POLTAVA STATE MEDICAL UNIVERSITY

Features of the blood system in children of different age groups. Clinical and hematological semiotics of the main syndromes and diseases of the blood system in children.

Assoc. Professor Soloviova Halyna

Plan of the lecture

1. Definition of the blood system in children.
2. Hematologic functions of bone marrow.
3. Hematologic functions of liver.
4. Hematologic functions of lymph nodes, tonsils and thymus.
5. Features of physical characteristics of child’s blood.
6. Methods of investigation of the blood system.
7. Methods of clinical examination of blood system.

Definition

The hematopoietic system consists of organs and tissues involved in the production of the cellular components of blood (bone marrow, liver, spleen, lymph nodes, tonsils and thymus).

Hematologic functions of Bone marrow

The production of all types of blood cells

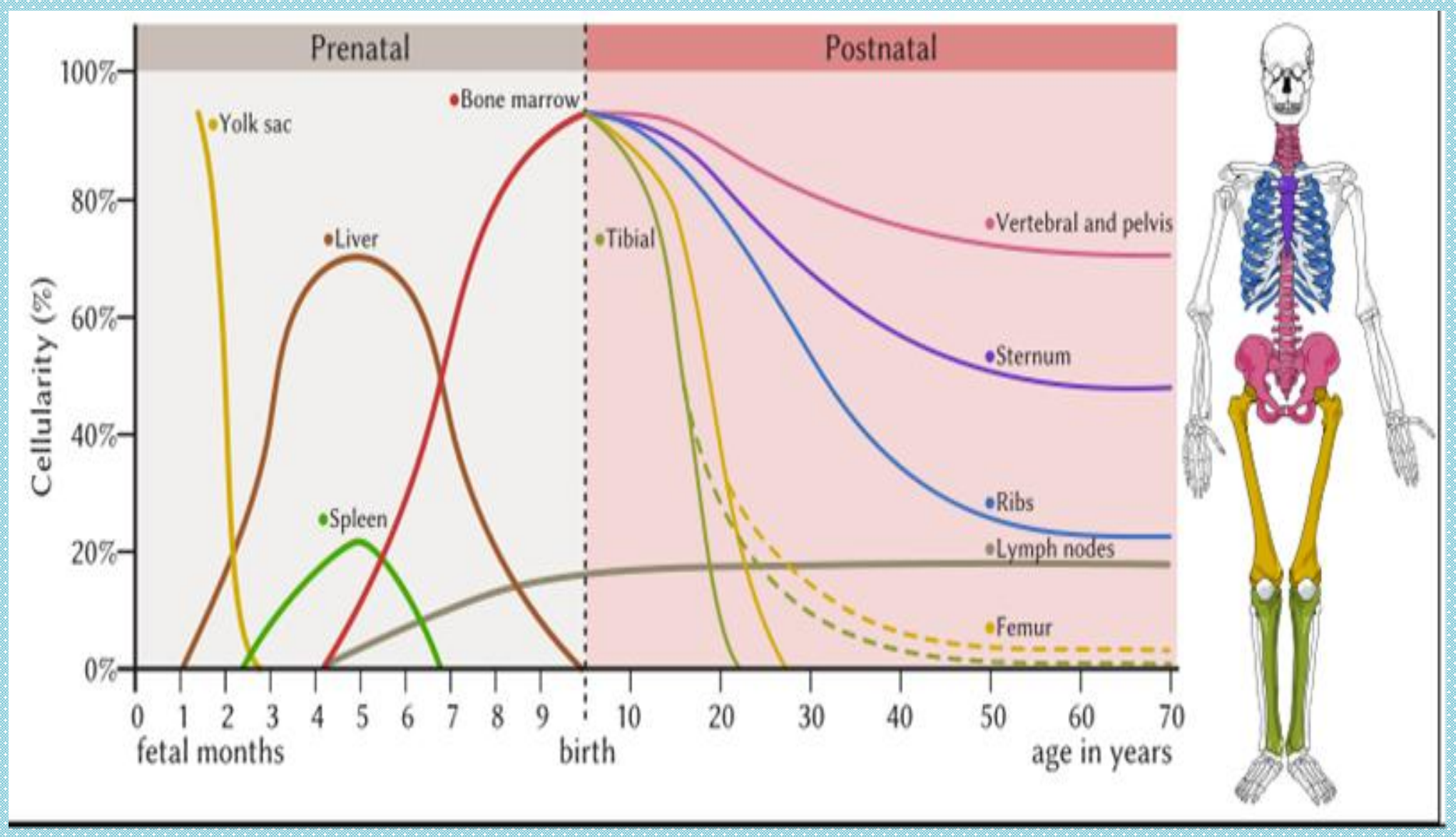
Bone marrow contains two types of stem cells:

- **hemopoietic** (which can produce blood cells)
- **stromal** (which can produce fat, cartilage and bone).

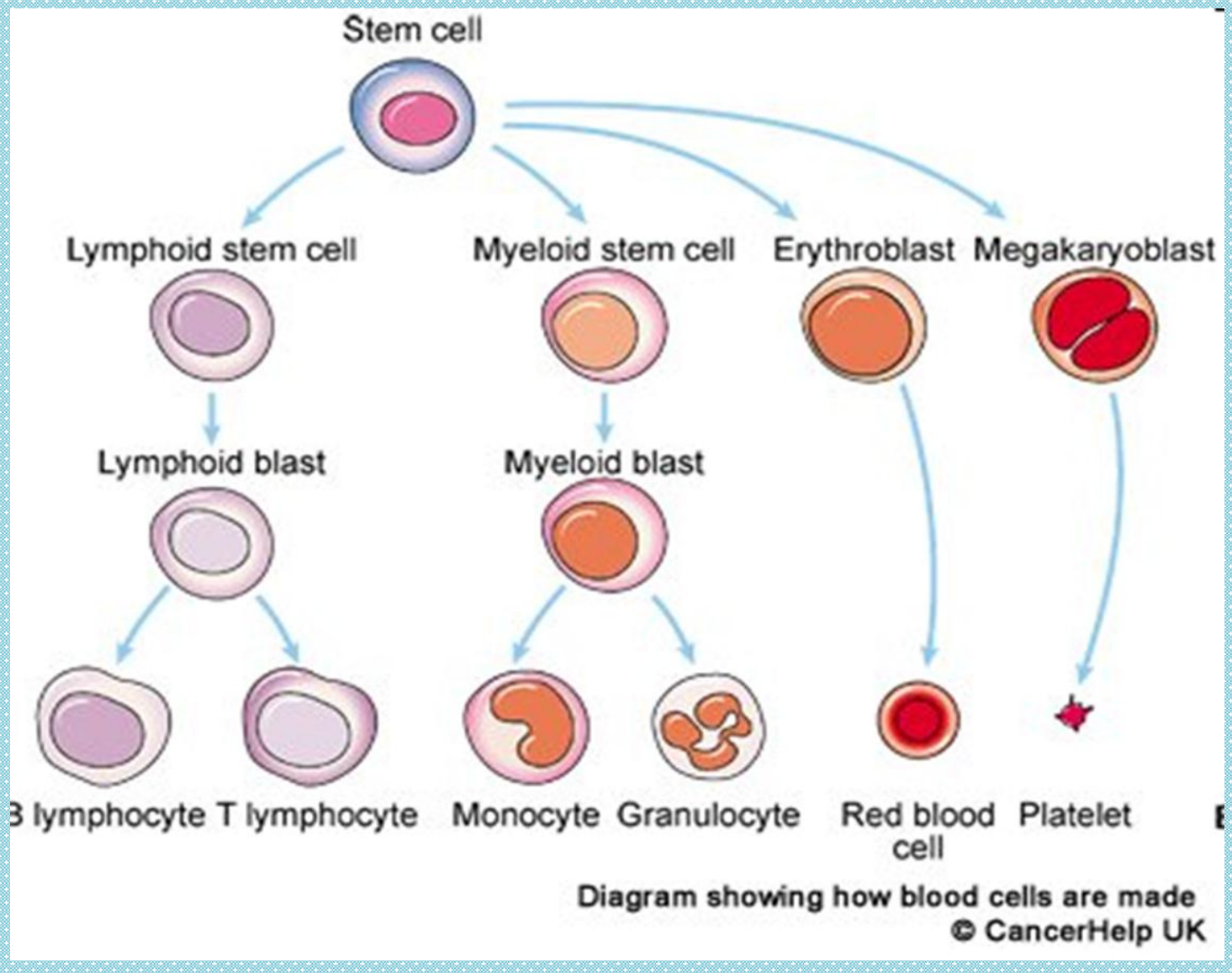
There are two types of bone marrow:

- **red marrow** (also known as myeloid tissue)
- **yellow marrow**.

Sites of human haematopoesis



Scheme of hematopoesis



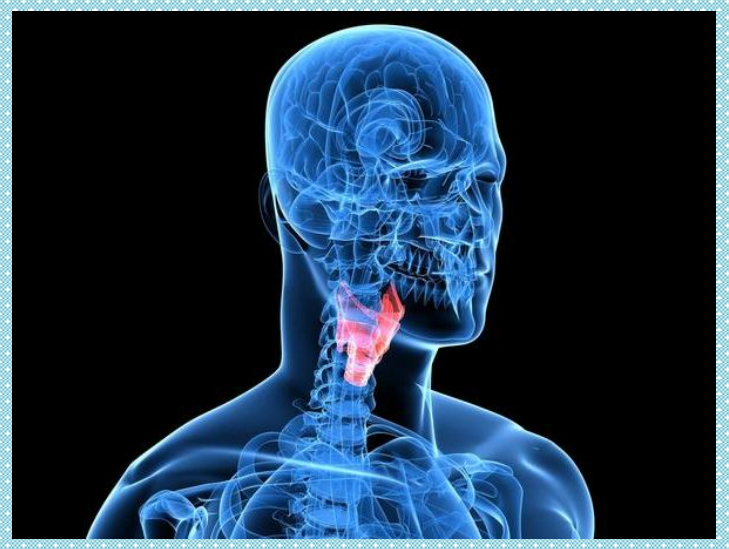
Hematologic functions of Liver

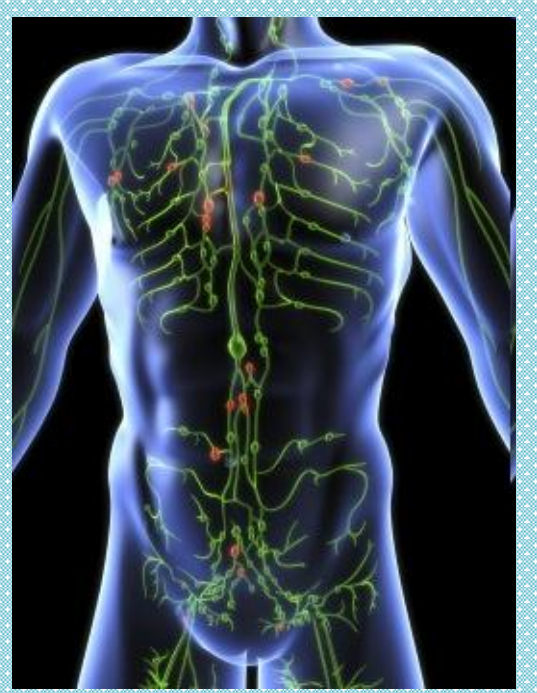
- synthesis plasma proteins including **clotting factors** and **albumin**
- clears damaged and non-functioning RBCs/erythrocytes from circulation
- main hemopoetic organ in intrauterine period

Hematologic functions of Spleen

- Produces fetal RBCs
- Removes old RBC's from circulation
- Immune function (Lymphocytes, monocytes)
- Storage function (30% platelets stored in spleen)

Hematologic functions of lymph nodes, tonsils and thymus





Play a role in the **formation of new limphocytes.**

Blood is a highly specialized, fluid tissue.

Blood is internal environment of organism

Blood is traditionally classified as a specialized form of connective tissue.

Functions of Blood

Blood performs a number of functions dealing with:

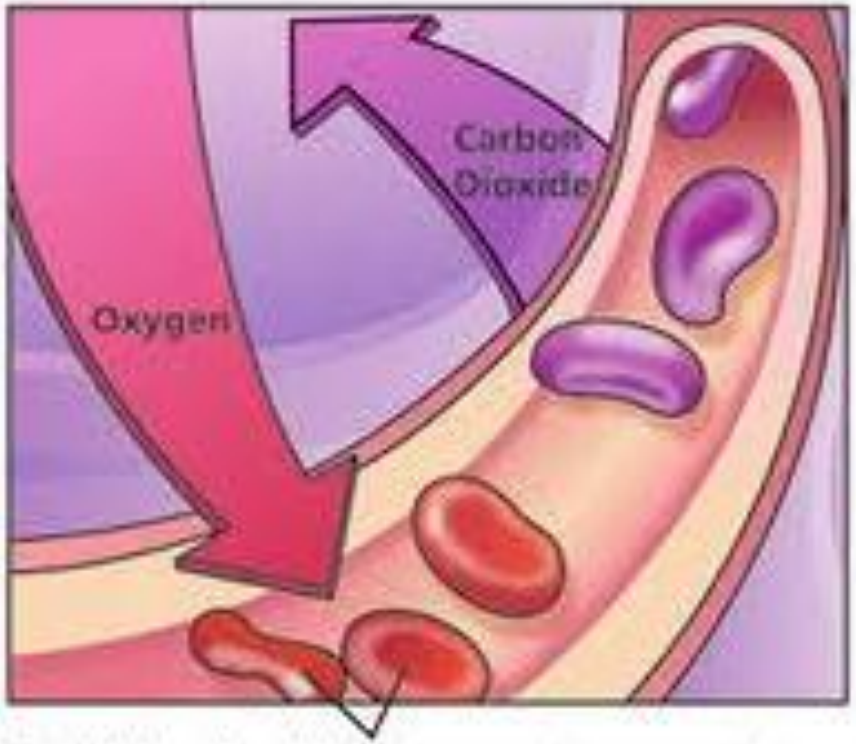
- **Substance distribution**
- **Regulation of blood levels of particular substances (Homeostatic)**
- **Body protection**

Blood Functions: Substance distribution

Blood transports:

- **Oxygen** from the lungs
- **Metabolic wastes** from cells to the lungs and kidneys for elimination
- **Nutrients** from the digestive tract
- **Hormones** from endocrine glands to target organs

Red blood cells take up oxygen from the lungs and release carbon dioxide back to the lungs.



Red blood cells transport oxygen to the rest of the body.

Blood Functions: Regulation

Blood maintains:

- **Appropriate body temperature** by absorbing and distributing heat to other parts of the body
- **Normal pH** in body tissues using buffer systems
- **Adequate fluid volume** in the circulatory system

Blood Functions: Protection

- Blood **prevents blood loss** by:

  - Activating plasma proteins and platelets
  - Initiating clot formation when a vessel is broken

- Blood **prevents infection** by:

- **Synthesizing** and **utilizing antibodies**
- **Activating complement** proteins
- **Activating WBCs** to defend the body against foreign invaders

Blood components

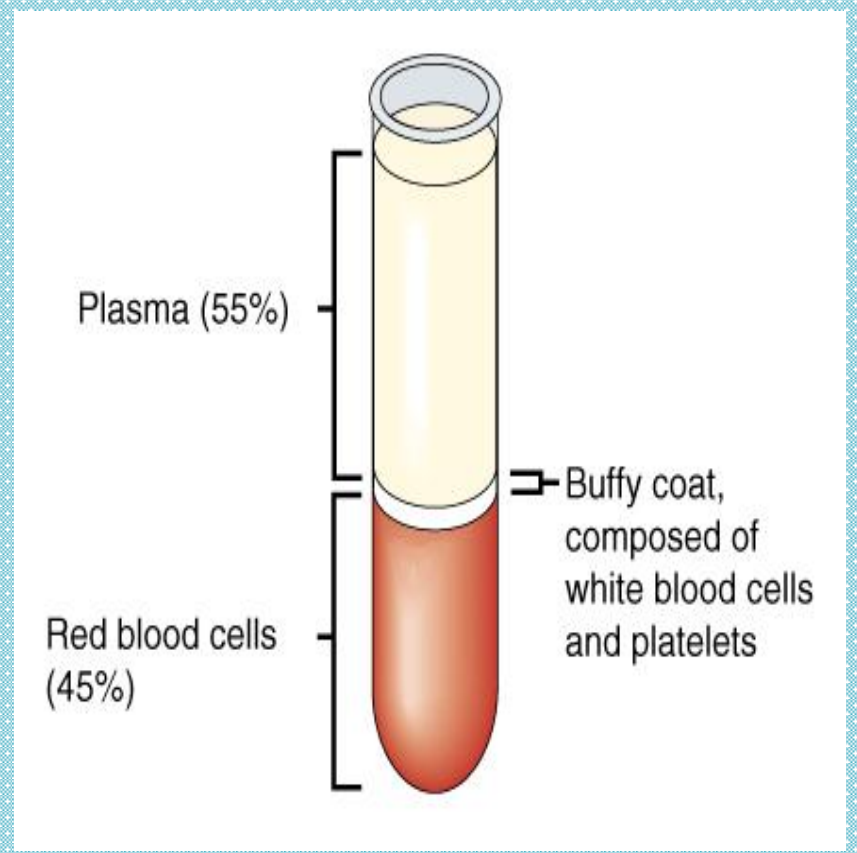
Blood Cells

Erythrocytes (RBCs),

Leukocytes (WBCs),

Thrombocytes

(Platelets)



Plasma

Protein,

Carbohydrates,

Fats,

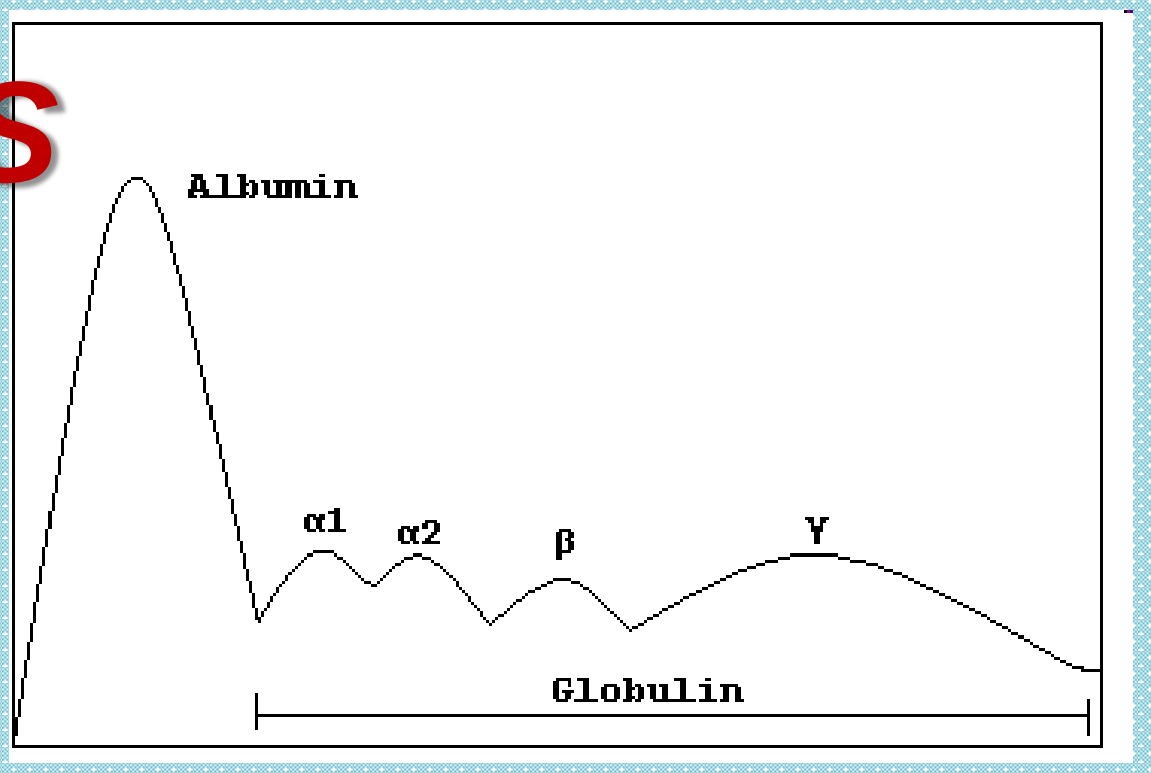
Amino Acids,

Nonprotein nitrogenous substances,

Hormones,

Vitamins

PLASMA PROTEINS



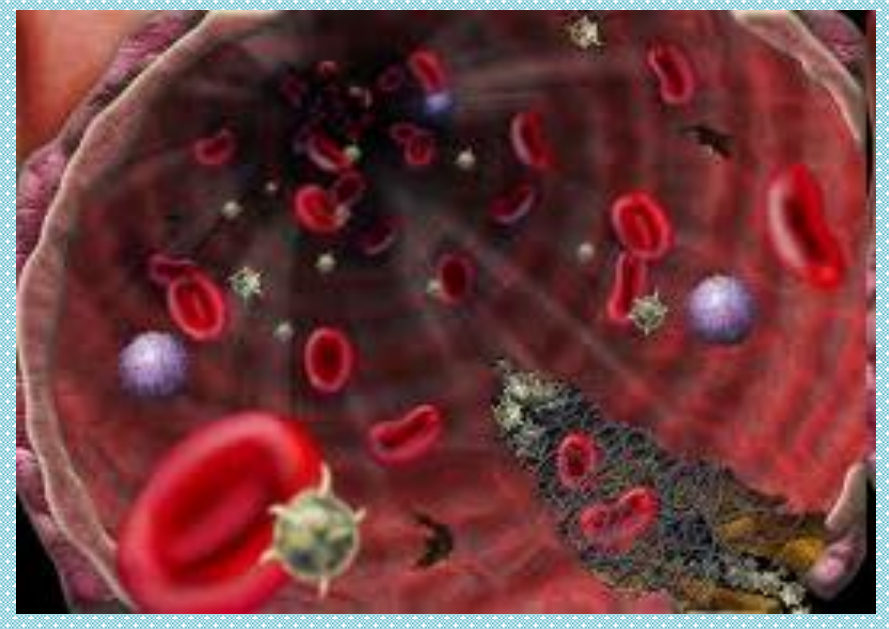
- **ALBUMIN: 54%.**
  - regulates osmotic pressure in the vascular space,
  - acts as a buffer, carries stuff.
- **GLOBULINS: 38%.**
  - ALPHA- Transports hormones & bilirubin.
  - BETA- Transports Iron & Copper.
  - Gamma- The antibodies.

- **FIBRINOGEN: 7%.**
  Clotting Factor I.,Converts to Fibrin (clotting factor Ia).

- **1-2%:** Hormones, Enzymes, Complement, Carriers for Lipids.

Features of Physical Characteristics of Child's Blood

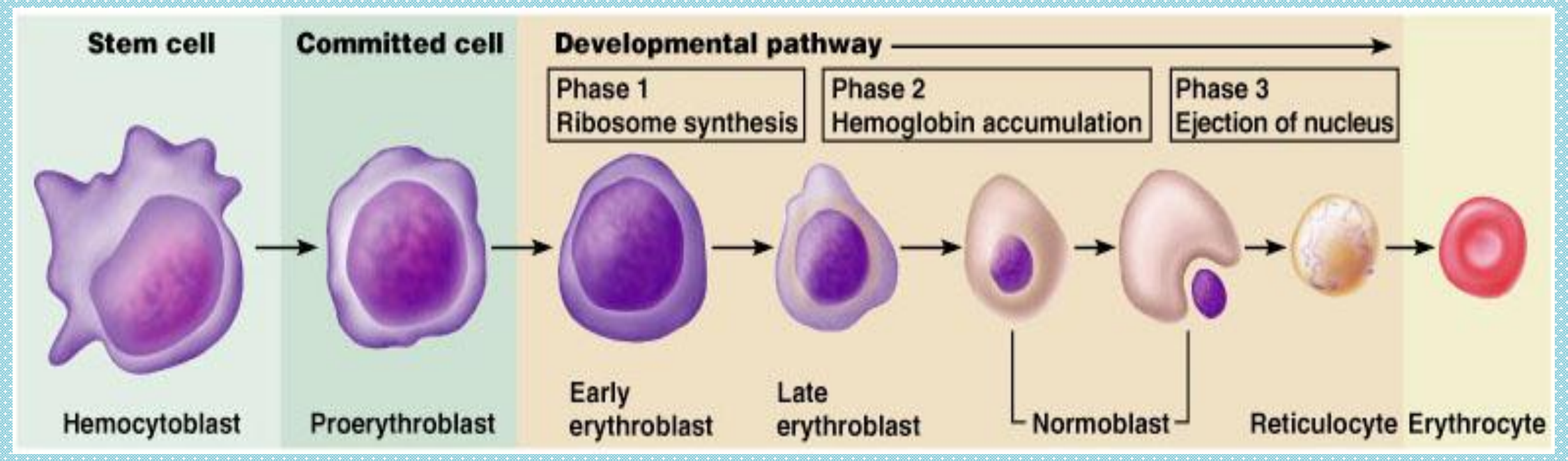
- Absolute volume of blood: 10 times lesser than in adults (0,5 liters & 5,0 liters respectively)
- Blood accounts for approximately 15% of baby body weight, 11% – infant, 7 % – adult
- Viscosity (thickness) is more than in adults
- Hematocrit in newborn is higher (55%) than in adults (40–45%). In infants it is 35% and the 15–year–olds reaching adults indicators.



Erythrocyte (RBC)

- Biconcave disc
- Anucleate,
  - no centrioles,
  - no organelles
- Filled with hemoglobin (Hb) – 97% of cell contents
- Lifespan of 120 days
- Old RBCs removed from blood by phagocytic cells in liver, spleen, & bone marrow
- Most numerous of the formed elements

Production of Erythrocytes: Erythropoiesis



Erythropoiesis (blood cell formation) occurs in the red bone marrow (myeloid tissue)

Normal range of RBCs

- Embryo – 5-6*10^{12}/l
- Newborn – 5-7*10^{12}/l
- Children – 4,5-5,5*10^{12}/l

Too **few** RBCs → leads to tissue hypoxia

Too **many** RBCs → increases blood viscosity

Control of Erythropoiesis

Hormonal controls

Erythropoietin (EPO)

- Direct stimulus for erythropoiesis
- Released by the kidneys in response to hypoxia

Dietary Requirements

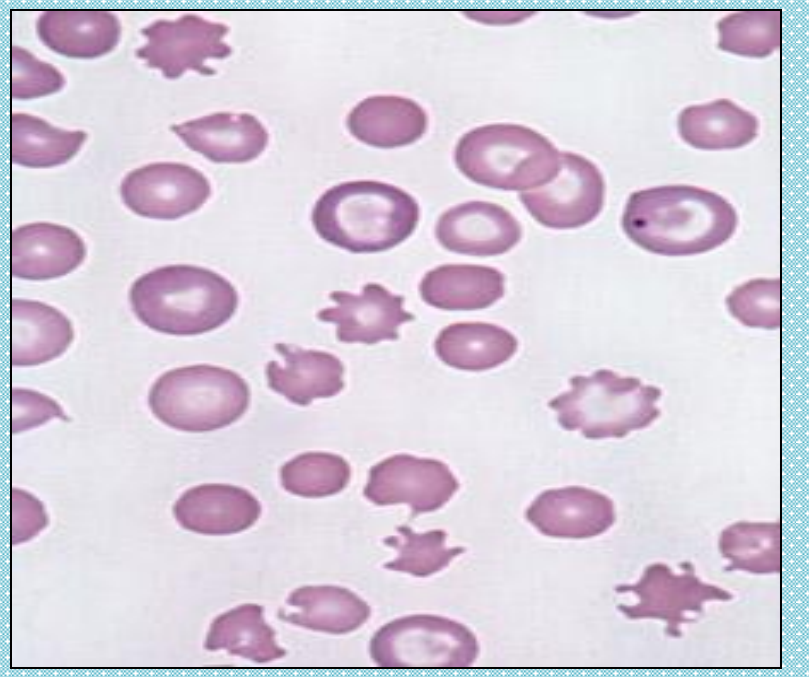
Adequate supplies of

- Proteins, lipids, and carbohydrates
- Iron, vitamin B12, and folic acid

RBCs Abnormal morphology

Shape changes ⇒ **Poikilocytosis**

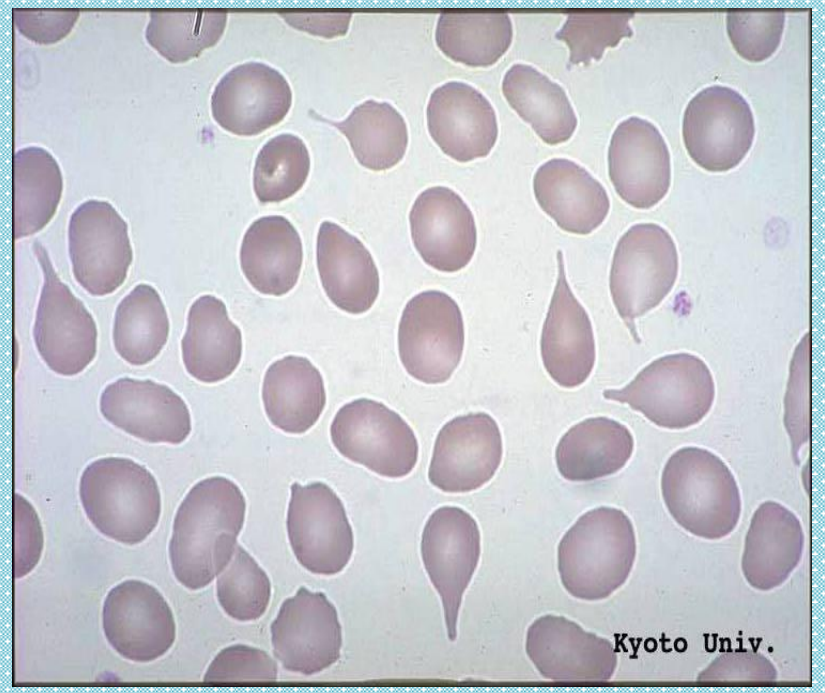
Sickle Cells



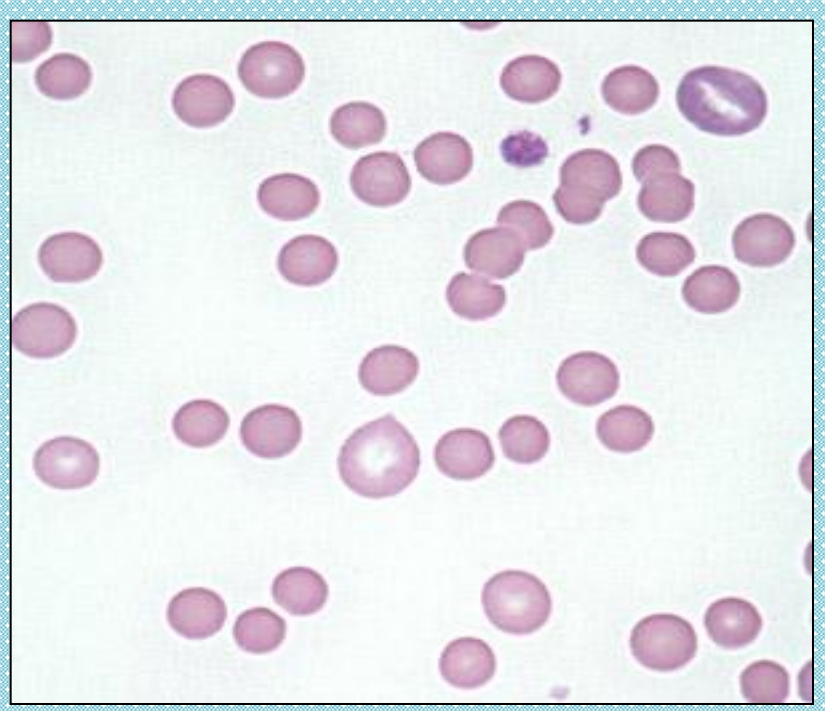
Acanthocytes

RBCs Abnormal morphology

Poikilocytosis



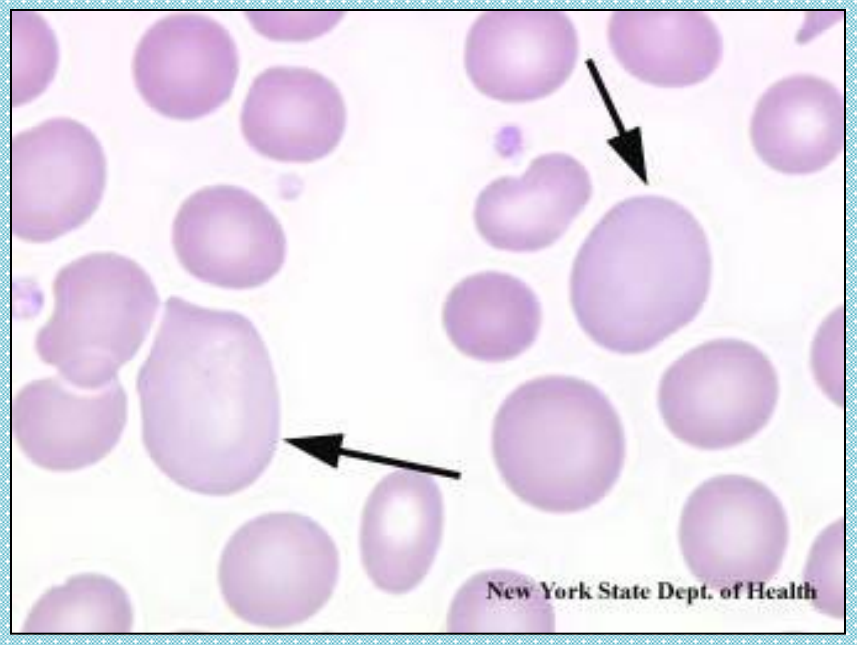
Tear Drop Cells



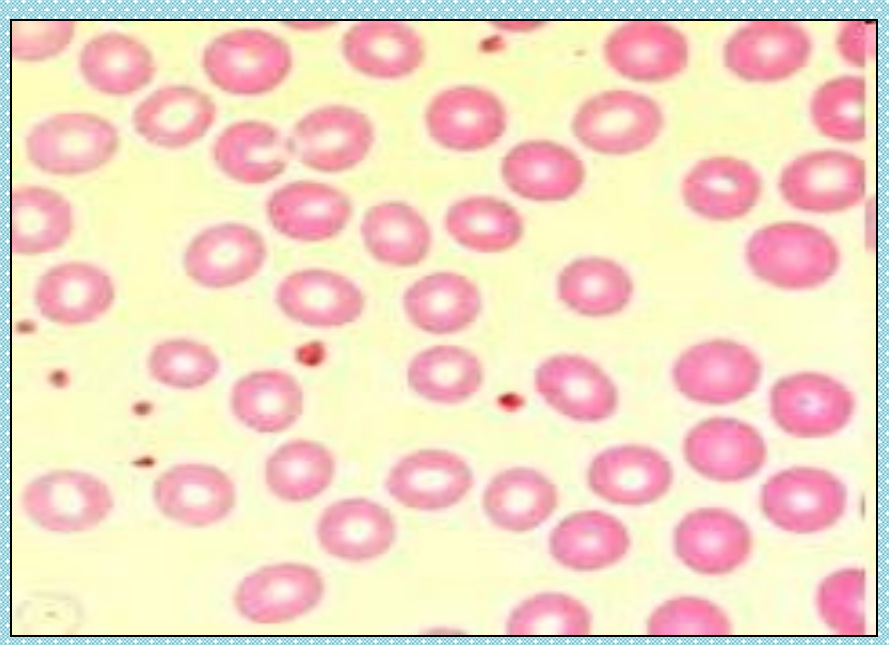
Spherocytes

RBCs Abnormal morphology

Size changes → **Anisocytosis**



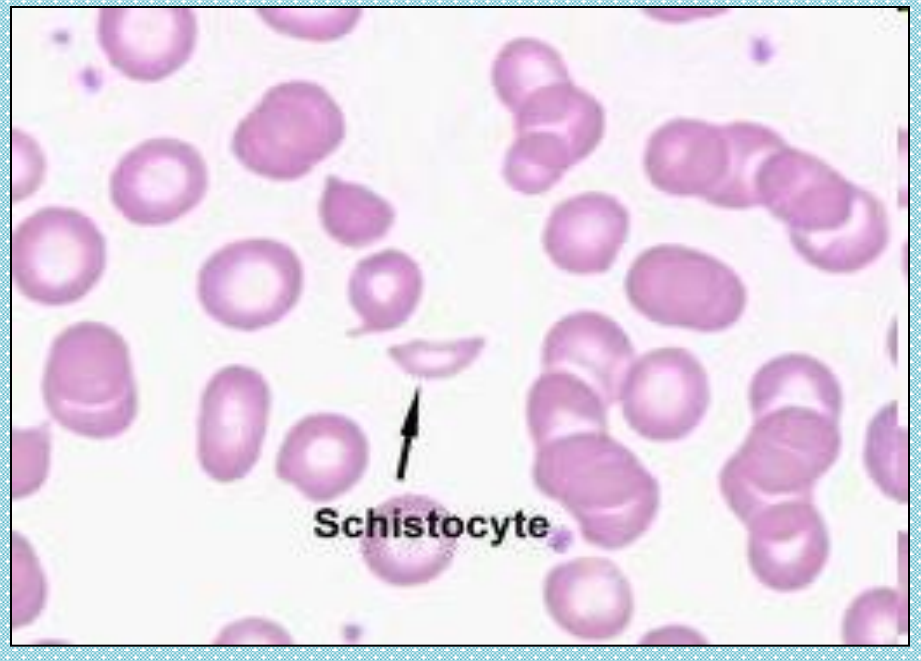
macrocytes



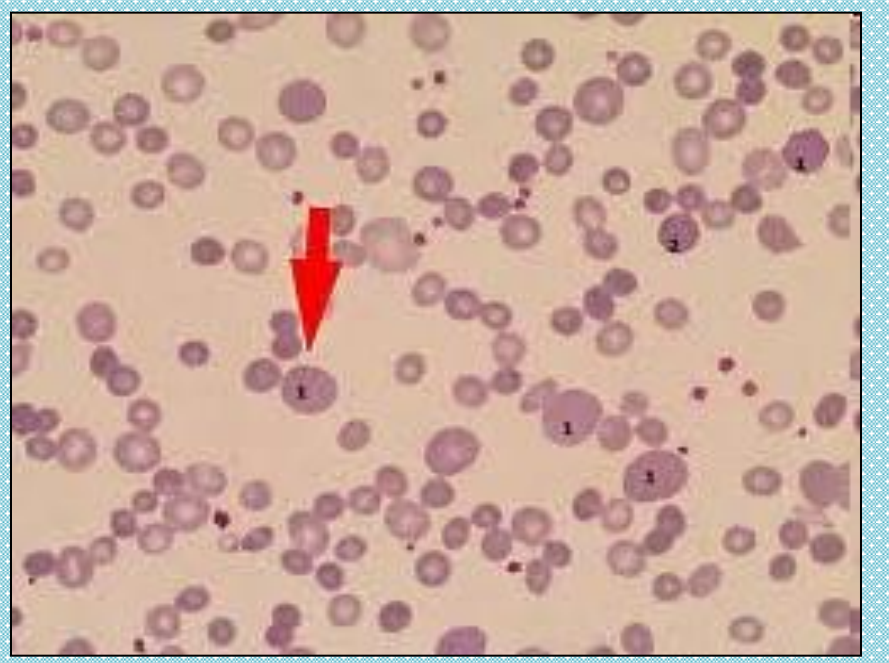
microcytes

RBCs Abnormal morphology

Anisocytosis



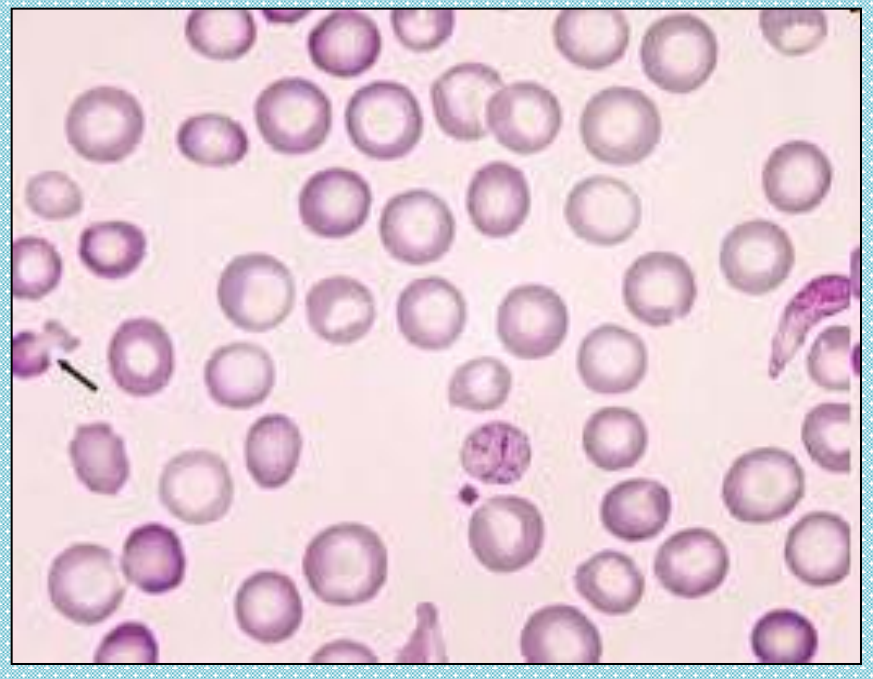
schistocytosis



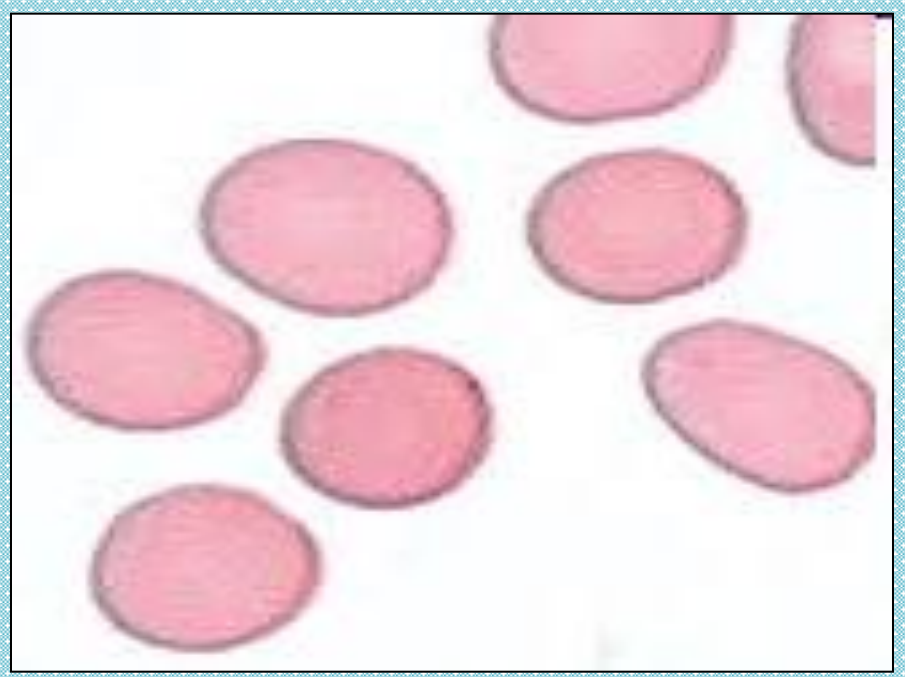
megalocytes

RBCs Abnormal morphology

Color changes ⇒ **Anisochromia**



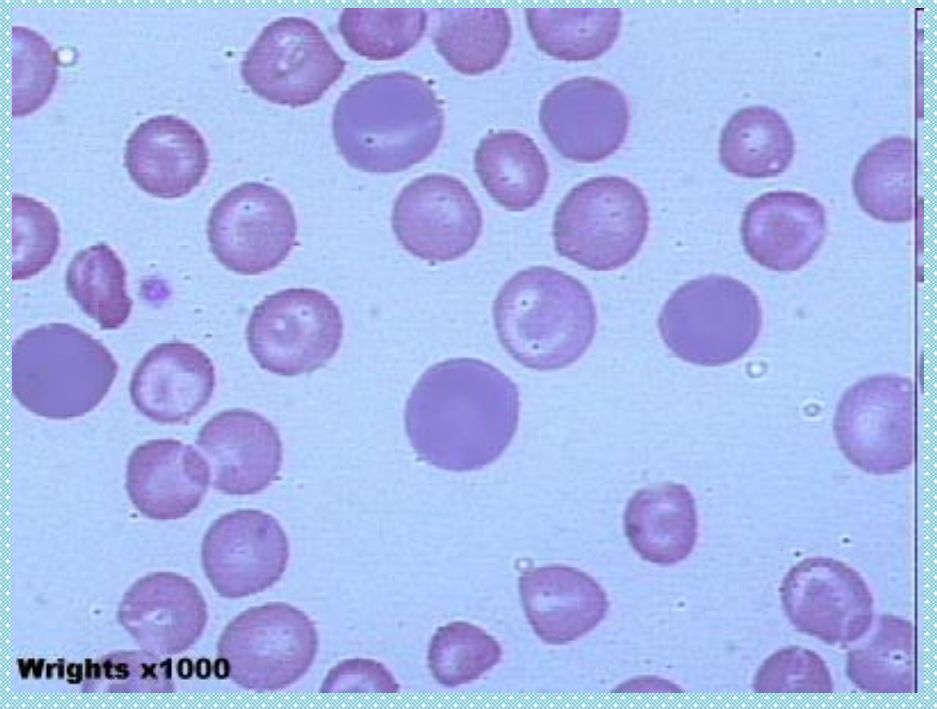
hypochromia



hyperchromia

RBCs Abnormal morphology

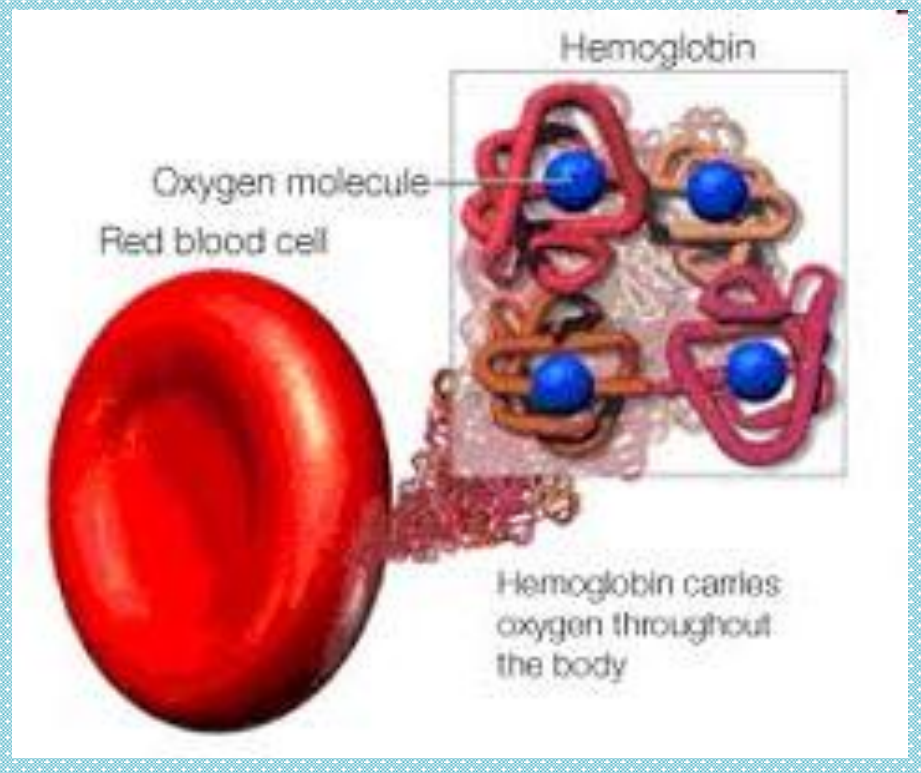
Anisochromia



Polychromasia

Hemoglobin

Hemoglobin is a protein in red blood cells that carries oxygen .



Normal range of Hemoglobin

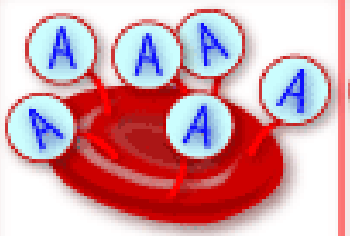
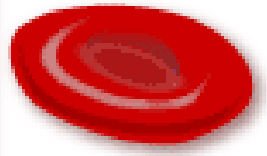
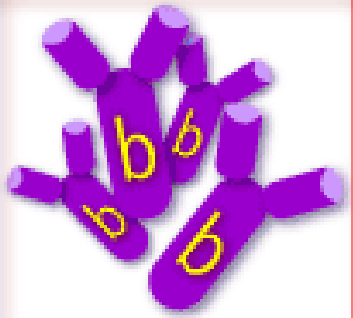
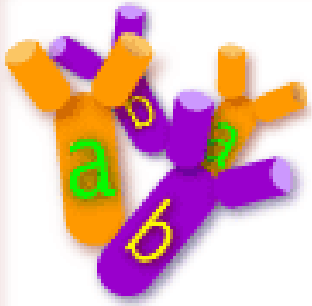
- Newborn – 180-220 g/l

- Children – 120-140 g/l

RBC Antigens & Blood Typing

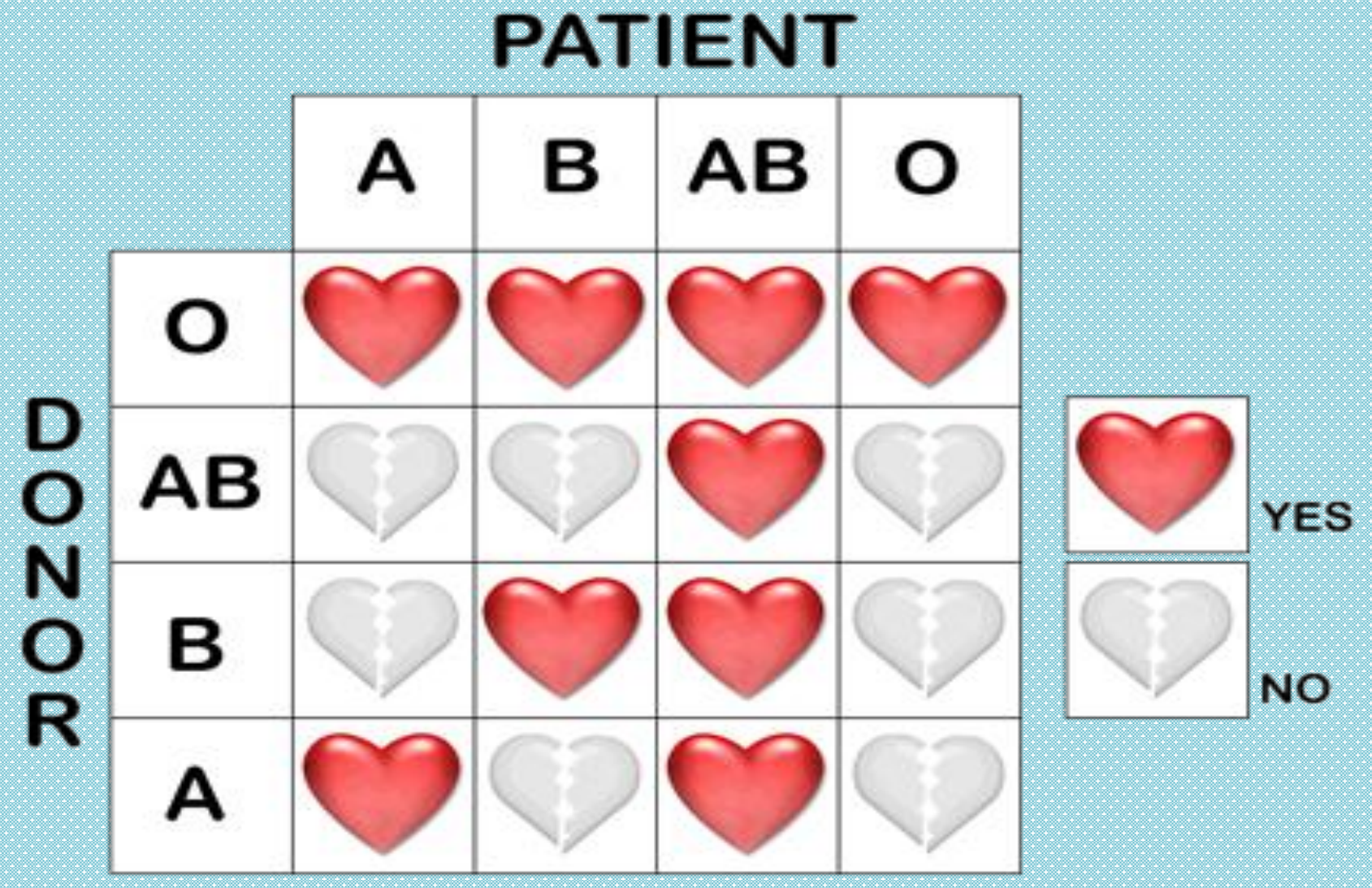
Antigens present on RBC surface specify blood type

The ABO Blood System

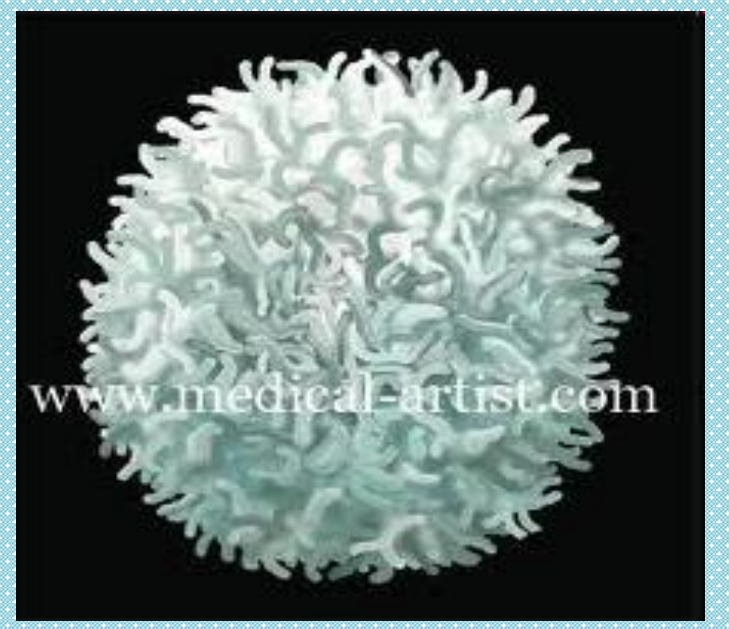
Blood Type (genotype)	Type A (AA, AO)	Type B (BB, BO)	Type AB (AB)	Type O (OO)
Red Blood Cell Surface Proteins (phenotype)	 A agglutinogens only	 B agglutinogens only	 A and B agglutinogens	 No agglutinogens
Plasma Antibodies (phenotype)	 b agglutinin only	 a agglutinin only	 No agglutinin	 a and b agglutinin

http://learn.genetics.utah.edu/units/basics/blood/types.cfm

Blood Groups and Compatibilities



Leukocyte (WBC)

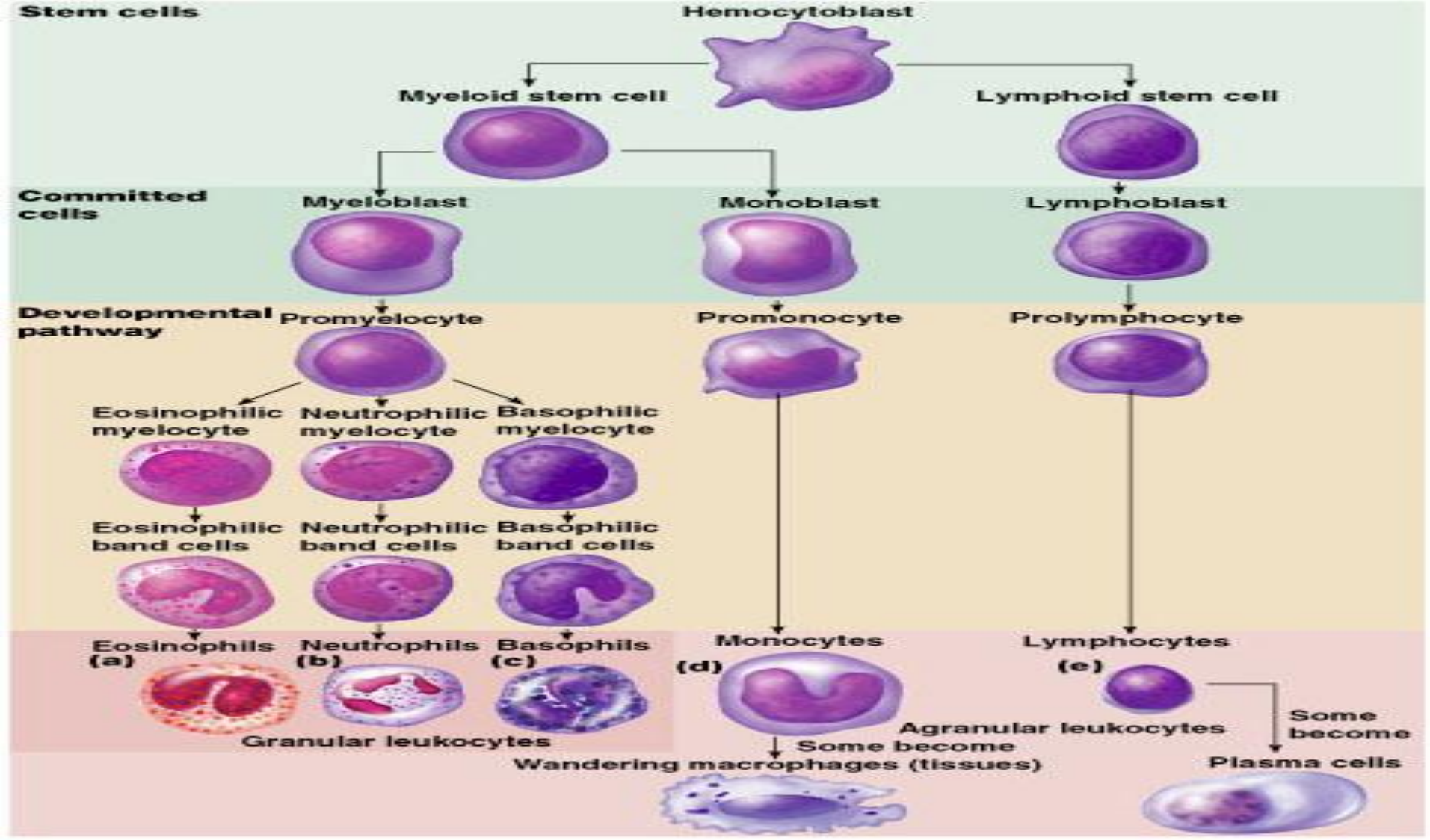


Has nucleus, mitochondria, & amoeboid ability

Granular leukocytes
help detoxify foreign substances & release heparin

Agranular leukocytes
are phagocytic & produce antibodies

Formation of Leukocytes



Normal range of Leukocytes

- Newborn – 10-30*10^9/l

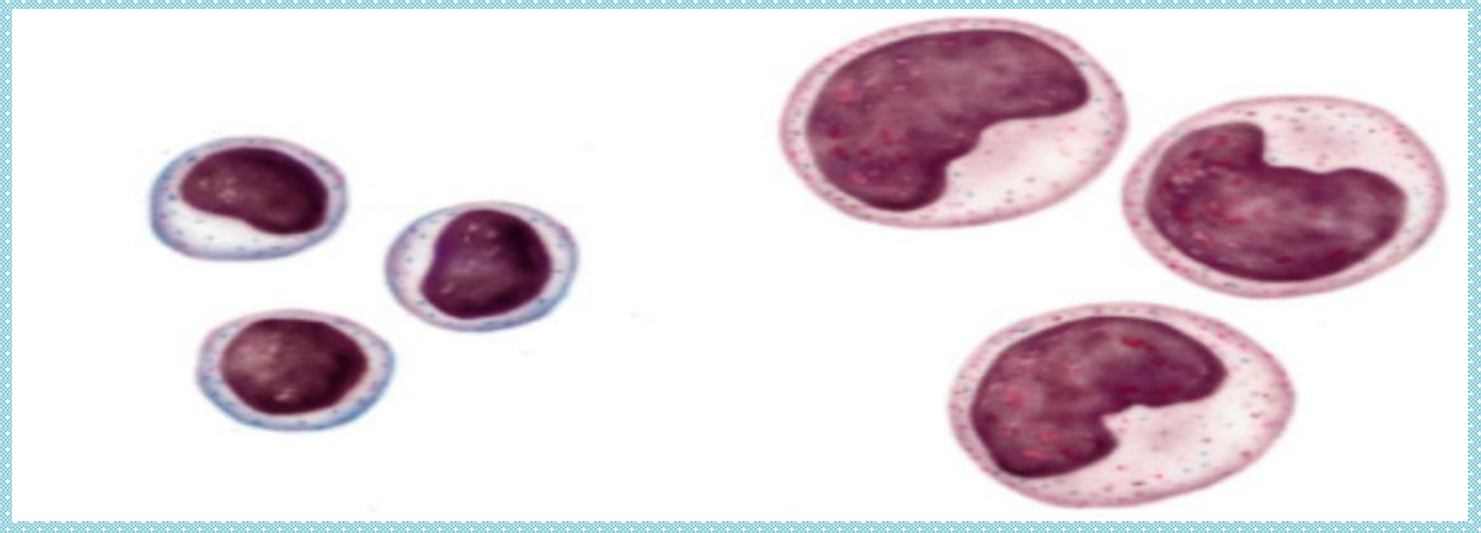
- Infant – 8-10*10^9/l

- Children – 4-9*10^9/l

Granular leukocytes

They make up about 50 to 70% of all white blood cells, play an important role in the immune system.

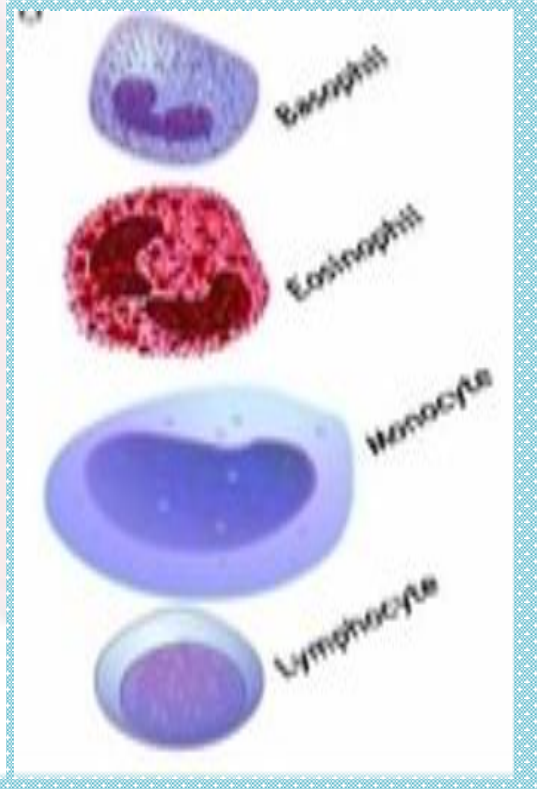
Agranular leukocytes



lymphocyte monocyte

Take charge of the overall cellular immune responses by releasing B, T cells and regulating their functions

Leukogram distribution of different white blood cell types (after 5 year)



metamyelocytes < 1 %
band neutrophils 1-2 %
segmented neutrophils 55-65 %

basophils 0-1 %

eosinophils 2-4 %

monocytes 4-8 %

lymphocytes 23-35 %

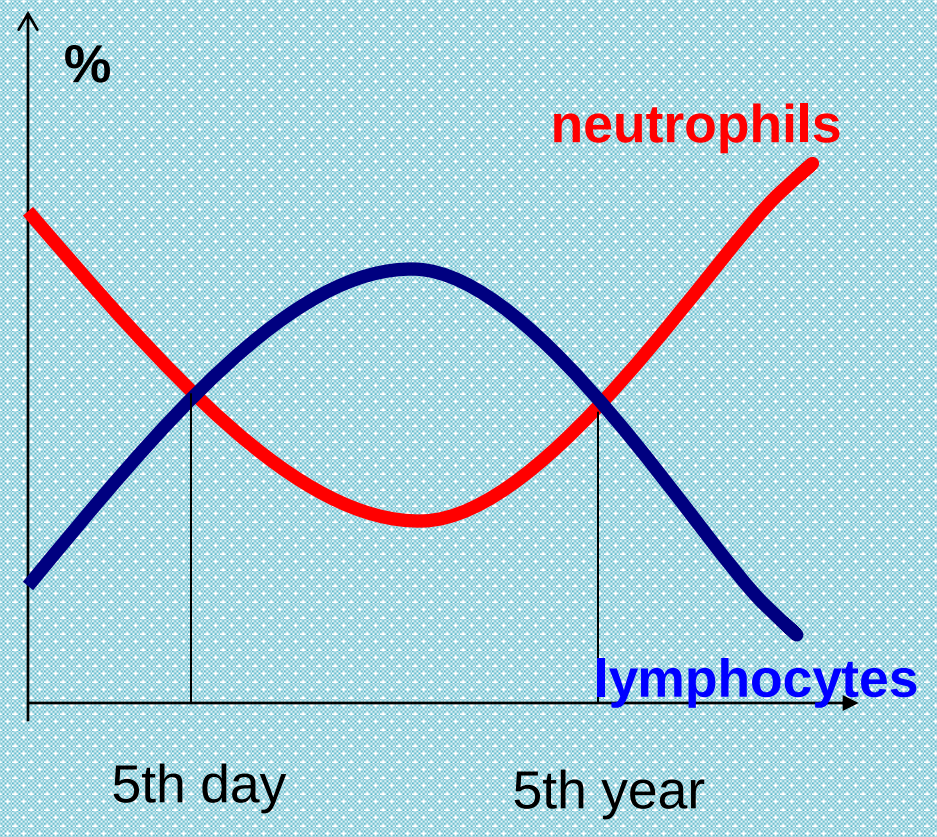
Alteration of the ratio of different WBC:

decrease		increase
Neutropenia	**Neutrophil**	Neutrophilia
Eosinopenia	**Eosinophil**	Eosinophilia
Basopenia	**Basophil**	Basophilia
Lymphopenia	**Lymphocyte**	Lympocytosis
Monocytopenia	**Monocytes**	Monocytosis

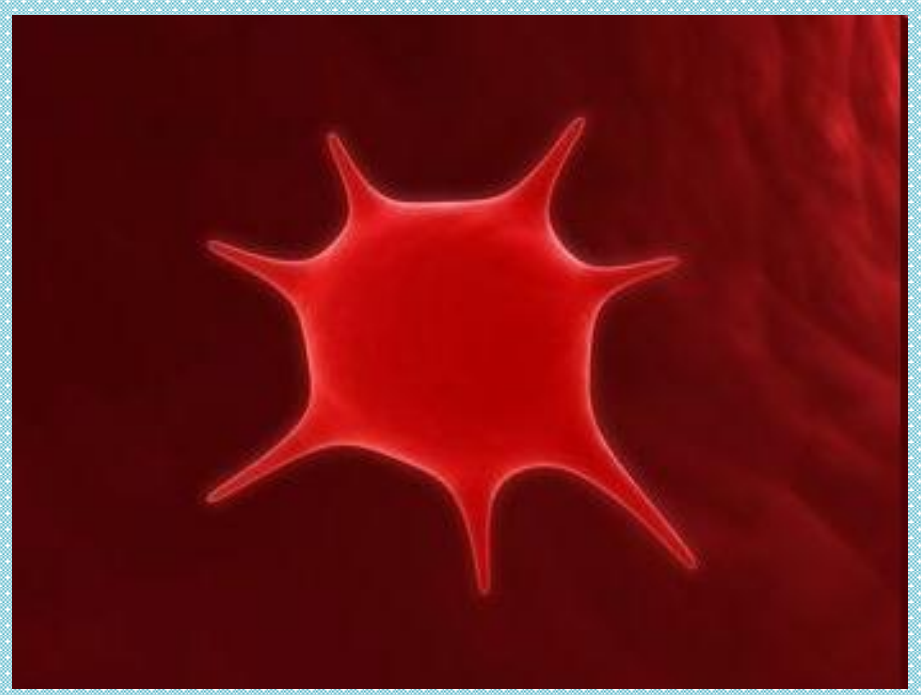
«Decussations» of the Leukogram

On a 4-5th day life “first decussation” is observed, when an amount of neutrophilic granulocytes and lymphocytes is equal and averages 40-45 %.

«Second decussation» comes in 4-5-years-old age, when the amount of neutrophilic granulocytes and lymphocytes is aligned and averages 40-45%.



Trombocyte (Platelet)

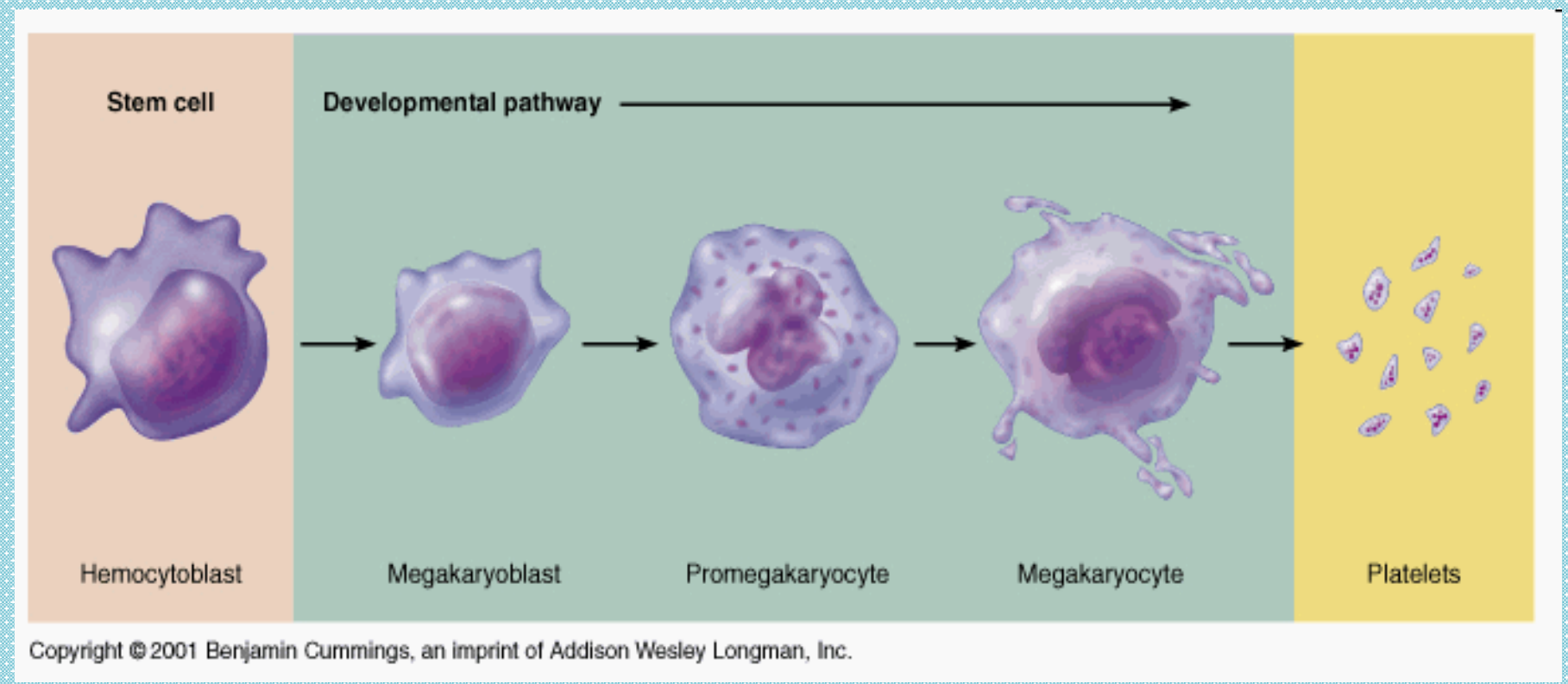


Small fragments of megakaryocytes

Lifespan – 8-9 days

- ✓ Main function – participation in the process of blood coagulation
- ✓ Formation is regulated by thrombopoietin
- ✓ Blue-staining outer region, purple granules

Formation of Platelets



Platelets come from larger progenitor cells called megakaryocytes, and platelet production represents the final stage of megakaryocyte development

Normal range of Trombocytes

- Newborn – 150-400*10^9/l
- Infant – 150-400*10^9/l
- Children – 150-400*10^9/l

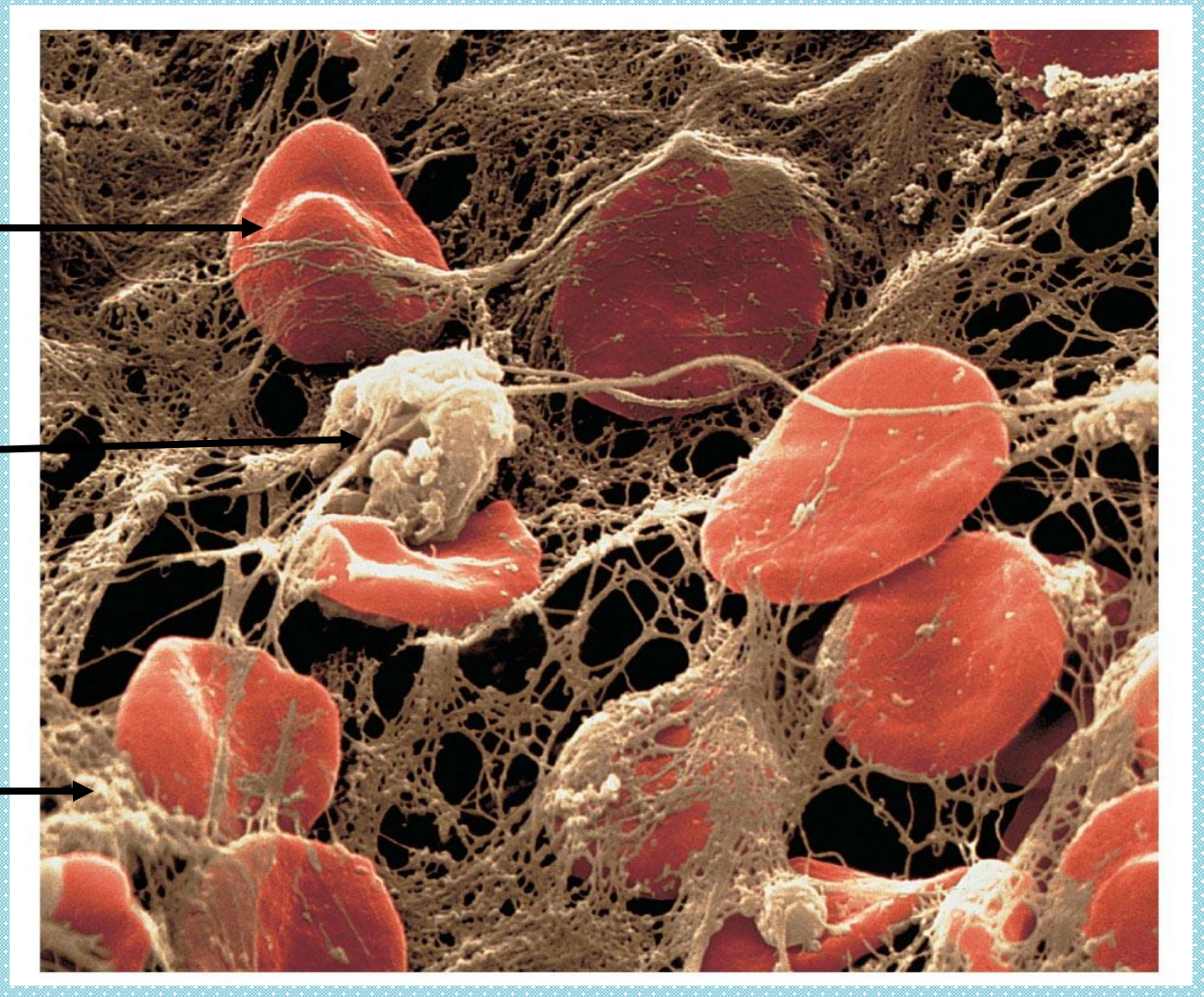
Blood Clotting

Blood clotting, or coagulation, is an important process that prevents excessive bleeding when a blood vessel is injured.

Normal haemostatic system

- **vessel wall**
- **circulating blood platelets**
- **blood coagulation and**
- **fibrynolysis**

Blood Clot



Methods of clinical examination of blood system

Collecting complaints

TYPICAL

- **Bleeding**
- **Infections**
- **Enlarged lymph nodes=lymphoadenopathy**
- **Pallor of skin and mucous membranes**
- **Jaundice**
- **Ostealgia = bone pain**

COMMON

- Body temperature rises
- Headache, dizziness
- Fatigue, weakness
- Night sweats
- Poor appetite
- Dyspnea after physical load

Anamnesis morbi

- When the patient got sick,
- What the disease began with first symptoms
- Possible reasons of its occurrence (in patient’s opinion).
- How the disease developed up to the moment of patient’s examination.
- Where the patient addressed for help
- Where he was examined and treated,

Anamnesis of life

- **Hereditary diseases**
- **Obstetrical anamnesis**
- **Parent’s health**
- **Mother’s harmful habits**
- **Pregnancy duration**

- Childbirth pathology
- Life conditions
- Irrational feeding
- Presence of other diseases (malnutrition, rickets, dysbacteriosis)

Physical Examination

- **Skin**
- **Eyes**
- **Mouth**
- **Lymph Nodes**
- Heart and Chest
- Abdomen
- Nervous System
- Musculoskeletal System

Physical exam of the skin - Inspection

1. Jaundice (hemolisis)

2. Florid (reddish) – polycythemia

Physical exam of the skin- Inspection

3. Pallor – anemia

4. Petechiae – tiny red dots in the skin

Physical exam of the skin- Inspection

5. Purpura – large purplish blotches related to multiple hemorrhages into the skin.

6. Bruising

Physical exam of the skin- Inspection

6. Albinism (white).

7. Cianosis

Physical exam of the skin- Palpation

difference between hemorrhages and infection rash

hematological → **hemorrhages**

Physical exam of the Eyes - Inspection

Physical exam of the Mouth - Inspection

Physical exam of the Lymph Nodes - Inspection

Physical exam of the Lymph Nodes - Palpation

- *Mobility*
- *Conglomeration*
- *Elastic or dense*
- *Painfulness*
- *Skin temperature in the node's place*
- *Surface of the node's place*

hematological

- Mobile
- Many groups
- First elastic, later - dense
- Painless
- firm

(leukemia, lymphomas)

Physical exam of the Liver – Palpation, percussion

- Size
- Surface of the edge

hematological

Hepatomegaly
(leukemia, hemorrhagic disorders)

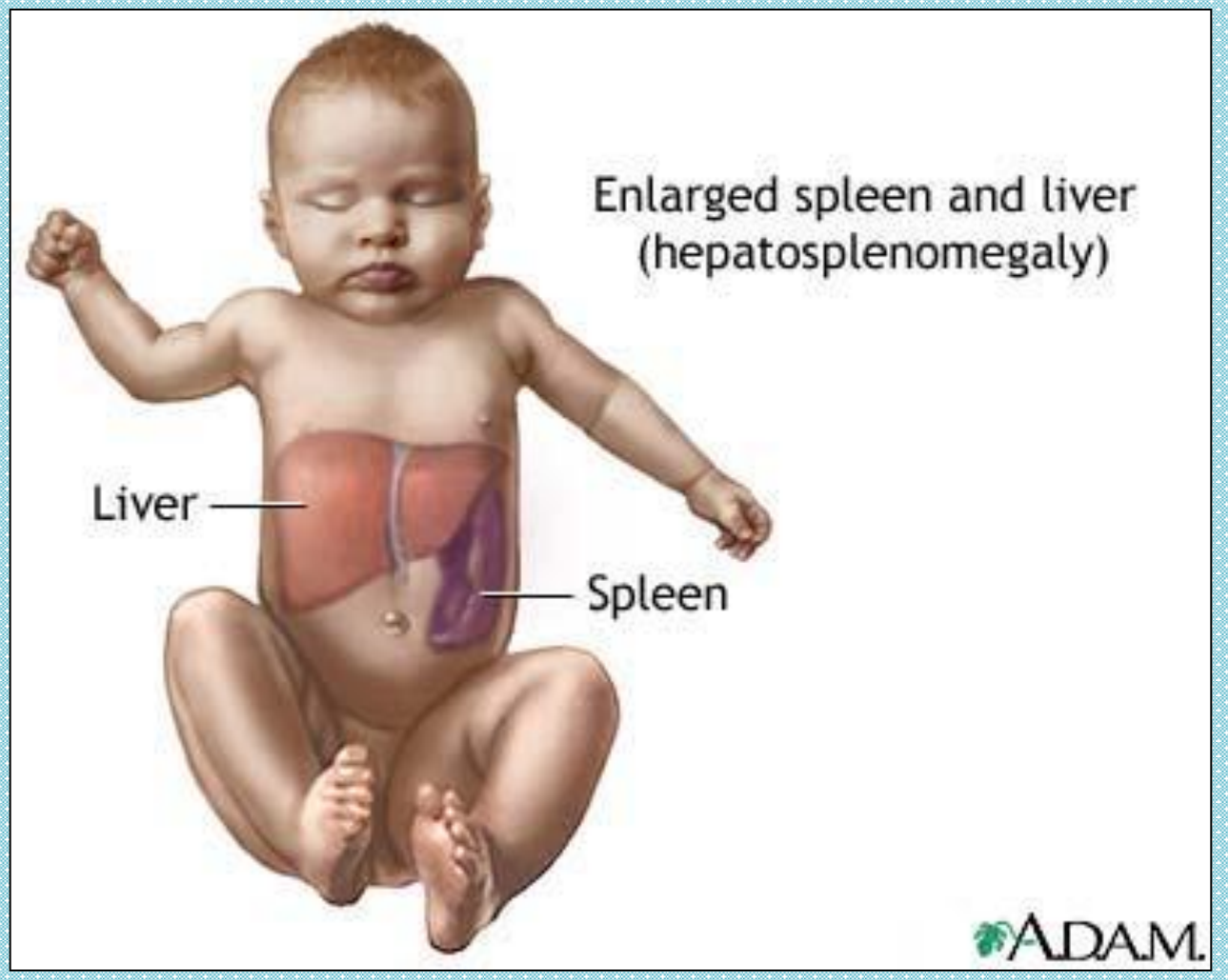
Physical exam of the Spleen – Palpation, percussion

- Size

hematological

Splenomegaly
(leukemia, hemorrhagic disorders)

Hepatosplenomegaly



Physical exam of the joints - Inspection

hematological

Hemarthrosis

(Hemophilia, Von Willebrand Disease)

Physical Exam of the **CVS** - *Palpation, percussion, auscultation*

- Dyspnea,
- Tachycardia
- Low blood pressure
- Chest pain
- Heart failure **(anemia)**

Additional methods of examination

Common blood count

1. RBC count,
2. Hb level,
3. Colour index (CI, mean corpuscular Hb concentration),
4. Erythrocyte sedimentation rate (ESR),
5. WBC count,
6. Platelet count.
7. Hematocrit.

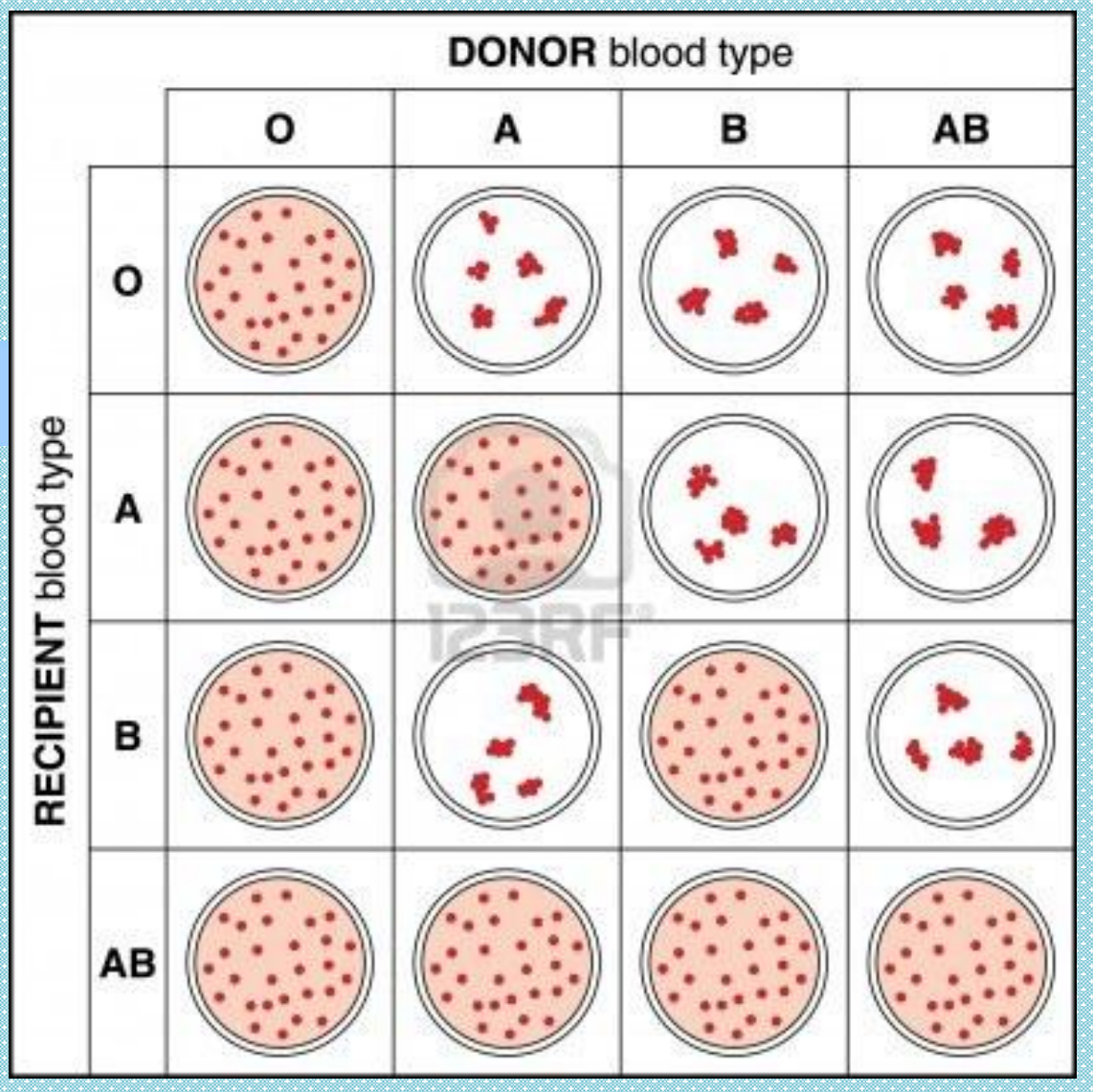
Additional methods of examination

Coagulation tests

1. Prothrombin index (N: 70-100 %),
2. Thrombin time (N: 14-16 sec)
3. Concentration of fibrinogen in plasma (N: 2-4 g/l)
5. Bleeding time (N: not more 360 sec)
6. Clotting time (Lee-White, Burker) (N: 6-10 min).
7. Tourniquet test (capillary fragility) .
8. Determination of specific coagulation factors deficiency (N: 0,6-1,5 each of them)

Additional methods of examination

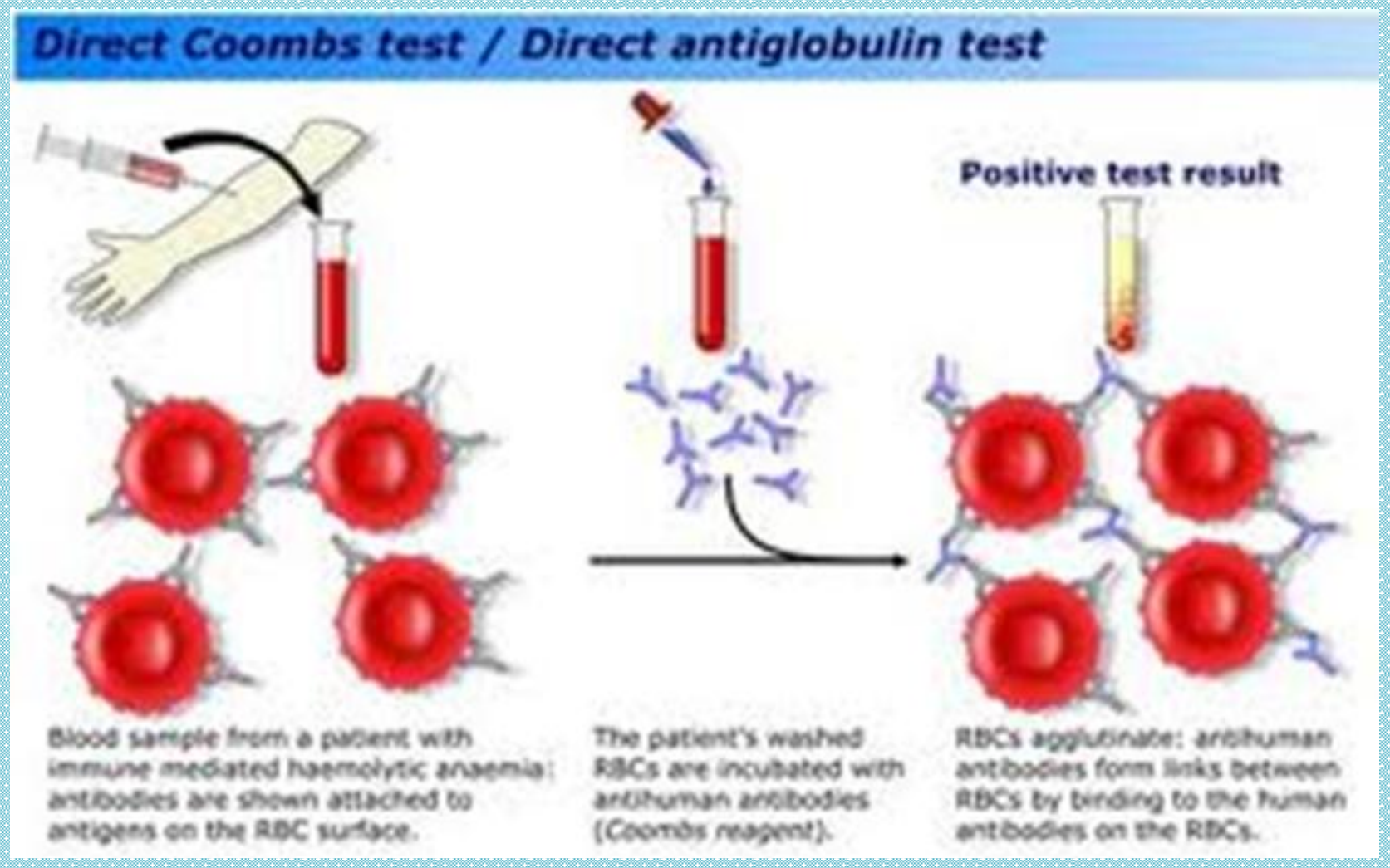
Blood Type and cross match.



Biochemical blood test

- Concentration serum iron (N: 7,7-33 mkmol/l)
- Iron-binding capacity (TIBC). (N: 40-70 mkmol/l)
- Serum bilirubin levels). (N: 8,5-20,5 mkmol/l)

Immunological blood test



Coombs test

Additional methods of examination

Ultrasound investigation of spleen, liver, lymph nodes.

Radiography.

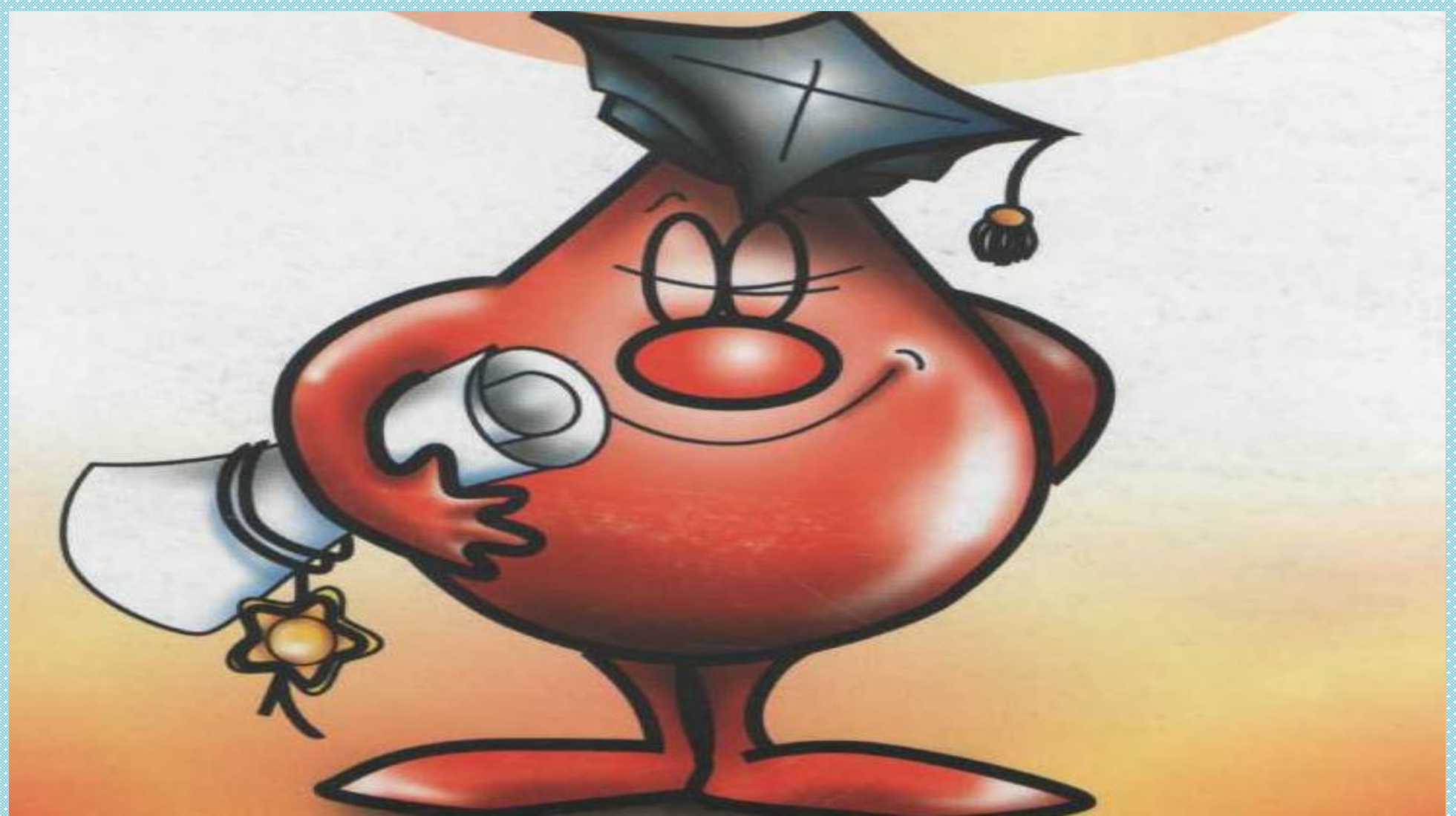
Biopsy of bone marrow.

Bone marrow puncture

- The ratio of the elements of white and red blood in children is 3: 1;
- granulocytes - 40–60%;
- lymphocytes - 10–20%;
- monocytes - no more than 3 - 5%;
- megakaryocytes - 0.5% of all formed elements.

In normal case! At pathology appear blast cells!

Thank you for your attention!



Literature, was used in the lecture

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Інтернет – ресурси: Сайти МОЗ України: https://moz.gov.ua/protokoli Онлайн-платформа з протоколами на засадах доказової медицини Джерела клінічних настанов Інформаційні ресурси http://www.booksmed.com/pediatriya http://pediatriya.info http://health-ua.com/parts/pediatrics http://medkniga.ucoz.net/publ/pediatrija/40 http://www.medport.info/index.php?option=com_content&view=section&id=48&Itemid=73. Medscape Pediatrics: http://www.medscape.com/pediatrics