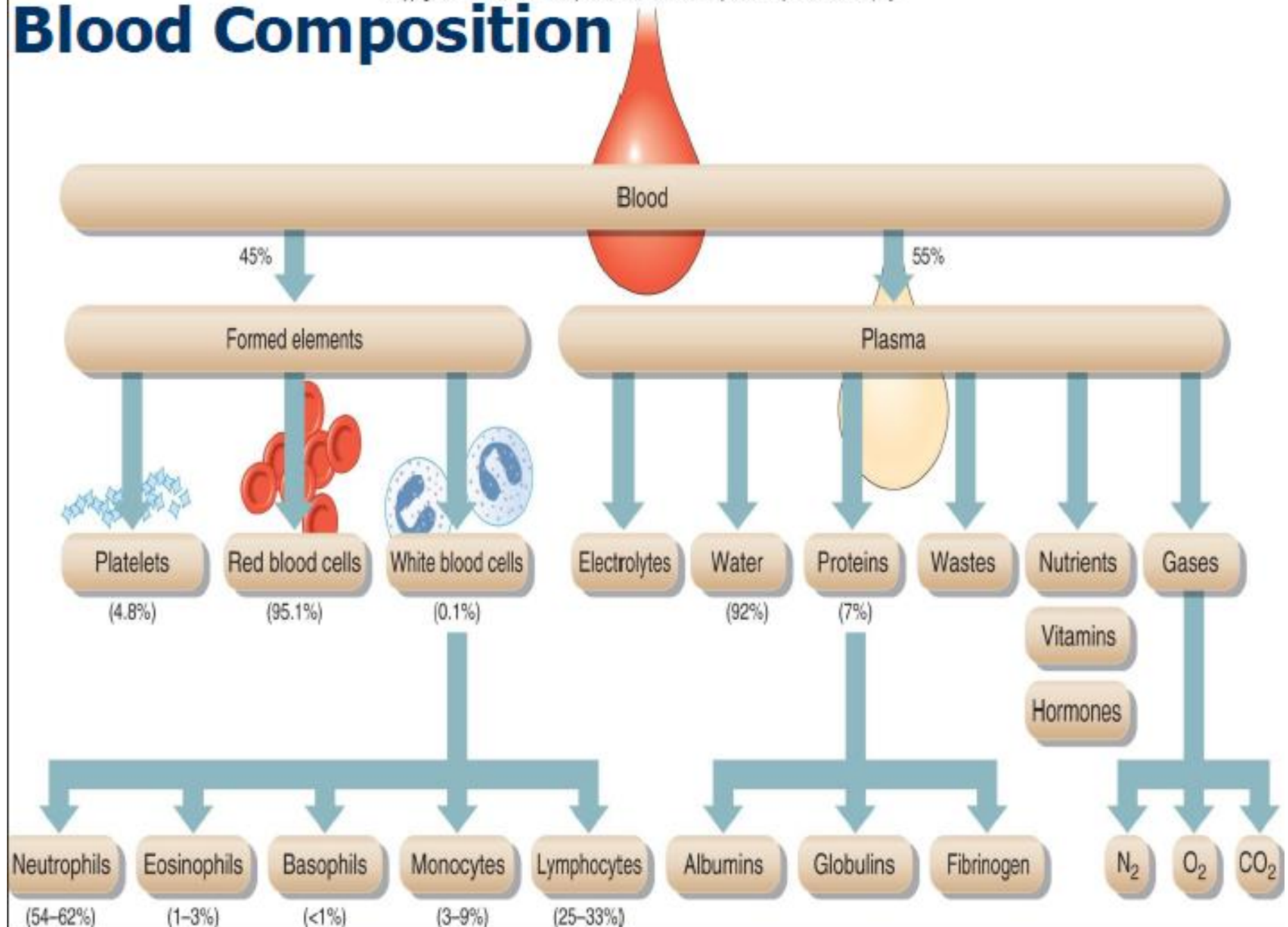
### PLASMA 55%

Constituent	Major functions
Water	Solvent for carrying other substances
Salts (electrolytes) Sodium Potassium Calcium Magnesium Chloride Bicarbonate	Osmotic balance, pH buffering, and regulation of membrane permeability
Plasma proteins Albumin  Fibrinogen Globulins	Osmotic balance, pH buffering Clotting of blood. Defense (antibodies), and lipid transport
Substances transported by blood Nutrients (e.g., glucose, fatty acids, vitamins, amino acids) Waste products of metabolism (urea, uric acid) Respiratory gases ( $O_2$ and $CO_2$ ) Hormones	

### Formed Elements (cells) 45%

Cell type	Number (per $mm^3$ of blood)	Functions
Erythrocytes (red blood cells) 	4–6 million	Transport oxygen and help transport carbon dioxide
Leukocytes (white blood cells)	4000–11,000	Defense and immunity
 Basophil  Eosinophil  Neutrophil  Lymphocyte  Monocyte		
 Platelets	250,000–500,000	Blood clotting

# Blood Composition





# Functions

Blood performs a diverse range of functions:

- **Transportation(Distribution)**

- O<sub>2</sub>, CO<sub>2</sub>, metabolic wastes, nutrients, hormones

- **Regulation**

- pH through buffers(acting as a buffer)
- body temperature (stabilizing body temperature)
- water content of cells by interactions with dissolved ions and proteins

- **Protection**

- defending against pathogens(disease): antibodies, WBC's
- loss of fluid from the circulation as a result of injury( loss of blood): by the clotting process (clot formation)

# Physical Characteristics of Blood

- **Color range**
  - Oxygen-rich blood is **scarlet** red
  - Oxygen-poor blood is **dull** red
- **pH** must remain between **7.35–7.45**
- **Blood temperature** is slightly higher than body temperature: 100.4 °F (38°C)
- **Thicker** (more viscous) than water and **flows more slowly** than water (4.5-5.5g/ml vs 1g/ml)
- **Blood volume :7-8 % of total body weight**
  - 5 to 6 liters in average male
  - 4 to 5 liters in average female
- **0.85-0.9% saline**

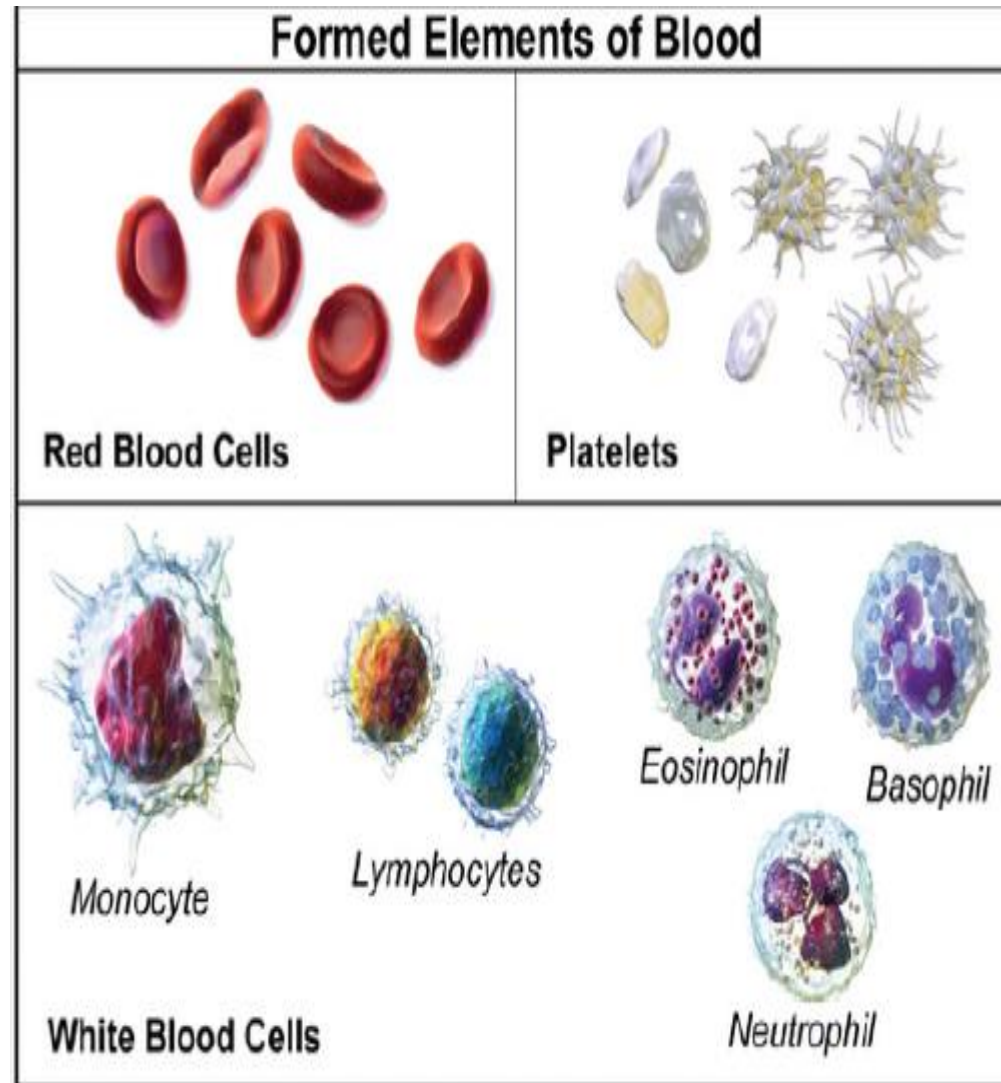
# Blood Plasma

- **Plasma**-straw colored liquid that contains dissolved substances including clotting factors
- **Serum** = plasma minus the clotting factors
- Clear, sticky fluid
- 90-92(91.5%) water
- 8.5% solutes = 7% proteins + 1.5% other solutes
- **Plasma proteins**
  - clotting factors (fibrinogen)
  - globulins (including antibodies)
  - albumins and specialized carrier proteins (lipoproteins)
- **Other solutes**: Glucose, Fatty acids, Enzymes, Hormones
- **Gases** : O<sub>2</sub>, CO<sub>2</sub>
- **Ions** : Na<sup>+</sup>, K<sup>+</sup>, HCO<sub>3</sub><sup>-</sup>, Cl<sup>-</sup>, Ca<sup>2+</sup>
- **Wastes**: urea, uric acid, ammonium salts, creatine, creatinine, and bilirubin



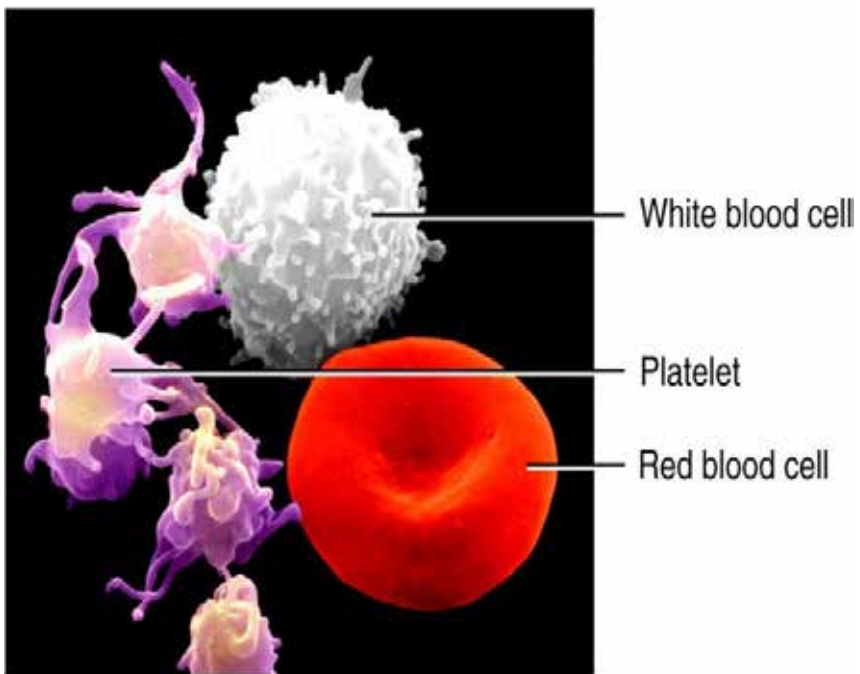
# Formed Elements of Blood

- **Living** blood **cells**
- Erythrocytes, leukocytes, and platelets!
- **2 of 3** are **not true** cells!
- Most formed elements **survive** in the blood for only **a few days!**
- Most blood cells **do not divide**
- **Hematopoiesis** occurs in liver, spleen, thymus, & bone marrow





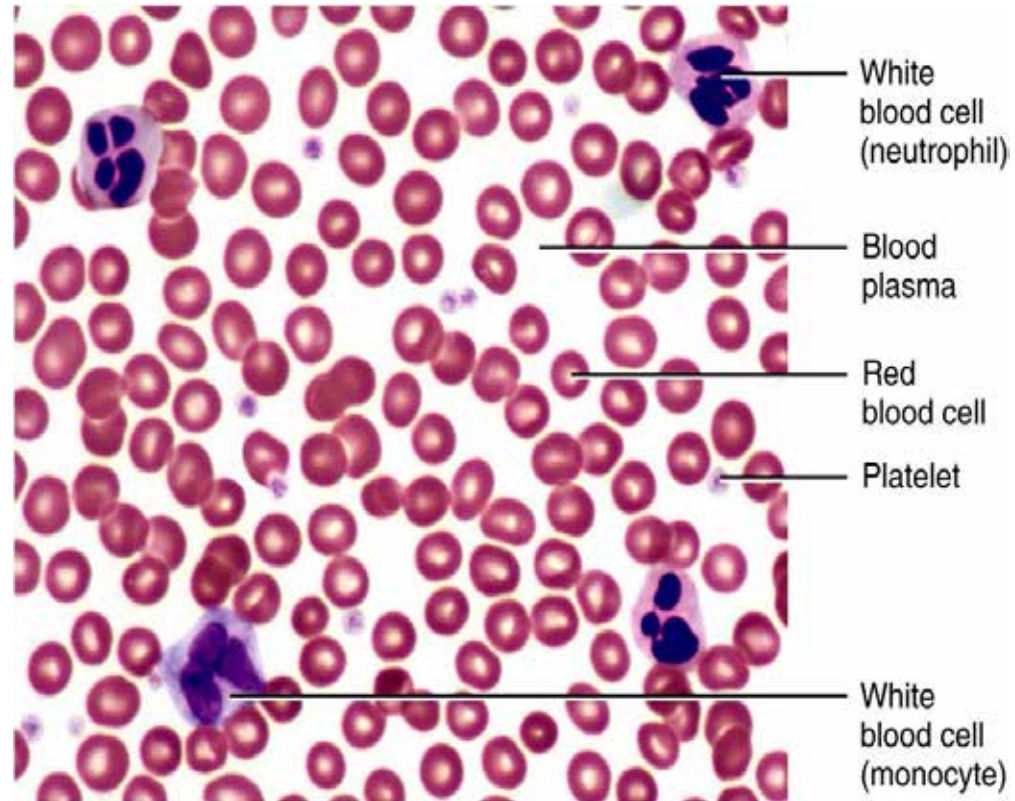
# Formed Elements of Blood



SEM 3500x

(a)

Figure 19.02a Tortora - PAP 12/e  
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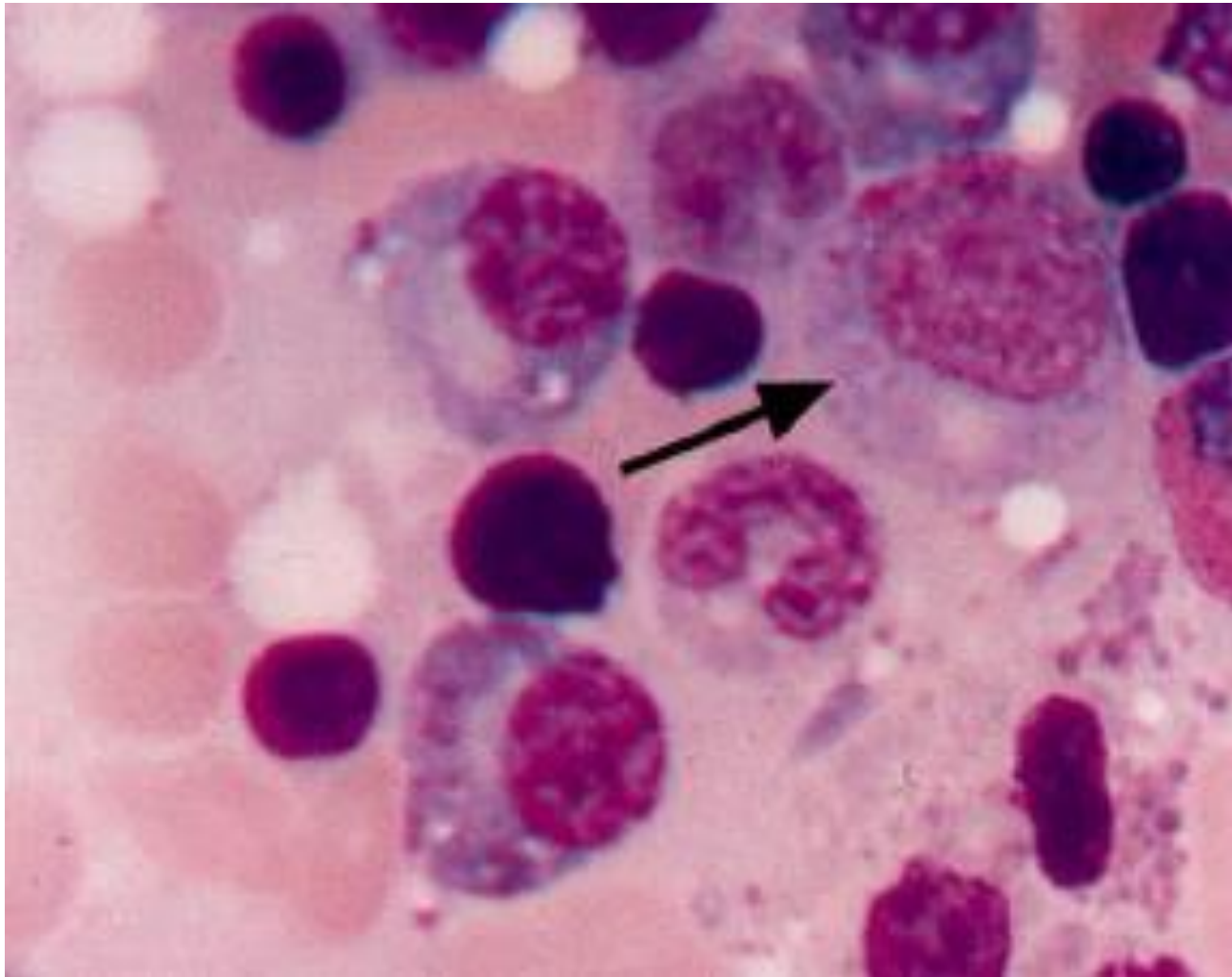


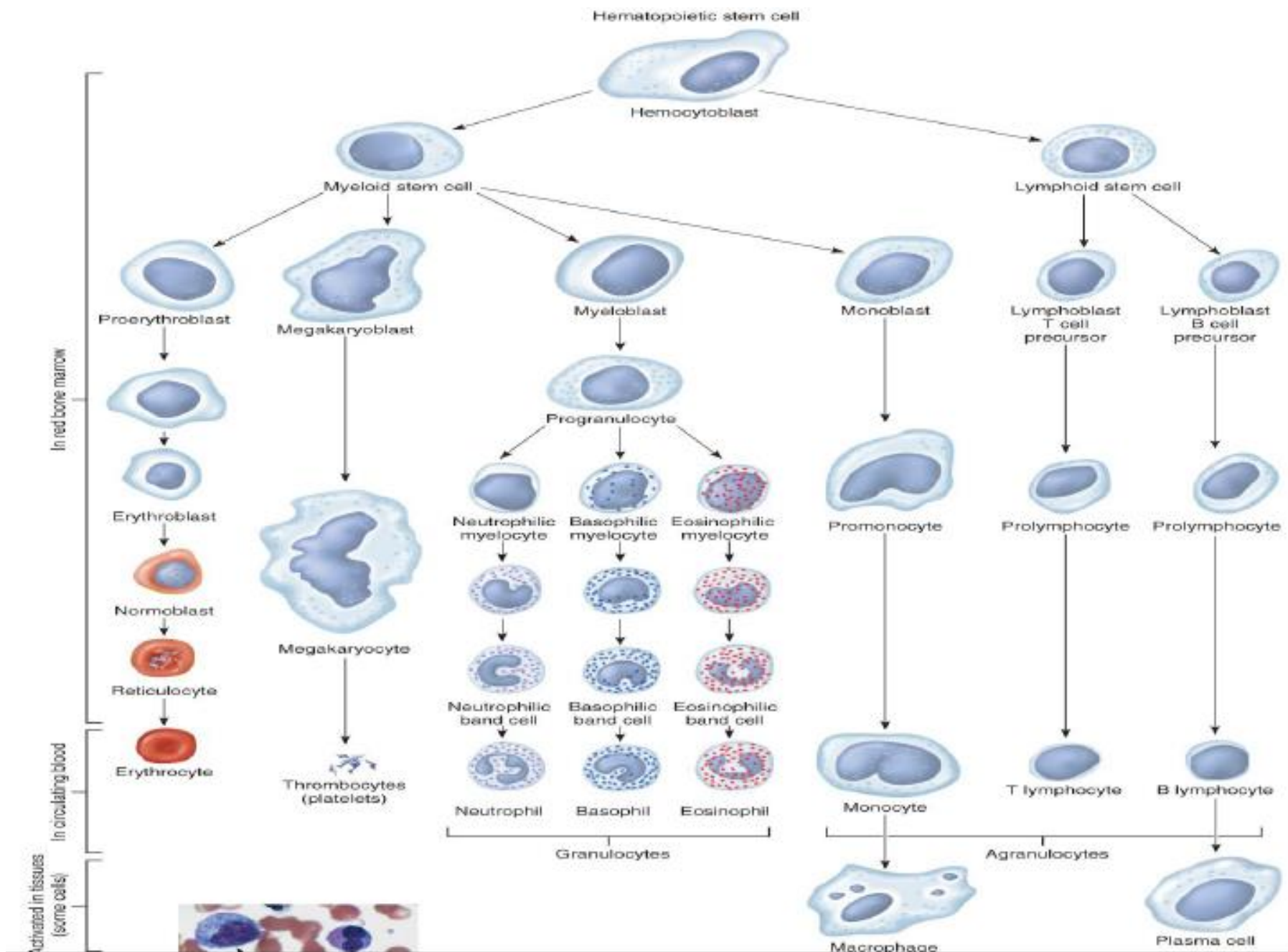
LM 400x

(b)

Figure 19.02b Tortora - PAP 12/e  
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All Blood Cells come from a Large Primitive Cell called a **Hemocytoblast**





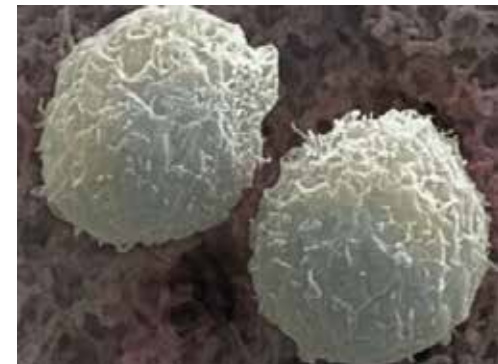
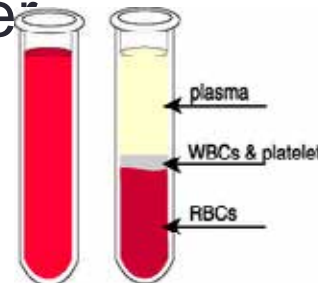
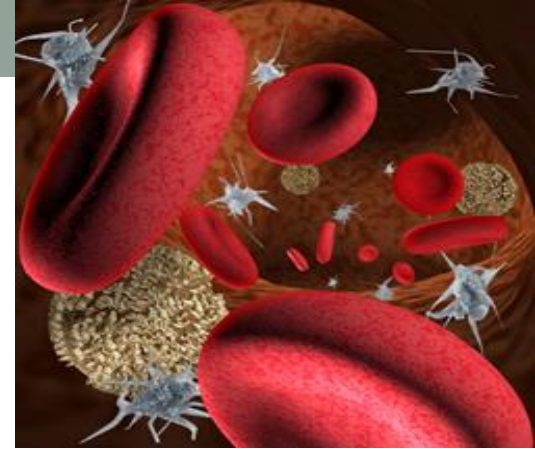
# Blood Cells

- Blood cells are the cells which are produced during hematopoiesis and found mainly in the blood
- **Erythrocytes**
- **Leukocytes**
- **Thrombocytes**



# White Blood Cells

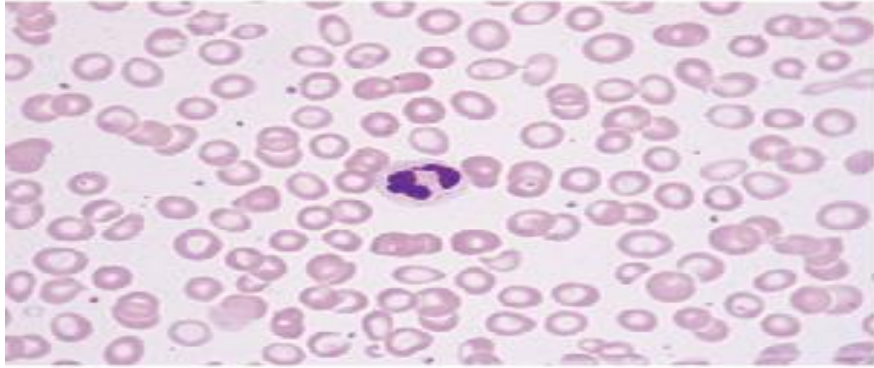
- Leukocytes or WBCs
- Since they do not possess any pigment they appear colourless due to lack of Haemoglobin
- Largest sized blood cells, 8-20 micrometers in diameter
- Lowest numbers in the blood  
(4,500 – 11,000 per microliter) in a healthy individual
- Formed in the bone marrow  
and some in lymph glands
- Contain nuclei with DNA, and other organelles
- The shape depends on type of cell
- Life span is from 24 hours to several years



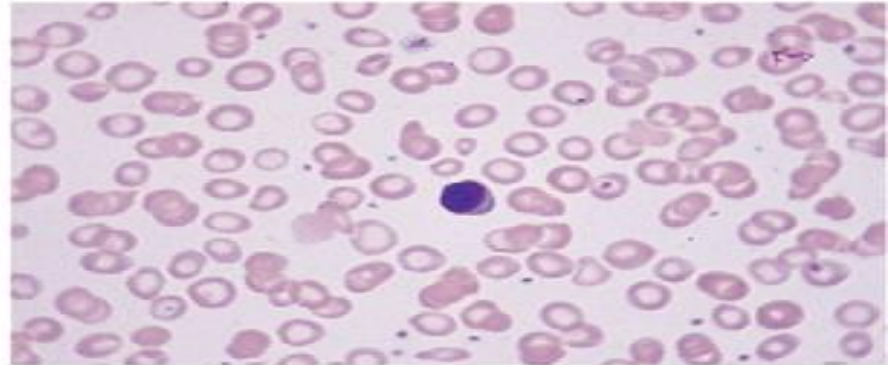
# Leukocytes (White Blood Cells)

- Primary cells of the immune system
- **Control Disease:** fights disease and foreign invaders
- Certain WBCs produce antibodies
- Able to move into and out of blood vessels (diapedesis)
  - Can move by ameboid motion
- Can respond to chemicals released by damaged tissues
- Their function is:
  - to defend the body against pathogens
  - and to remove damaged cells, toxins and other waste products.
- These are also called Scavengers & Microscopic policemen

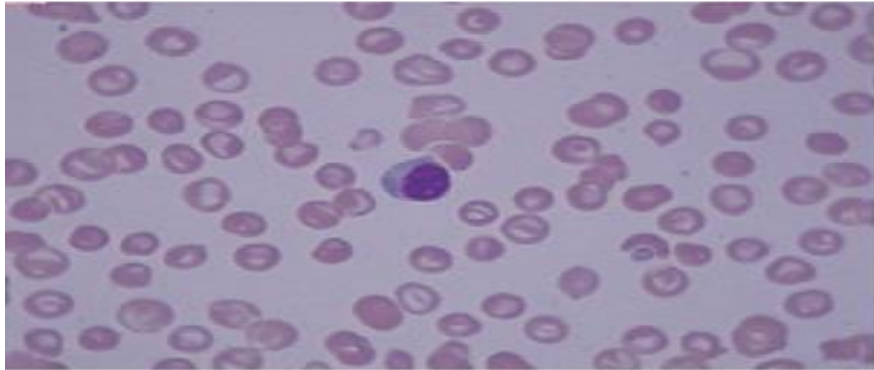
Neutrophil



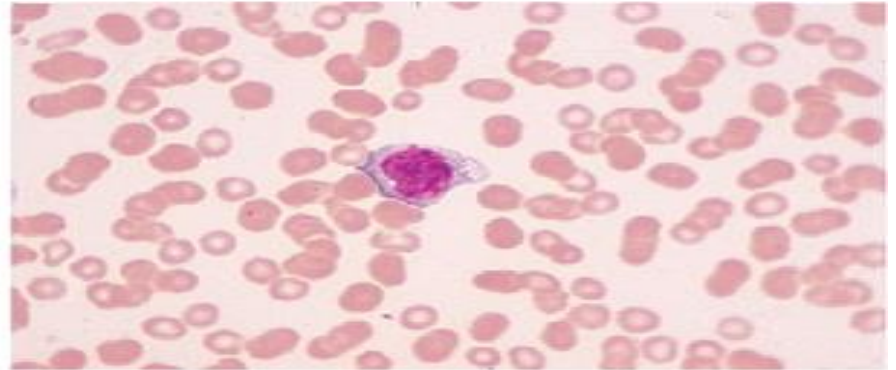
Lymphocyte



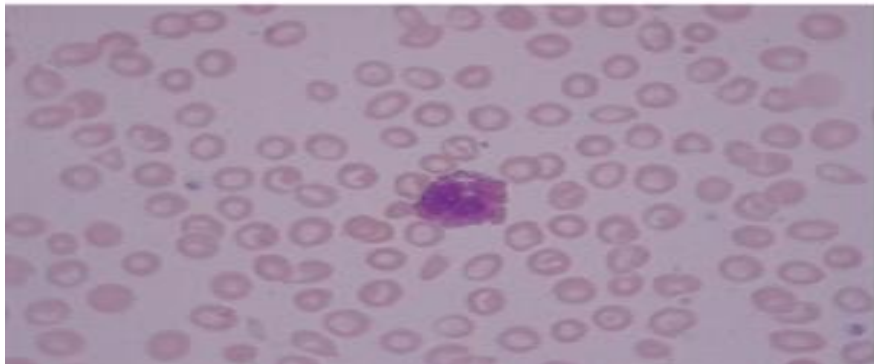
Large granular lymphocyte



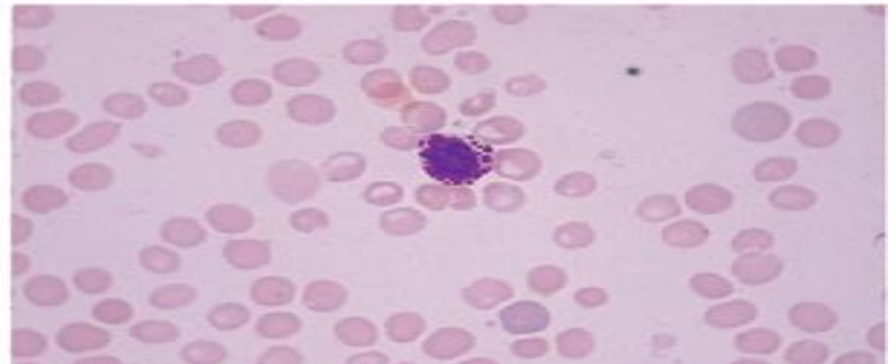
Monocyte



Eosinophil



Basophil



# Types of Leukocytes

- Classified according to:
  - the presence or absence of granules
  - and the staining characteristics of their cytoplasm.
- Leucocytes appear brightly colored in stained preparations, they have a nuclei and are generally larger in size than RBC's.
- Several types of leucocyte can be identified using either Wright's or Giemsa stains.
- Leucocytes can be divided into granulocytes (neutrophils, eosinophils and basophils) and agranulocytes (monocytes and lymphocytes).
- This nomenclature is somewhat misleading, as both types of leucocyte contain secretory vesicles and lysosomes; however, in the agranulocytes these are difficult to observe under the light microscope



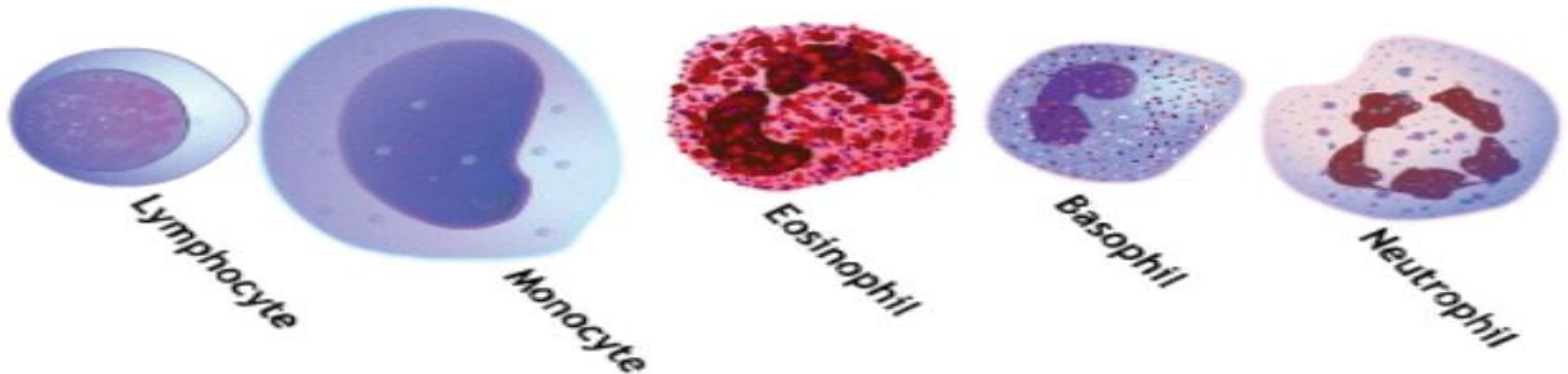
# Types of Leukocytes

## Granulocytes

- Neutrophils
- Eosinophils
- Basophils

## Agranulocytes

- Monocytes
- Lymphocytes



# Characteristics of Leucocytes

Leucocytes have four characteristics that distinguish them from erythrocytes:

- They can migrate out of the bloodstream, In fact leucocytes spend most of their life outside of the blood.
- When activated, they attach to the endothelial lining of the blood vessel, and eventually pass between endothelial cells into the interstitial fluid. This process is known as **emigration** or **diapedesis**.
- They are capable of amoeboid movement: Flow of cytoplasm into cellular processes by means of actin filament rearrangement allows the cells to move around tissues.
- They are attracted by chemical stimuli
  - Positive chemotaxis directs leucocytes to damaged tissue, pathogens and other leucocytes.

# Emigration of WBCs

- Many WBCs leave the bloodstream
- Emigration (formerly diapedesis)
- Roll along endothelium
- Stick to and then squeeze between endothelial cells
- Precise signals vary for different types of WBCs

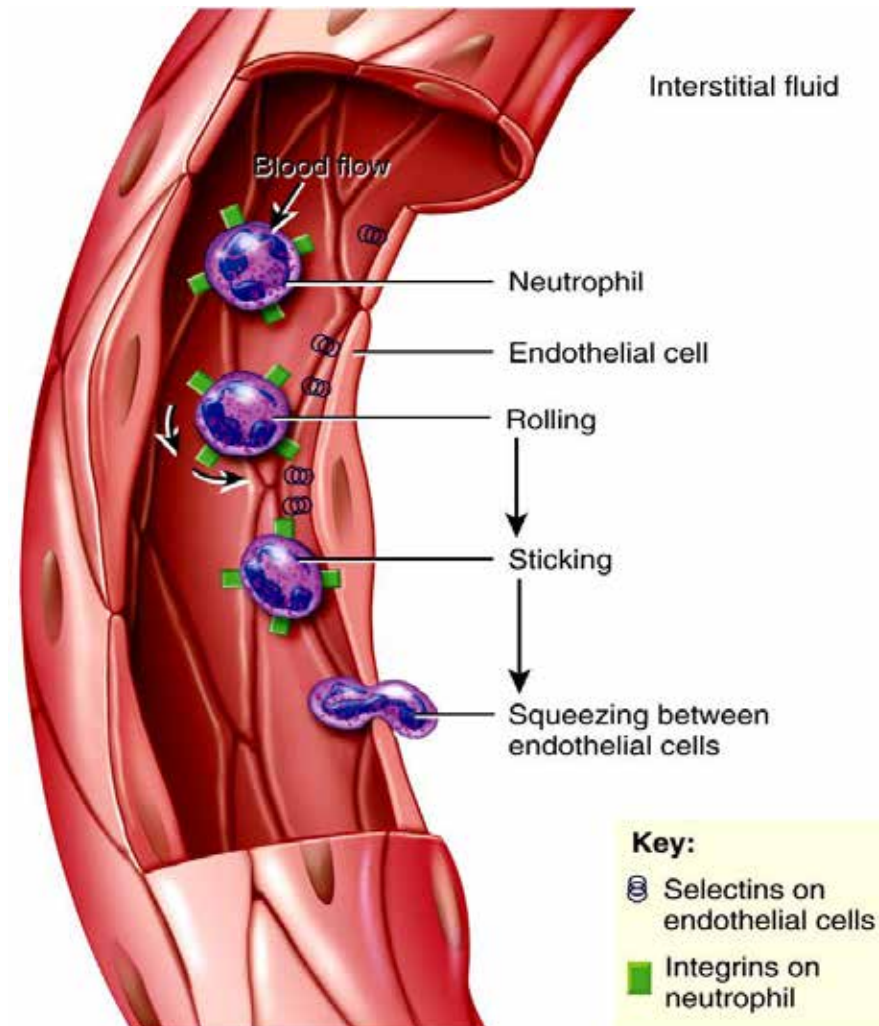


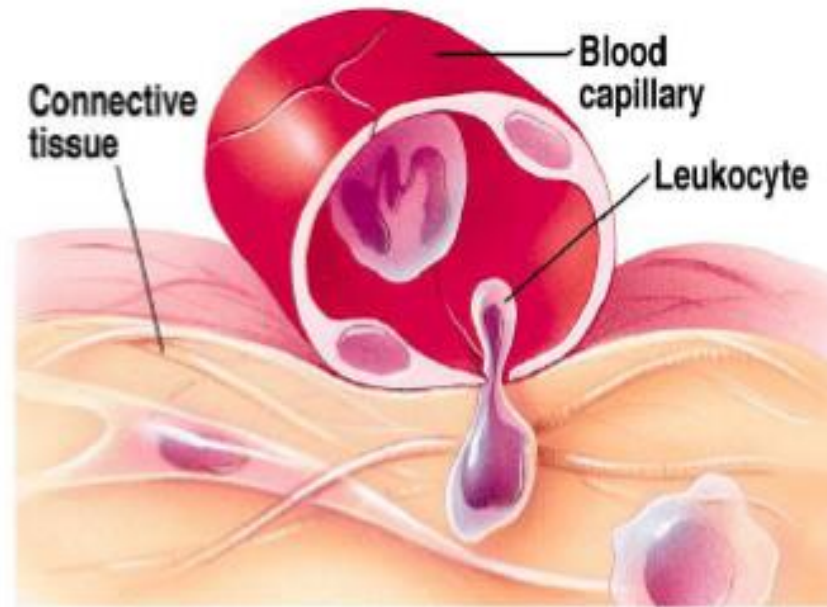
Figure 19.08 Tortora - PAP 12/e  
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# Leukocytes

- **DIAPEDESIS**

- The process by which a leukocyte moves through a capillary wall to enter tissues.

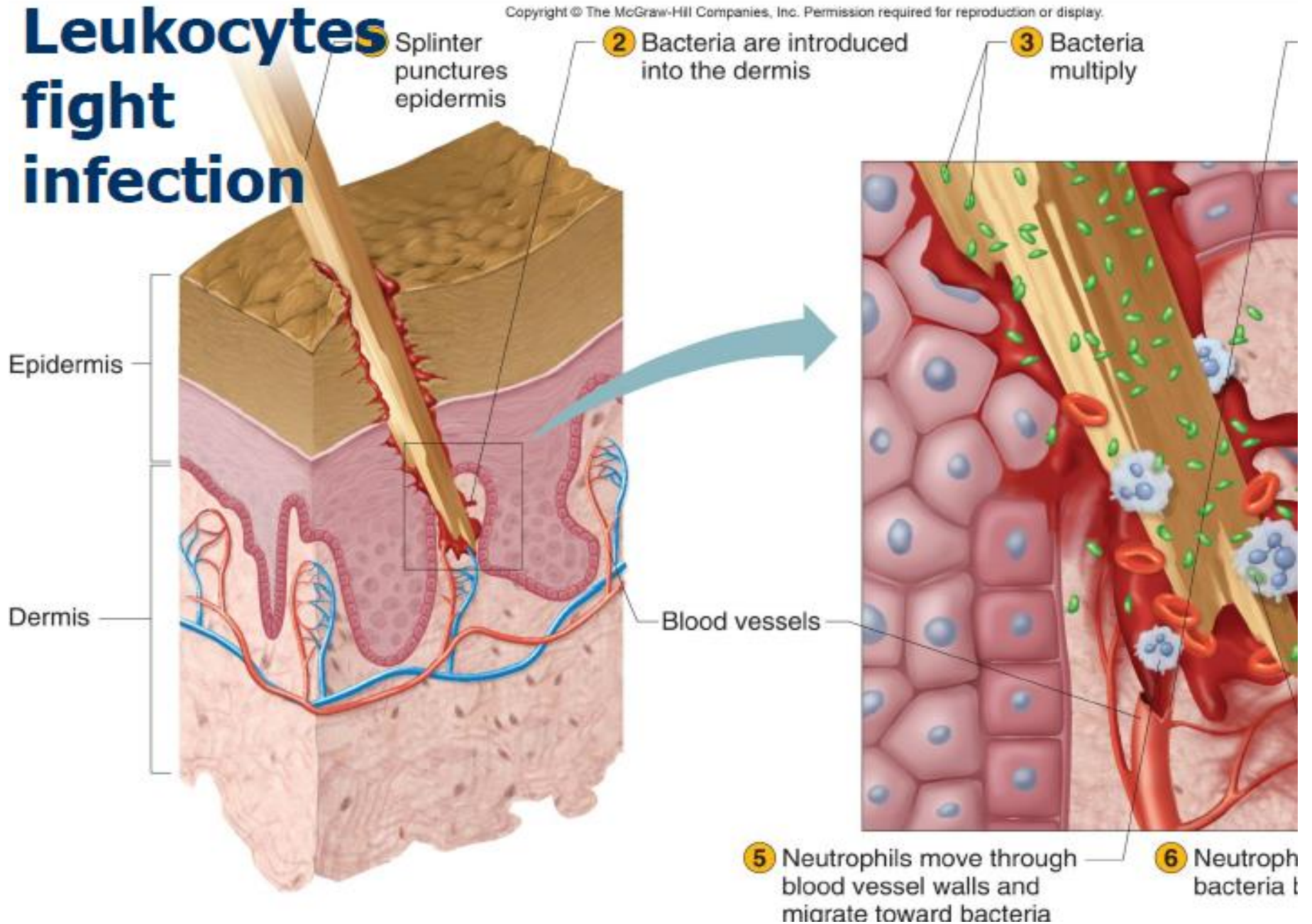
## Leukocyte—Diapedesis





# Leukocytes fight infection

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# Characteristics of Leucocytes

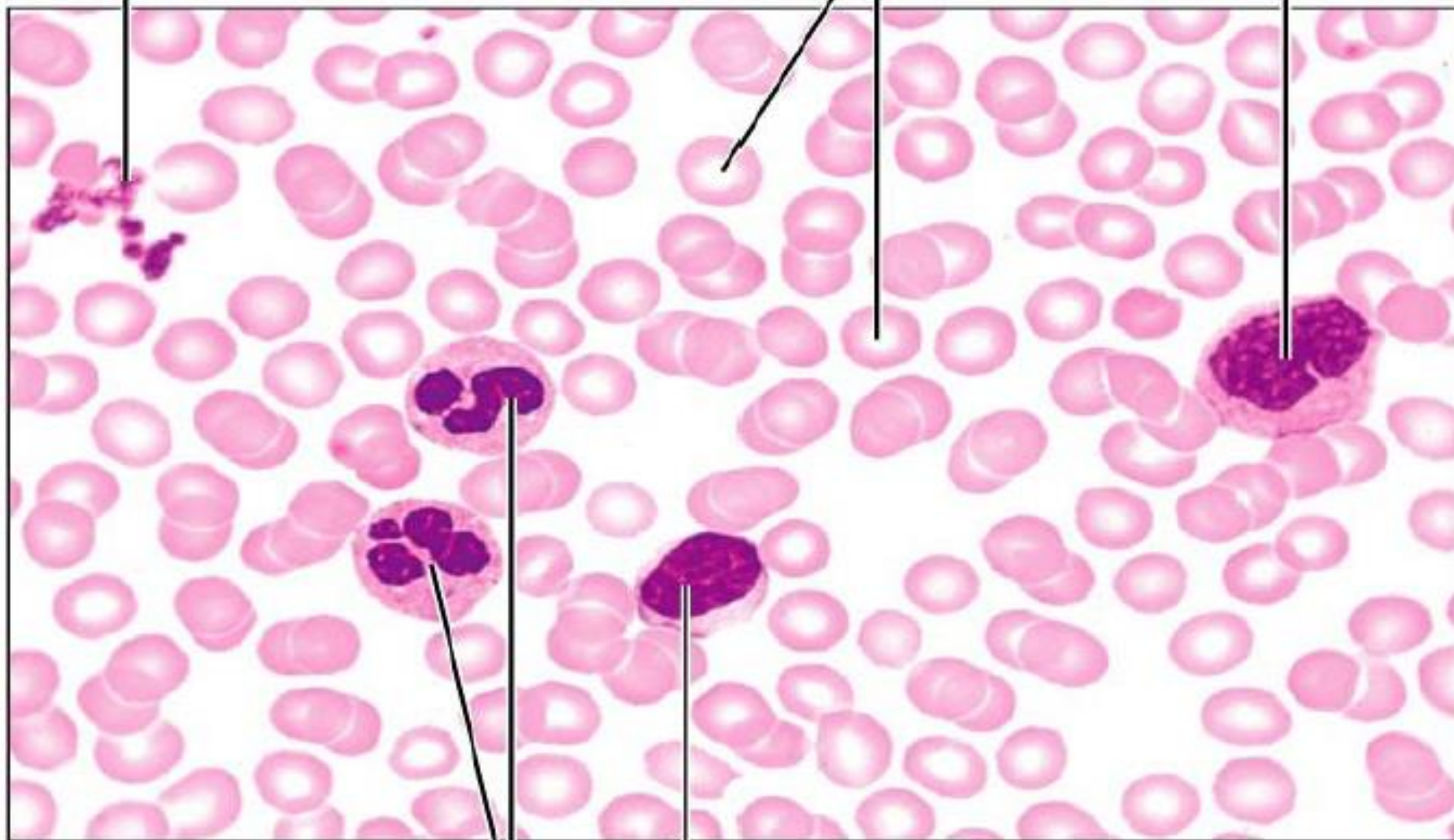
All types of leucocyte play a role in the body's defence mechanism.

- Neutrophils, eosinophils, basophils and monocytes are considered to be **nonspecific**, as they are activated by a variety of stimuli.
- Lymphocytes are responsible for **specific** (immune) responses to infection.

**Platelets**

**Erythrocytes**

**Monocyte**

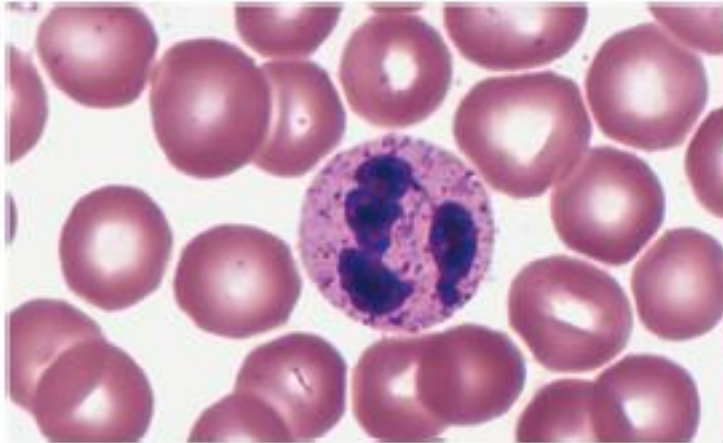


**Neutrophils**

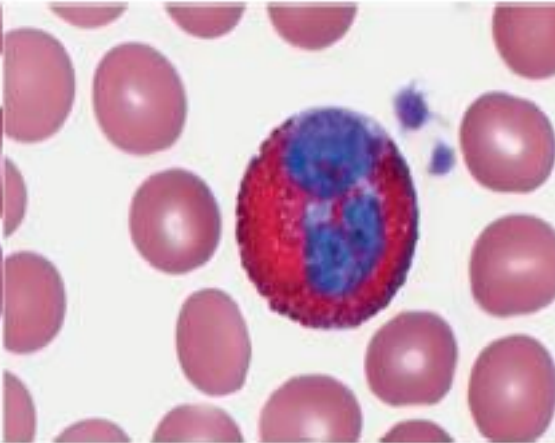
**Lymphocyte**



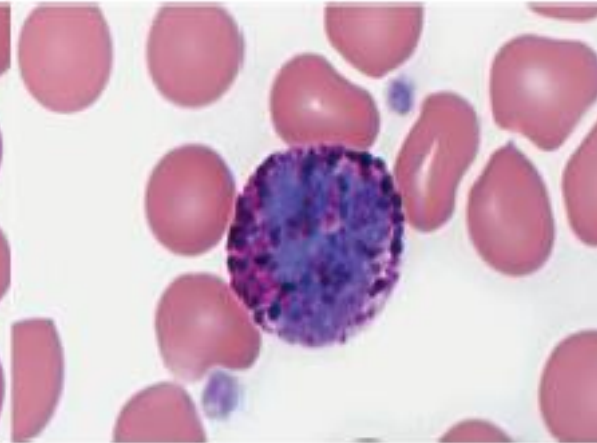
# Leukocytes



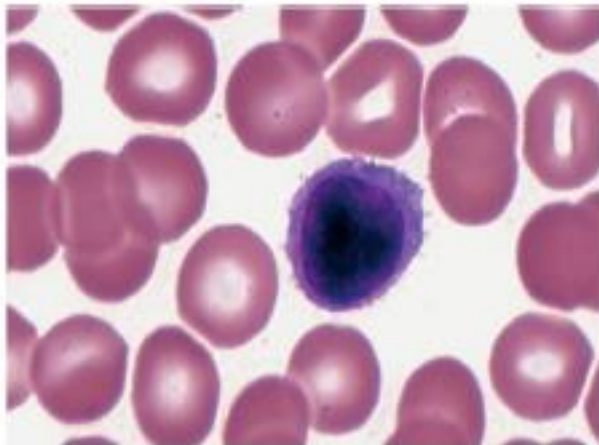
Neutrophil: 54-62%



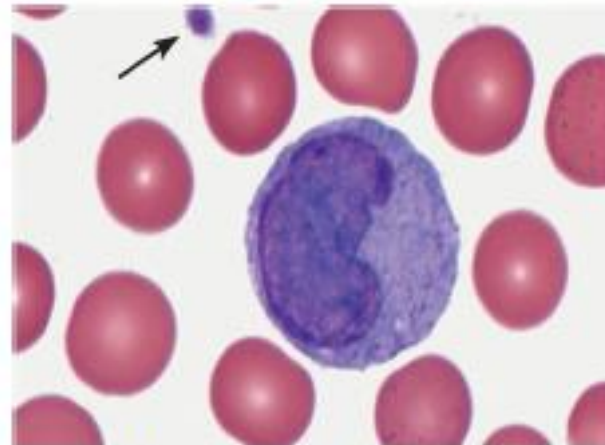
Eosinophil: 1-3%



Basophil: <1%



Lymphocyte: 25-33%



Monocyte: 3-9%



# Neutrophils

- Neutrophils are the **most common** form of leucocyte, representing **50-70%** of circulating white blood cells.
- Neutrophils are also known as **polymorphonuclear** leucocytes, because of the lobular structure of their dense nucleus.
- They are also are **highly mobile**.
- They are the front line in defence against bacterial infections.
- They recognize bacteria that have been labelled with antibodies or complement proteins

# Neutrophils

- The neutrophil releases prostaglandins, which increase capillary permeability and cause inflammation.
- The precise function of fibrinogen is unclear, but it is thought that it may trap microorganisms and facilitate the migration of neutrophils, so limiting the spread of infection.

# Neutrophils

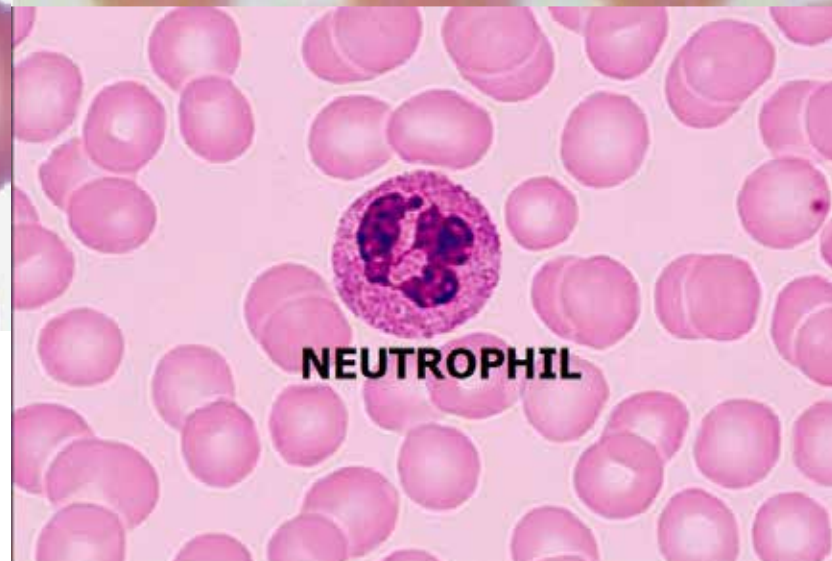
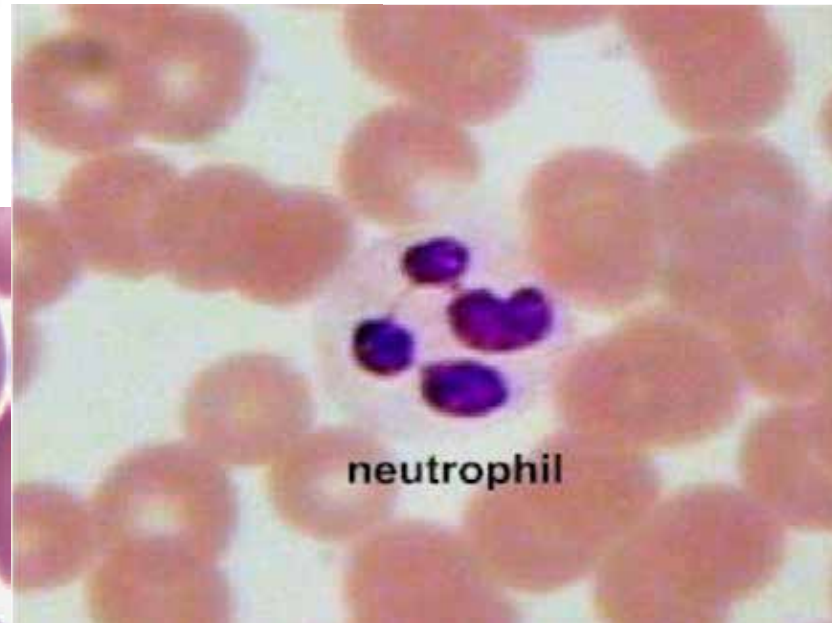
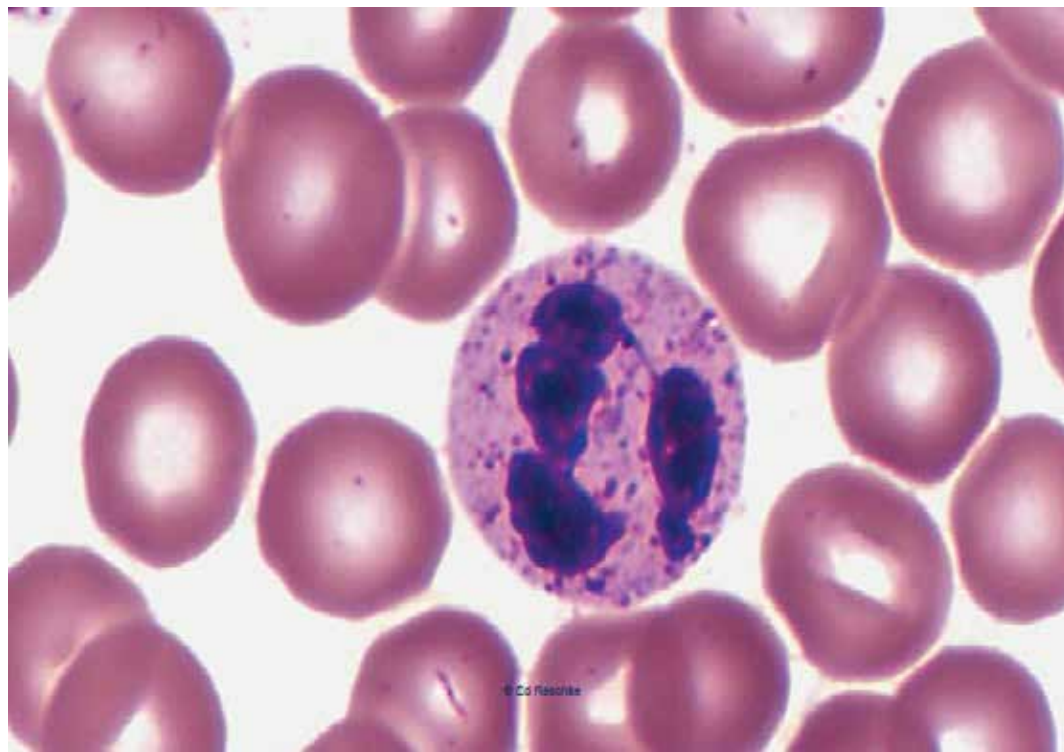
- The lifespan of a neutrophil is short: typically 10 hours, but can be as short as 30 minutes when a neutrophil is actively engulfing bacteria
- The largest pool of neutrophils is in the marrow (reserve pool),
- A small number circulate in the peripheral blood (circulating pool)
- A number similar to that of the circulating pool exists in tissues (tissue pool).

# Neutrophils

- The circulating pool can be further subdivided into two roughly equal compartments:
  - a margined pool of cells loosely adherent to vascular endothelium,
  - and a freely circulating pool.
  - Only the latter can be counted.
- The half-life of a circulating neutrophil is short (6–8 h)



# Neutrophils

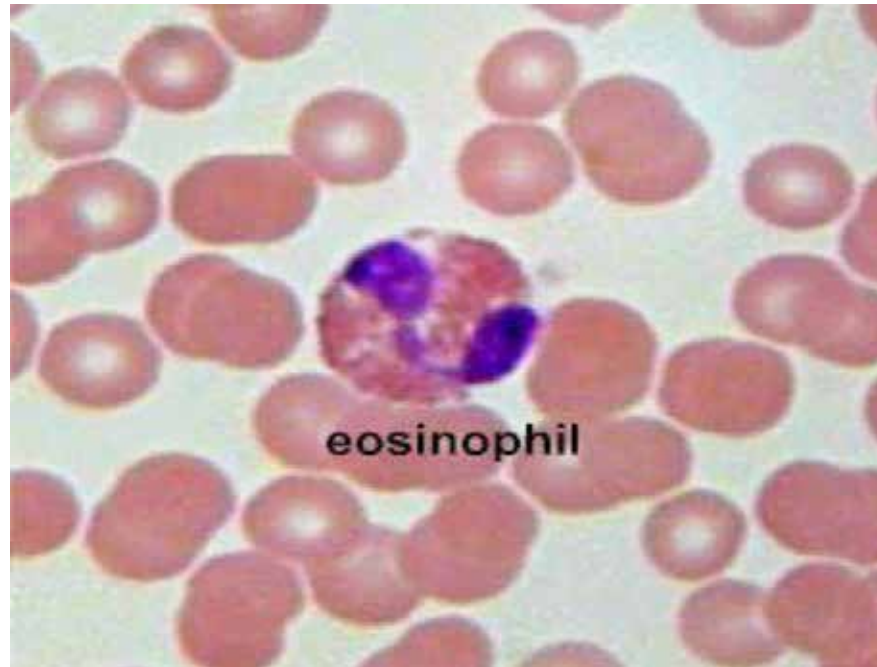
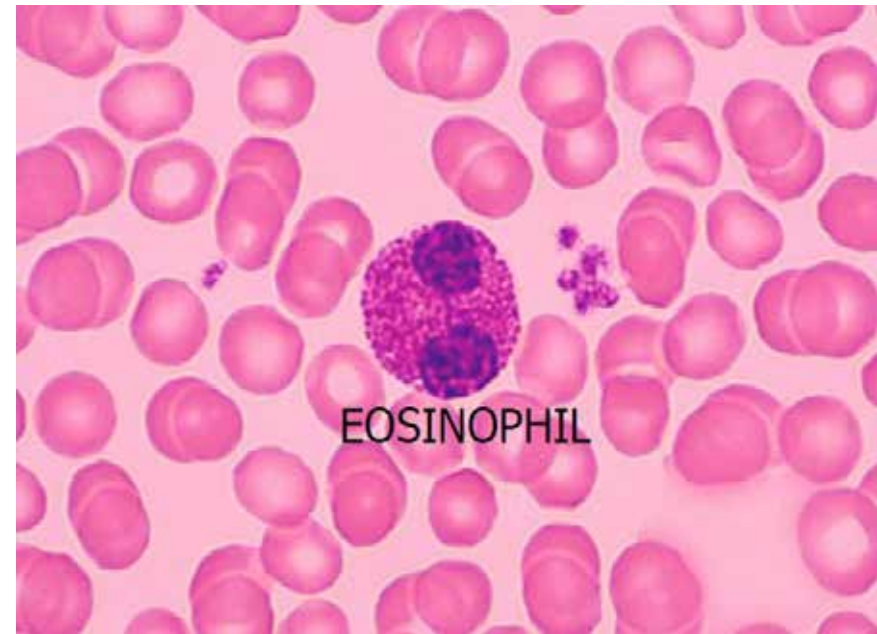
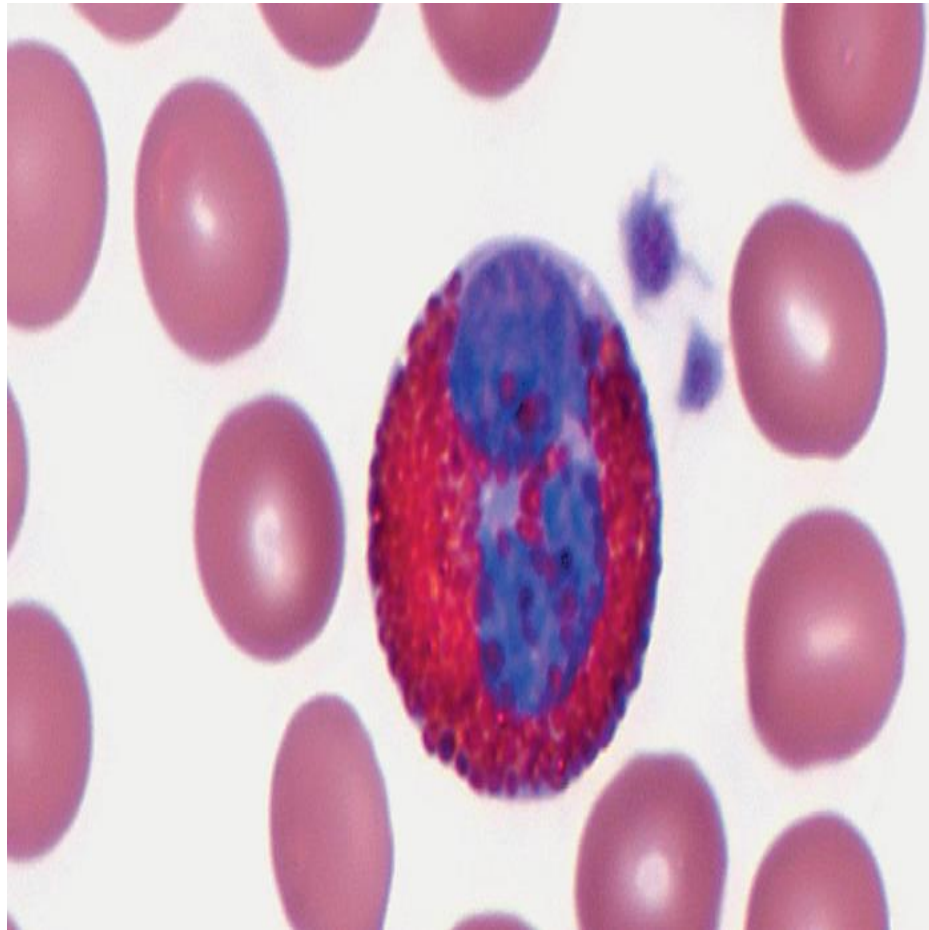


# Eosinophils

- Account for **2-4%** of circulating leucocytes
- Mature eosinophils, which make up 5–10% of granulocytes ( $0.2 \times 10^9/\text{L}$ )
- They are similar in size to neutrophils
- Recognized by their bilobed nucleus and profuse red cytoplasmic granules.

# Eosinophils

- Eosinophils will engulf antibody-tagged bacteria and cell debris, but their main form of attack on foreign bodies is the release of toxic compounds such as nitric oxide and cytotoxic enzymes.
- This approach is effective in tackling large, multicellular organisms that are too big to be engulfed.
- Consequently, the number of eosinophils increases dramatically during a parasitic infection.
- Eosinophils also respond to circulating allergens and may increase in number during an allergic reaction.
- Their other role is to reduce inflammation, restricting the inflammatory actions of neutrophils and mast cells to the site of injury or infection





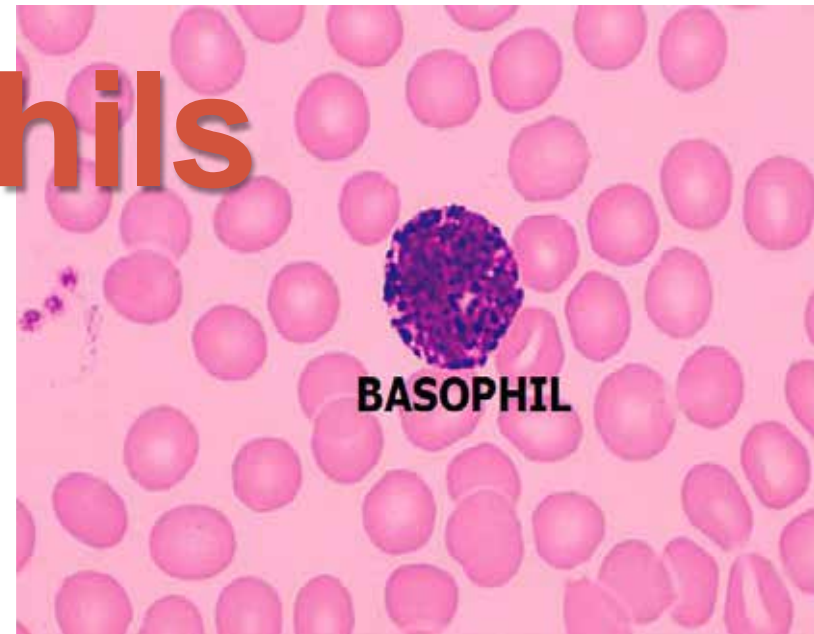
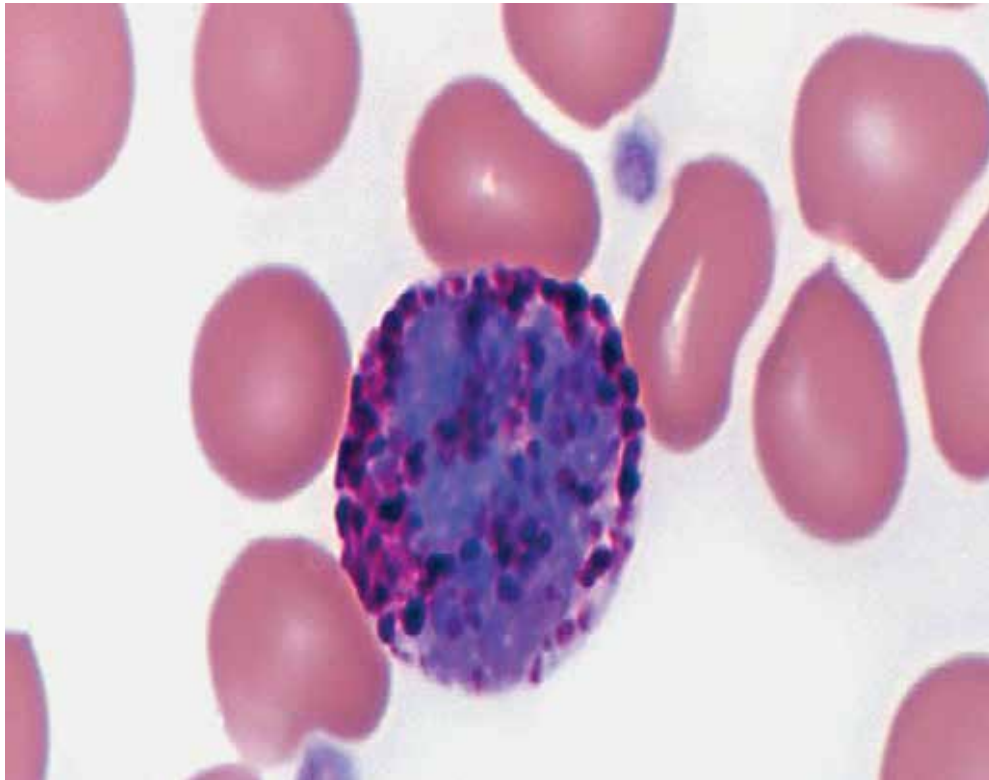
# Basophils

- Basophils are rare, accounting for 1% of leucocytes, and are smaller than neutrophils
- Basophils are the least common granulocytes and are distinguished from eosinophils by large metachromatic (purple-black) granules rich in histamine, serotonin, and leukotrienes.
- Mast cells are related to, but distinct from, basophils.
- Basophils are bilobed, whereas mast cells are long-lived cells that reside in tissues rather than peripheral blood and are capable of cell division.
- Both cell types are involved in immediate and cutaneous hypersensitivity reactions including asthma, urticaria, allergic rhinitis, and anaphylaxis

# Basophils

- Their principal mode of action is to migrate to sites of injury and release histamine and heparin.
- Histamine causes vasodilatation and heparin prevents blood clotting, ensuring that the blood supply to the injured site is maintained.
- Increase during inflammatory reactions
- May leave blood stream and develop into mast cells
  - Antibodies attach and cause mast cells to burst, releasing allergy mediators
  - Have histamine-containing granules
  - Initiate inflammation

# Basophils



# Agranulocytes

- **Lymphocytes** (25% of WBC's!)
  - very rare in blood!
- **Monocytes** (3-8% of WBC's!)
  - differentiate into macrophages once they leave the blood!
  - macrophages highly phagocytic

# Lymphocytes

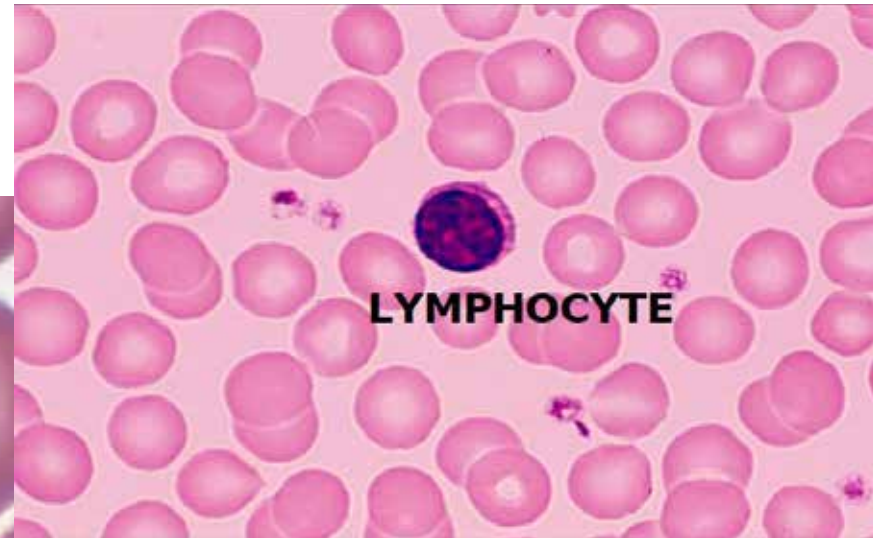
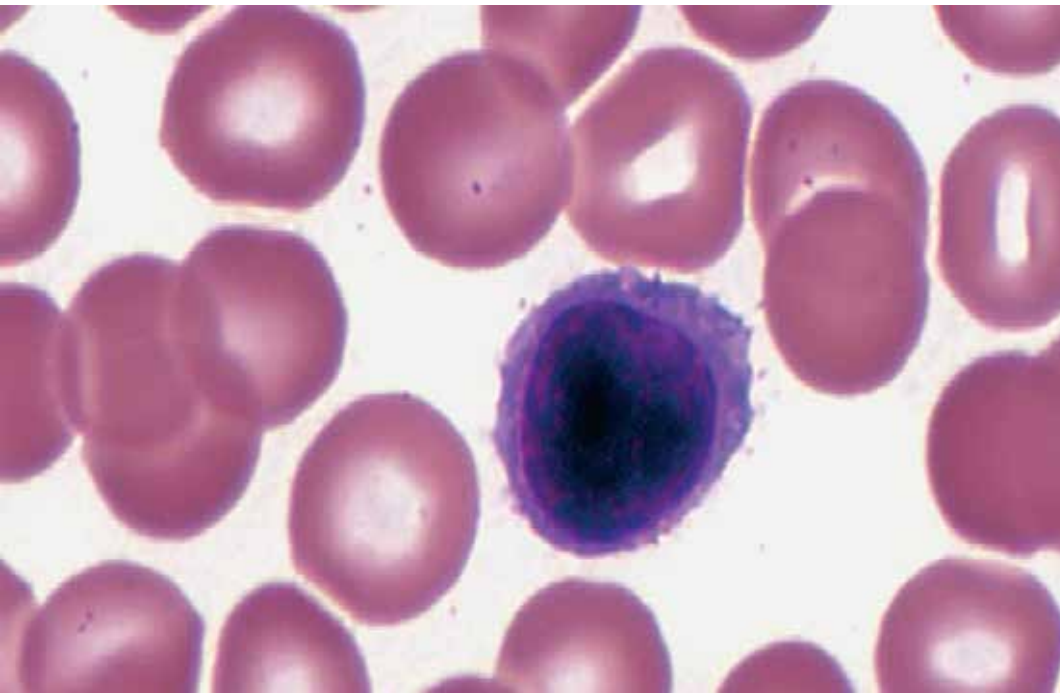
- Lymphocytes have a large, round nucleus surrounded by a thin halo of cytoplasm.
- Nucleus fills most of the cell
- Range in size from 10-14 $\mu$  to small 6-9 $\mu$
- Lymphocytes represent about a third of the white blood cells in the peripheral blood ( $1.0\text{--}4.0 \times 10^9/\text{L}$ ).
- Live for months to years .
- Lymphocytes are responsible for the specific defence response to infection known as immunity.
- Increased during viral infections (TB, whooping cough), and tumors
- Decreased in immune disorders



# Lymphocytes

- They may be divided into three types: T cells, B cells, and natural killer (NK) cells.
- Two thirds are T cells, which participate in cell-mediated immune responses
- The remainder are B cells, which are programmed to produce antibodies
- B and T lymphocytes cannot be distinguished morphologically
- The third class of lymphocyte is the NK cell, which is responsible for immunological surveillance of normal tissues.
- These cells are called natural killer cells because of their ability to destroy virus infected and HLA-incompatible target cells.
  - Cancer cells expressing tumour specific antigens can be identified and destroyed in this manner.
  - cells infected with viruses express viral antigens on their membranes
  - transplanted cells and thus play role in the rejection of allogeneic bone marrow cells and solid organ transplants

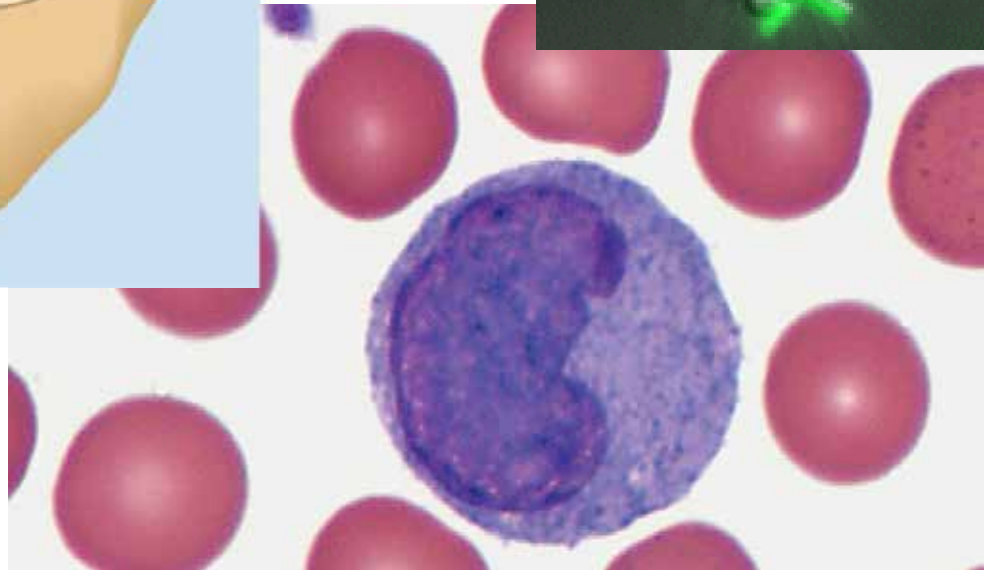
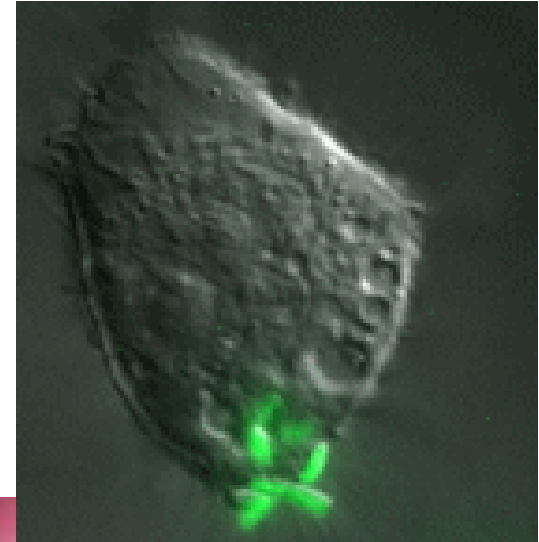
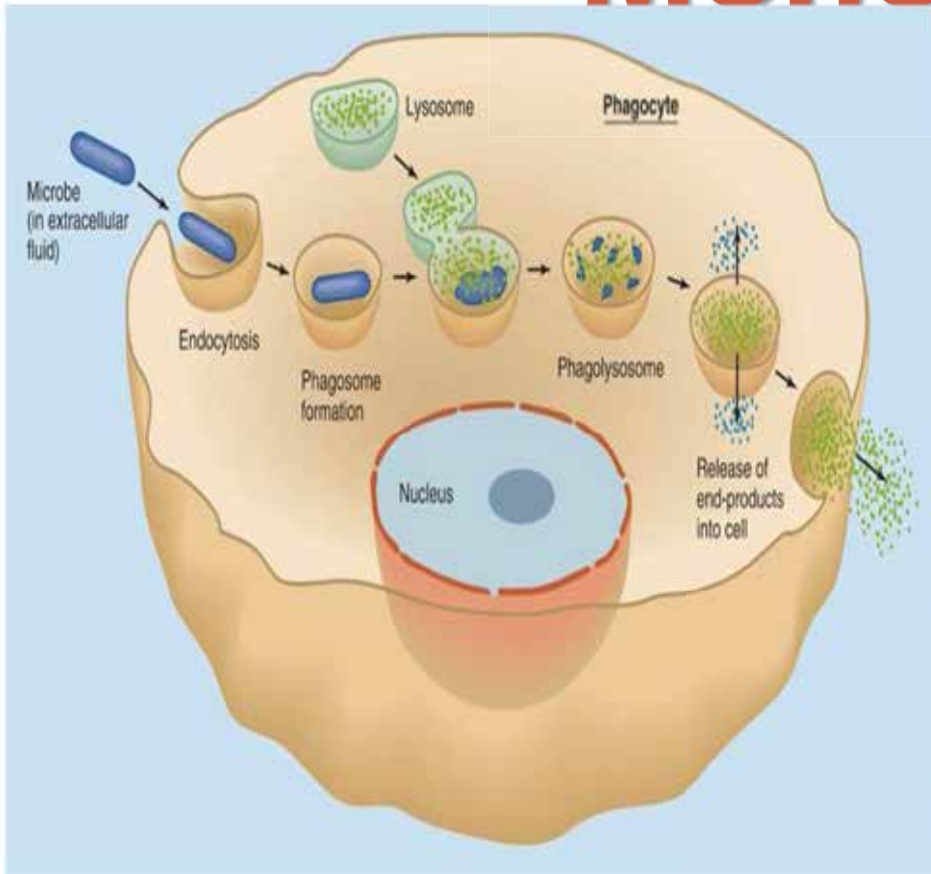
# Lymphocytes



# MONOCYTES

- Largest leukocyte (12-20u)
- 2-8% of leucocytes. ( $0.3 \times 10^9/L$ )
- Oval or kidney-shaped (folded) nucleus
- They spend only a short time in the circulation (24 hours) before entering the tissue where they become tissue macrophages.
- In blood, phagocyte
- In tissues, macrophage(active phagocytes that engulf large objects)
- Increased in viral and fungal infections (typhoid fever, malaria, mononucleosis) and chronic disease

# Monocytes



<b>Leukocyte Type</b>	<b>Normal Differential Percentage</b>	<b>High Count May Indicate</b>	<b>Low Count May Indicate</b>
<b>Neutrophils</b>	<b>54-62%</b>	<b>Bacterial infection, burns, stress, inflammation</b>	<b>Radiation exposure, drug toxicity, B12 deficiency, SLE</b>
<b>Lymphocytes</b>	<b>25-33%</b>	<b>Viral Infections, Some leukemias</b>	<b>Prolonged illness, immunosuppression, cortisol treatment</b>
<b>Monocytes</b>	<b>3-9%</b>	<b>Viral or fungal infections, TB, some leukemias, other chronic diseases</b>	<b>Bone marrow depression, cortisol treatment</b>
<b>Eosinophils</b>	<b>1-3%</b>	<b>Allergic reactions, parasitic infections, autoimmune disease</b>	<b>Drug toxicity, stress</b>
<b>Basophils</b>	<b>&lt;1%</b>	<b>Allergic reactions, leukemias, cancers, hypothyroidism</b>	<b>Pregnancy, ovulation, stress, hyperthyroidism</b>

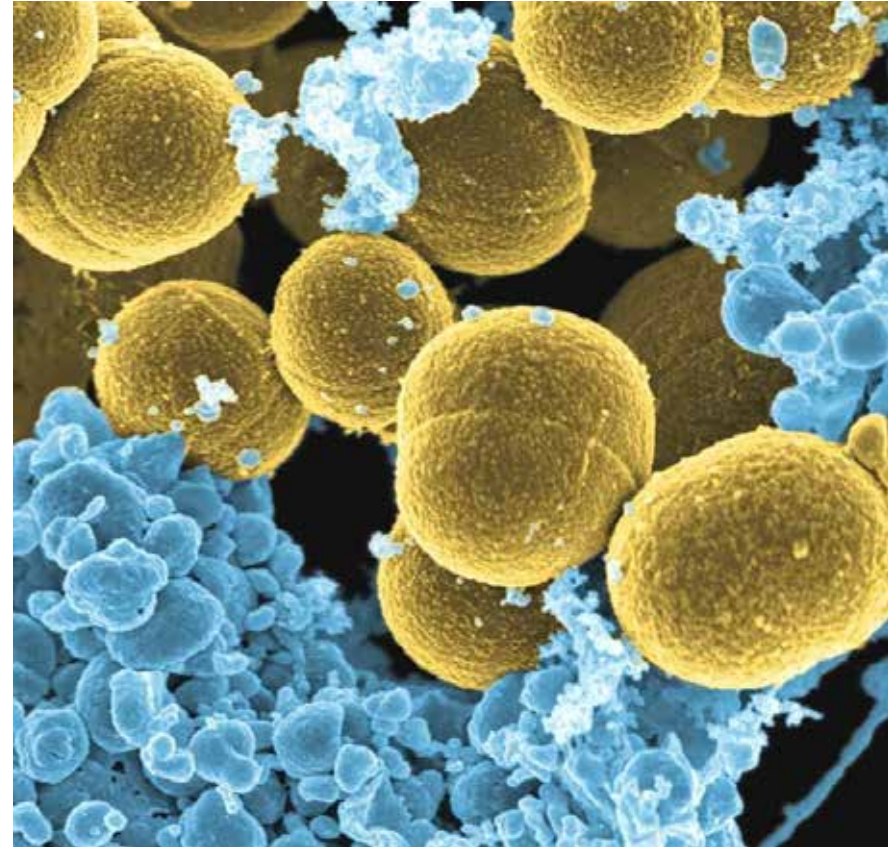


# Leukocytes (White Blood Cells)

- Total white blood cell count: 4,000 and 11,000 cells/  $\mu$ l
- The number of leukocytes ranges during the day , there is a maximum in the evening.
- **Leukocytosis** is a high white blood cell count:
  - microbes, strenuous exercise, anesthesia or surgery
- **Leukopenia** is low white blood cell count:
  - radiation, shock or chemotherapy
- Only **20 %** of total WBC population is in circulating blood at any given time, rest is in lymphatic fluid, skin, lungs, lymph nodes & spleen

# Physiological leukocytosis are:

- Food: after eating , especially protein
- Hard physical work
- Stress (psycho-emotional)
- Pregnant
- Ovulation
- In newborns



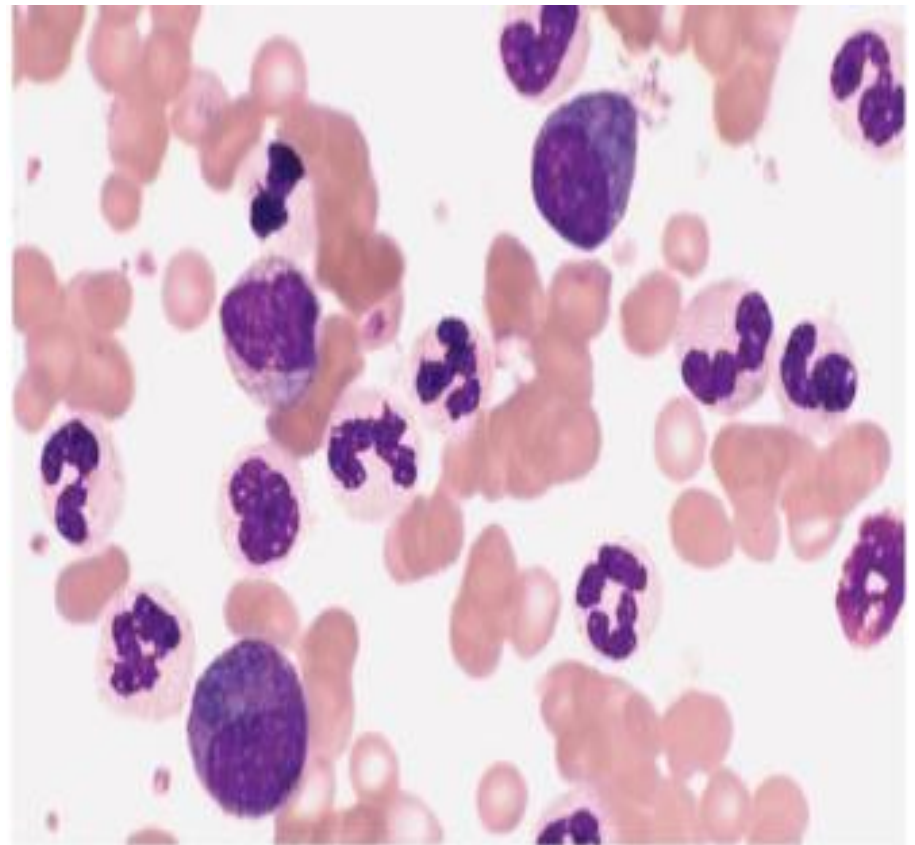
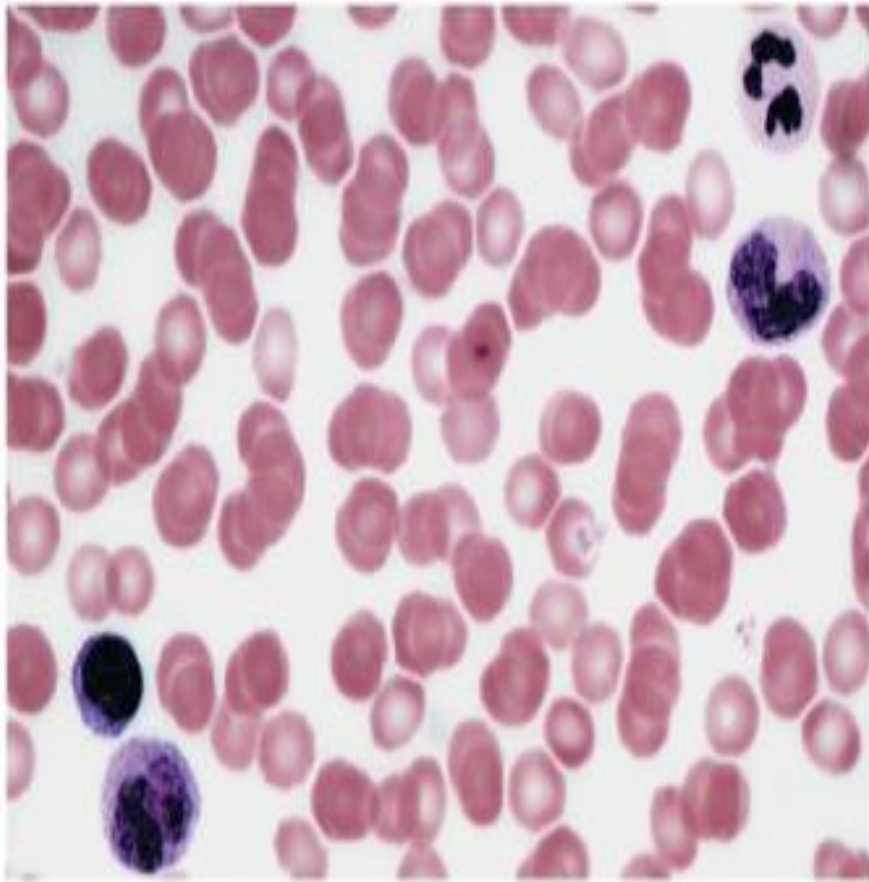
# Leukocyte Disorders

- Leukemias
- Infectious Mononucleosis

# Leukemia

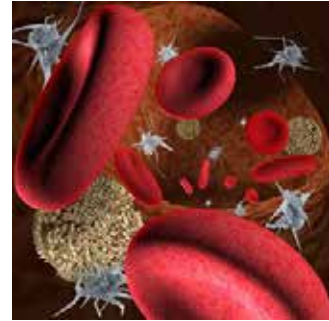
- Abnormal (uncontrolled) production of a specific type of immature leukocyte

# Normal versus leukemia (granulocytic leukemia – a type of myeloid leukemia)

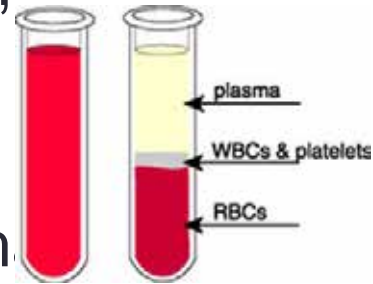




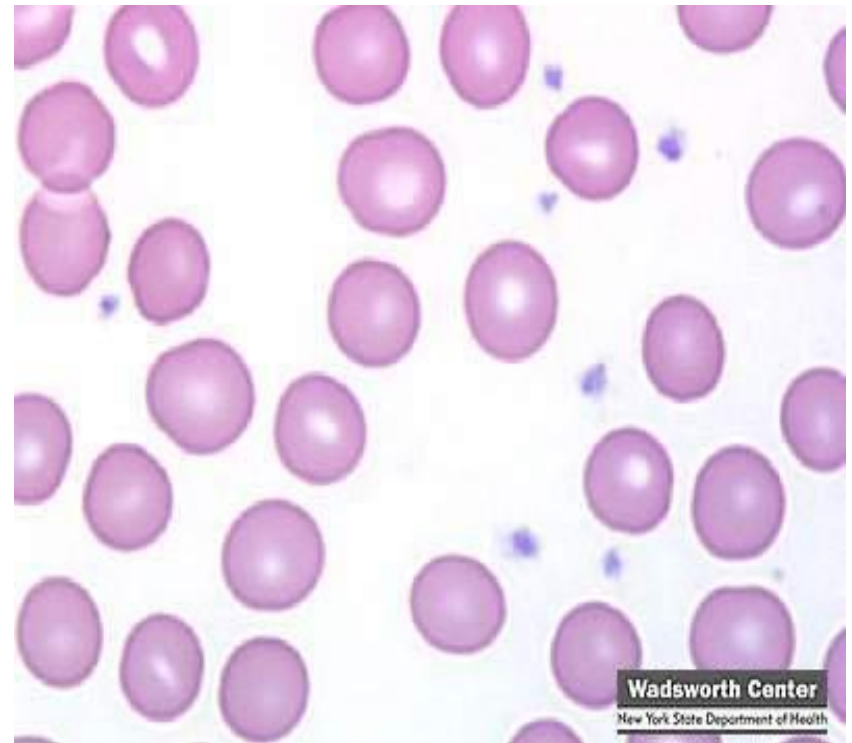
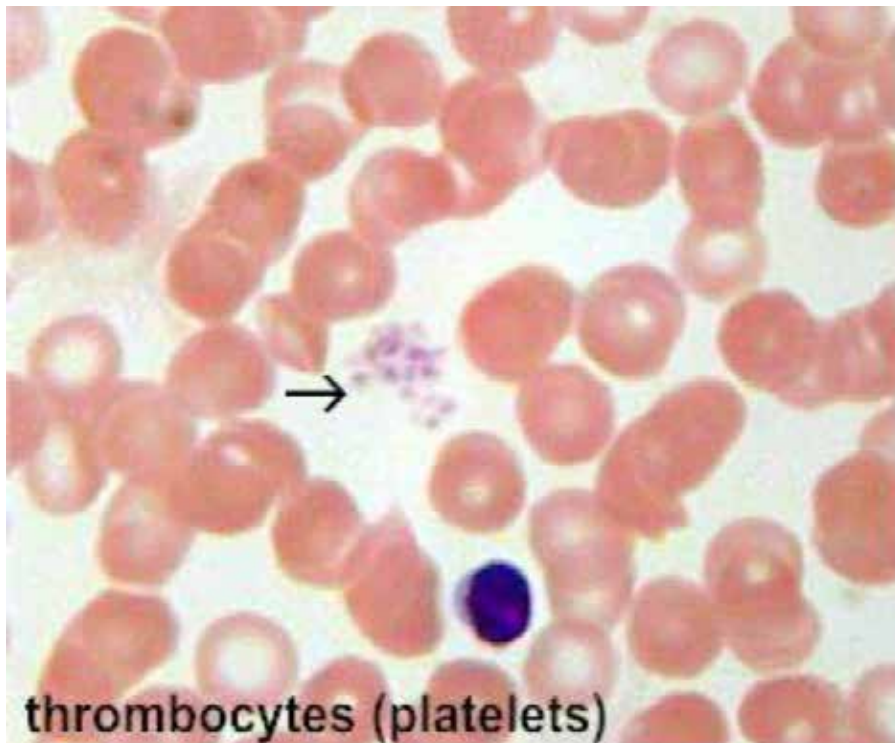
# Platelets



- Thrombocytes or Platelets (special cell fragments, thrombocytes)
- Smallest of the blood cells
- Disc-shaped, 2 - 4 micron cell fragment with with m. vesicles but no nucleus
- Shape can be round, oval, or appear spiky
  - Platelets stain bluish with reddish or purple granules
  - Normal platelet count is 150,000-400,000/drop of blood
- Short life span – 5-9 days



# Platelets



# Platelets



- Fragments of extraordinary large cells (megakaryocytes)
- Thrombopoietin
- Myeloid stem cells develop eventually into a megakaryocyte
- Splinters into 2000-3000 fragments
- Each fragment enclosed in a piece of plasma membrane
- Granules contain blood clot promoting chemicals
- Platelets help stop blood loss from damaged vessels by forming a platelet plug

