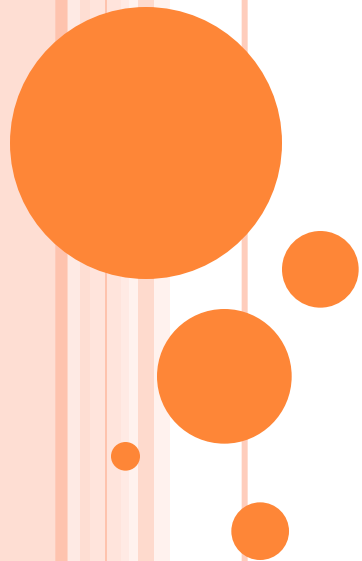


BLOOD

RNDr. Hana Zoubková, Ph.D.



BLOOD

Part of an extracellular fluid – intravascular

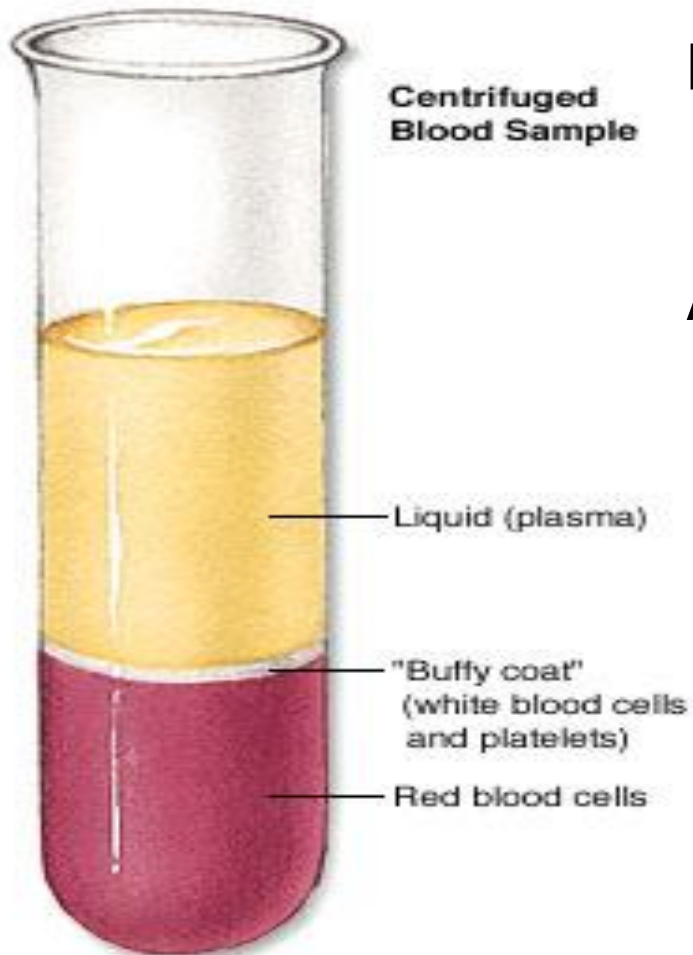
The blood consists of a suspension of special cells - **formed elements = erythrocytes, leukocytes, thrombocytes** in a liquid called **plasma**

In an adult man:

the blood is about $1/12^{\text{th}}$ (6-8%) of the body weight and this corresponds to **4,5-6 liters**



HEMATOCRIT – RELATION (VOLUME %) OF ERYTHROCYTES (45 %) TO FULL BLOOD



Normal values vary with
age and sex.

Adult male range is **39-49, 44 ± 5 %**

adult female **35-43, 39 ± 4 %**



BLOOD FUNCTIONS

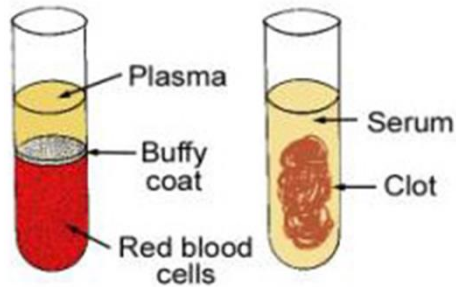
- **maintenance of homeostasis** - osmotic pressure stability
pH = 7.4 ± 4) (bicarbonate buffer system - HCO_3^-)
- **transport of respiratory gases**: **oxygen** O_2 to tissues (by the hemoglobin in red cell), **carbon dioxide** CO_2 from tissues (by the plasma in the form of soluble carbonates HCO_3^-)
- of nutrients**: amino acids, sugars, fatty acids
- of waste products of metabolism** which will be excreted through the renal filter
- of hormones, enzymes, vitamins, mineral salts**
- performs **thermoregulation** of the organism
- performs **the defense** of the organism



PLASMA

is a slightly alkaline fluid, with a typical yellowish color. By centrifugation can be obtained cells free **serum** - clotted

plasma - unclotted due to adding anticoagulants



It consists of **91 % water** and **9% dry matter**: 9/10 is made up by organic substances and 1/10 is made up by minerals. The **mineral substances** are dissolved in ionic form, positive and negative:

- **main cation is sodium Na^+ ,**
- **main anion is chloride Cl^- and bicarbonate HCO_3^-**

They maintain of osmotic pressure, blood volume, and acid-base balance

PLASMA / SERUM

These organic substances are composed of

saccharides glucose (3,9-5,9mmol/l)

lipids cholesterol, triglycerides, phospholipids, lecithin

proteins (60-80g/l) albumins(42g/l), globulins ($\alpha, \beta, \gamma,$) fibrinogen

glycoproteins, lipoproteins, amino acids

urea, uric acid

hormones, vitamins



HEMATIC CELLS

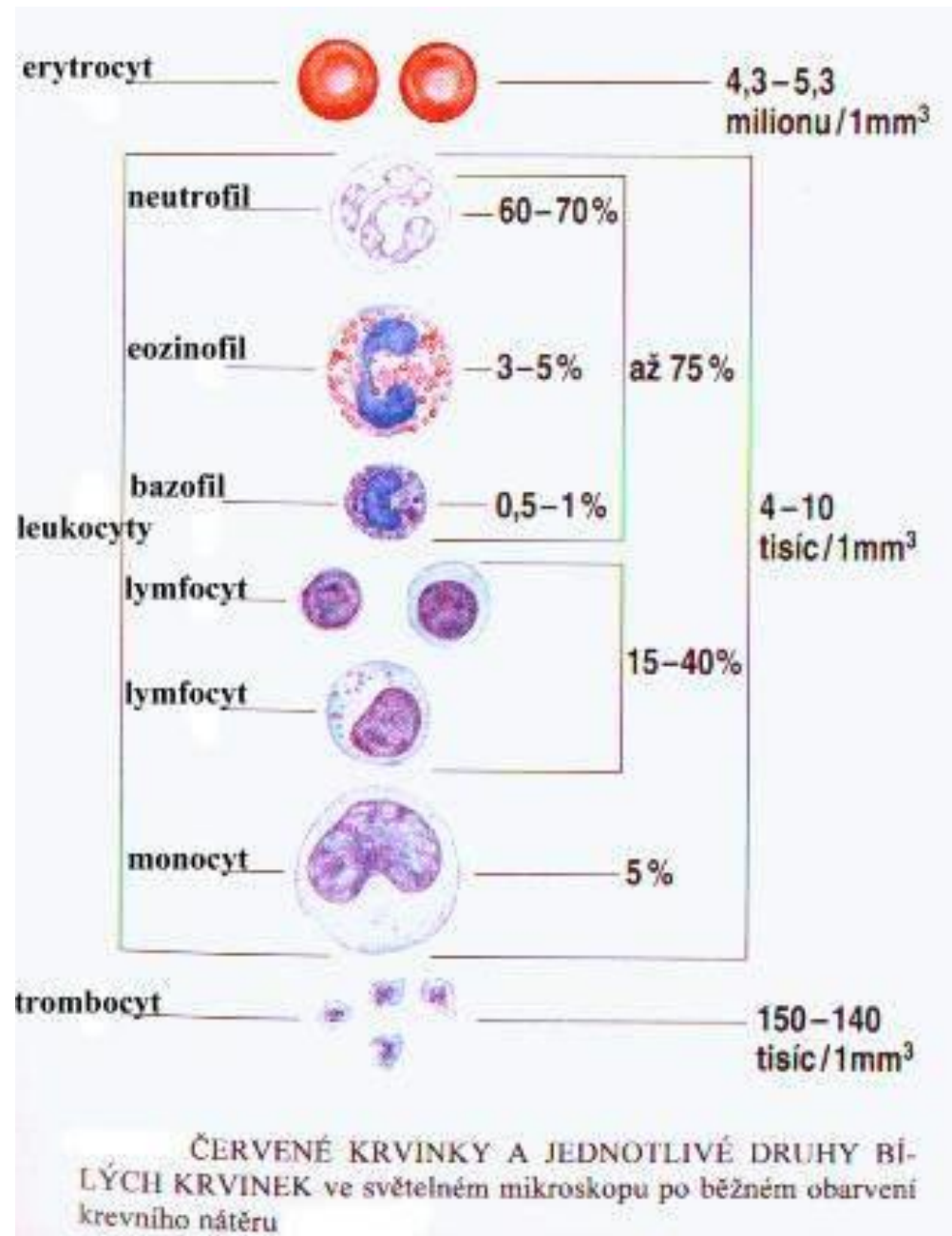
Special cells

- erythrocytes

- leukocytes

- thrombocytes

are not considered
real cells



ERYTHROCYTES = ERY (RED BLOOD CELLS) PROVIDING OXYGEN IN HEMOGLOBIN TO TISSUES

3.8 – 4.8 x 10¹² / l in female

4.3 - 5.3 x 10¹² / l in male

7 .10¹² / l in newborn

8 .10¹² / l in sportsmen

size 7,2 µm in diameter

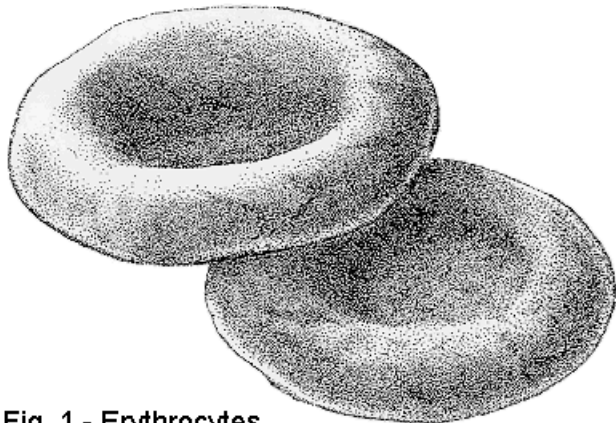


Fig. 1 - Erythrocytes

In man and in all mammals:

they are devoid of a nucleus

In the other vertebrates:

they have a nucleus

the lack of nucleus allows more room for hemoglobin =>

the shape of a biconcave lens raises the surface and cytoplasm volume ratio.

=> more efficient the diffusion of oxygen

The mean life is about 120 days



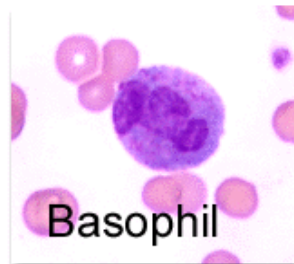
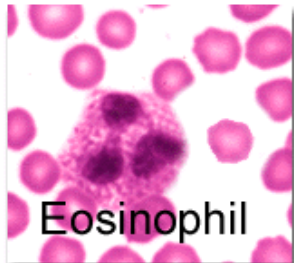
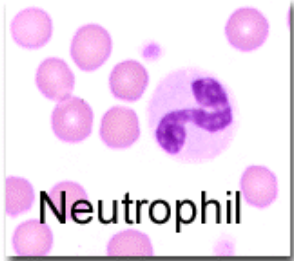
HEMOGLOBIN

- **Hem and globin** – four protein chains HbA $\alpha_2\beta_2$ at adult
HbF $\alpha_2\gamma_2$ at fetus
- **Hem contains four atoms of iron. Each hemoglobin protein can bind four oxygen molecules = oxyhemoglobin.**
It depends on to temperature, pH and CO_2
- Carbon dioxide binds globin = **karbaminohemoglobin**
- Myoglobin and hemoglobin are able to bind oxygen because of the presence of iron atom
- HbS = mutated hemoglobin gene for sickle cell anemia.



LEUCOCYTES = LEUCO (WHITE CELLS)

4-10 $\cdot 10^9 / l$, size $\geq 10 \mu m$ in diameter



granulocytes (presence of granules in the cytoplasm) 70%
granules have a different affinity towards neutral, acid or basic stains and give the cytoplasm different colors.

neutrophils 50-70%, microphages, diapedesis, chemotaxis

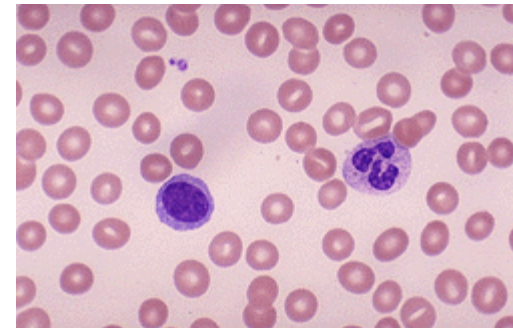
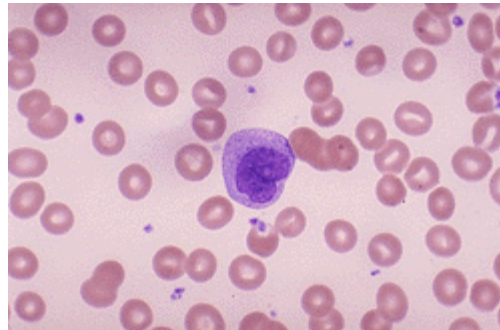
eosinophils do 5%, diapedesis, allergy, phagocytosis

basophils to 1%, histamine, heparin

agranulocytes (lymphoid cells) 30%

lymphocytes (right pict.) 24-40% cell and humoral immunity

monocytes (left pict.) macrophages, secretion of growth factors

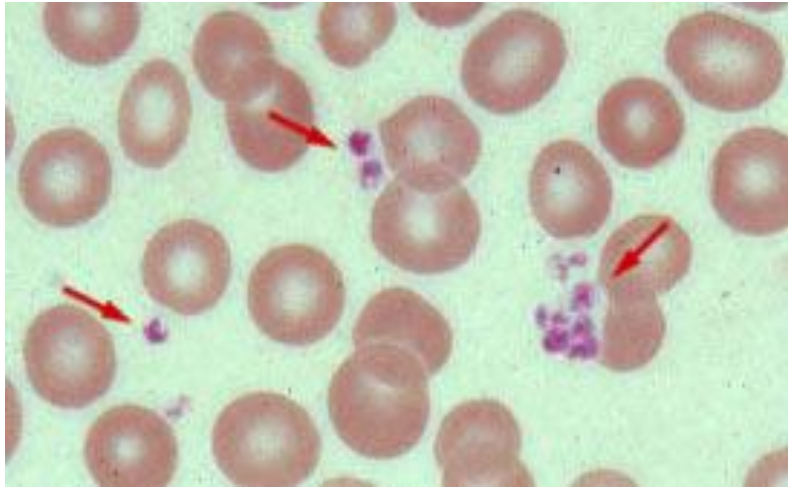


THROMBOCYTES = TROM (PLATELETS)

150-350 .10⁹ / l

size 3µm in diameter

They are formed by the splitting of parts of the cytoplasm of megakaryocytes cells in the bone marrow.



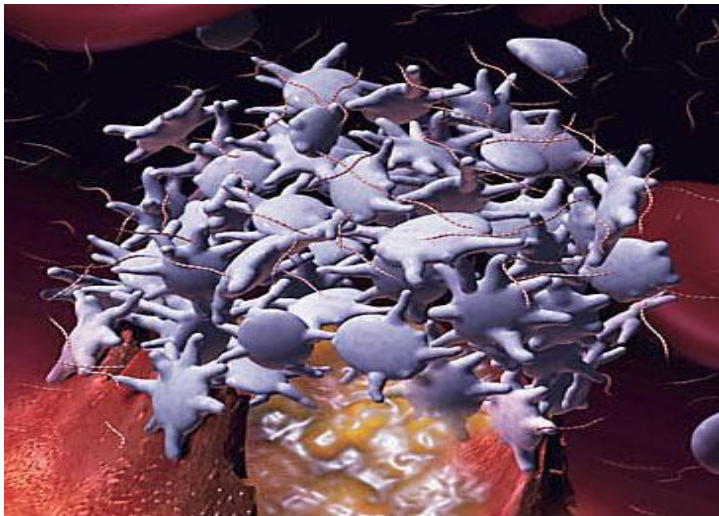
main function: **hematostasis**

to stop the loss of blood from

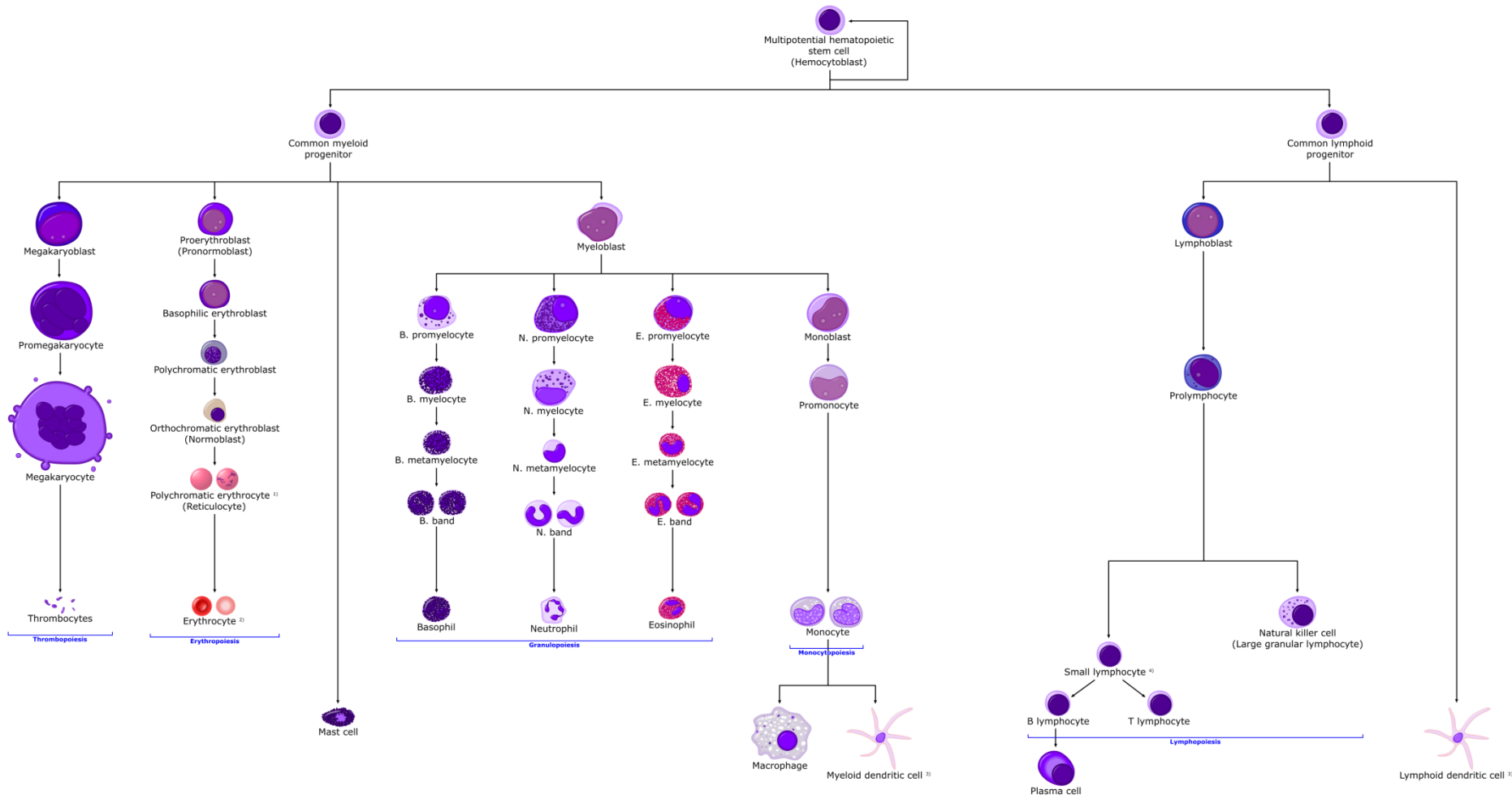
wounds => they aggregate and release factors which promote the blood coagulation:

serotonin - vasoconstriction

fibrin - traps cells + forms clotting



HEMATOPOIESIS



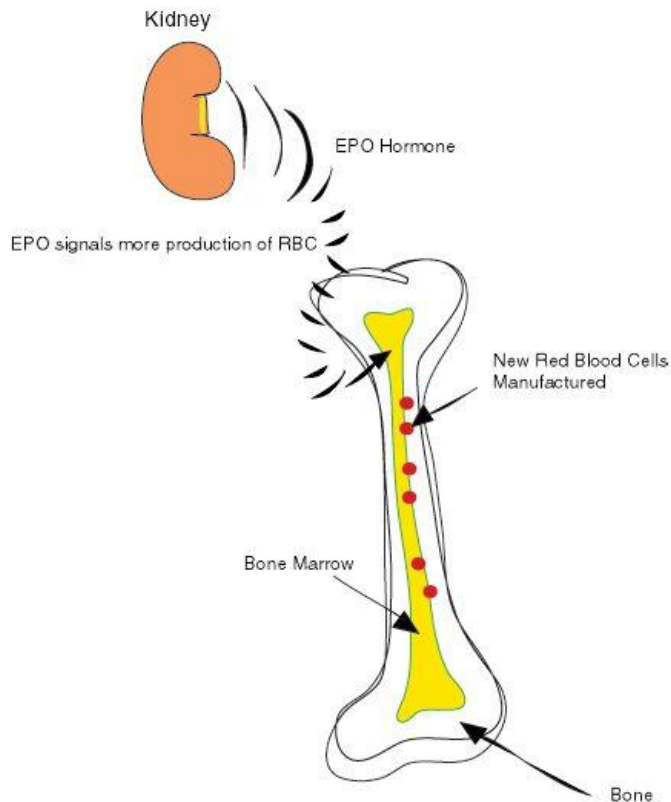
STEM cells – self-renewal, differentiation

Hematopoiesis requires: **iron, AA, folic acid, vitamin B12, growth factors G-CSF, GM-CSF, erythropoietin, trombopoietin**

ERYTHROPOIETIN

IS CONVERTED FROM A PLASMA PROTEIN IN THE KIDNEY

Erythropoietin stimulates production of erythrocytes in the bone marrow.



A negative-feedback mechanism

- is sensitive to the amount of O_2 in the blood = tissue hypoxia:

$\downarrow O_2 \Rightarrow \uparrow$ erythropoietin

$\uparrow O_2 \Rightarrow \downarrow$ erythropoietin



BLOOD GROUPS

Antigens on the cell membrane of ERY determine different blood groups. They are glycoproteins and lipoproteins.

ABO (H) System

Antigens = agglutinogens A, B, H

Antibodies = immunoglobulins = agglutinins

anti-A, anti-B

1. group A, 2. group B, 3. group AB,





anti-B anti-A -

4. group O (with H)

anti-A anti-B

Allele	Carbohydrate
I^A	A \blacktriangle
I^B	B \bullet
i	none

(a) The three alleles for the ABO blood groups and their associated carbohydrates

Genotype	Red blood cell appearance	Phenotype (blood group)
$I^A I^A$ or $I^A i$		A
$I^B I^B$ or $I^B i$		B
$I^A I^B$		AB
ii		O

(b) Blood group genotypes and phenotypes

ABO Blood Groups

TABLE 17.4 ABO Blood Groups

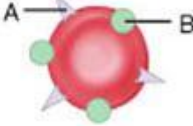
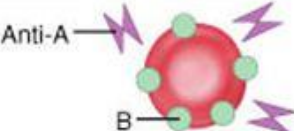
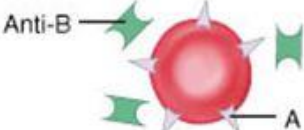
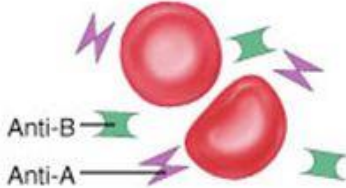
Blood Group	Frequency (% U.S. Population)				RBC Antigenes (Agglutinogens)	Illustration	Plasma Antibodies (Agglutinins)	Blood That Can Be Received
	White	Black	Asian	Native American				
AB	4	4	5	<1	A B		None	A, B, AB, O Universal recipient
B	11	20	27	4	B		Anti-A (a)	B, O
A	40	27	28	16	A		Anti-B (b)	A, O
O	45	49	40	79	None		Anti-A (a) Anti-B (b)	O Universal donor

Table 17.4

Rh System

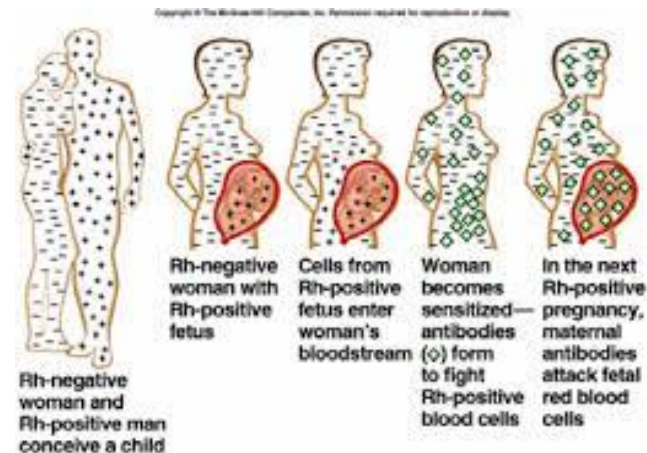
Agglutinogens on the cell membrane of ERY: **C, D, E, c, d, e.**

The system does not have natively occurring antibodies. **The strongest is D antigen**, occurs at 85% of white population = **Rh positive (+)**

15% of population without is **Rh negative (-)**

Antibodies anti-D occurs, when the Rh negative blood contacts the Rh positive blood. It happens during pregnancy, when mother is Rh neg and child (as father) is pos. When placenta is disrupted, during birth and abortion ery of the child enter mother's bloodstream. The mother produces antibodies, a production increases with the number of births, abortions. Antibodies causes

fetal erythroblastosis



BLOOD TRANSFUSION

- A transfer of blood from a donor to recipient
- full blood, packed red blood cells, plasma, thrombocyte
- **A recipient must receives only blood of his own blood group (ABO and Rh system).**
- Crossmatching is testing before a blood transfusion

Blood Group	Antigens	Antibodies	Can give blood (RBC) to	Can receive blood (RBC) from
AB	A and B	None	AB	AB, A, B, O
A	A	B	A and AB	A and O
B	B	A	B and AB	B and O
O	None	A and B	AB, A, B, O	O

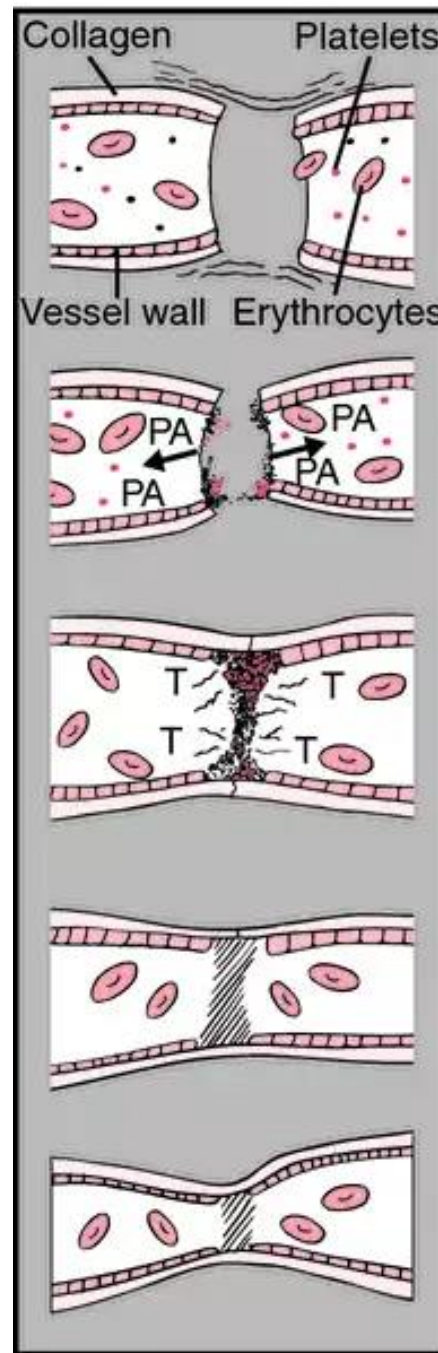


HEMOSTASIS – BLOOD CLOTTING

= arrest of the escape of blood by clot formation or vessel spasm

Stages:

- . **Vasoconstriction**
- . **Platelet adhesion - plug**
- . **Coagulation and Fibrin**
clot's formation with
trapped cells



Tissue damage

Blood flow restricted by vascular system

Exposed collagen attracts platelets

Platelet plug formation

Blood coagulation:
Stage 1

Damaged cells and platelets initiate reactions resulting in prothrombin activator (PA)

Stage 2

Ca^{++} (PA)

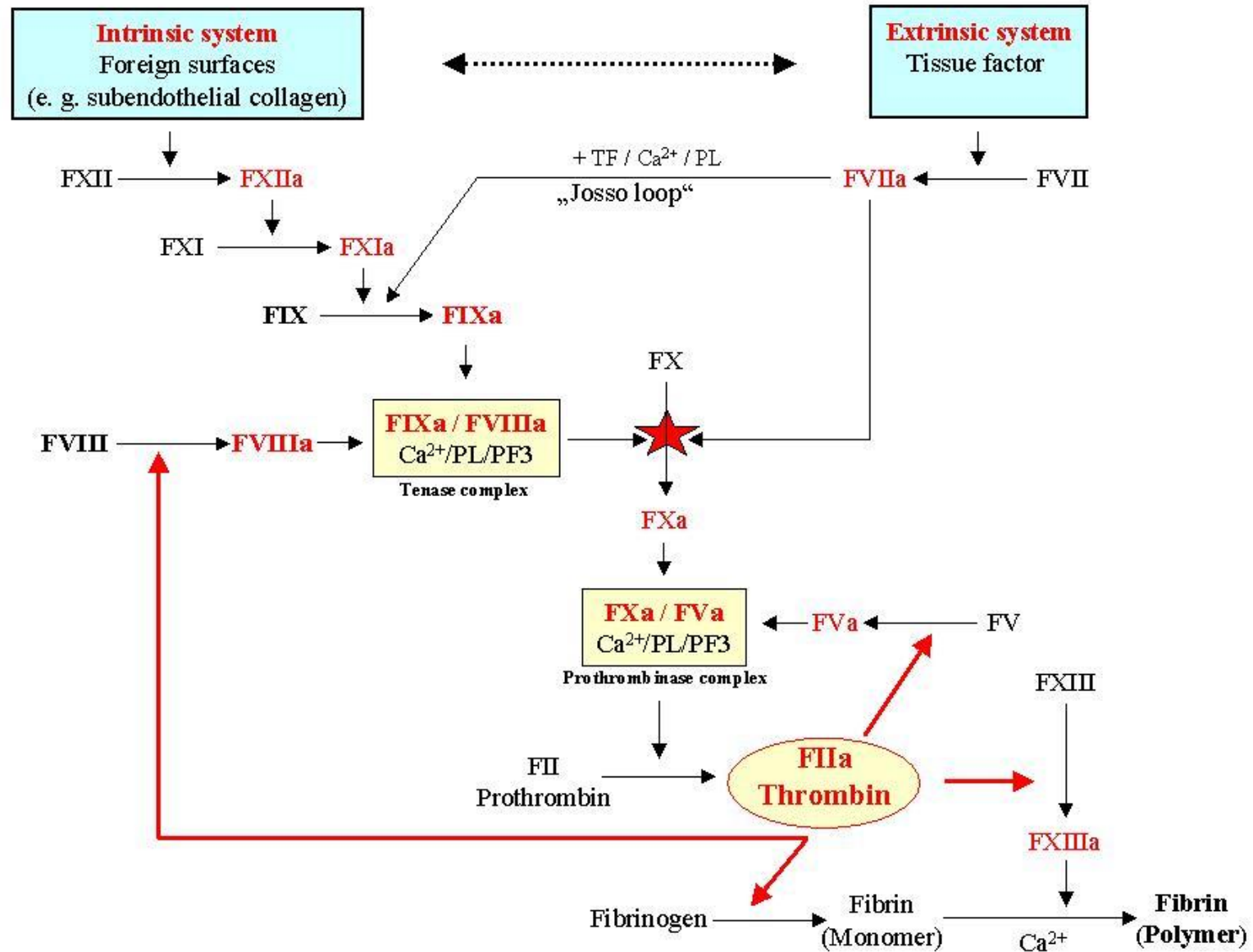
Prothrombin → thrombin (T)

Stage 3

Fibrinogen → fibrin

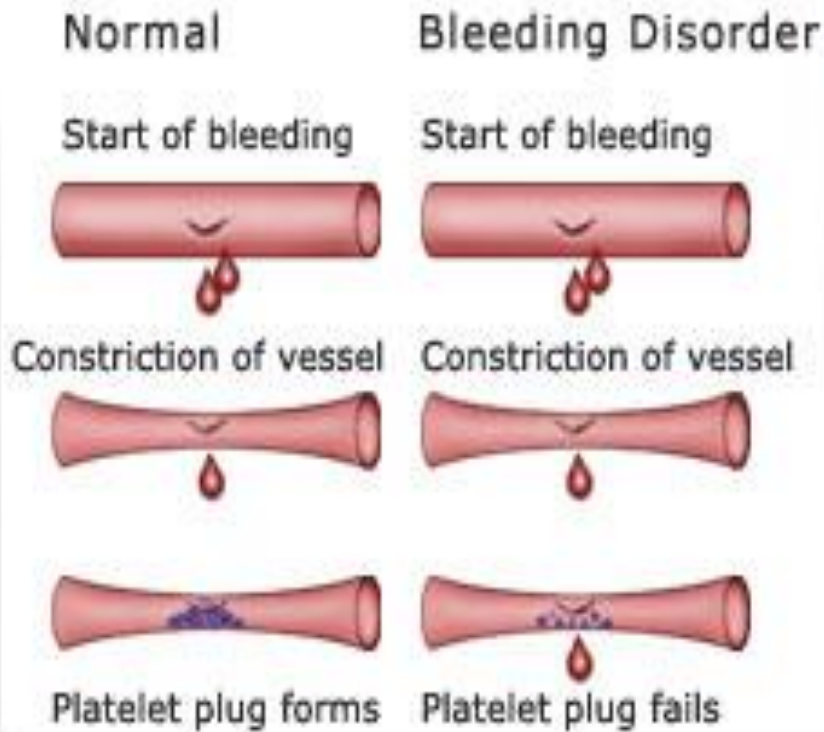
Blood cells trapped in fibrin threads. Clot formed

BLOOD CLOTTING



BLOOD CLOTTING

Blood Clotting



Hemophilia A

X-linked disease

missing -

coagulation factor VIII

symptoms:

- spontaneous bleeding
- bleeding into organs (joint, brain)



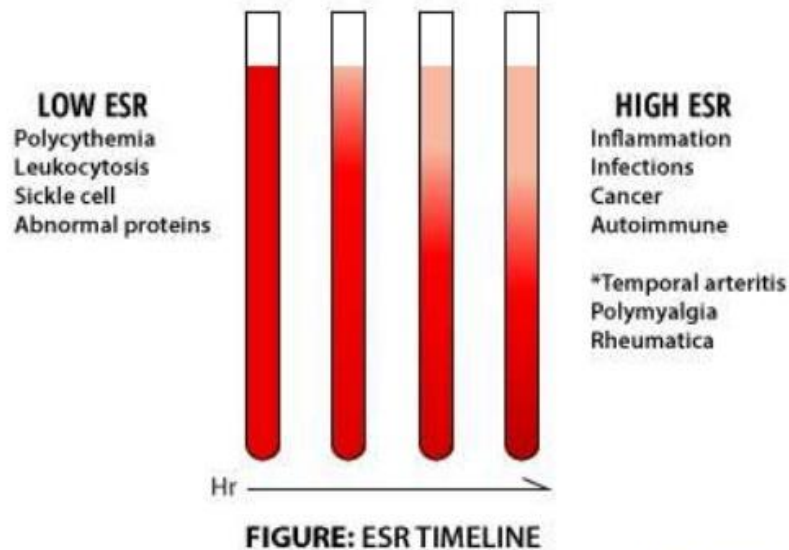
HOW TO TAKE INCOAGULABLE BLOOD?

- To remove calcium ions by sodium citrate
- To remove a fibrin
- To administer a heparin
- To administer a anticoagulant hirudin
- To administer an inhibitors of vitamin K – kumarin



ERY SEDIMENTATION

- The erythrocyte sedimentation rate (ESR), is a measure of the settling of red blood cells in a tube during one hour. The rate is an indication of inflammation and increases in many diseases.
- ESR is increased in rheumatoid diseases, most infections, and in cancer



LITERATURE

Biology, eighth edition,
Campbell, Reece

Unit seven: Animal Form and Function

Chapter 42: Circulation and Gas Exchange

Concept 42.4

Pages 911 – 915

