CHAPTER TWO:
Blood And Its Function

Blood

- By the end of the lesson you should be able to:
- State the composition of Blood
- State the function of red blood cells,white blood cells and plasma
- State the function of haemoglobin in the transport of oxygen
- State the function of macrophages and lymphocytes

Blood

- Blood is a specialized tissue consisting of several types of cells suspended in fluid medium called plasma.
- the average human has 5 litres of blood
- it is a transporting fluid
- it carries vital substances to all parts of the body

Blood

- Performs a wide range of functions.

Blood

- The only fluid tissue in the human body
- Taste, Odor, 5x thicker than water
- Classified as a connective tissue
  - Living cells = formed elements
  - Non-living matrix = plasma (90% water)

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
- Slightly alkaline
- Blood temperature is slightly higher than body temperature
- 5-6 Liters or about 6 quarts /body

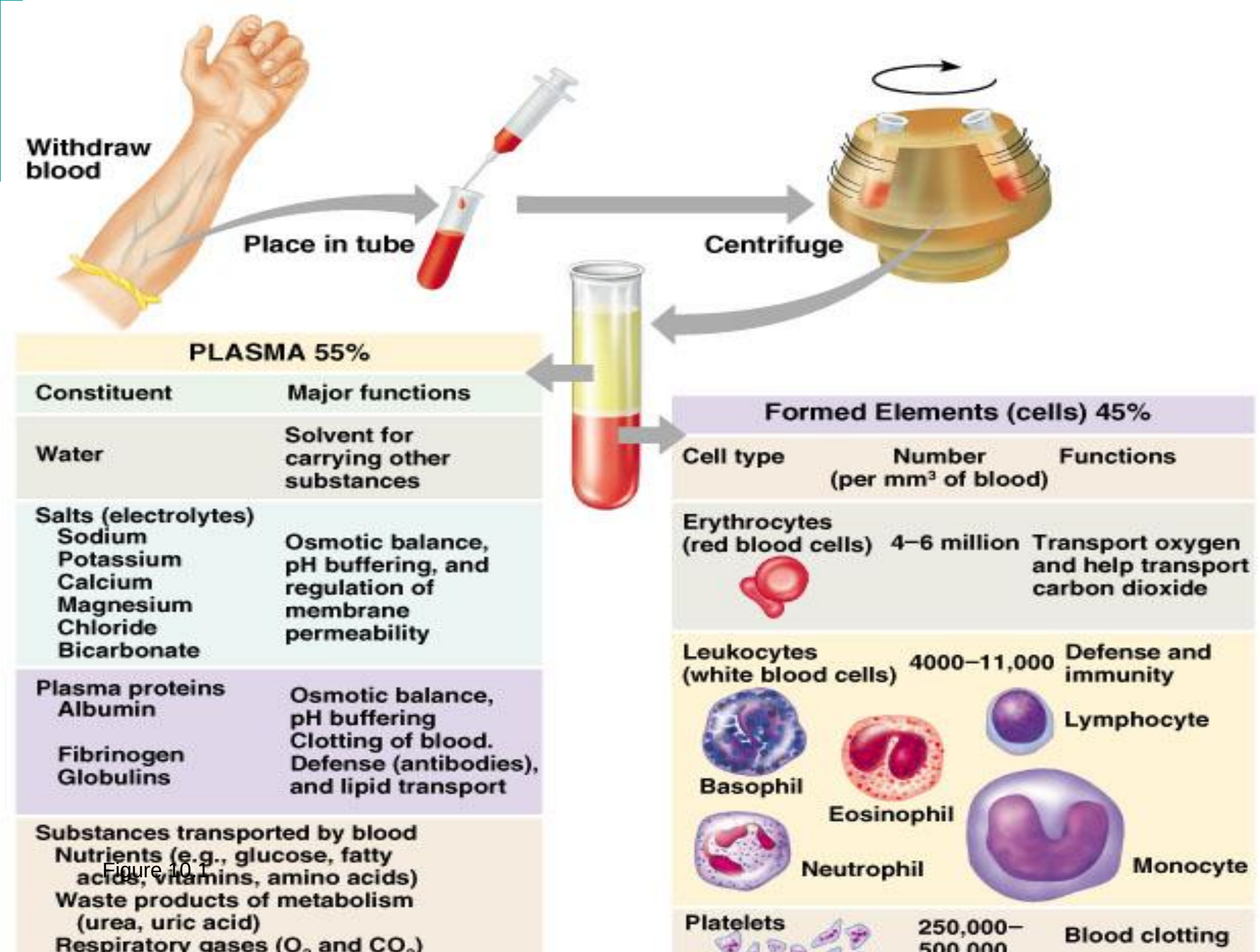
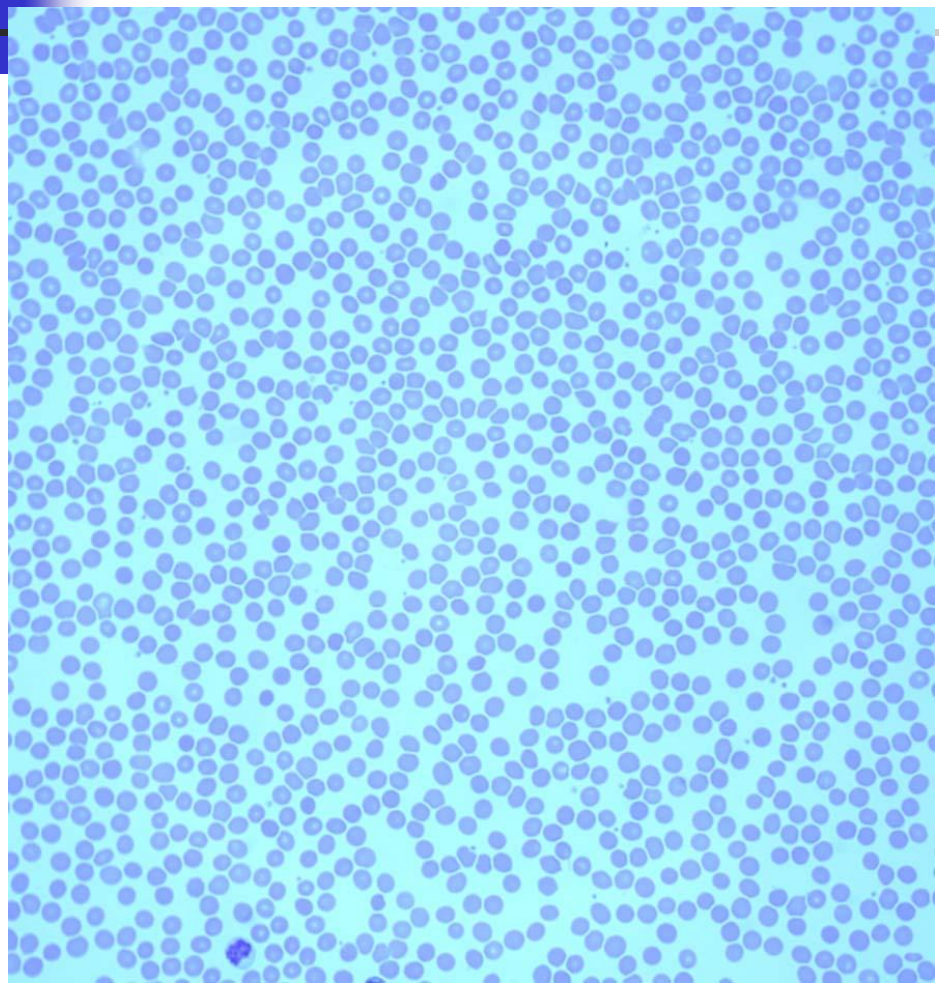
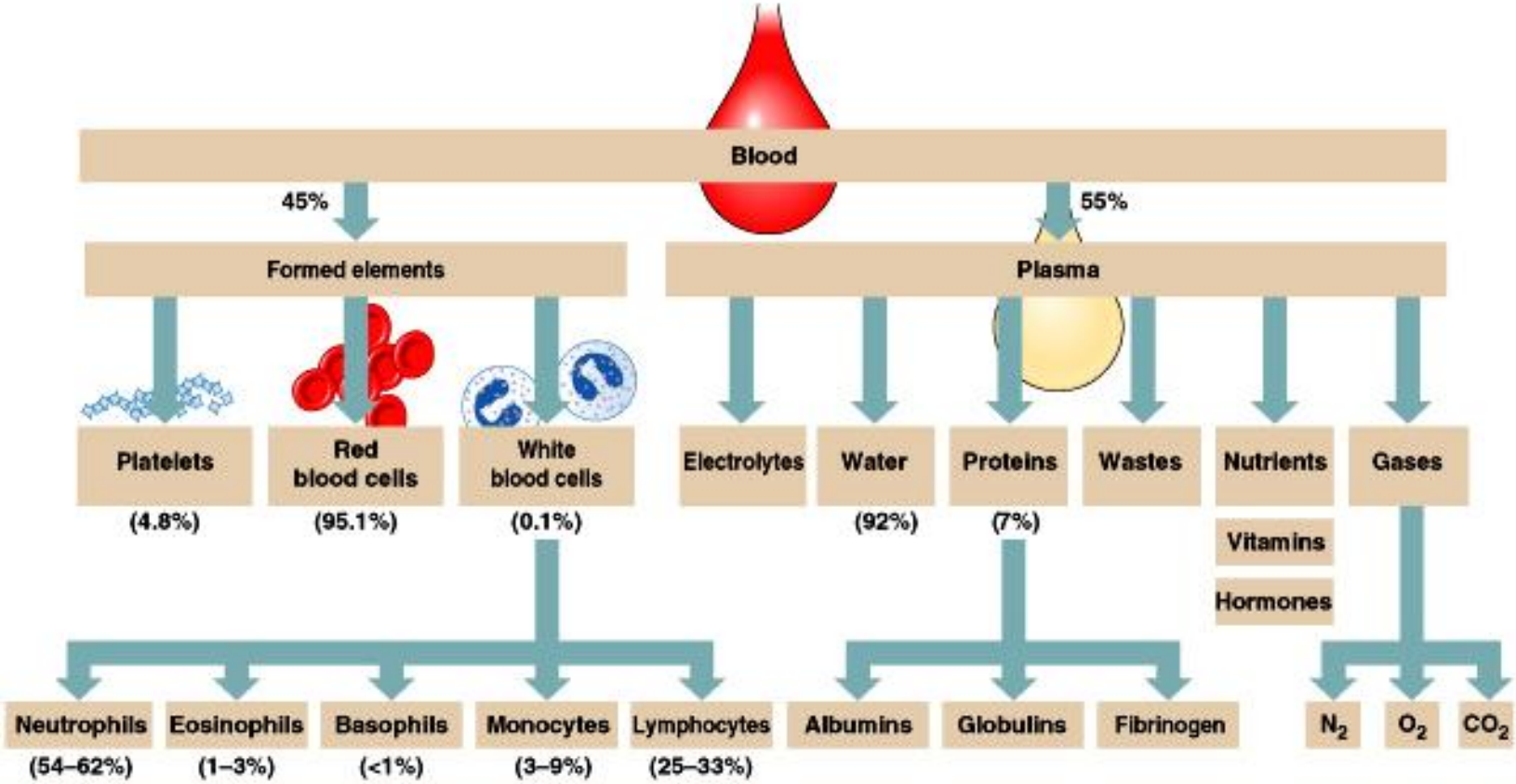

Withdraw blood
Place in tube
Centrifuge
PLASMA 55%
Constituent
Major functions
Water
Solvent for carrying other substances
Salts (electrolytes)
Sodium
Potassium
Calcium
Magnesium
Chloride
Bicarbonate
Osmotic balance, pH buffering, and regulation of membrane permeability
Plasma proteins
Albumin
Fibrinogen
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 (O2 and CO2)
Formed Elements (cells) 45%
Cell type
Number (per mm³ 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
Lymphocyte
Basophil
Eosinophil
Neutrophil
Monocyte
Platelets
250,000–500,000
Blood clotting

Figure 10.1

Human blood smear



X 500



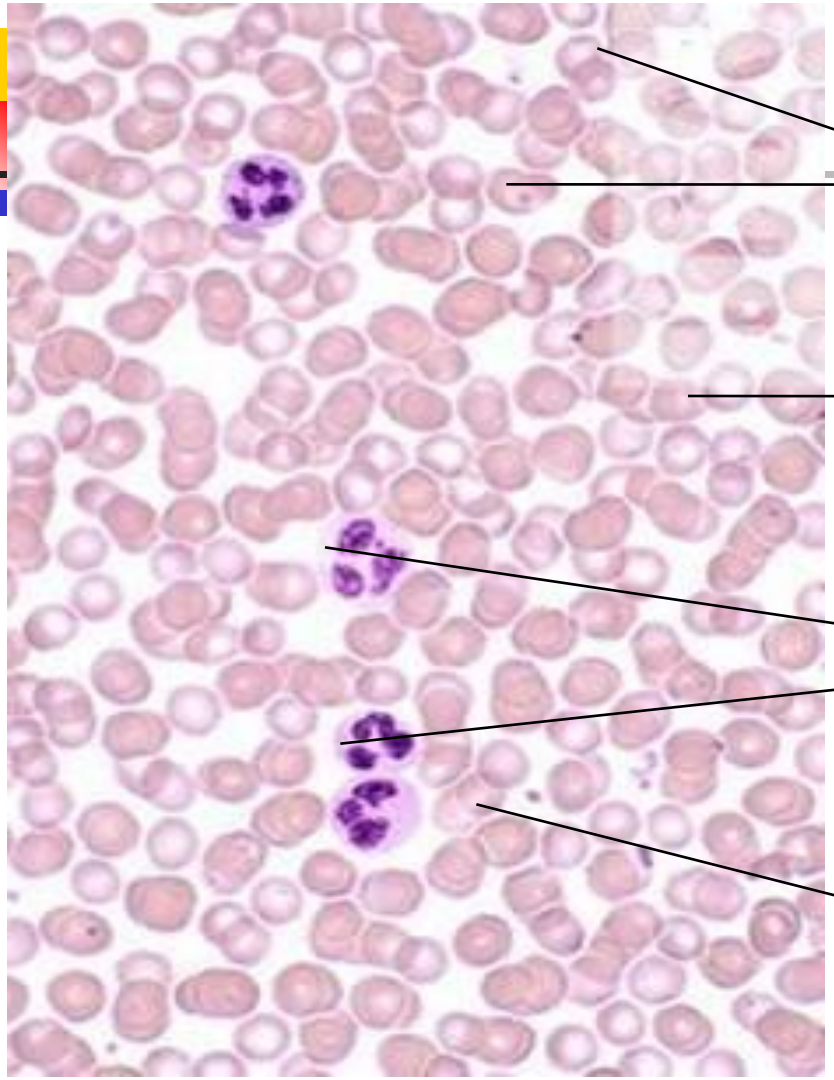
Blood Plasma

- Composed of approximately 90 percent water
- Includes many dissolved substances
  - Nutrients, Salts (metal ions)
  - Respiratory gases
  - Hormones
  - Proteins, Waste products

Plasma Proteins

- Albumin – regulates osmotic pressure
- Clotting proteins – help to stem blood loss when a blood vessel is injured
- Antibodies – help protect the body from antigens

school blood plasma



plasma (55%)

red blood cells(44%) - erythrocytes

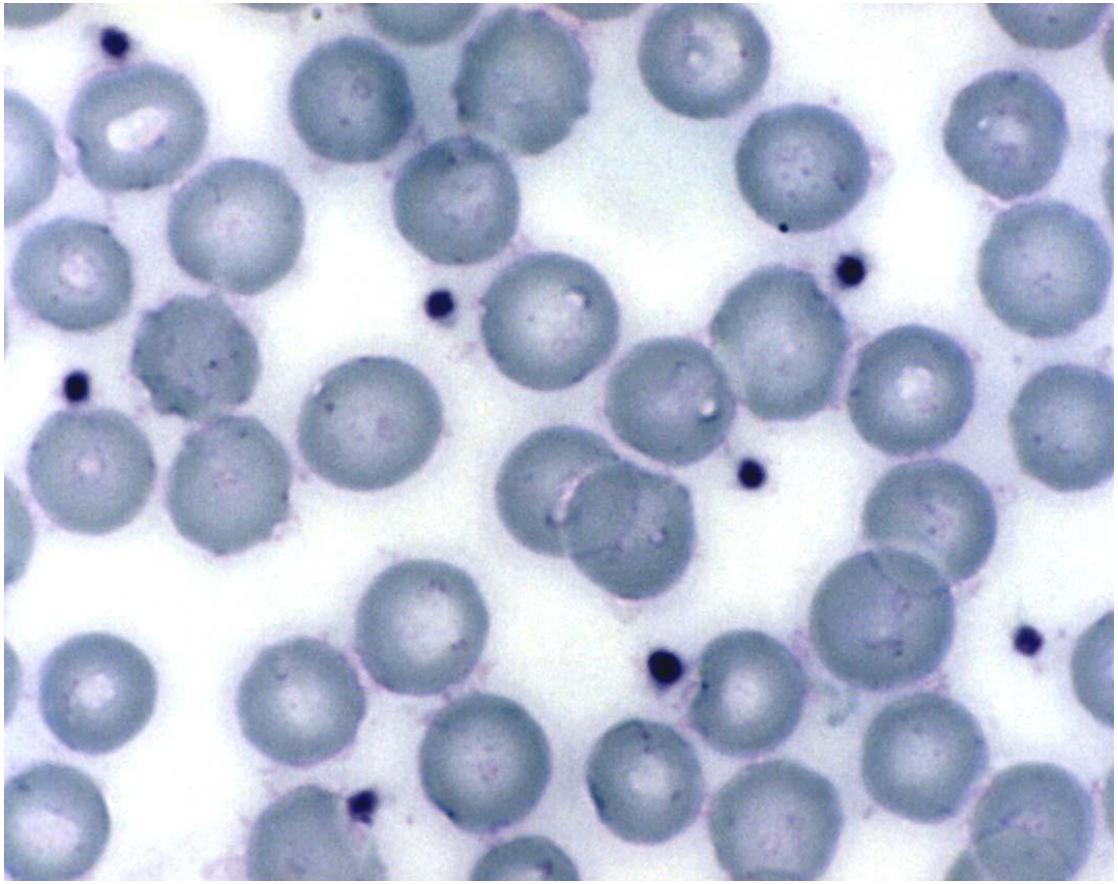
(5-6-million /ml)

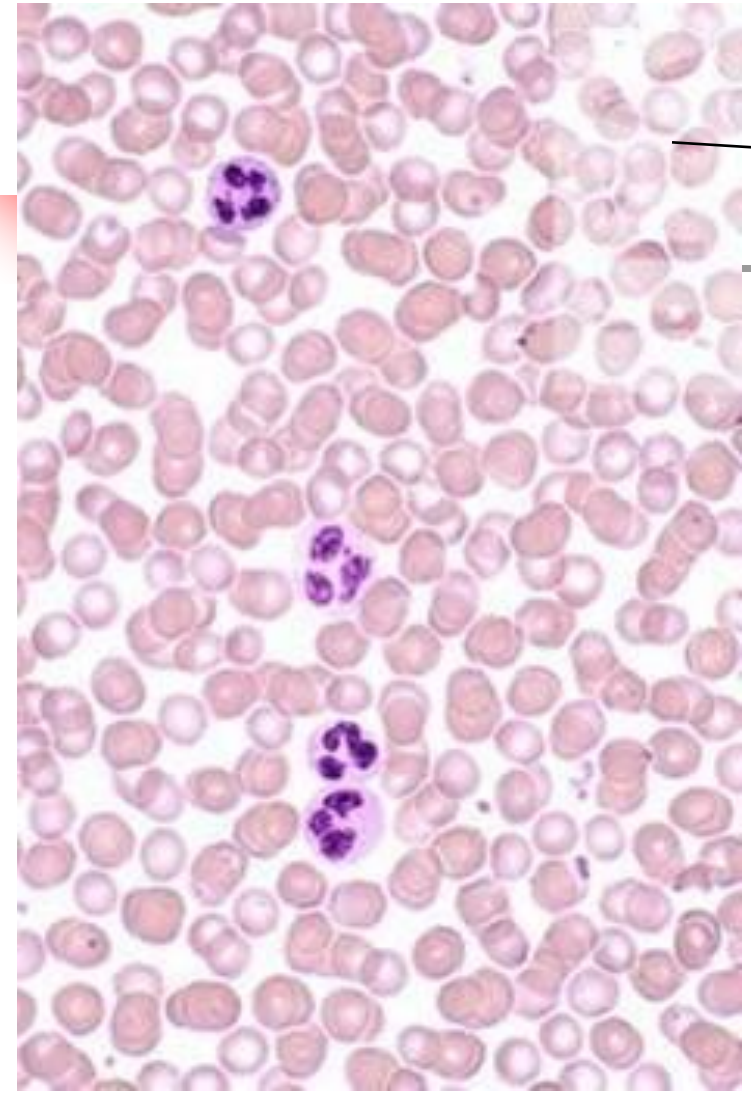
white blood cells

-leucocytes (5000/ml)

Platelets

x 1000





Plasma(55%)

- Plasma is yellowish fluid in blood.
- Blood plasma – main transport medium
- Water (90%)
- Ions
- Plasma proteins (albumin, Fibrinogen, Immunoglobulins)
- Hormones
- Dissolved substances (Nutrients), waste products, respiratory gaseous

Substance transported by plasma	Function
Salts a. Sodium ion (Na+), potassium ion (K+), and chloride ion (Cl-) b. Calcium ion (Ca2+)	•Osmotic balance conduction of nerve impulses •Blood clotting
Products of digestion Glucose, amino acids, fatty acids, and glycerol	•Nourishment of cells
Vitamins	•Regulation of cell functions
Soluble proteins a. Fibrinogen and protrombin b. Albumin c. Antibodies	•Blood clotting •Osmotic balance •Immunity
Enzymes	•Catalyse chemical reactions
Waste products Urea, carbon dioxide,	•None, they are removed by excretion
Hormones a. Insulin b. Aldosteron	•Lowers blood glucose concentration •Regulates concentration of sodium and potassium ions in the blood.

Formed Elements

- Erythrocytes = red blood cells
- Leukocytes = white blood cells
- Platelets = cell fragments

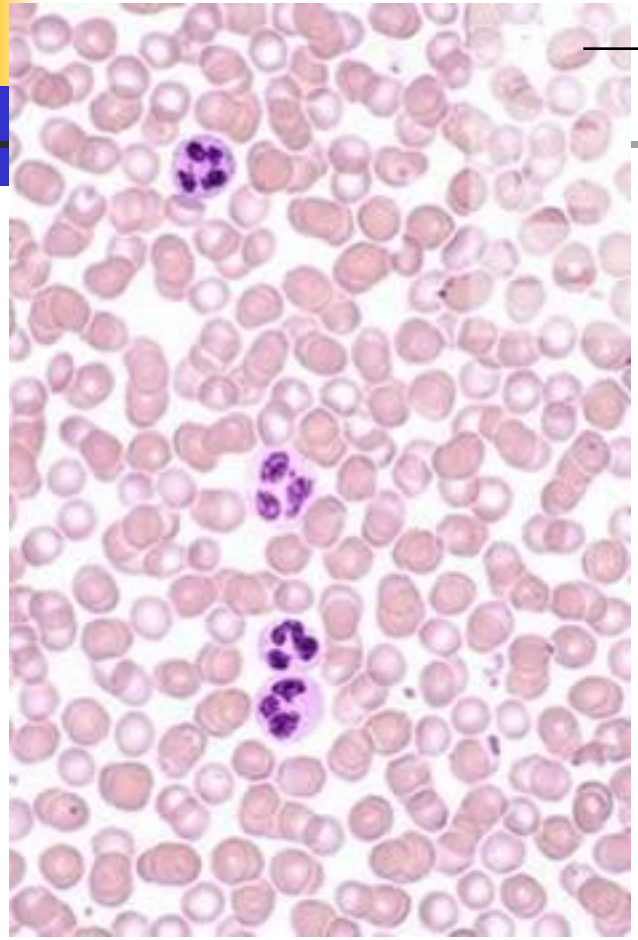
Table 10.2 Characteristics of Formed Elements of the Blood

Cell type	Occurrence in blood (per mm^3)	Cell anatomy*	Function
Erythrocytes (red blood cells, or RBCs)	4–6 million	Salmon-colored biconcave disks; anucleate; literally, sacs of hemoglobin; most organelles have been ejected	Transport oxygen bound to hemoglobin molecules; als transport small amount of carbon dioxide
Leukocytes (white blood cells, or WBCs)	4000–11,000		
Granulocytes			
• Neutrophils	3000–7000 (40–70% of WBCs)	Cytoplasm stains pale pink and contains fine granules, which are difficult to see; deep purple nucleus consists of three to seven lobes connected by thin strands of nucleoplasm	Active phagocytes; numbe increases rapidly during short-term or acute infections
• Eosinophils	100–400 (1–4% of WBCs)	Red coarse cytoplasmic granules; figure-8 or bilobed nucleus stains blue-red	Kill parasitic worms; increa during allergy attacks; migl phagocytize antigen-antibo complexes and inactivate s inflammatory chemicals

*Appearance when stained with Wright'

Cell type	Occurrence in blood (per mm^3)	Cell anatomy*	Function
• Basophils 	20–50 (0–1% of WBCs)	Cytoplasm has a few large blue-purple granules; U- or S-shaped nucleus with constrictions, stains dark blue	Granules contain histamine (vasodilator chemical), which is discharged at sites of inflammation
Agranulocytes			
• ymphocytes 	1500–3000 (20–45% of WBCs)	Cytoplasm pale blue and appears as thin rim around nucleus; spherical (or slightly indented) dark purple-blue nucleus	Part of immune system; one group (B lymphocytes) produces antibodies; other group (T lymphocytes) involved in graft rejection, fighting tumors and viruses, and activating B lymphocytes
• Monocytes 	100–700 (4–8% of WBCs)	Abundant gray-blue cytoplasm; dark blue-purple nucleus often kidney-shaped	Active phagocytes that become macrophages in the tissues; long-term "clean-up team"; increase in number during chronic infections such as tuberculosis
Platelets	250,000–500,000	Essentially irregularly shaped cell fragments; stain deep purple	Needed for normal blood clotting; initiate clotting cascade by clinging to broken area; help to control blood loss from broken blood vessels

*Appearance when stained with Wright'



<u>Red blood cells</u>
(erythrocytes)
(RBCs)

- transport **<u>oxygen</u>**
- specialised to do this

Also carry some CO_2

Erythrocytes

- Biconcave disc
- Does not hv nucleus & mitochondria
- Small, about 7.5μm in diameter
- TSA/V is ↑
- Elastic membrane (enable it to squeeze easily into the tiniest blood capillaries)
- Packed with haemoglobin
- Haemoglobin – protein pigment – haem group – ion atom

Erythrocytes

- Lifespn – 120 days
- Destroyed – liver & spleen
- Manufactured – bone marrow of long bones, ribs, skull & vertebrae
-

Erythrocytes

1) **biconcave shape**

- increases the surface area so more oxygen can be carried
- Flexible and allows it to squeeze through blood capillary

2) **no nucleus**

→ extra space inside

3) contain **haemoglobin**

→ the oxygen carrying molecule

→ 250million molecules / cell

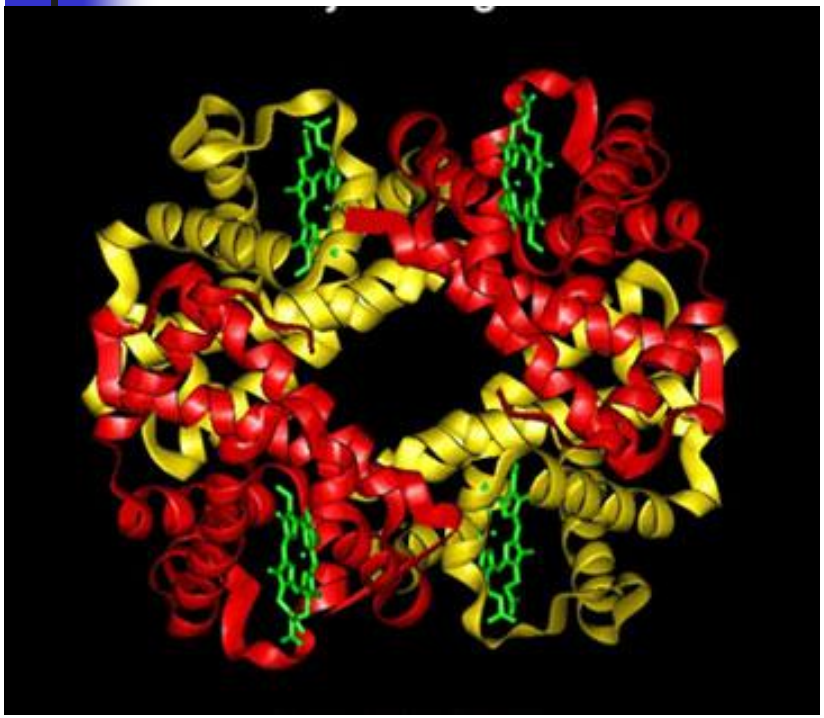
Erythrocytes (Red Blood Cells)

- The main function is to carry oxygen
- Anatomy of circulating erythrocytes
  - Biconcave disks
  - Essentially bags of hemoglobin
  - Anucleate (no nucleus)
  - Contain very few organelles
- Outnumber white blood cells 1000:1

Hemoglobin

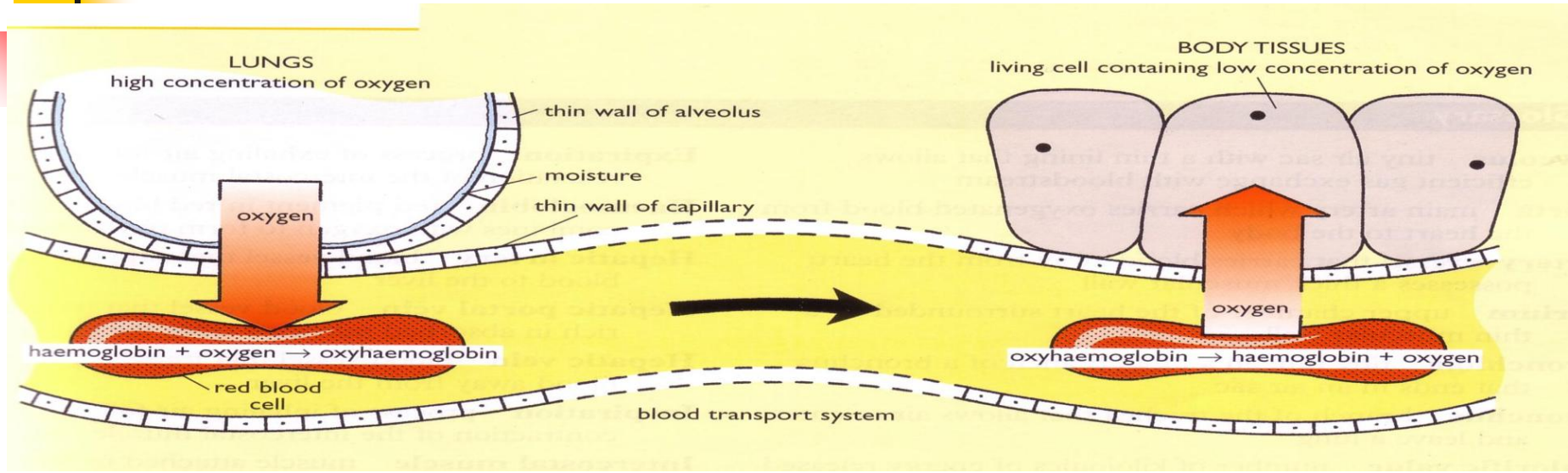
- Iron-containing protein
- Binds strongly, but reversibly, to oxygen
- Each hemoglobin molecule has four oxygen binding sites
- Each erythrocyte has 250 million hemoglobin molecules

Haemoglobin



- Is the iron containing pigment
- gives red blood cells their colour
- can carry up to 4 molecules of O_2
- associates and dissociates with O_2
- contains iron

Function of Haemoglobin



When there is a high concentration of oxygen e.g in the alveoli haemoglobin combines with oxygen to form oxyhaemoglobin. When the blood reaches the tissue which have a low concentration of oxygen the haemoglobin dissociates with the oxygen and the oxygen is released into body tissues

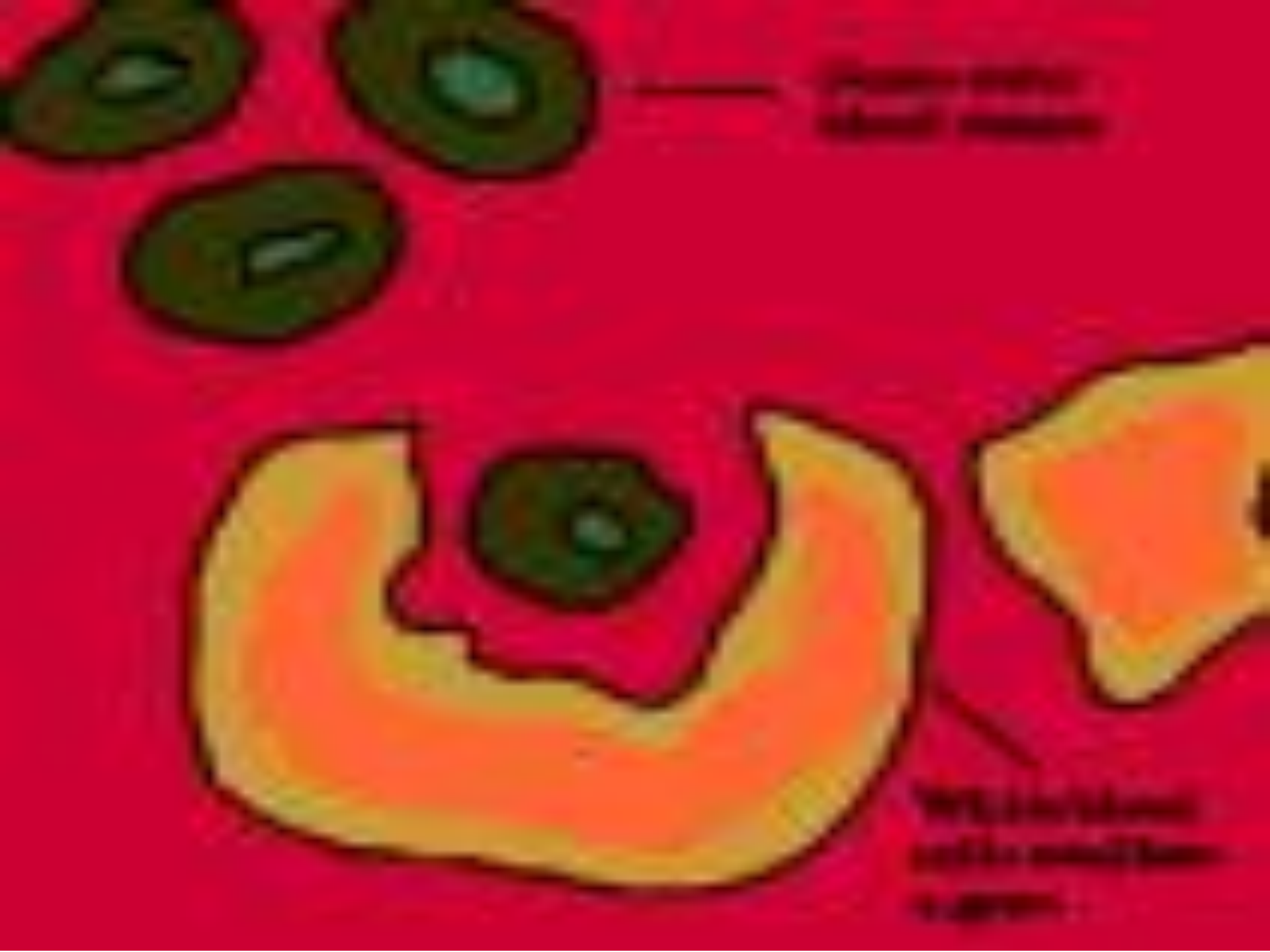
Haemoglobin

$$\underset{\text{Haemoglobin}}{Hb} + 4O_2 \underset{\text{tissues}}{\overset{\text{lungs}}{\rightleftharpoons}} \underset{\text{Oxyhaemoglobin}}{HbO_8}$$

- 98% oxygen carried the blood as oxyhaemoglobin while remaining 2% dissolved in plasma.
- Carbaminohaemoglobin ($HbCO_2$)

Leucocytes

- Colourless
- Have nucleus & mitochondria
- Irregular in shape
- Less than 1%
- Larger than RBC
- Made – stem cells in the bone marrow and lymph nodes
- Fight infection



Leucocytes

- Activities – interstitial fluid
- Squeeze through the pores in bc
- Can be divided into two group
- Granulocytes (Neutrophils, Eosinophils, Basophils)
- Agranulocytes (Lymphocytes, monocytes)

Leukocytes (White Blood Cells)

- Crucial in the body's defense against disease
- These are complete cells, with a nucleus and organelles
- Able to move into and out of blood vessels (diapedesis)
- Can respond to chemicals released by damaged tissues

Leukocyte Levels in the Blood

- Normal levels =4,000 to 11,000 cells/ml
- Abnormal leukocyte levels
  - Leukocytosis
    - Above 11,000 leukocytes/ml
    - Generally indicates an infection
  - Leukopenia
    - Abnormally low leukocyte level
    - Commonly caused by certain drugs

Types of Leukocytes

- Granulocytes
  - Granules in their cytoplasm can be stained
  - Include neutrophils, eosinophils, and basophils

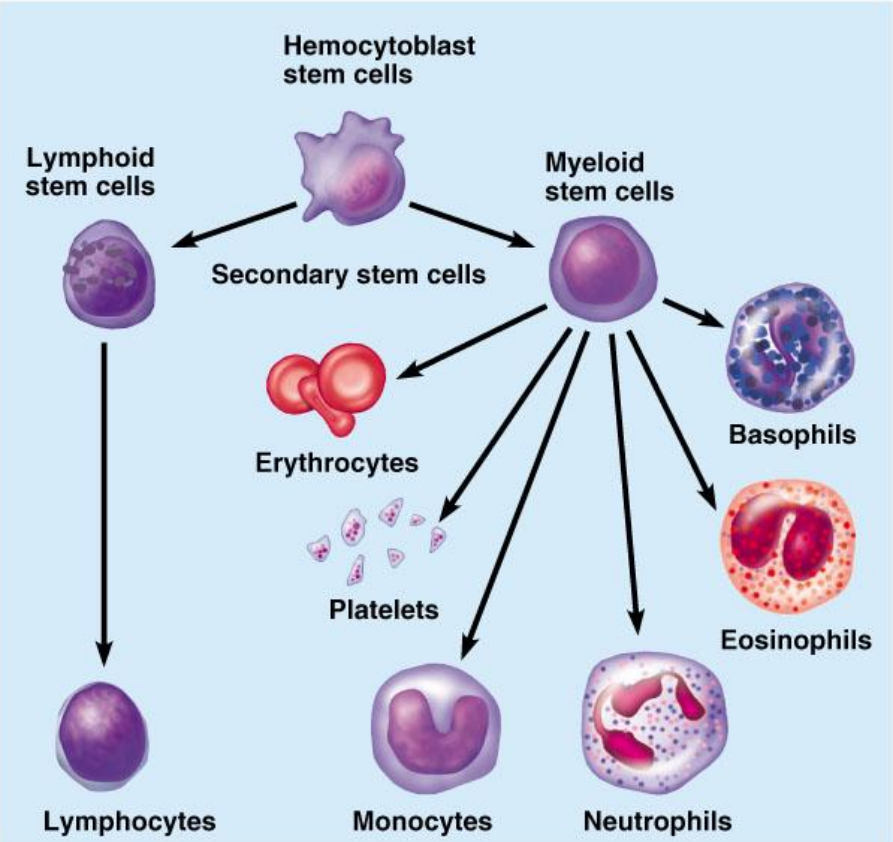


Figure 10.4

Types of Leukocytes

- Agranulocytes
  - Lack visible cytoplasmic granules
  - Include lymphocytes and monocytes

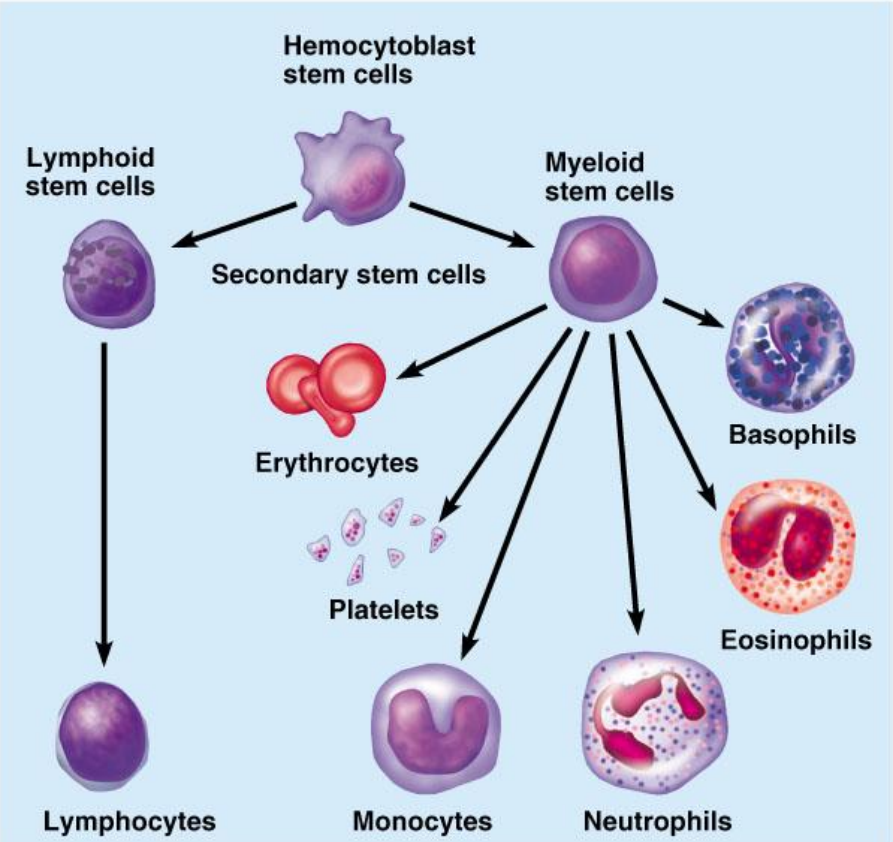
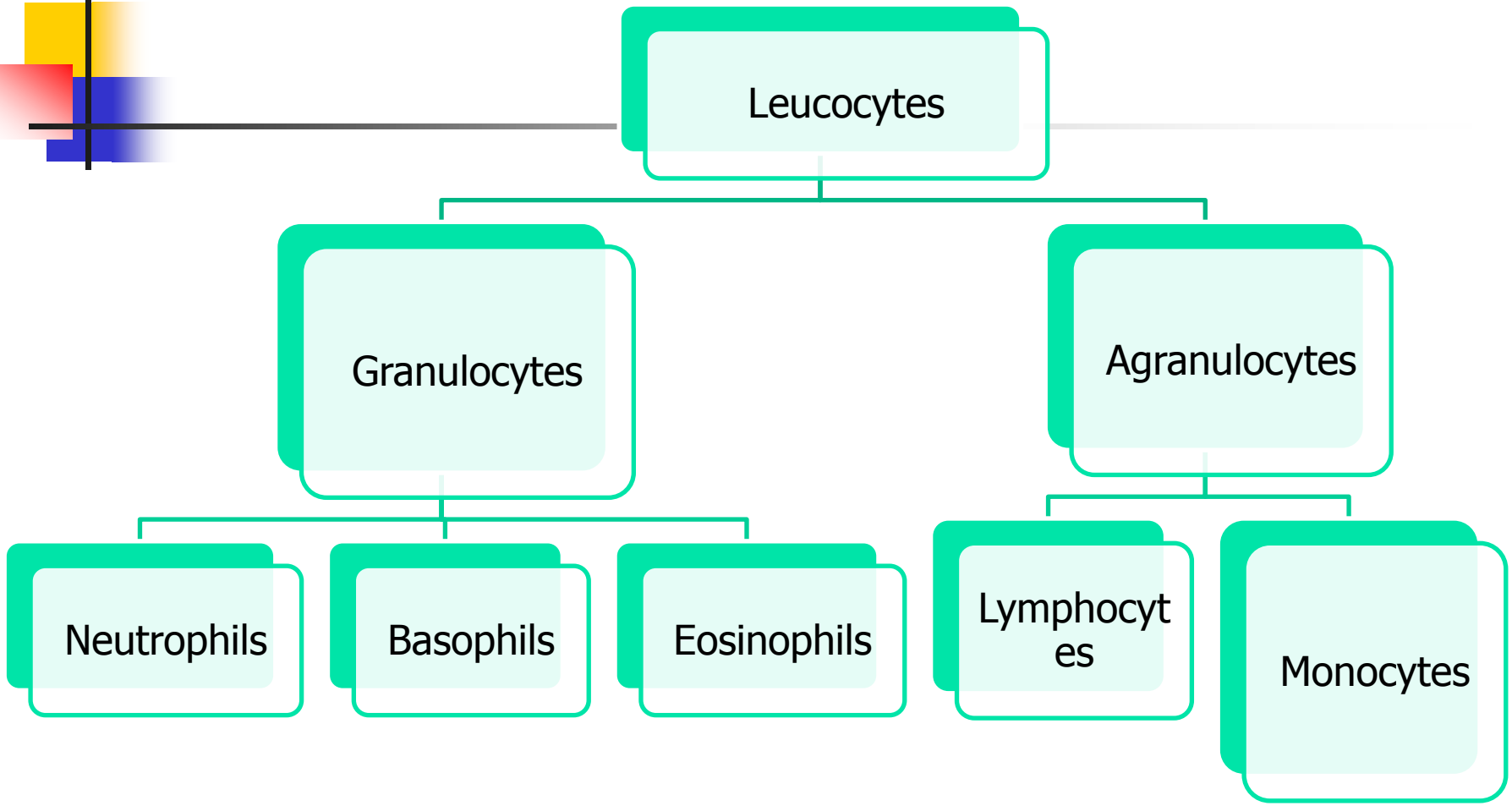


Figure 10.4


Leucocytes
Granulocytes
Agranulocytes
Neutrophils
Basophils
Eosinophils
Lymphocytes
Monocytes

Granulocytes

- Neutrophils
  - Multilobed nucleus with fine granules
  - Act as phagocytes at active sites of infection
- Eosinophils
  - Large brick-red cytoplasmic granules
  - Found in repsonse to allergies and parasitic worms

Granulocytes

- Basophils
  - Have histamine-containing granules
  - Initiate inflammation

Agranulocytes

- Lymphocytes
  - Nucleus fills most of the cell
  - Play an important role in the immune response
- Monocytes
  - Largest of the white blood cells
  - Function as macrophages
  - Important in fighting chronic infection

Type of leucocytes	Characteristic	Abundance (per mm^3 of blood)	Function
Neutrophils (62%) 	• Irregularly lobed nucleus. • Granules in the cytoplasm remain **unstained** when treated with Leishmanís stain.	4000 – 6000	Phagocytosis of bacteria.
Eosinophils (2%) 	• Nucleus with two lobes. • Granules in the cytoplasm **stain red** when treated with Leishman's stain.	100 – 400	• Amount increases in people with **allergic conditions** such as asthma. • Possess anti-histamine properties.
Basophils (0.5%) 	• Nucleus with two lobes or is S-shaped. • Granules in the cytoplasm **stain blue** with Leishmanís stain.	25 – 200	• Produce **heparin** (anti-clotting protein) which helps to prevent blood clotting. • Secrete **histamine** which is involved in inflammation of damaged tissues and allergic reactions.

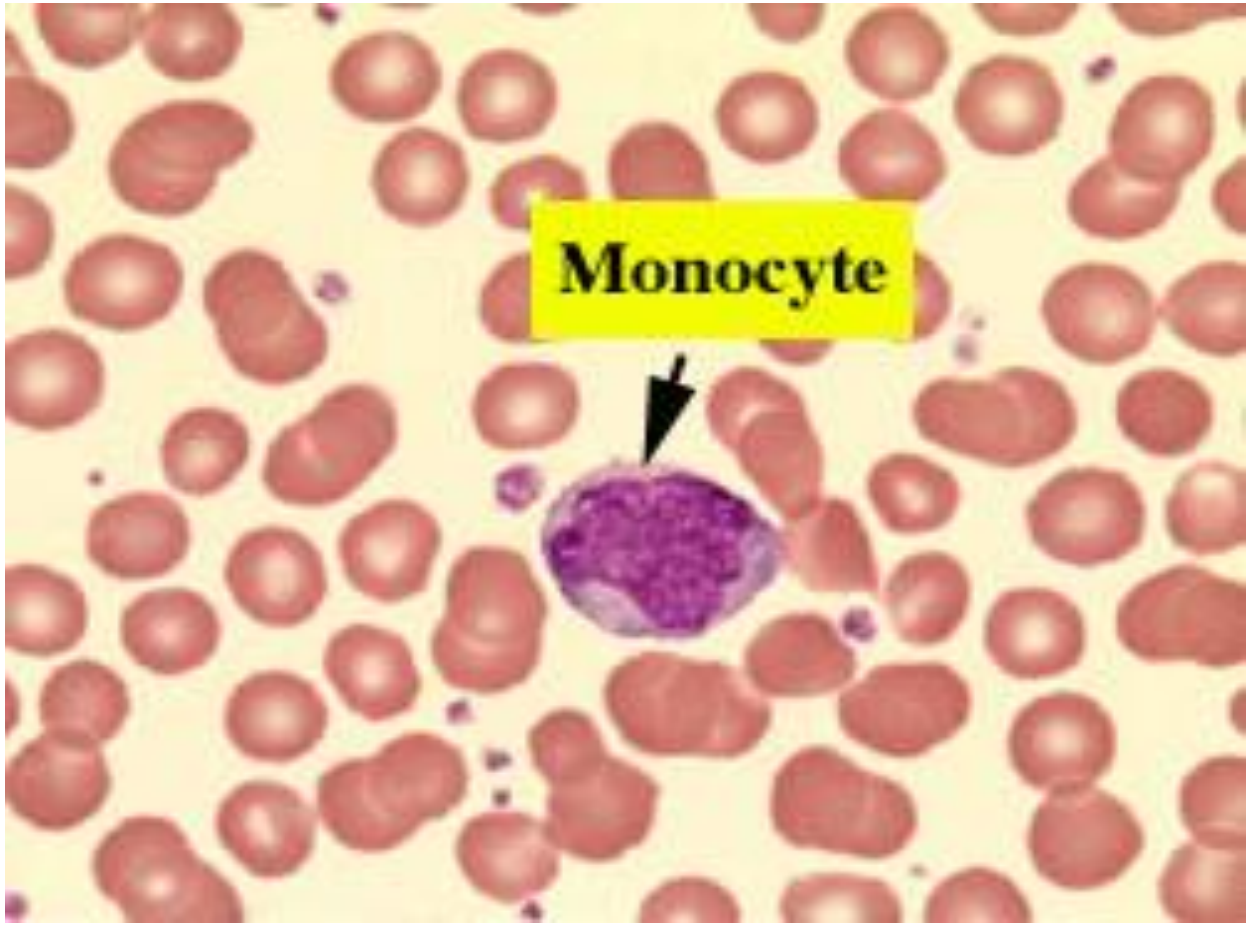
Lymphocytes (32%) 	• The smallest type of leucocyte. • Rounded nucleus with little cytoplasm.	1500 – 2700	Provide specific immunity, for example, production of **antibodies**.
Monocytes (4%) 	• The largest type of leucocyte. • Large bean-shaped nucleus.	100 – 700	Phagocytosis of bacteria.

Tutorial

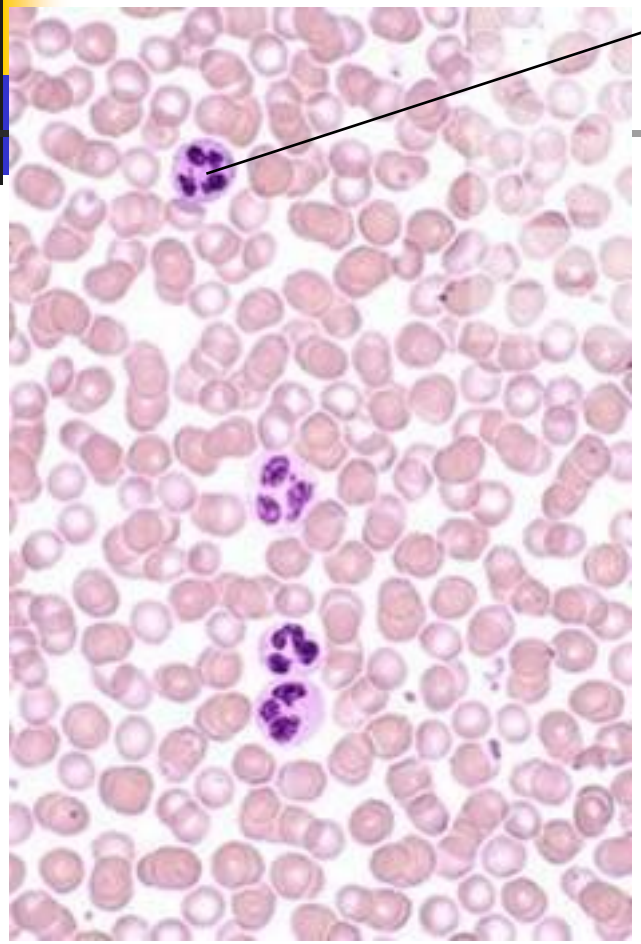
Which of the following descriptions is true about human leucocytes?

	Leucocyte	Description
A	Basophil	A granular leucocyte that is involved in blood clotting.
B	Eosinofil	A non-granular leucocyte that kills parasitic worms.
C	Lymphocyte	A granular leucocyte that produces antibodies.
D	Monocyte	A non-granular leucocyte that destroys pathogen by phagocytosis.

Monocytes



White blood cells

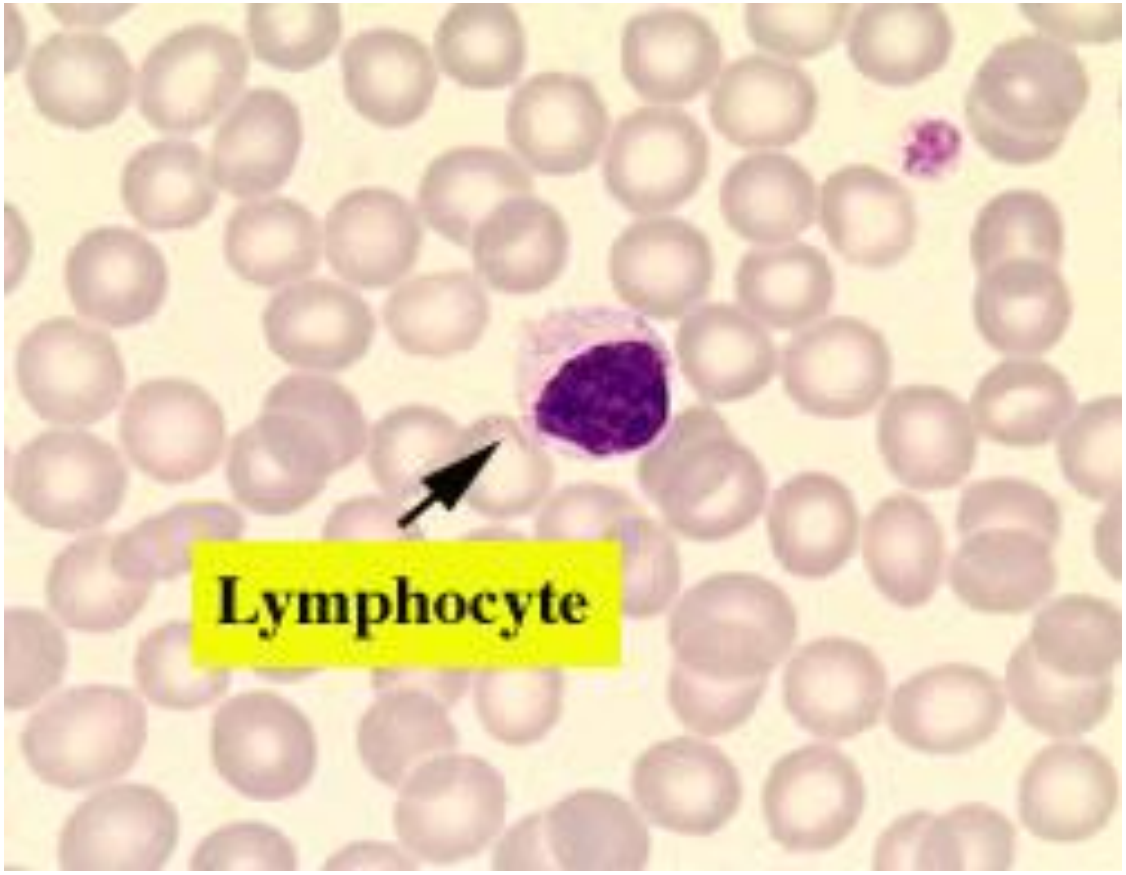


- the bodies "**defence**"
- part of the immune system
- much **larger** than RBCs
- far **fewer**
- have a nucleus
- 4000-13000 per mm^3
- 2 types monocytes and lymphocytes

Other important jobs of the white blood cells:

- They produce <u>antibodies</u> which can recognise and fight bacteria
- They produce <u>antitoxins</u> which neutralise the toxins (poisons) that bacteria produce, which make us feel ill

Lymphocyte



Lymphocytes

Provide a **specific immune response** to infectious diseases.

There are 2 types: -

- T-cells
- B-cells

They produce **antibodies**.

Platelets

- Derived from ruptured multinucleate cells (megakaryocytes)
- Needed for the clotting process
- Normal platelet count = 300,000/mm^3

Platelets

- Fragments of large cells from the bone marrow
- Does not have nucleus
- Blood clotting

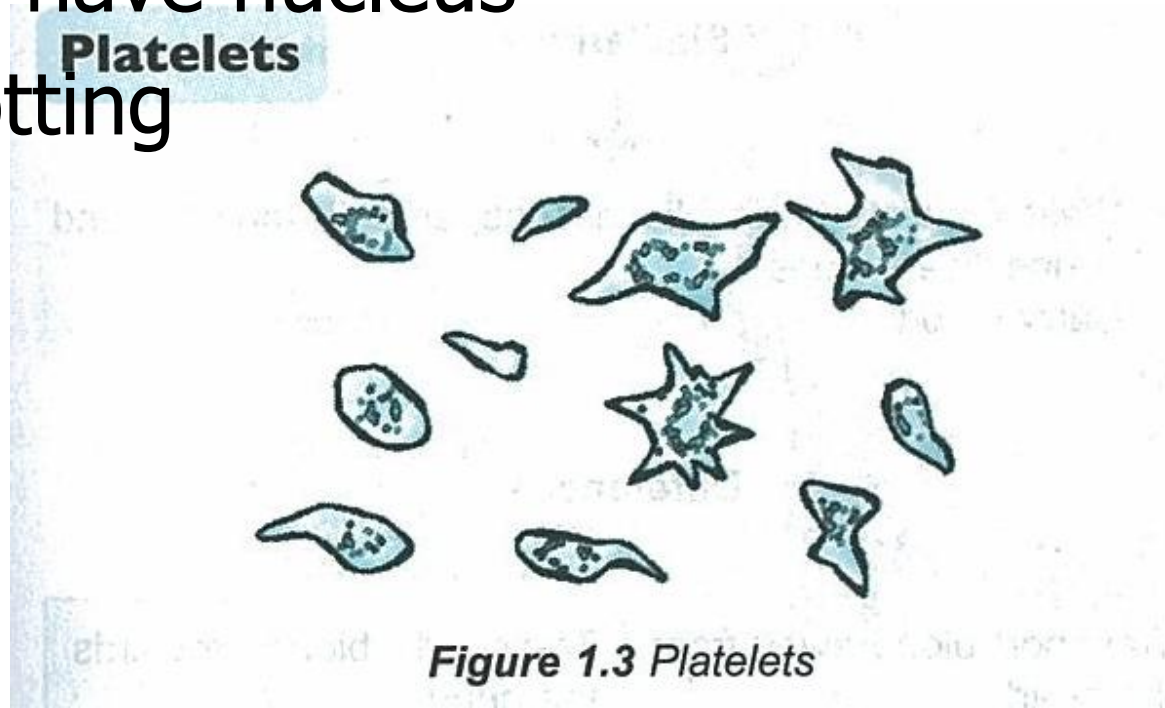
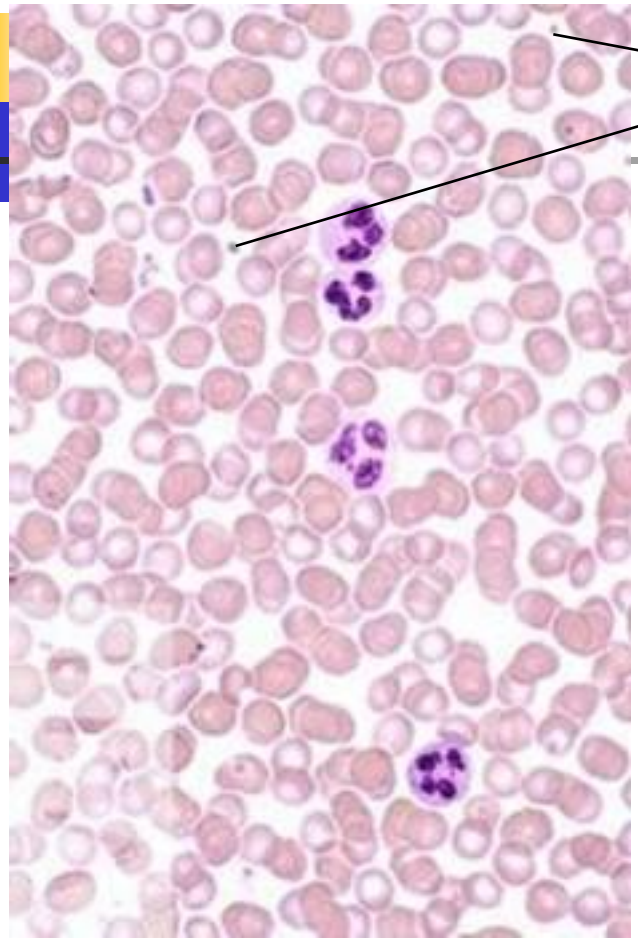


Figure 1.3 Platelets



Platelets

if you get cut:-

- platelets produce tiny fibrin threads
- these form a web-like mesh that traps blood cells.
- these harden forming a clot, or "scab."
- 150,000 to 400,000 per mm^3

Tutorial

Can you?

- State the composition of Blood
- State the function of red blood cells and plasma
- Explain the function of haemoglobin in the transport of oxygen
- State the function of macrophages and lymphocytes

Hematopoiesis – Blood Cell Formation

- Occurs in red bone marrow
- All blood cells are derived from a common stem cell (hemocytoblast)

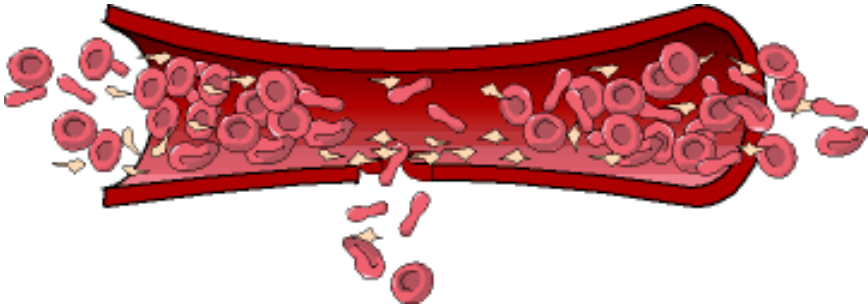
Fate of Erythrocytes

- Unable to divide, grow, or synthesize proteins
- Wear out in 100 to 120 days
- When worn out, are eliminated by phagocytes in the spleen or liver
- Lost cells are replaced by division of stem cells

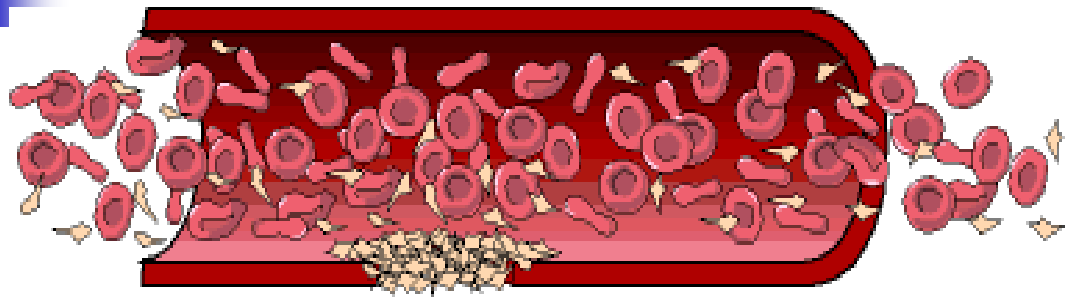
Hemostasis

- Stoppage of blood flow
- Result of a break in a blood vessel
- Hemostasis involves three phases
  - Platelet plug formation
  - Vascular spasms
  - Coagulation

1. Vessel damage, blood loss
2. Vascular spasm.



3. Platelet plug forms
4. Coagulation



Platelet Plug Formation

- Collagen fibers are exposed by a break in a blood vessel
- Platelets become “sticky” and cling to fibers
- Anchored platelets release chemicals to attract more platelets
- Platelets pile up to form a platelet plug

Vascular Spasms

- Anchored platelets release serotonin
- Serotonin causes blood vessel muscles to spasm
- Spasms narrow the blood vessel, decreasing blood loss

Coagulation

- Injured tissues release thromboplastin
- PF_3 (a phospholipid) interacts with thromboplastin, blood protein clotting factors, and calcium ions to trigger a clotting cascade
- Prothrombin activator converts prothrombin to thrombin (an enzyme)

Coagulation, cont.

- Thrombin joins fibrinogen proteins into hair-like fibrin
- Fibrin forms a meshwork (the basis for a clot)

Blood Clotting

- Blood usually clots within 3 to 6 minutes
- The clot remains as endothelium regenerates
- The clot is broken down after tissue repair

Undesirable Clotting

- Thrombus
  - A clot in an unbroken blood vessel
  - Can be deadly in areas like the heart
- Embolus
  - A thrombus that breaks away and floats freely in the bloodstream
  - Can later clog vessels in critical areas such as the brain

Bleeding Disorders

- Thrombocytopenia (caused by viruses, medications or post-bone CA trtment)
  - Platelet deficiency
  - Even normal movements can cause bleeding from small blood vessels that require platelets for clotting
- Hemophilia
  - Hereditary bleeding disorder
  - Normal clotting factors are missing

Blood Groups and Transfusions

- Large losses of blood have serious consequences
  - Loss of 15 to 30 percent causes weakness
  - Loss of over 30 percent causes shock, which can be fatal
- Transfusions are the only way to replace blood quickly
- Transfused blood must be of the same blood group

Human Blood Groups

- Blood contains genetically determined proteins
- A foreign protein (antigen) may be attacked by the immune system
- Blood is “typed” by using antibodies that will cause blood with certain proteins to clump (agglutination)

Human Blood Groups

- There are over 30 common red blood cell antigens
- The most vigorous transfusion reactions are caused by ABO and Rh blood group antigens

ABO Blood Groups

- Based on the presence or absence of two antigens
  - Type A
  - Type B
- The lack of these antigens is called type O

Blood Types Determine Blood Compatibility

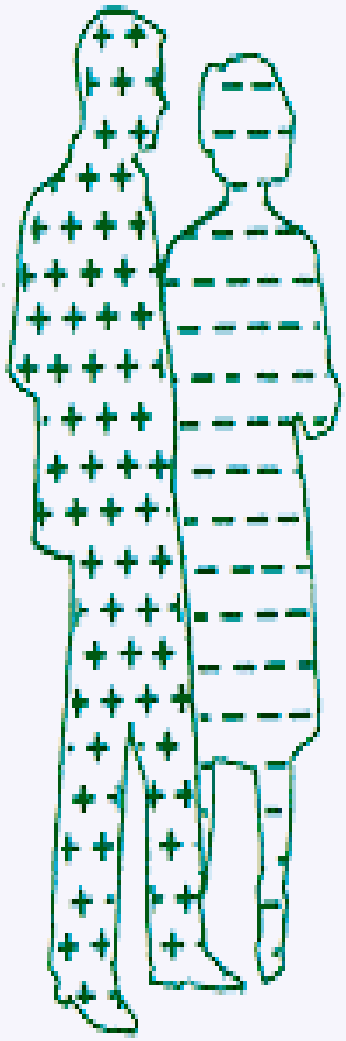
	Type A	Type B	Type AB	Type O
Red blood cells	Antigen A	Antigen B	Antigens A and B	Neither A nor B antigens
Plasma antibodies	B	A	Neither A nor B	A and B
Incidences:				
U.S. Caucasian	40%	10%	5%	45%
U.S. African-American	27%	20%	4%	49%
Native Americans	8%	1%	0%	91%

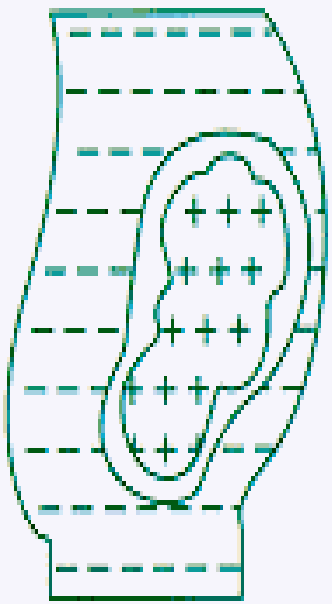
ABO Blood Groups

- The presence of both A and B is called type AB
- The presence of either A or B is called types A and B, respectively

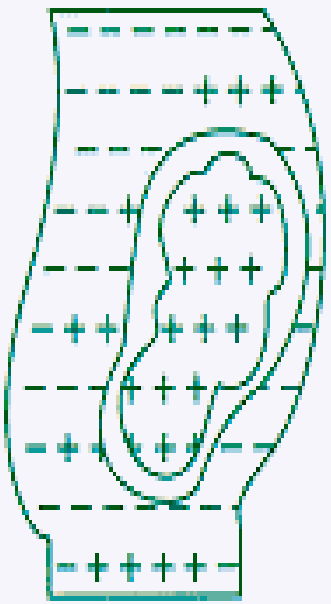
Rh Blood Groups

- Named because of the presence or absence of one of eight Rh antigens (agglutinogen D)
- Most Americans are Rh^+
- Problems can occur in mixing Rh^+ blood into a body with Rh^- blood

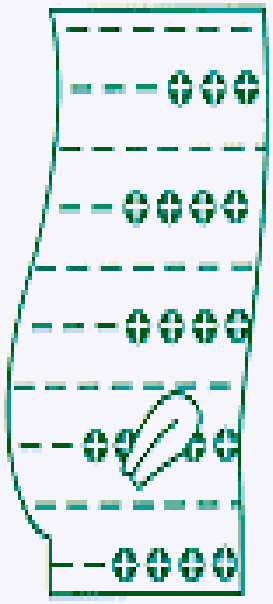




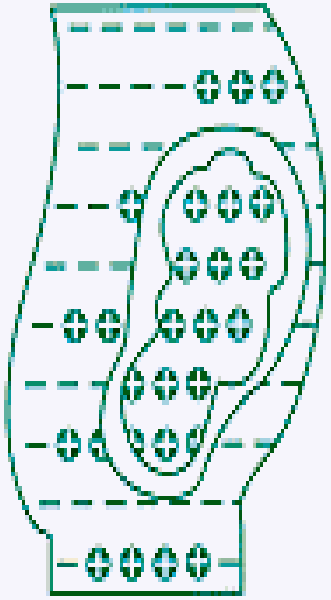
Rh-negative woman with Rh-positive fetus



Cells from Rh-positive fetus enter mother's bloodstream



Woman becomes sensitized—antibodies (⊕) form to fight Rh-positive blood cells



In the next Rh-positive pregnancy, antibodies attack fetal blood cells

How Rh sensitization occurs.

Rh Dangers During Pregnancy

- Danger is only when the mother is Rh^- and the father is Rh^+, and the child inherits the Rh^+ factor

Rh Dangers During Pregnancy

- The mismatch of an Rh^- mother carrying an Rh^+ baby can cause problems for the unborn child
  - The first pregnancy usually proceeds without problems
  - The immune system is sensitized after the first pregnancy
  - In a second pregnancy, the mother's immune system produces antibodies to attack the Rh^+ blood (hemolytic disease of the newborn)

Blood Typing

- Blood samples are mixed with anti-A and anti-B serum
- Coagulation or no coagulation leads to determining blood type
- Typing for ABO and Rh factors is done in the same manner
- Cross matching – testing for agglutination of donor RBCs by the recipient's serum, and vice versa