



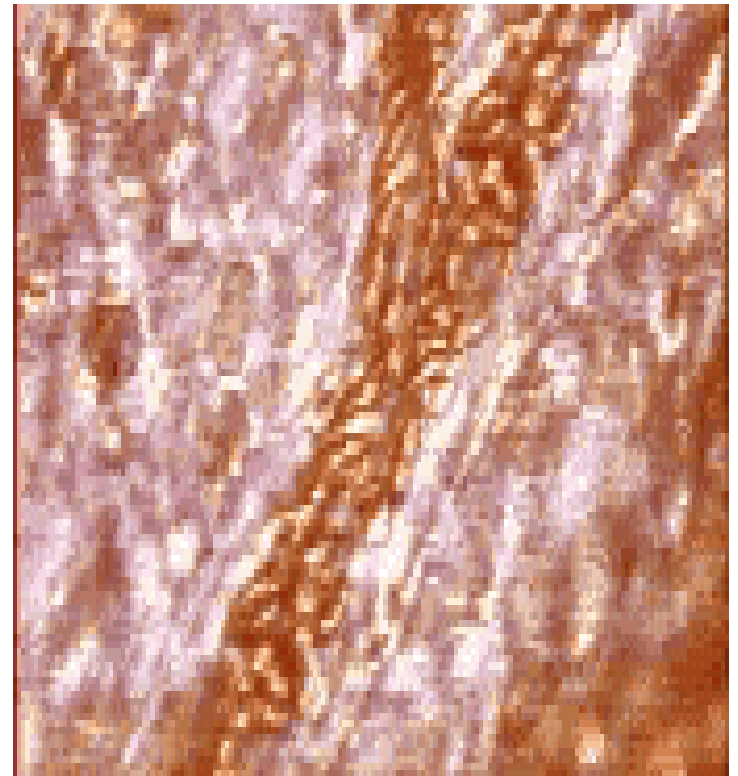
Section III

BLOOD

Dr. Ning Song
ningdoc@yahoo.com.cn
Rm 423, Boya Bld

Blood-circulating body fluid

- A suspension solution of blood cells in plasma
- **Circulating** through the cardiovascular system



Arteriole



General Functions of Blood

1. Transportation

- O₂ & nutrients (ischemia-hypoxia)
- CO₂ & metabolic wastes
- hormones



2. Regulation (Buffering capacity)

- plasma pH (acidity/alkalinity)
- body temperature (specific heat)

3. Protection

- clotting mechanism, against hemorrhage
- immune defense

Blood Routine Examination

青岛大学医学院附属医院检验报告单

门诊

血常规 (门诊)

姓名: 病员号: 03787145 样本编号: 20090531G0140031
性别: 女 科别: 方便门诊 临床诊断:
年龄: 53岁 床号: 备注:

No	项 目	结 果	单 位	参 考 值	No	项 目	结 果	单 位	参 考 值
1	白细胞计数	5.34	$10^9/L$	4.0-10.0	16	红细胞比积	0.404	L/L	0.36-0.54
2	中性粒细胞百分率	61.60	%	50.0-75.0	17	平均血红蛋白浓度	334.0	g/L	320-360
3	淋巴细胞百分率	31.50	%	20.0-40.0	18	RBC体积分布宽度(SD)	41.10	fL	37-54
4	单核细胞百分率	5.60	%	3.0-8.0	19	RBC体积分布宽度(CV)	12.8	%	0-14
5	嗜酸粒细胞百分率	1.30	%	0.5-5.0	20	血小板	155	$10^9/L$	100-300
6	嗜碱粒细胞百分率	0.00	%	<1.0	22	血小板压积	0.17	%	0.160-0.430
7	中性粒细胞计数	3.29	$10^9/L$	2.0-7.5	21	大血小板比率	30.80	%	13-43
8	淋巴细胞计数	1.68	$10^9/L$	0.8-4.0	23	平均血小板体积	10.9	fL	7.4-11.0
9	单核细胞计数	0.30	$10^9/L$	0.1-0.8	24	血小板体积分布宽度	13.0	fL	12.00-16.50
10	嗜酸细胞计数	0.07	$10^9/L$	<0.5					
11	嗜碱细胞计数	0.00	$10^9/L$	<0.1					
12	红细胞计数	4.52	$10^{12}/L$	3.50-6.00					
13	血红蛋白	135	g/L	110-160					
14	平均红细胞体积	89.40	fL	80.0-100.0					
15	平均血红蛋白含量	29.9	pg	27.0-34.0					

送检日期: 2009-05-31

报告日期: 2009-05-31

检验者: 姜忠信

审核者:

姜忠信

注: 报告单仅对该标本负责! 如有疑问请当日与门诊化验科室联系!

青岛大学医学院附属医院检验报告单

血凝

姓名:
性别: 男
年龄: 76岁

病员号: 673322
科别: 泌尿外科
标本种类: 血浆

样本编号: 20090825G0080304
临床诊断: 前列腺增生
床号: A02

No	项 目	结果	单位	参考值	提示
1	凝血酶原时间	10.80	sec	8-14	
2	PT-比值	0.94	INR	0.8-1.2	
3	PT百分比活度	117.00	%	70-200	
4	纤维蛋白原	3.45	g/l	1.7-4.7	
5	部分凝血活酶时间	41.00	sec	24-42	
6	APTT比值	1.39	R	0.81-1.40	
7	凝血酶时间	13.60	sec	10.00-18.00	
8	TT比值	0.97	R	0.85-1.30	
9	抗凝血酶III	101.00	%	80.0-140.0	

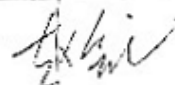
Clotting Related Examination

检验日期: 2009-08-25

报告日期: 2009-08-25

检验者: 黄秀玲

审核者:



此报告单仅对该标本负责! 如有疑问请当日与病房化验室联系!

青島大學醫學院附屬醫院檢驗報告單

住院

姓名: 男	病員號: 673322	標本種類: 血清	樣本編號: 20090825G0017055
性別: 男	科別: 內	開單日期: 09-08-24 16:27	臨床診斷: 前列腺增生
年齡: 76歲	床號: A02	送檢醫生: 孫立江	備注:

No	項 目	結果	參考值	單位
1	總蛋白	62.27	60.00-85.00	g/L
2	白蛋白	35.69	35.00-55.00	g/L
3	球蛋白	26.58	20-40	g/L
4	白/球比	1.34	1.0-2.5	
5	前白蛋白	288.00	200.00-400.00	mg/L
6	總膽紅素	10.34	3.00-22.00	umol/L
7	直接膽紅素	2.85	0-8.0	umol/L
8	間接膽紅素	7.49		umol/L
9	谷丙轉氨酶	16.00	0-60	U/L
10	谷草轉氨酶	19.00	0-42	U/L
11	ALT/AST	0.84		
12	谷氨酰轉肽酶	15.00	0-64	U/L
13	鹼性磷酸酶	69.00	35-125	U/L
14	α-L-岩藻糖苷酶	28.00	5-40	U/L
15	甘油三酯	1.45	0.30-1.92	mmol/L
16	總膽固醇	5.26	2.32-5.62	mmol/L
17	高密度脂蛋白	1.25	0.80-1.80	mmol/L
18	低密度脂蛋白	2.93	1.90-3.12	mmol/L
19	乳酸脫氫酶	143.00	91-245	U/L
20	肌酸激酶	83.00	0-170	U/L
21	肌酸激酶同工酶	18.00	0-17	U/L
22	α-羟丁酸脫氫酶	114.00	72-182	U/L
23	腺苷脫氨酶	12.00	4-18	U/L
24	超敏C反應蛋白	0.80	0.01-3	mg/L
25	尿素氮	3.62	2.14-7.14	mmol/L
26	肌酐	88.00	31-132	umol/L
27	尿素氮/肌酐	0.04		
28	葡萄糖	4.33	3.90-6.16	mmol/L
29	果糖胺	1.36	1.0-1.9	mmol/L
30	尿酸	318.00	89.2-416	umol/L
31	鉀	4.35	3.5-5.5	mmol/L
32	鈉	141.09	135-145	mmol/L
33	氯	102.44	96-108	mmol/L
34	二氧化碳	25.72	23-31	mmol/L
35	陰離子間隙	12.9	8-16	mmol/L
36	鈣	2.21	2.0-2.80	mmol/L
37	鎂	0.97	0.6-1.2	mmol/L
38	磷	1.16	0.8-1.6	mmol/L
39	滲透壓	273.48	200-320	mOSM/L
40	總胆汁酸	7.00	0-12	umol/L

標本接收日期: 09-08-25 07:51 報告日期: 09-08-25 10:51 檢驗者: 任立晟 審核者: 任立晟



Section Outline

- **Composition and properties of blood**
- **Physiology of blood cells**
- **Hemostasis**



Composition and Properties of Blood



Blood Volume (summation of plasma and blood cells)

- **BV = 7-8% of the body weight (b.w)**

70 ~ 80 ml blood /kg b.w.

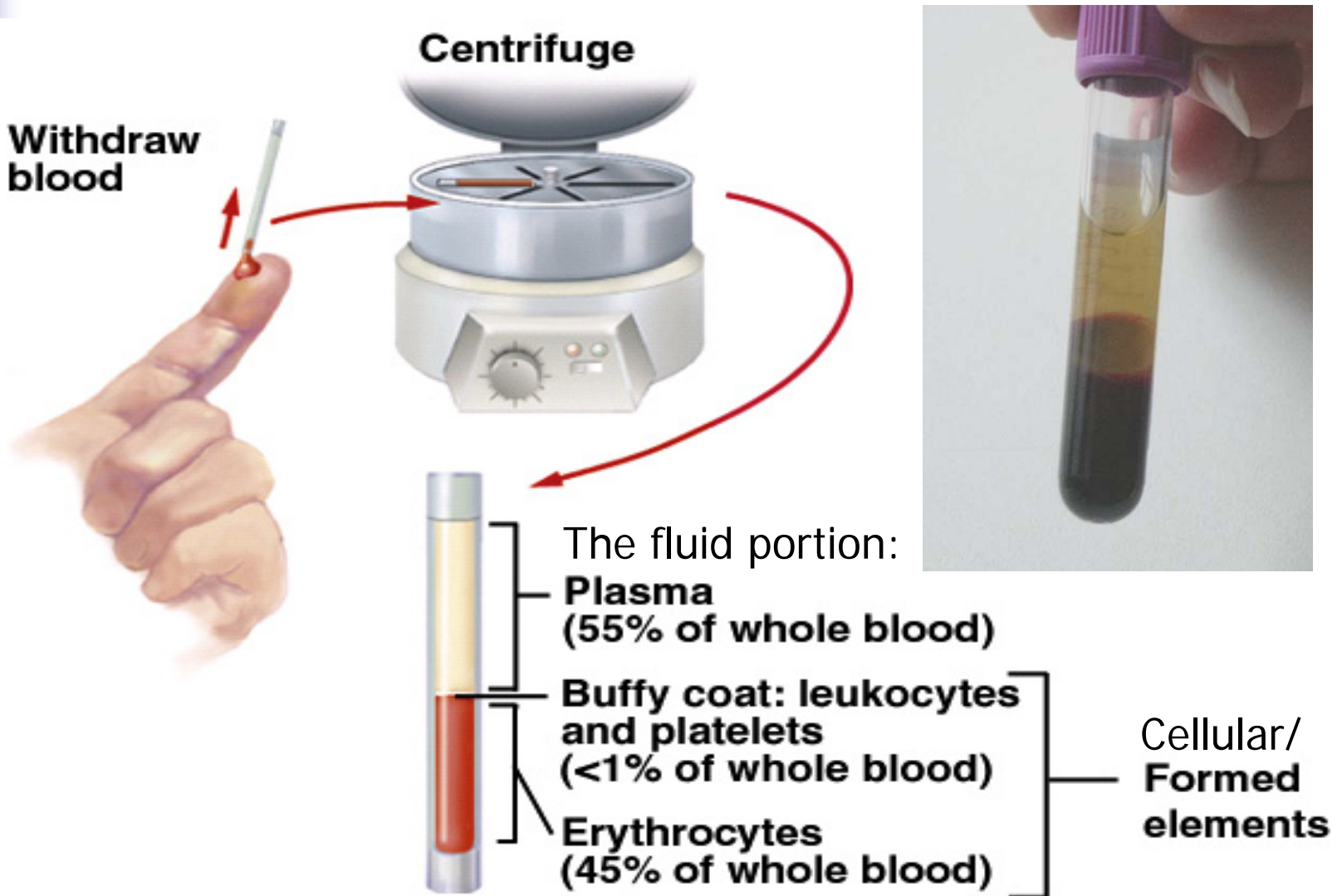
60kg: over 4 L

- **Total blood volume**

= circulating volume + reserve volume

(venous sinus/subcutaneous plexus mobilize)

1、 Components of Blood



Blood

Plasma
(55%)

Water (91%–92%)

Plasma proteins

organic/inorganic molecules

Ion

Gas

Blood cells
(45%)

RBC (erythrocyte)

WBC (leukocyte)

Platelet (thrombocyte)

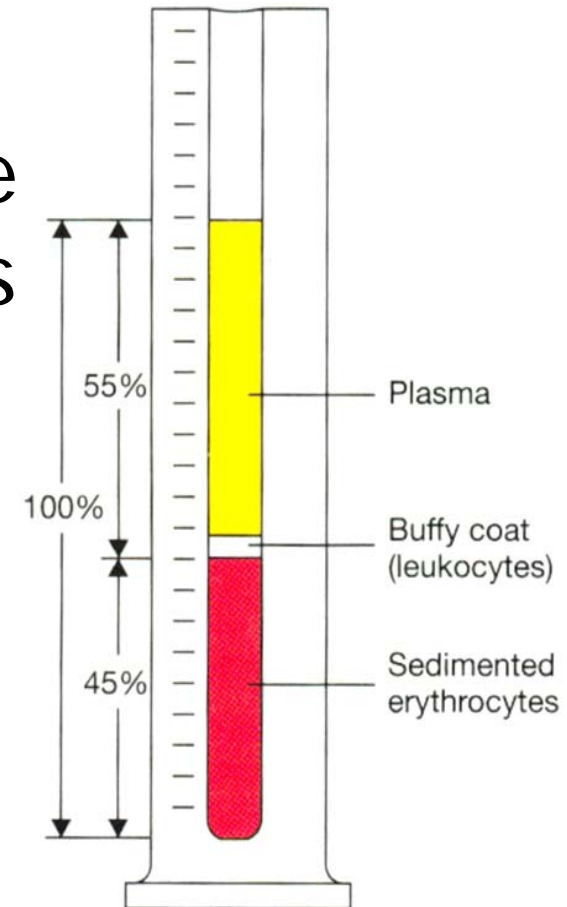
Hematocrit

In any sample of whole blood, the percentage of blood volume that is occupied by erythrocytes is called ~

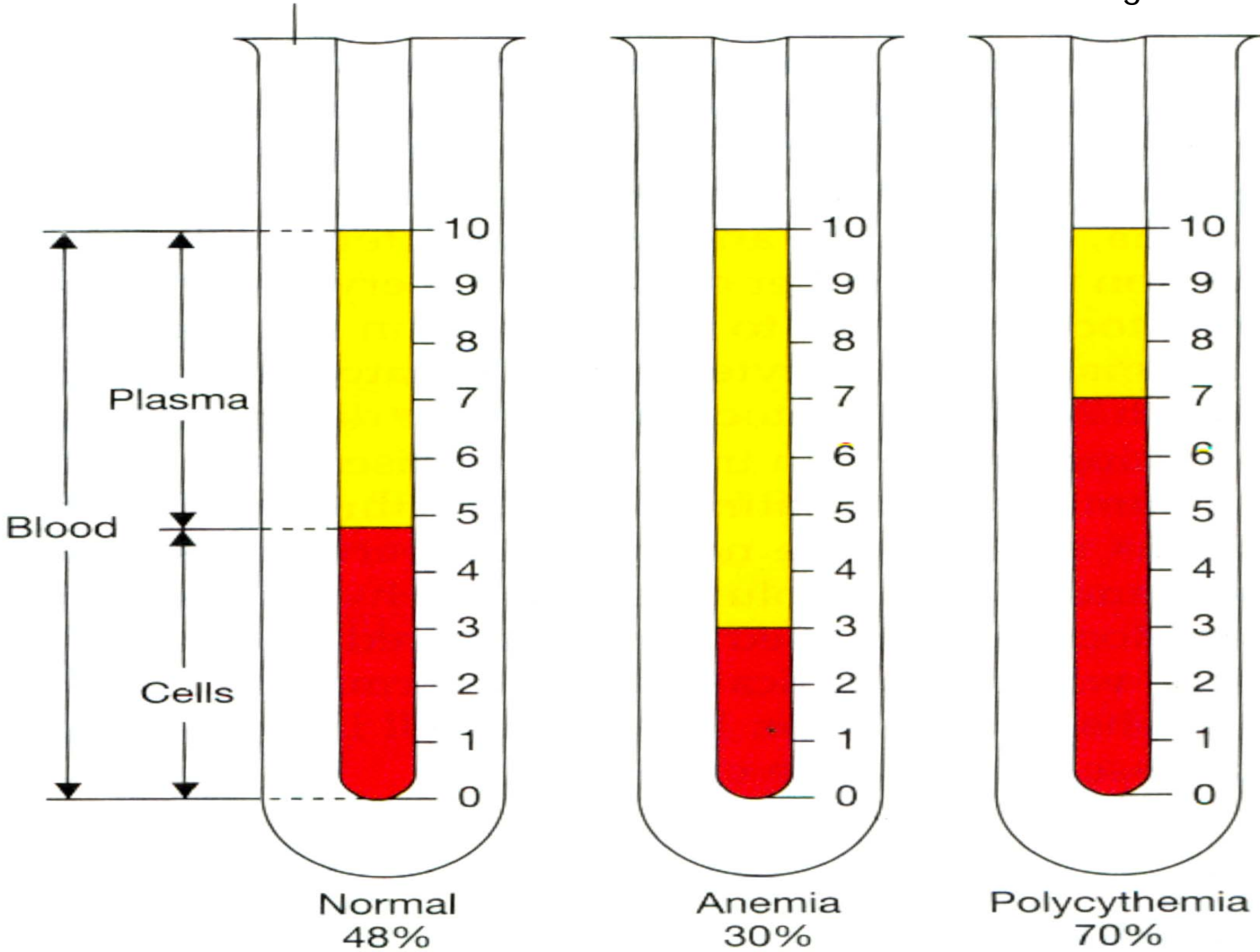
adult male: 40-50%

adult female: 37-48%

newborn: 55%



Wintrobe tube :To memorize wintrobe-a famous hematologist



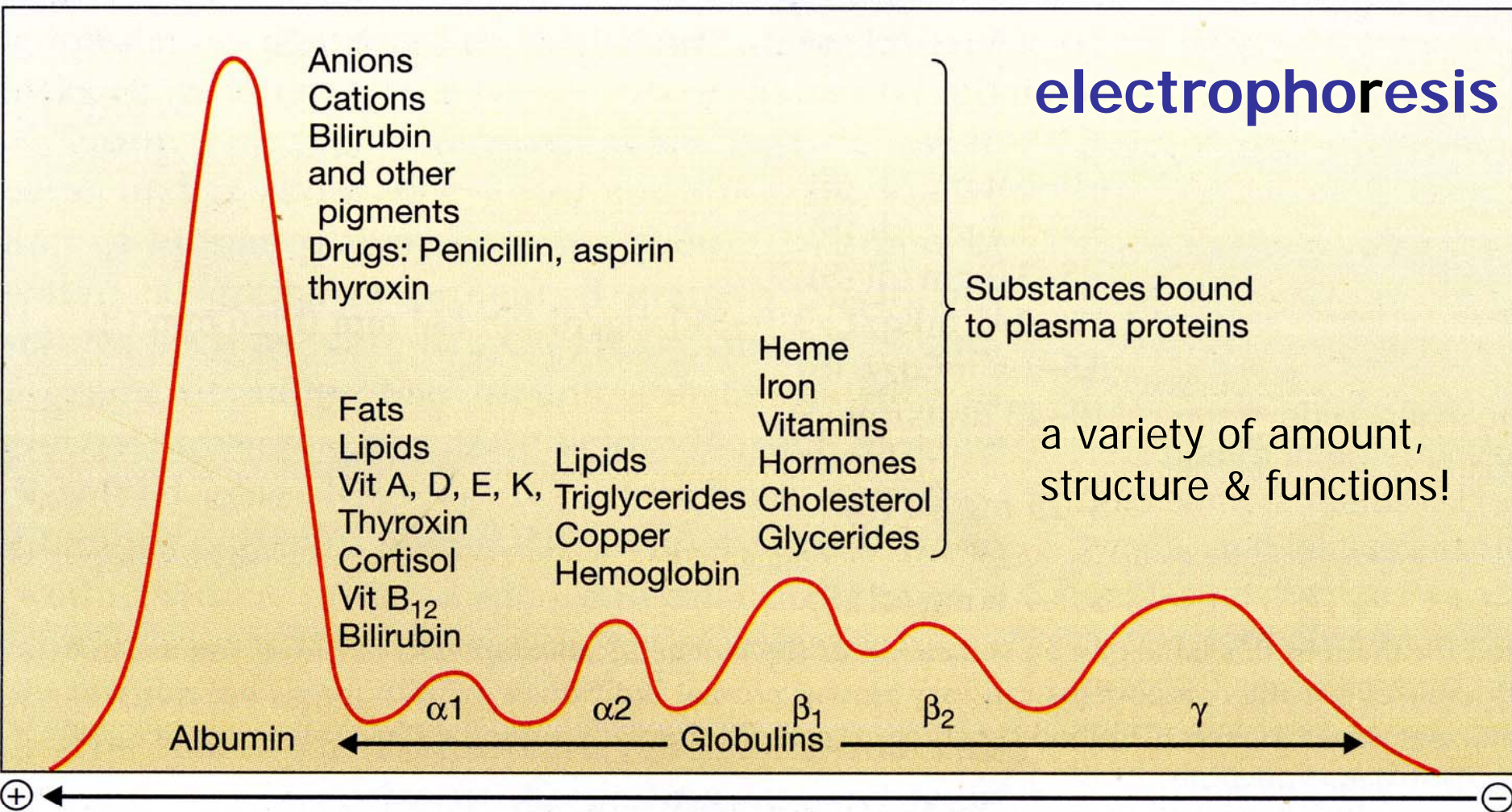
tendency to thrombus formation
microcirculation perfusion disturbance



2、 Components of Plasma

- Solution
- Plasma proteins (65 ~ 85g/L)
 - albumins: 30-50 g/L
 - globulins: α_1 - α_2 - β_1 - β_2 - γ - globulins
manufactured in plasma cells
 - fibrinogen

electrophoresis



Substances bound to plasma proteins

a variety of amount, structure & functions!

Albumin

α₁

α₂

Globulins

β₁

β₂

γ

(+)

(-)

Plasma proteins

Transcortin	Ceruloplasmin	Transferrin	Fibrinogen	I _g G
Thyroxide-binding globulin	Erythropoietin	Complement		I _g A
High-density lipoproteins	Prothrombin	Low-density lipoproteins		I _g M
Bilirubin-binding globulin	Angiotensinogen	Lipoproteins		I _g E
Transcobalamin	Haptoglobin	Profibrinolysin		



Main functions of plasma proteins

- (1) Maintain **plasma colloid osmotic pressure**
 - Albumin: Major contributor
- (2) Maintain normal **plasma pH**
 - 15% of the buffering capacity of the blood
- (3) Function of **transportation**
 - hormones, lipids, ions, vitamins, drugs



(4) Function of **nutrition (hypoproteinemia)**

**(5) Blood coagulation- anticoagulation
and fibrinolysis-antifibrinolysis**

(6) Functions of **catalysis
Aspartate / Alanine aminotransferase (ALT,AST)**

(7) Immune functions



3、 Properties of Blood

1. Blood relative density (delamination)

- whole blood: 1.050 ~ 1.060
- plasma: 1.025 ~ 1.030
- RBC: 1.090 ~ 1.111



2. Blood viscosity (internal friction force)

■ **Whole blood: 4 ~ 5 (to water)**

- **RBC number (polycythemia)**

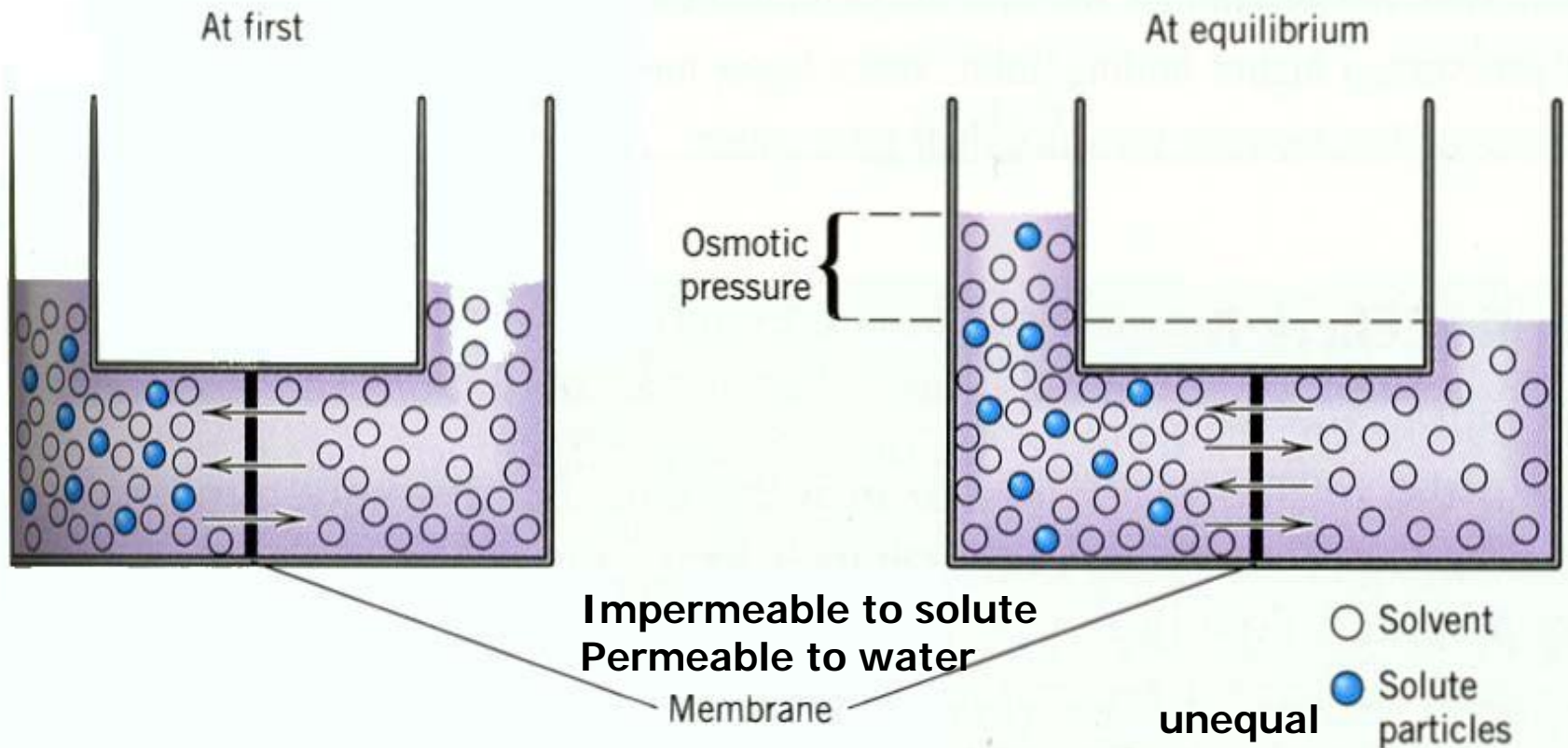
- **plasma macromolecules / particles**

(hyperlipidemia/hypercholesterolemia)

■ **Plasma: 1.6 ~ 2.4**

3. Plasma osmotic pressure

Model of osmosis phenomenon



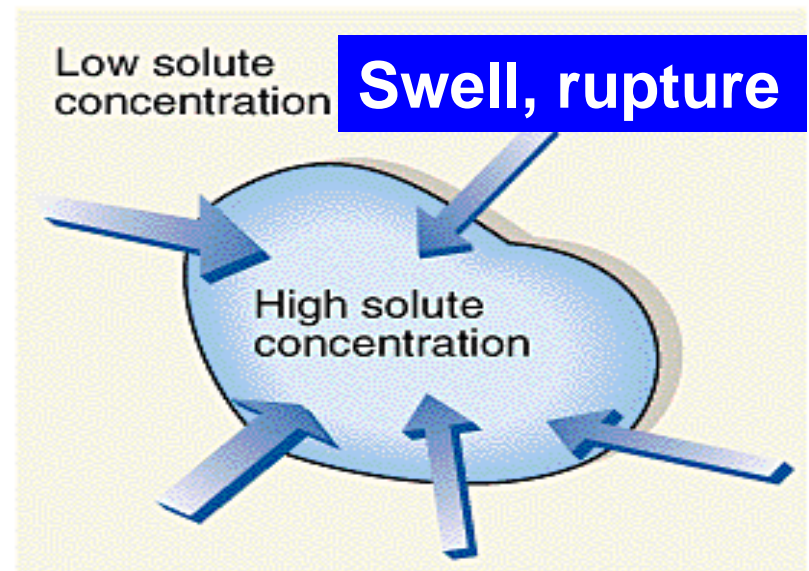
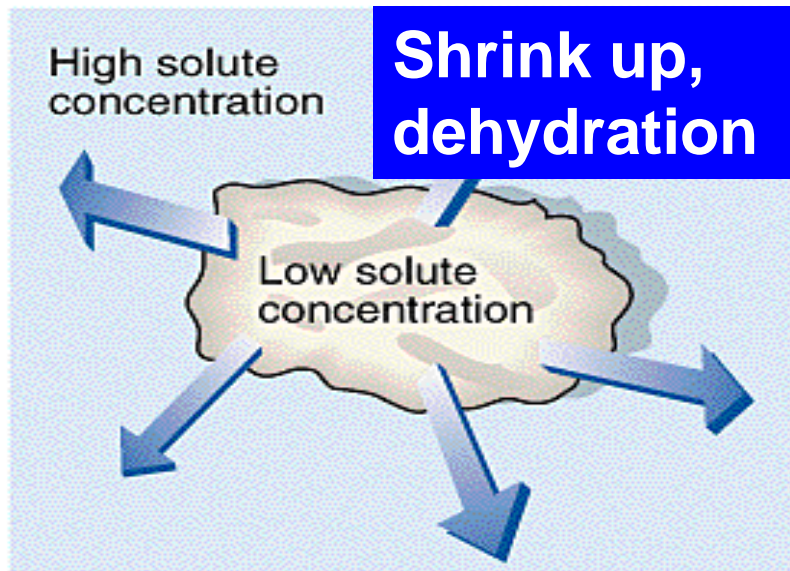


**Total osmotic pressure of plasma:
280-320 mmol/L**

- **Crystal osmotic pressure**
- **Colloid osmotic pressure
(oncotic pressure)**

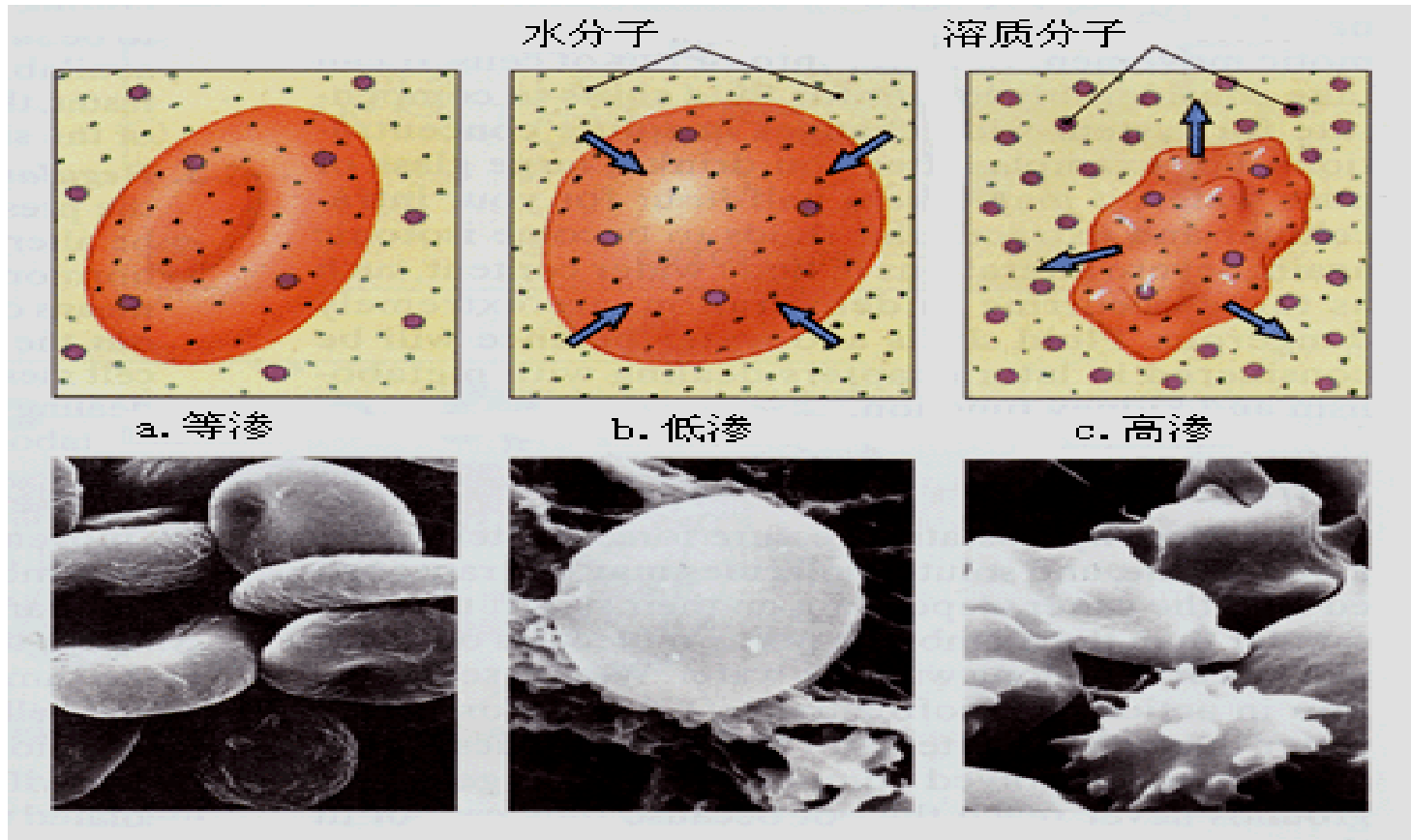
Crystal osmotic pressure

- 80% due to Na^+ 、 Cl^- (develop from sea water)
- equal between interstitial fluid and plasma
- flow into and out of cells



Swell, hemolysis

Shrink up



a. 等渗

b. 低渗

c. 高渗

- Vomiting: saline but not water
- Encephaledema: 20% mannitol (hyperosmotic)

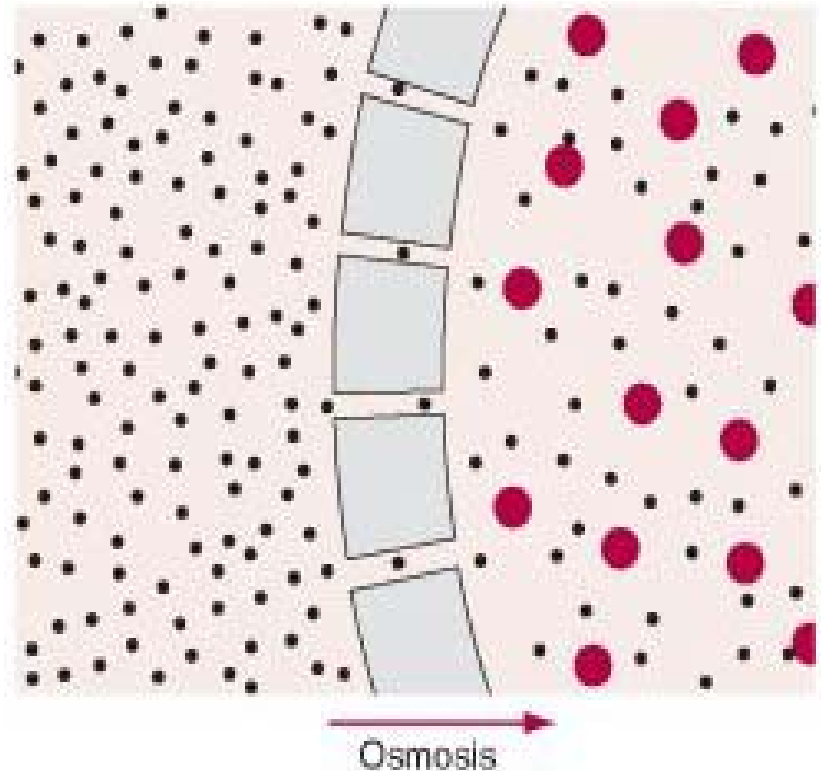
Intravenous Solution

(rectify and maintain normal crystal osmotic pressure)

Solution	Also known as	Osmolarity
0.9% saline	Normal saline	isosmotic
D ₅ -0.9% saline	5% dextrose in normal saline	Hyperosmotic
D ₅ W	5% dextrose in water	isosmotic
0.45% saline	Half normal saline	Hyposmotic
D ₅ -0.45% saline	5% dextrose in Half normal saline	Hyperosmotic

■ Colloid osmotic pressure

- 80% due to albumin
- $< 1.5 \text{ mmol/L}$
($< 0.4\%$)
- flow into and out of capillaries
- hypoproteinemia



Maintain blood volume
Relieve edema



4. Plasma pH: 7.35 ~ 7.45

- **Plasma buffer systems**

 - NaHCO₃ / H₂CO₃ (main)

 - Na⁺ -Protein / H⁺ - Proteins (15%)

 - Na₂HPO₄ / NaH₂PO₄

- **RBC buffer systems**

 - K-Hemoglobin(Hb) / H-Hb; K-HbO₂ / H-HbO₂

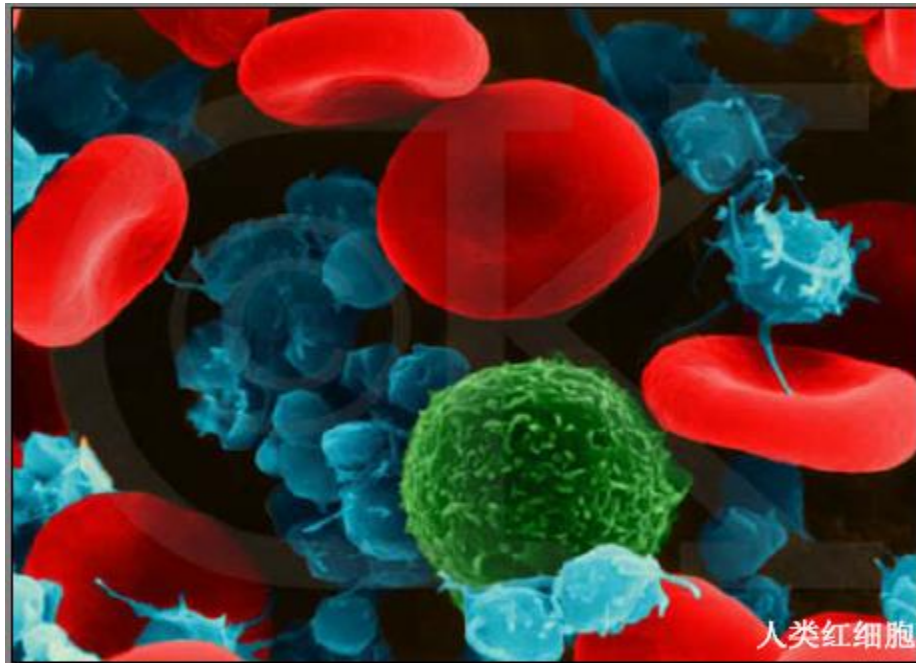
- **Kidney** (excrete bicarbonate/reabsorb hydrogen ions)

- **lung** (expire CO₂)

- **Acidosis/alkalosis (fluctuation)**



Physiology of blood cells





1、 Hematopoiesis (Genesis of blood cells)

1. Hematopoietic organs

fetus: yolk sac → liver and spleen

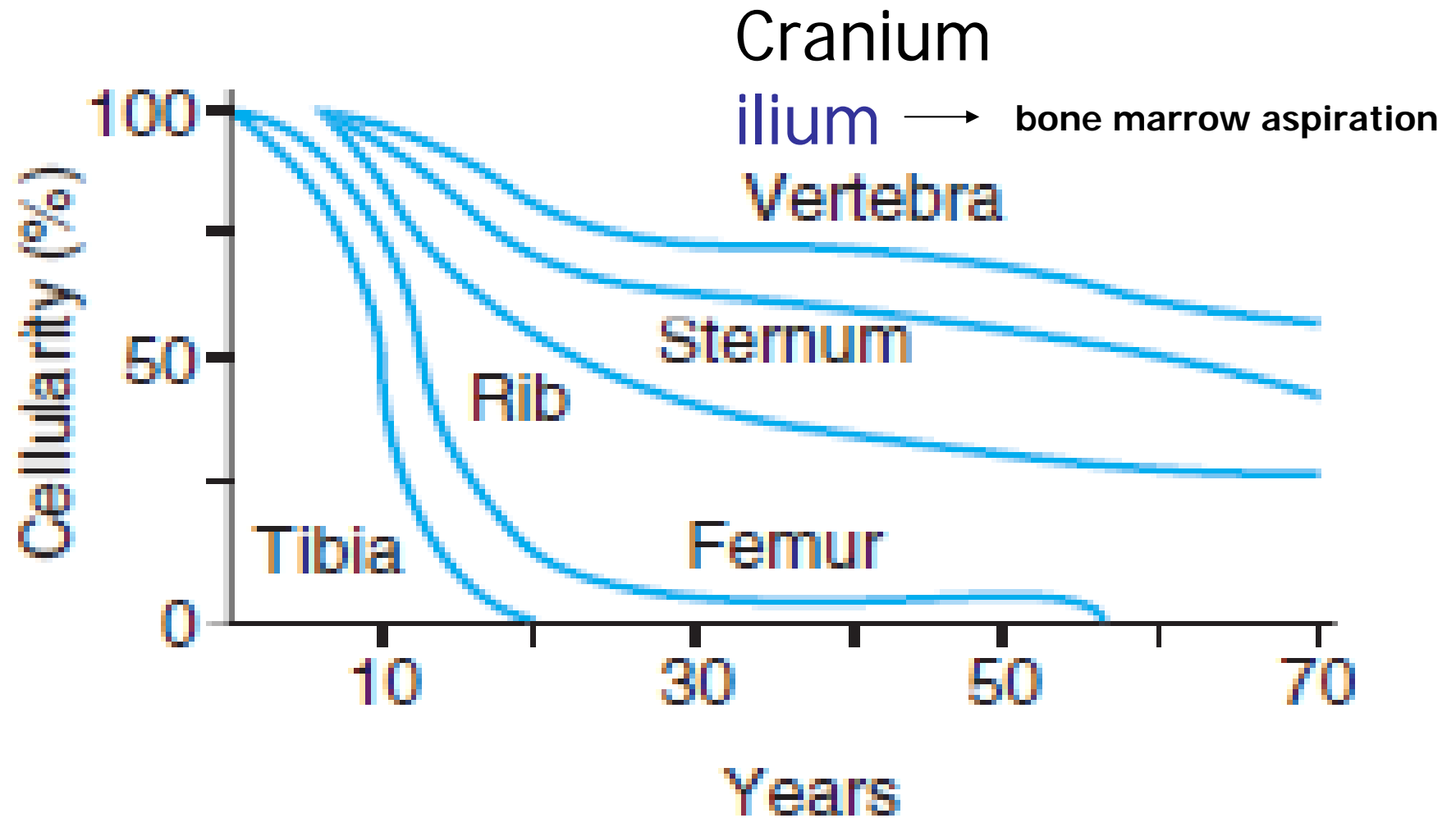
→ bone marrow

child: bone marrow (main)

liver and spleen

adults: bone marrow (red marrow)

extramedullary hematopoiesis

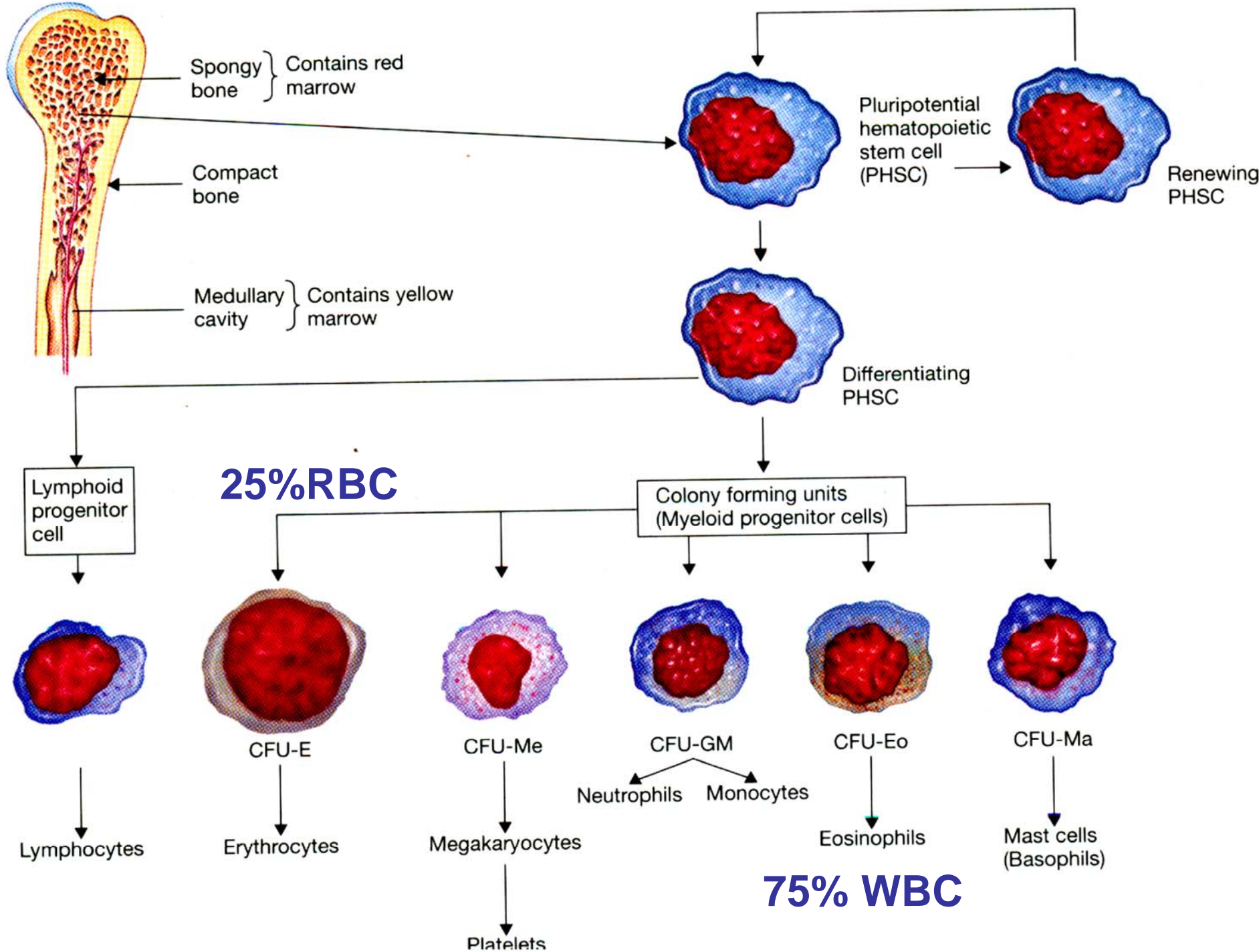


**Changes in bone marrow cellularity with age.
100% equals the degree of cellularity at birth.**

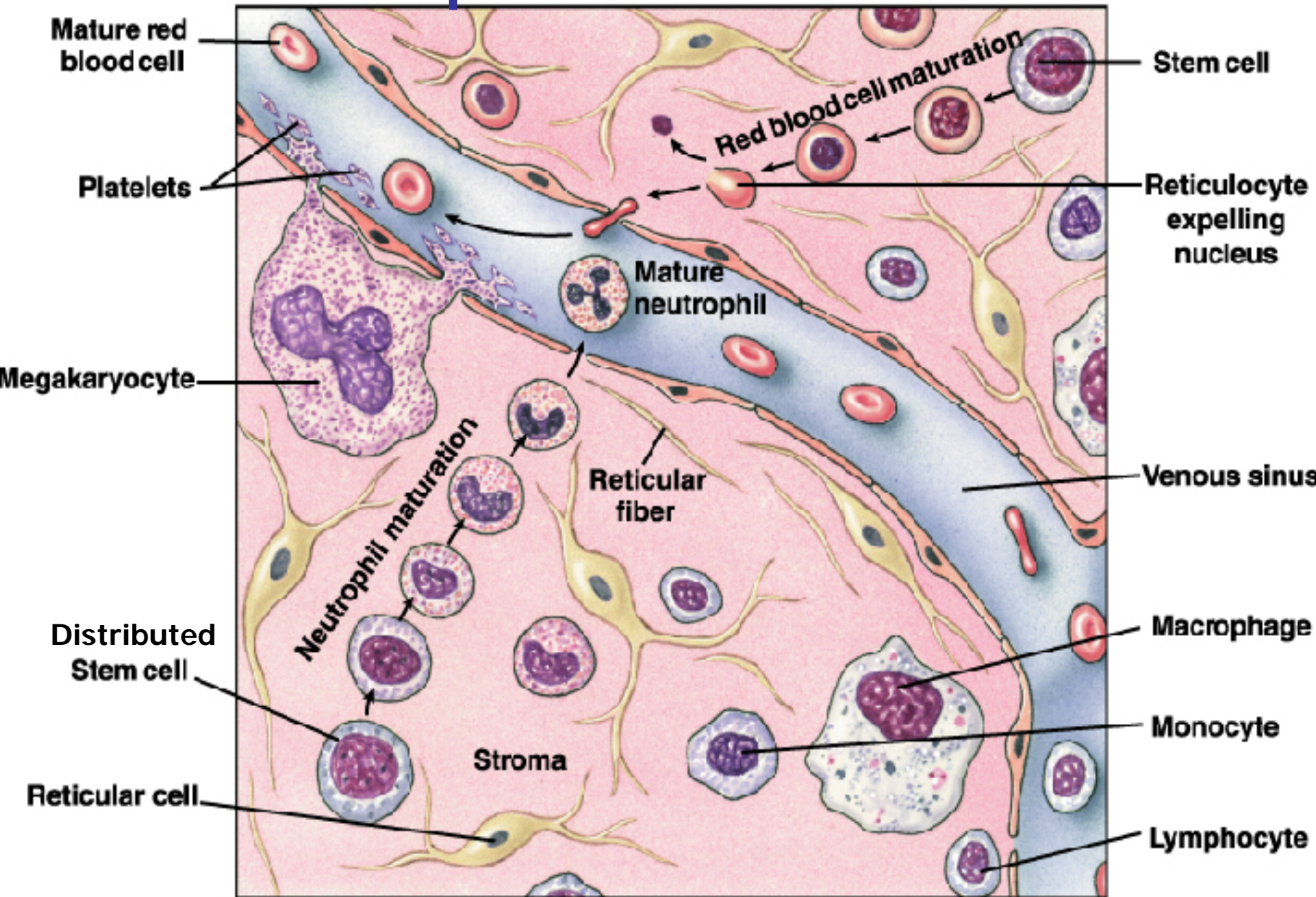


Hematopoietic process

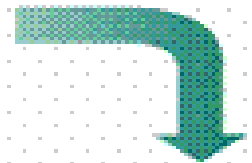
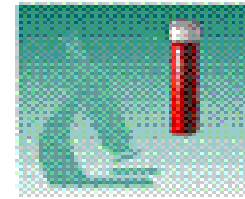
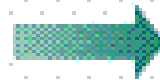
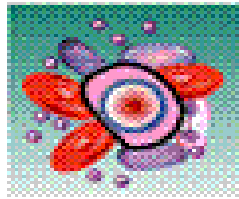
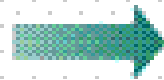
- **Hematopoietic stem cell**
self renewal, pluripotential
 - **Committed stem cell**
Colony-forming unit (CFU)
progenitor cells
 - **Precursor cells (identifiable in morphology)**
- } **proliferation**



Hematopoietic Microenvironment



The Allogeneic Transplant Process

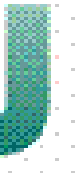
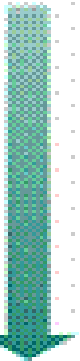


1 *Collection*

Stem cells are collected from the patient's bone marrow or blood.

2 *Processing*

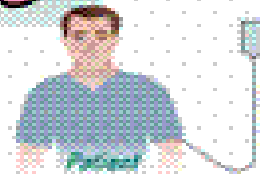
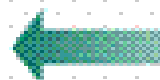
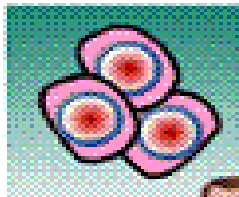
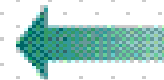
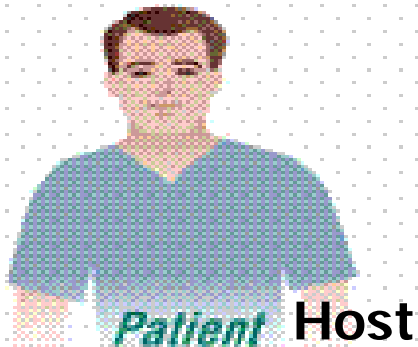
Bone marrow or peripheral blood is taken to the processing laboratory where the stem cells are concentrated and prepared for the freezing process.



3 *Cryopreservation*

Bone marrow or blood is preserved by freezing (cryopreservation) to keep stem cells alive until they are infused into the patient's bloodstream.

Umbilical cord blood
peripheral blood



4 *Chemotherapy*

High dose chemotherapy and/or radiation therapy is given to the patient.

Avoid immunological rejection

5 *Infusion*

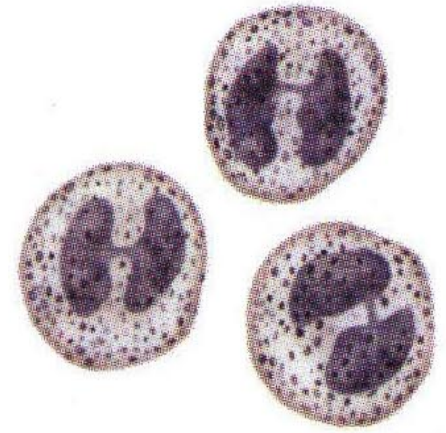
Thawed stem cells are infused into the patient.



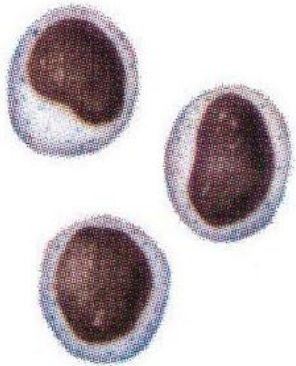
Neutrophils



Eosinophils



Basophils



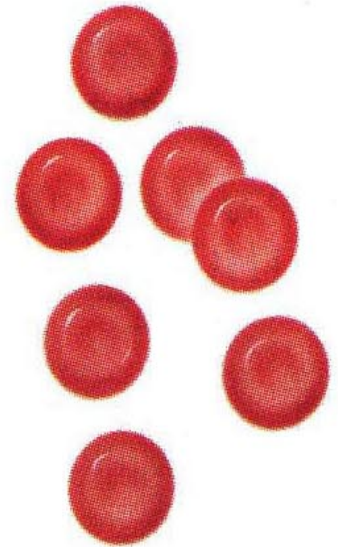
Lymphocytes



Monocytes



Platelets



Erythrocytes



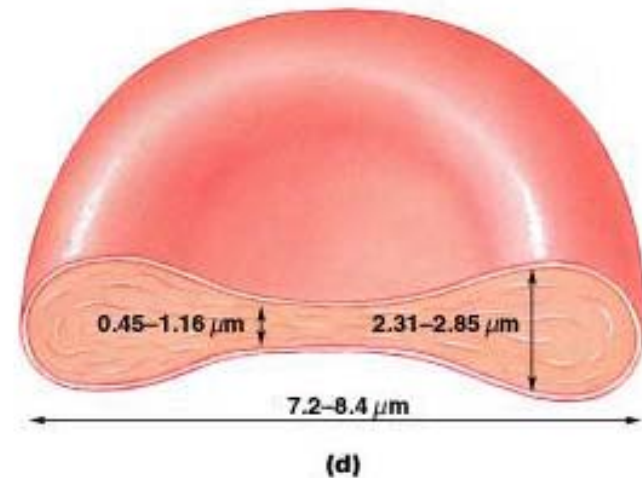
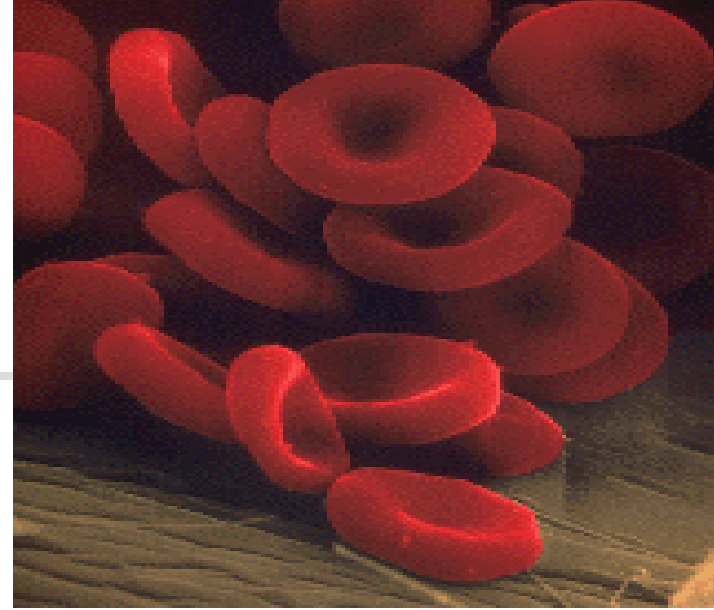
2、Physiology of RBC

Number and shape

	RBC ($10^{12}/L$)	Hb (g/L)
male:	4.0 ~ 5.5	120 ~ 160
female:	3.5 ~ 5.0	110 ~ 150
new-born:	6.0	200

Shape of RBC

- biconcave discs, 7 ~ 8 μm
- lack mitochondria
- lack nucleus
- lack ribosome
- Dominant- Hemoglobin (Hb)
(hematocyanin-copper)





Physiological characteristics

1. Permeability of erythrocyte membrane

Simple Diffusion: O_2 , CO_2

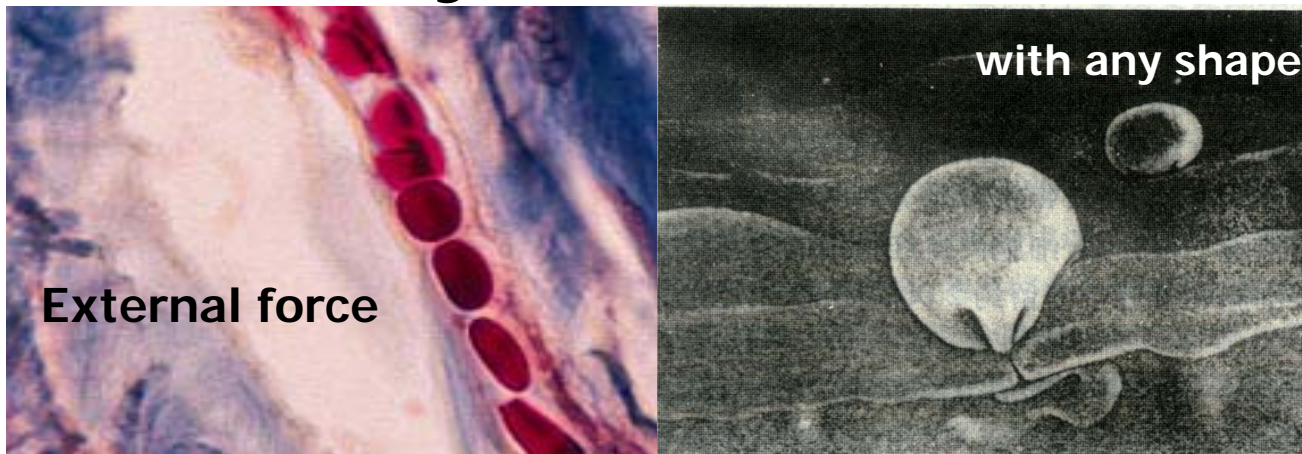
Facilitated Diffusion: Glucose

Active Transport: Na^+ pump

2. Plastic deformability of erythrocyte

Factors affecting deformability

- **Surface / volume ratio** Spherical sickle
- **Flexibility of RBC membrane**
- **Viscosity in RBC**





3. Suspension stability

A very slow sedimentation rate/suspend stably

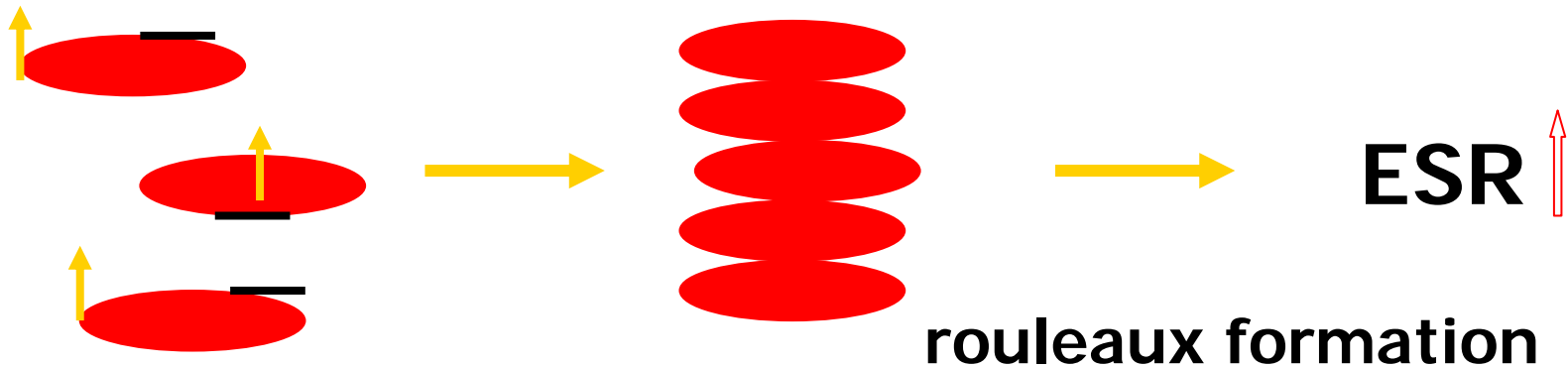
Reasons for Suspension stability

- **greater surface / volume ratio** Friction--buoyant force
- **negative charge repulsion of RBC membrane**

ESR (erythrocyte sedimentation rate)

The distance red blood cells travel in one hour in a sample of blood

- male: 0~15 mm/h female: 0~20 mm/h



Factors affecting ESR

Globulin/cholesterol

abnormal changes in the plasma

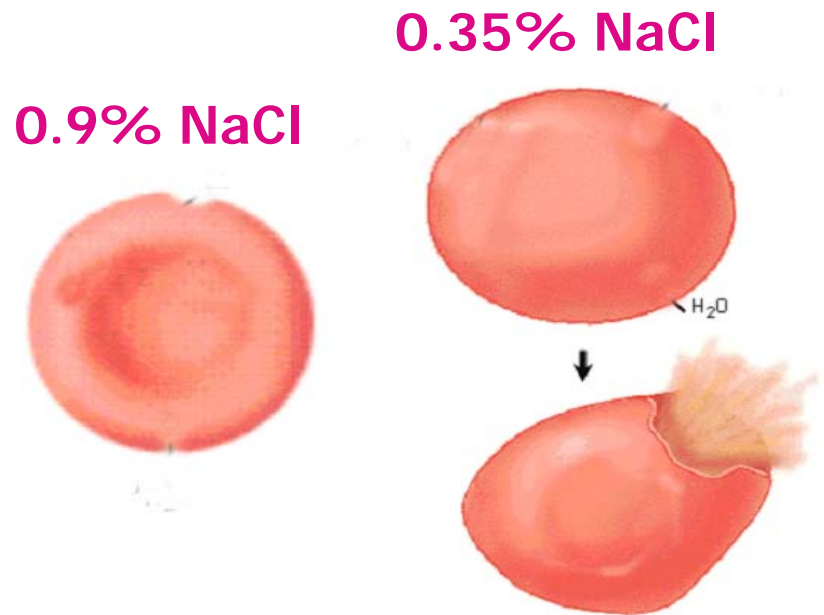
4. Osmotic fragility

The susceptibility of erythrocytes to haemolysis when exposed to hyposmotic saline solutions.

NaCl:	0.5 %	0.35%
RBC:	hemolysis (initial)	hemolysis (complete)

Factors affecting fragility

- Senile
- Surface / volume
- Hereditary spherocytosis





RBC Functions

- transport O_2 & CO_2 (biconcave disc)

Directly dissolved in plasma		in RBC
O_2	1.5%	HbO_2 (98.5%)
CO_2	5.0%	HCO_3^- (88%) carbonic anhydrase $HbCO_2$ (7%) carbaminohemoglobin

- maintain stable plasma pH
- The red-cell immune system

Promote phagocytosis/ clearance of circulation immune complex

Erythropoiesis

■ DNA Synthesis (mitosis)

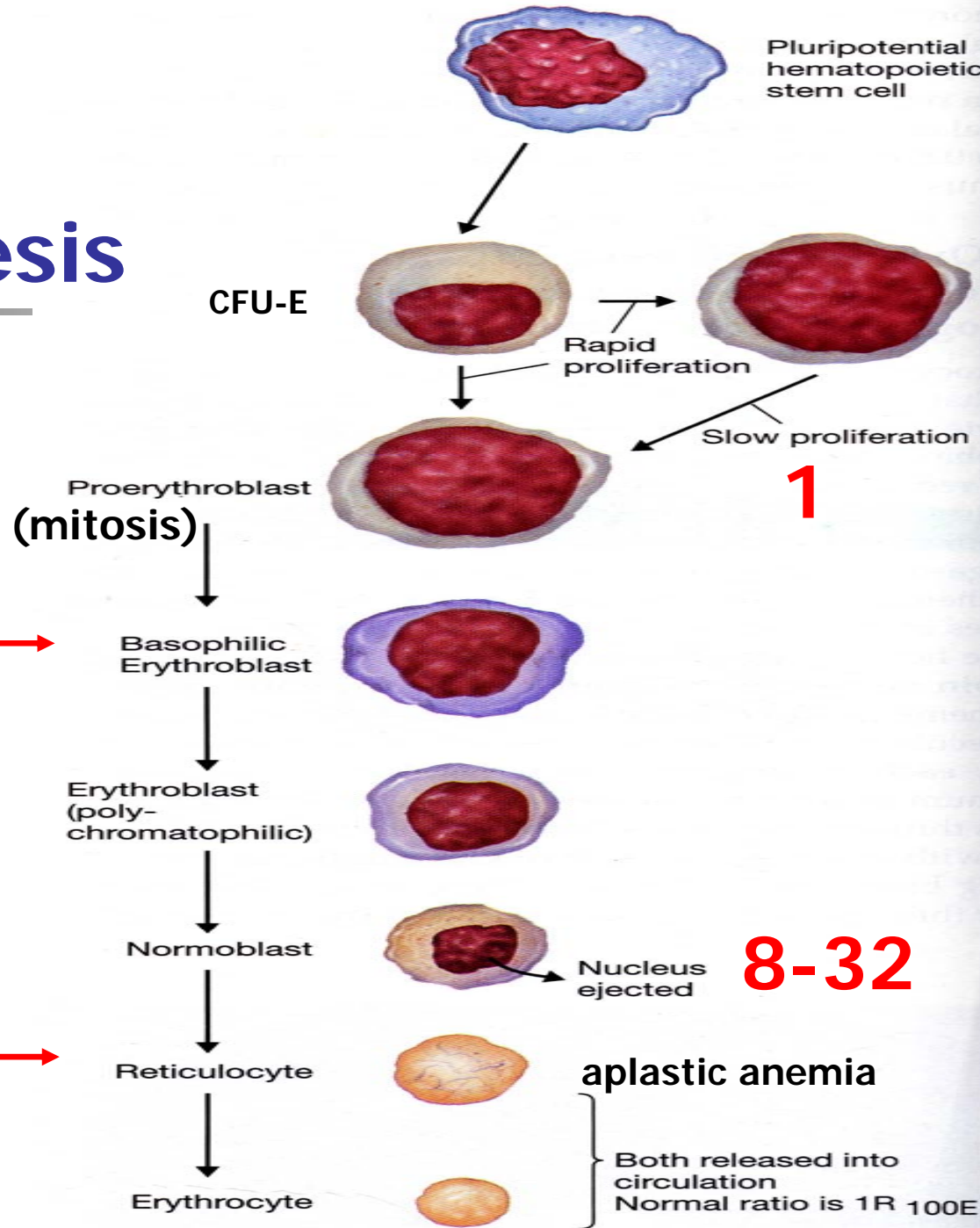
proerythroblast →

normoblast

■ Hb Synthesis

Proerythroblast →

reticulocyte





Substances for erythropoiesis

■ General substances

- amino acids, lipids, carbohydrates

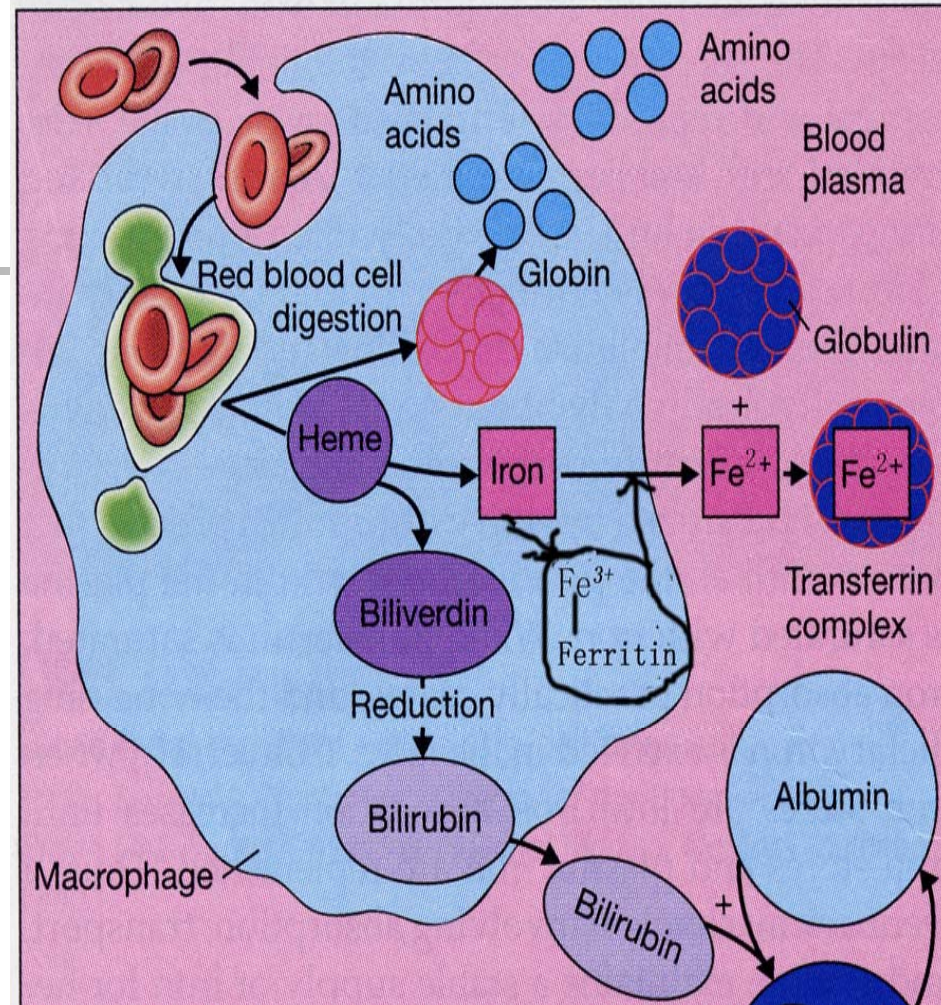
■ Special substances

- folic acid and vitamin B₁₂ for DNA
- iron for hemoglobin

Iron

- 20 ~ 30 mg/day
- Intrinsic:
95% from RBC
- Extrinsic:
1mg from food
- Iron Deficiency Anemia (IDA)

Malabsorption syndrome/chronic blood loss





Vitamin B₁₂

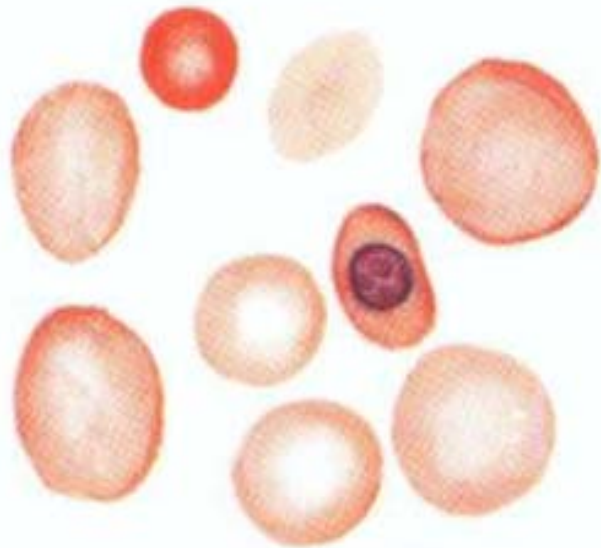
- animal food (liver, kidney, heart)
- Intrinsic factor (parietal cells in stomach) -
B₁₂ Complex for absorption (ileum)
adequate storage and small consumption
- megaloblastic anemia (gastrectomy, ileectomy)
↑
Premature RBC



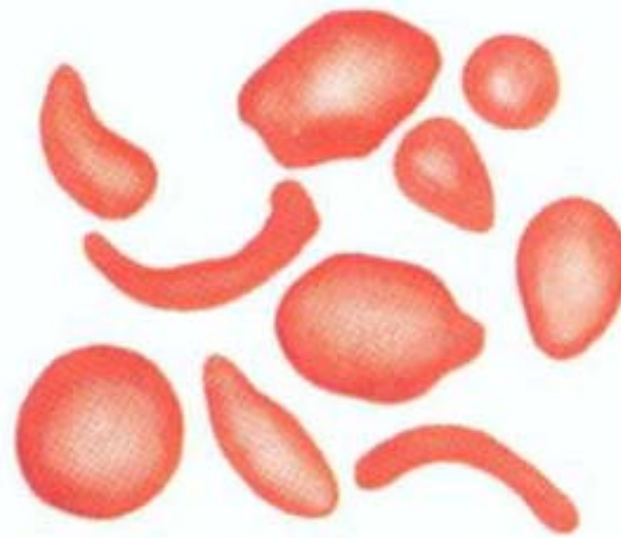
Folic acid

- Liver, yeast, plants
- tetrahydro-folic acid (THFA) for utilization in the presence of B₁₂
- megaloblastic anemia

fetal neural tube defects



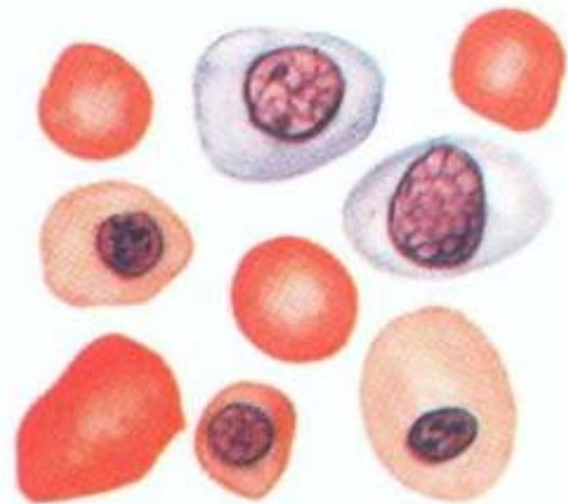
Megaloblastic anemia



Sickle cell anemia



**Microcytic,
hypochromic anemia**



Erythroblastosis fetalis



Regulators for erythropoiesis

■ Erythropoietin (EPO)

Source of EPO

- **Kidney (85%)** Nephrectomy/renal disease

Interstitial cells in the peritubular capillary bed

- **liver (15%)**

Perivenous hepatocytes

Recombinant EPO for anemia therapy



Target cells of EPO

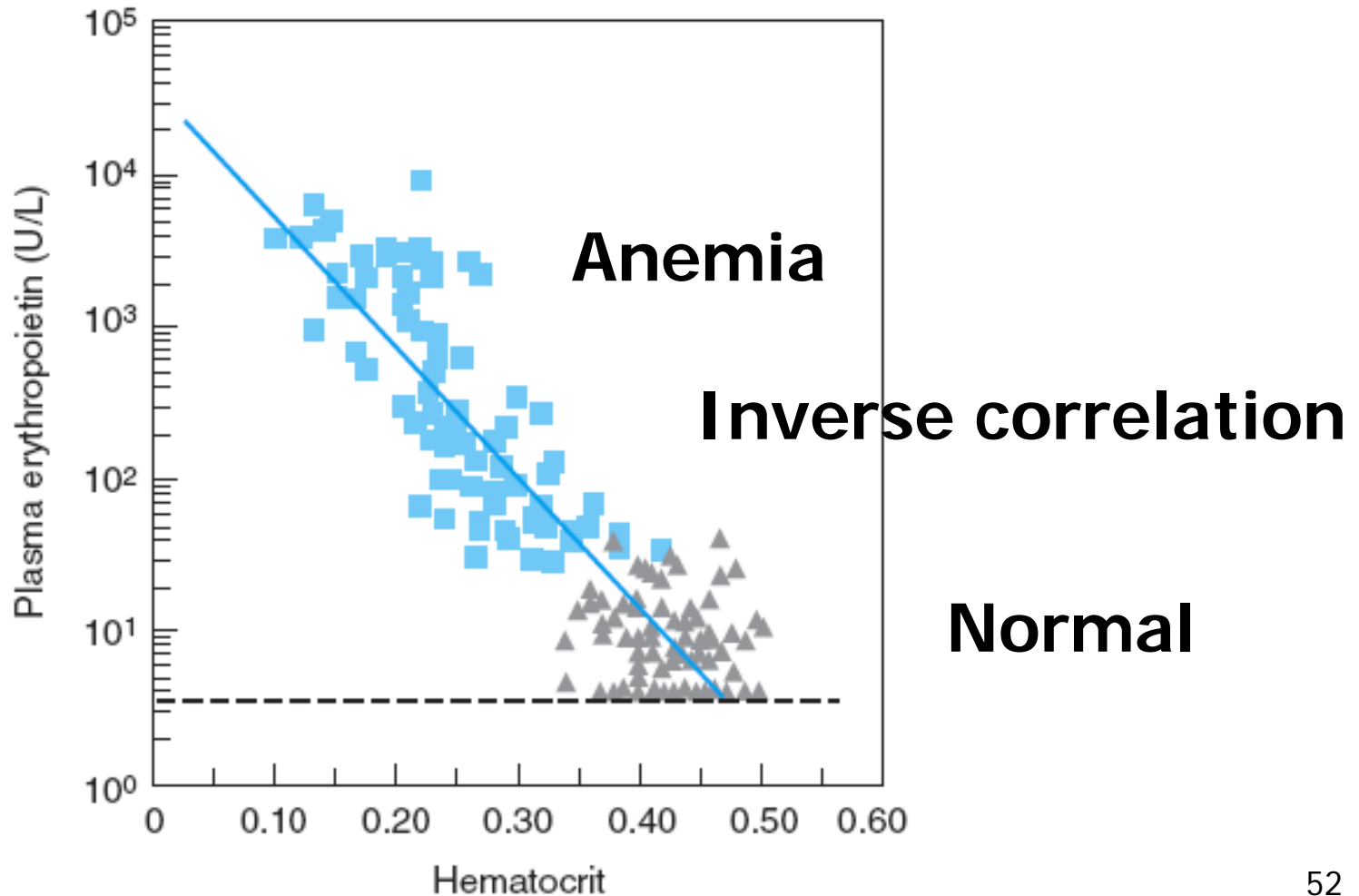
- CFU-E (main, EPO-sensitive)
- precursor cells (reticulocyte)

Stimulator of EPO secretion

Hypoxia → O_2 sensor in kidney/liver

Eg. People in plateau look red on their face

Negative Control of EPO secretion





Regulators for erythropoiesis

■ Hormones: Testosterone → EPO
→ CFU-E

Estrogen inhibited CFU-E sensitivity to EPO

Thyroid hormone
Growth hormone

3. Damage (Clearance) of senescent RBC

- lifespan: 120 days

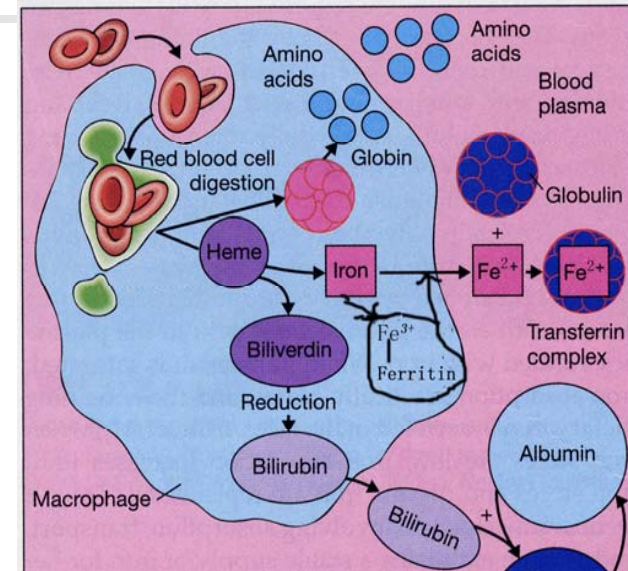
0.8% of circulating RBC

- Extravascular damage (90%)

Macrophages of liver, spleen, and bone marrow

- Intravascular damage (10%)

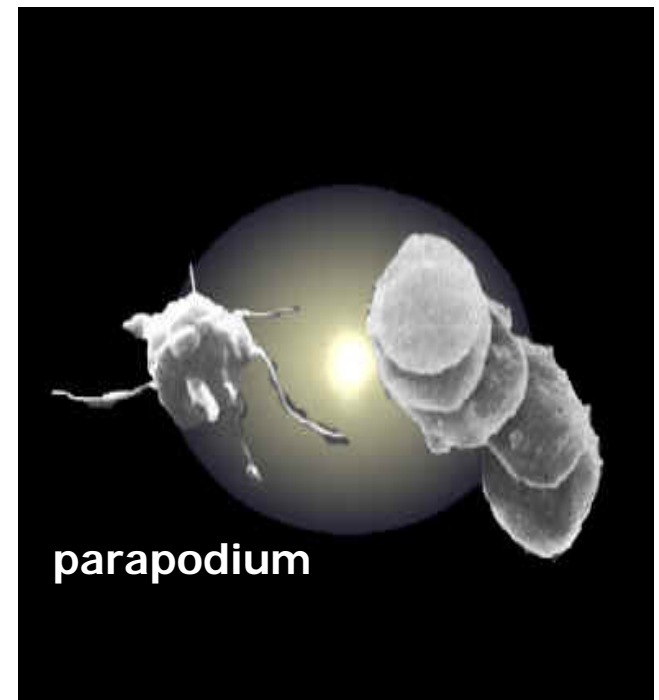
hematoglobulinuria



3、 Physiology of Platelets

Counts and Morphology

- $(100 \sim 300) \times 10^9 / L$
- biconvex, 2-3 μm
- lack nucleus



Thrombocytosis

■ Megakaryocyte (MK)

↓
Platelets

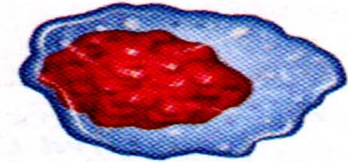
1---200~700

■ **Life Span:**

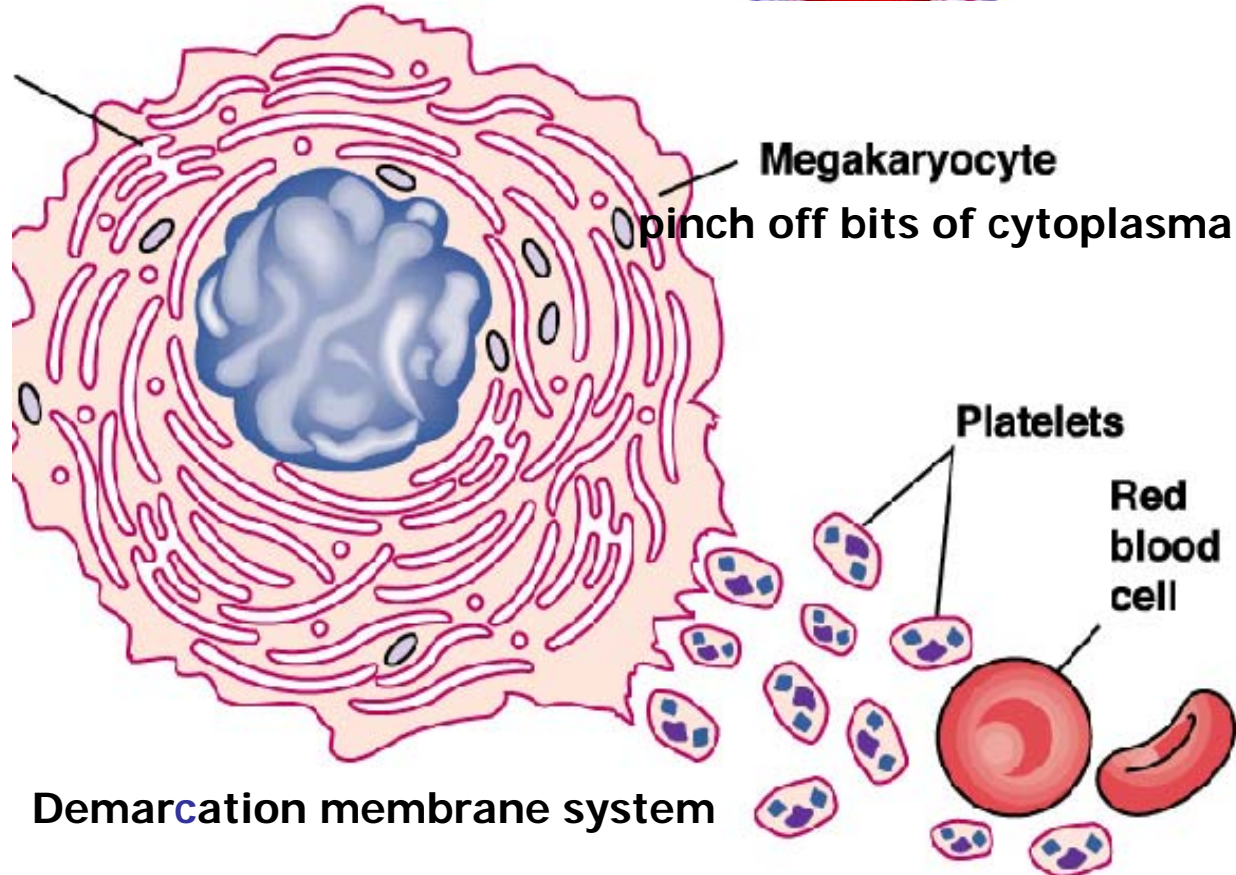
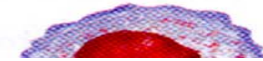
7-14 d

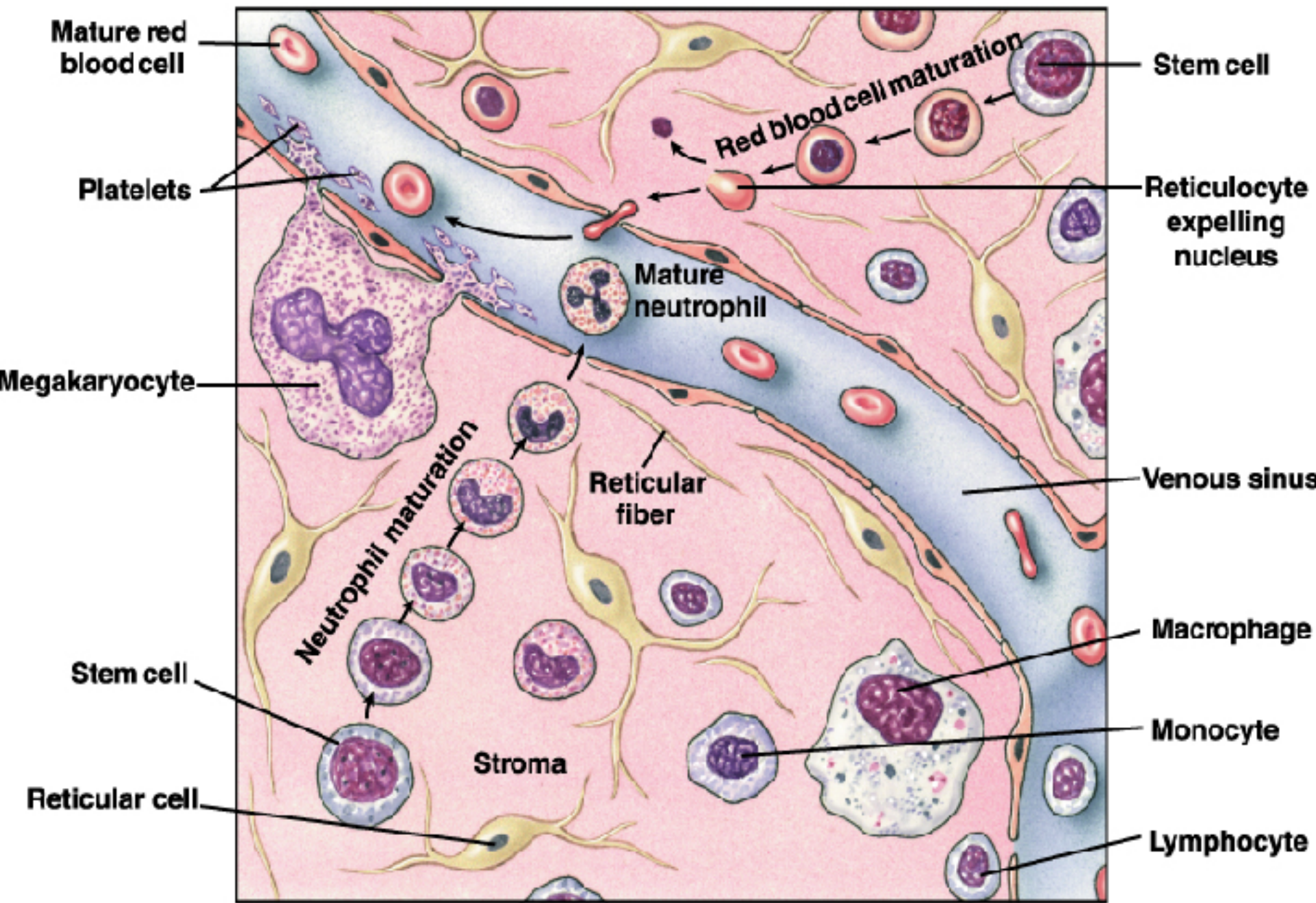
60-75% circulating
in spleen

Pluripotential hematopoietic stem cell



↓
CFU-Me





Regulators for thrombocytosis

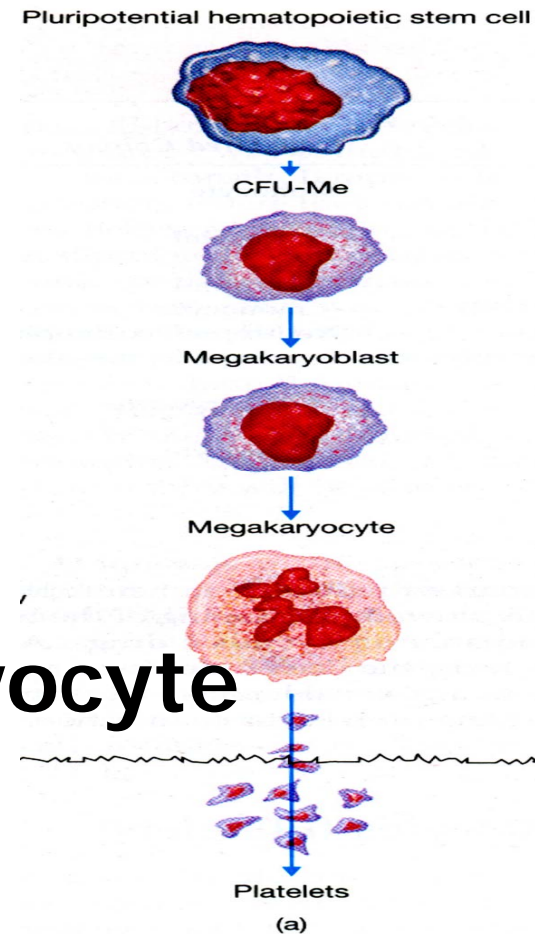
■ Thrombopoietin (TPO)

Source of TPO

- Liver (Main)、Kidney

Target of TPO

- Process during megakaryocyte maturation





Functions of platelets

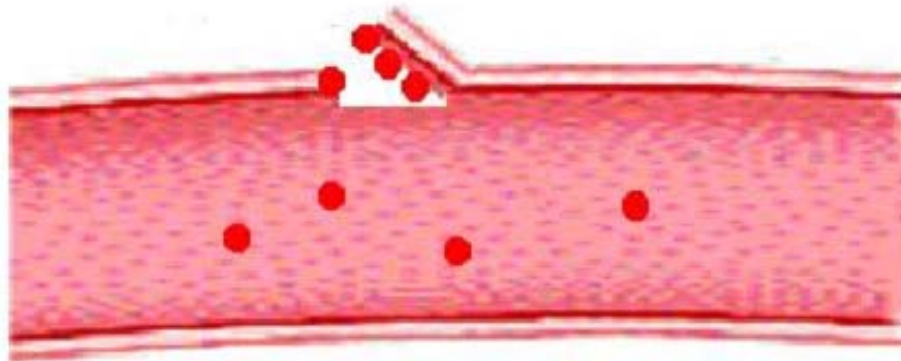
- **Play important roles in hemostasis**
- **Keep Vessel Wall Integrity**
 - **Direct adhesion and fusion**
 - **Platelet-derived growth factor (PDGF)**
 - **Vascular endothelial growth factor (VEGF)**

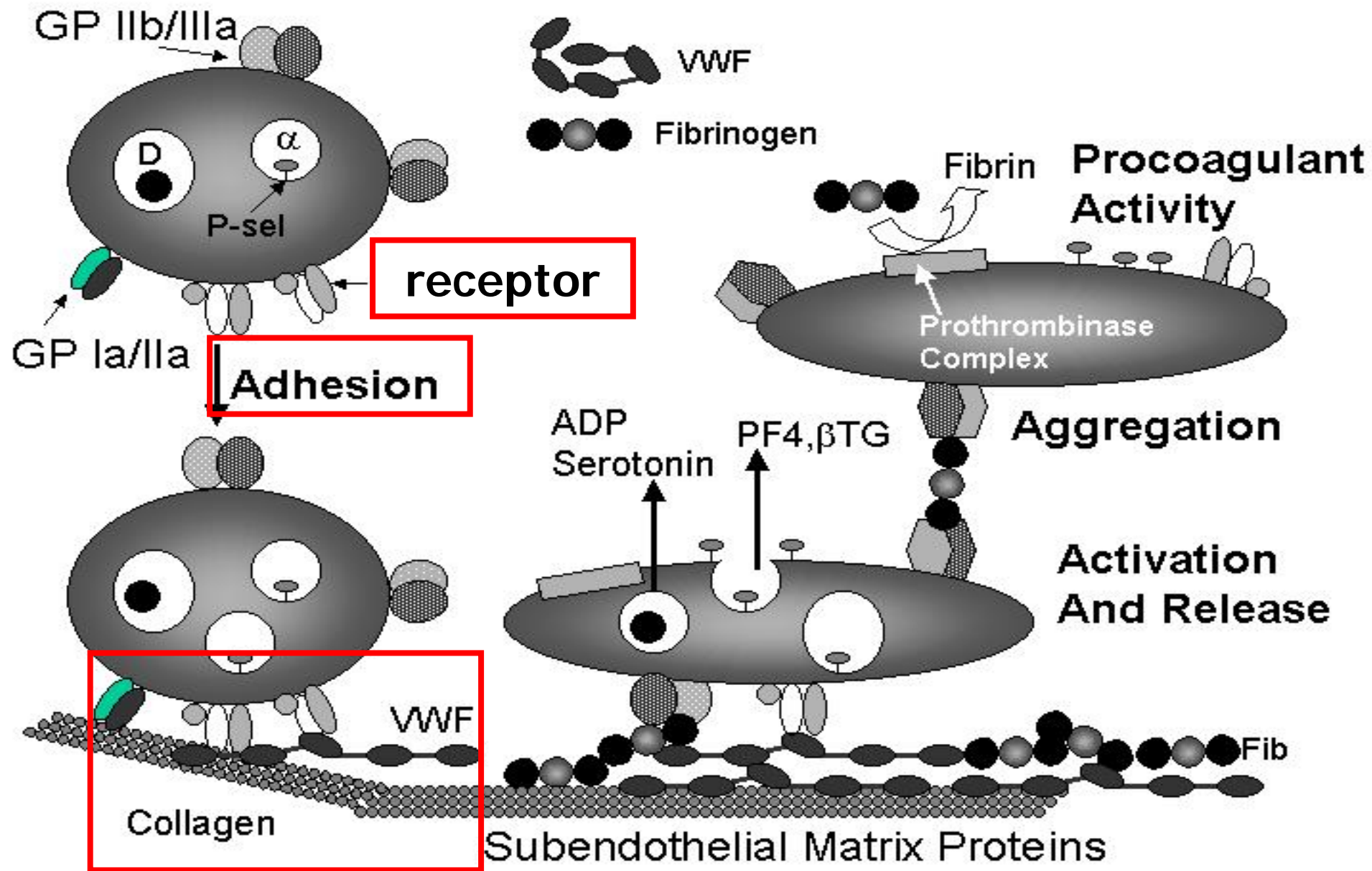


Physiological characteristics

(1) adhesion

Exposed collagen: injured vessel wall
von Willebrand factor (vWF): plasma
Receptors for vWF: platelets







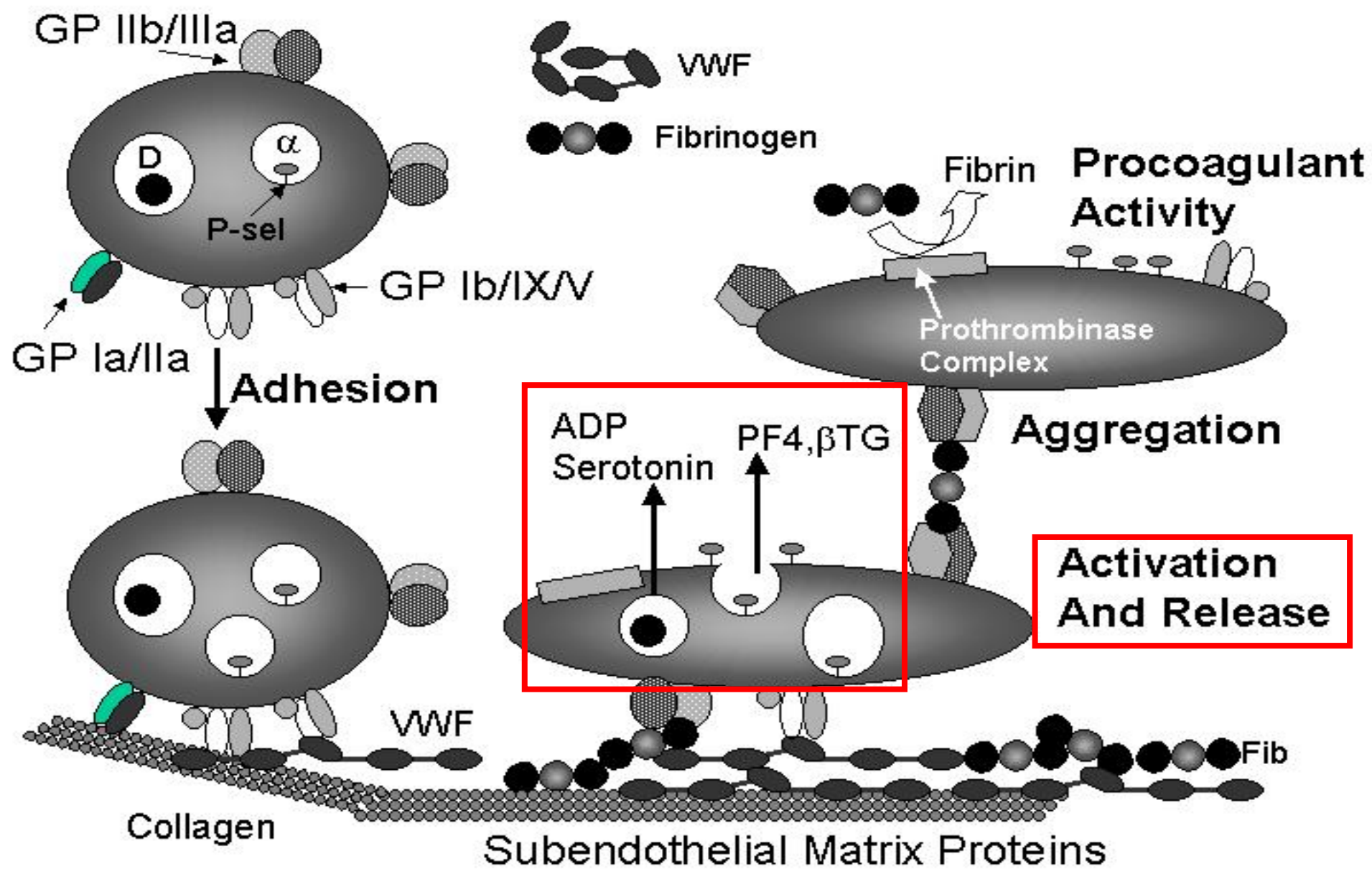
(2) release/secretion

α -granules: **β -thromboglobulin (β -TG), PF4,
PF5, fibrinogen, vWF, PDGF**

dense body: **ADP, ATP, serotonin (5-HT), Ca^{2+}**

lysosome: **hydrolases**

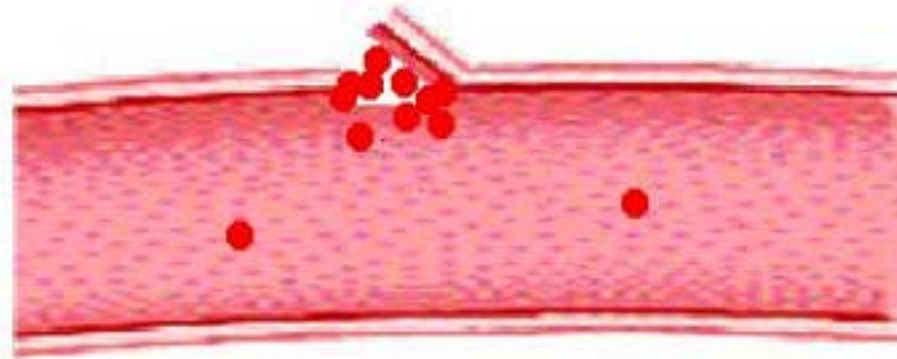
Instant synthesis and release: **Thromboxane A_2
(TXA_2)**



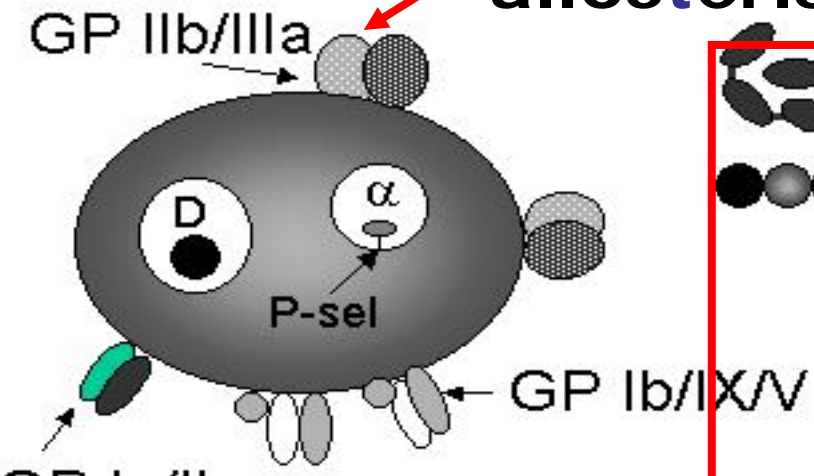


(3) Aggregation

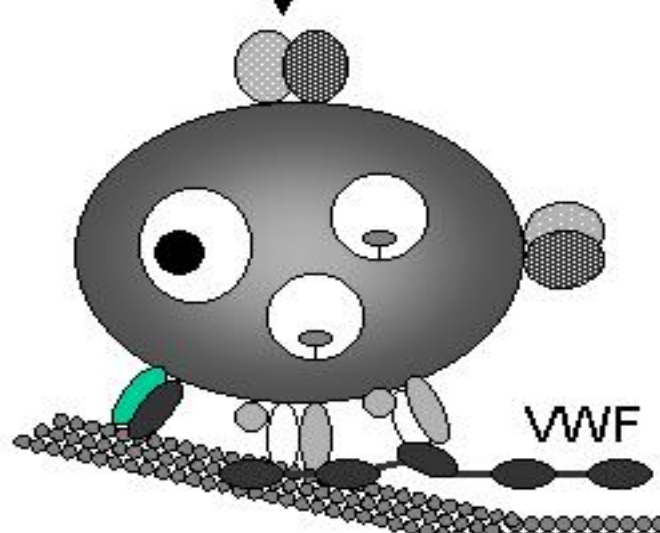
Ca^{2+}
receptors – fibrinogen - receptors



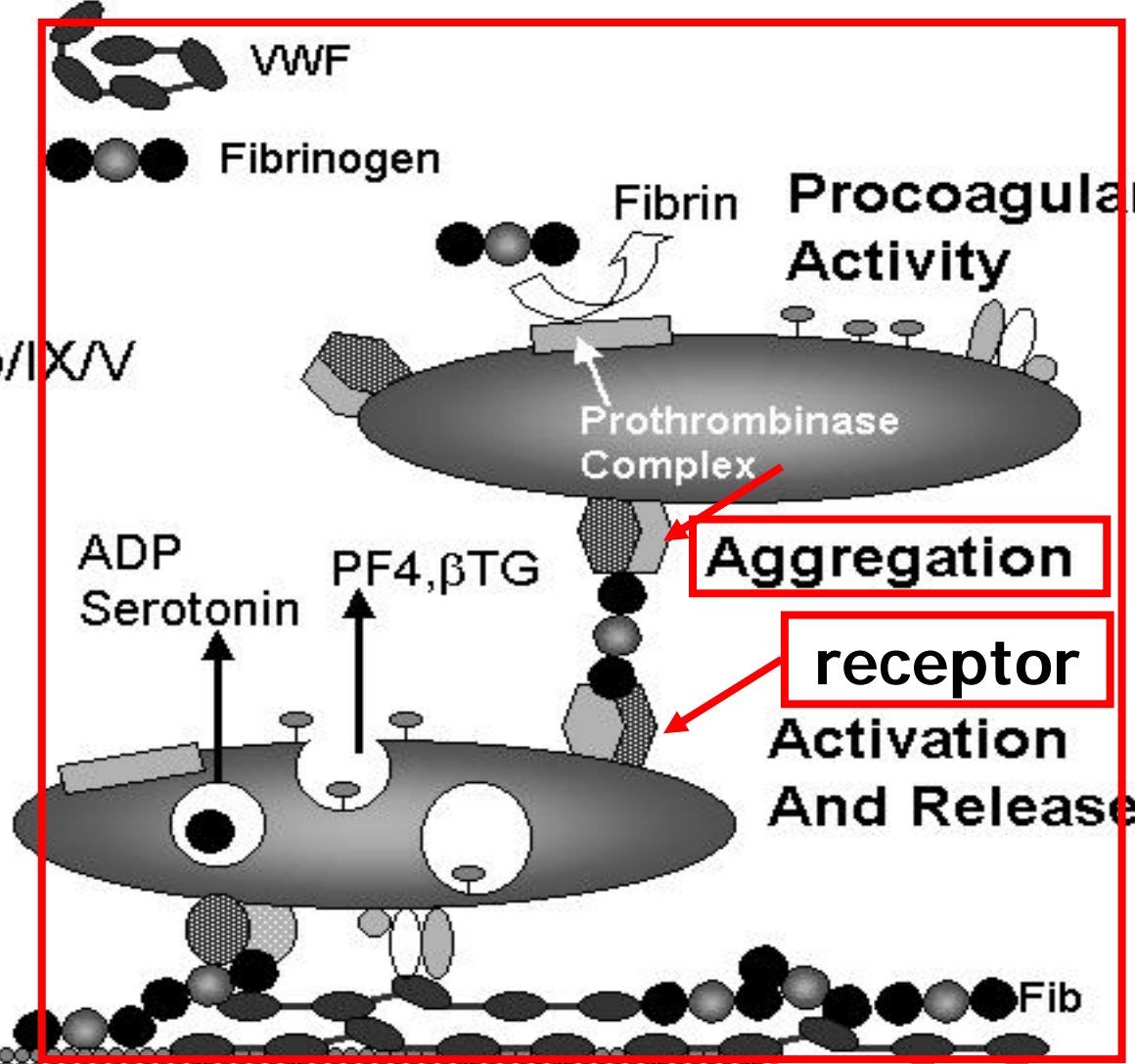
allosterism



Adhesion



Collagen

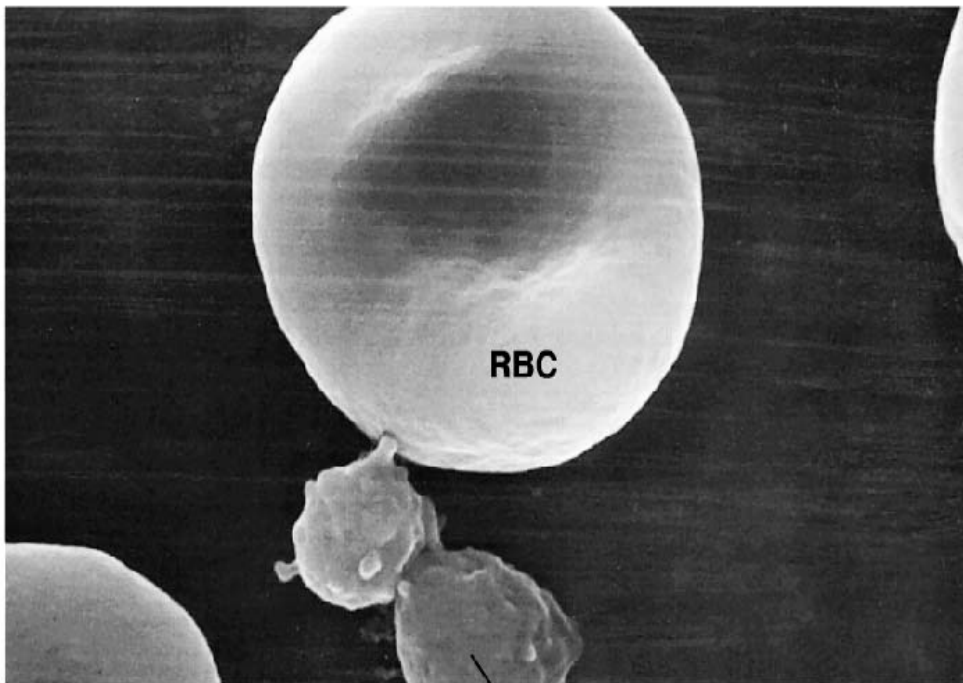


Aggregation

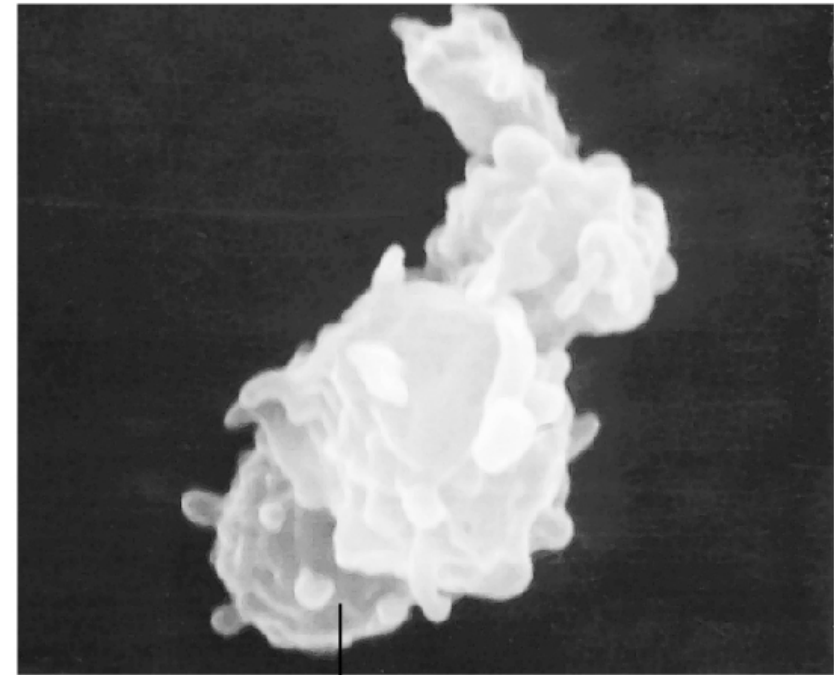
**receptor
Activation
And Release**

Subendothelial Matrix Proteins

Activated platelets develop a spiky outer surface and aggregated together



Inactive platelet



Activated platelet



Aggregators

Physiological: ADP、 serotonin (5-HT)、
thromboxane (TXA)₂、 adrenaline、
Histamin、 collagen、 thrombin

Pathological: Bacteria、 Virus、 immune
complex、 drugs

cAMP ↓ or Ca²⁺ ↑



Aggregation Inhibitors

➤ **Prostacyclin (PGI₂)**

-Produced by endothelial cells

-Antagonize TXA₂

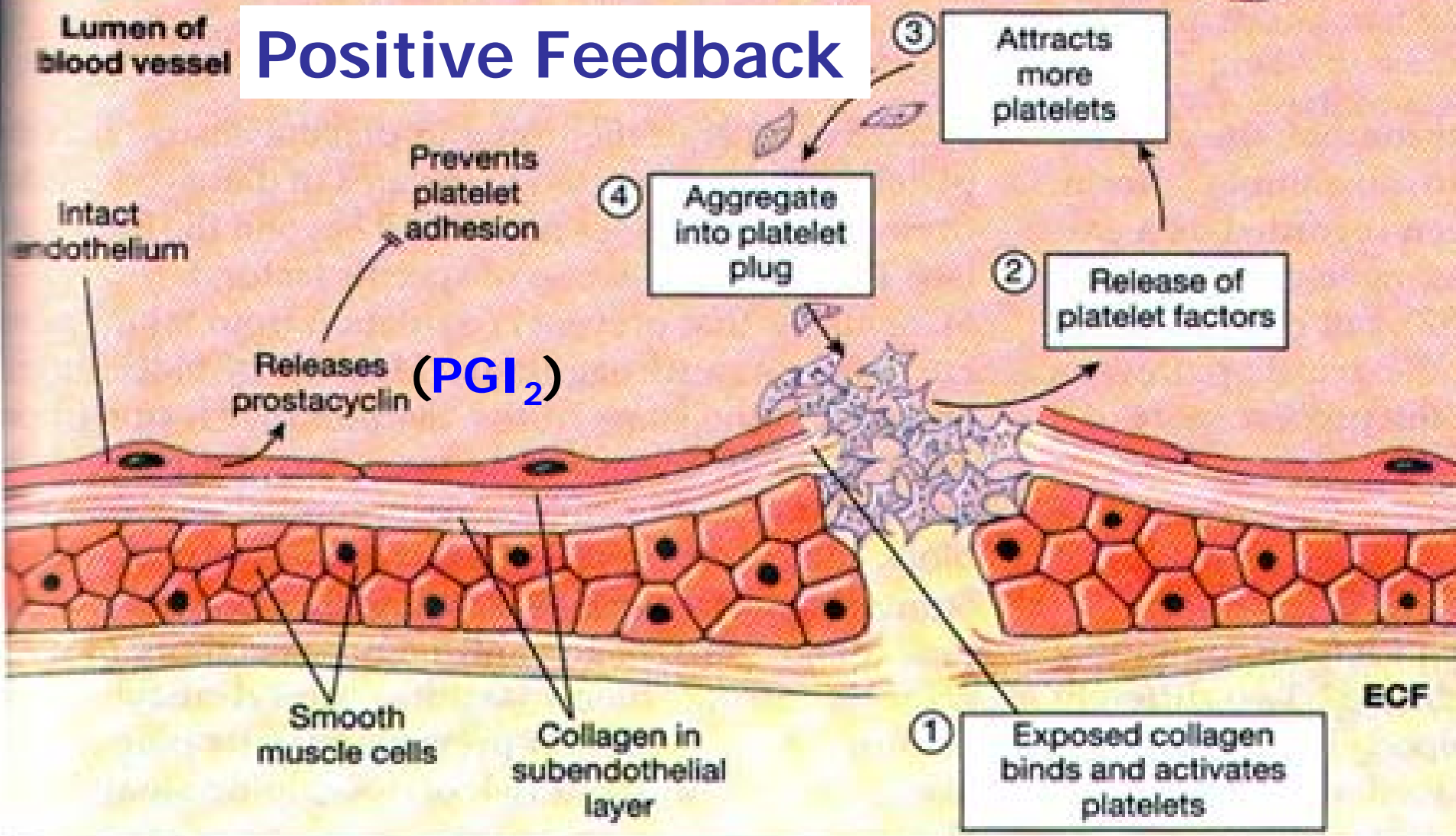
➤ **Nitric Oxide**

- produced by endothelial cells and platelets

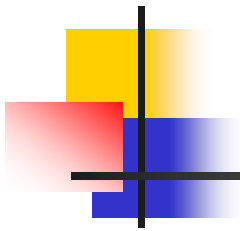
➤ **Aspirin**

-Inhibit TXA₂ synthesis

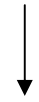
Positive Feedback



Platelet adhesion and aggregatic



Contractile elements: myosin/actin/tropomyosin/troponin



(4)constriction: Relate to deformation,
parapodium formation and clot retraction

(5)absorption: absorb Factor I, V, XI,XIII



Hemostasis

is the process of forming clots in the walls of damaged blood vessels and preventing blood loss while maintaining blood in a fluid state within the vascular system.

A series of events lead to the formation of clot!

Basic process

-Vasoconstriction

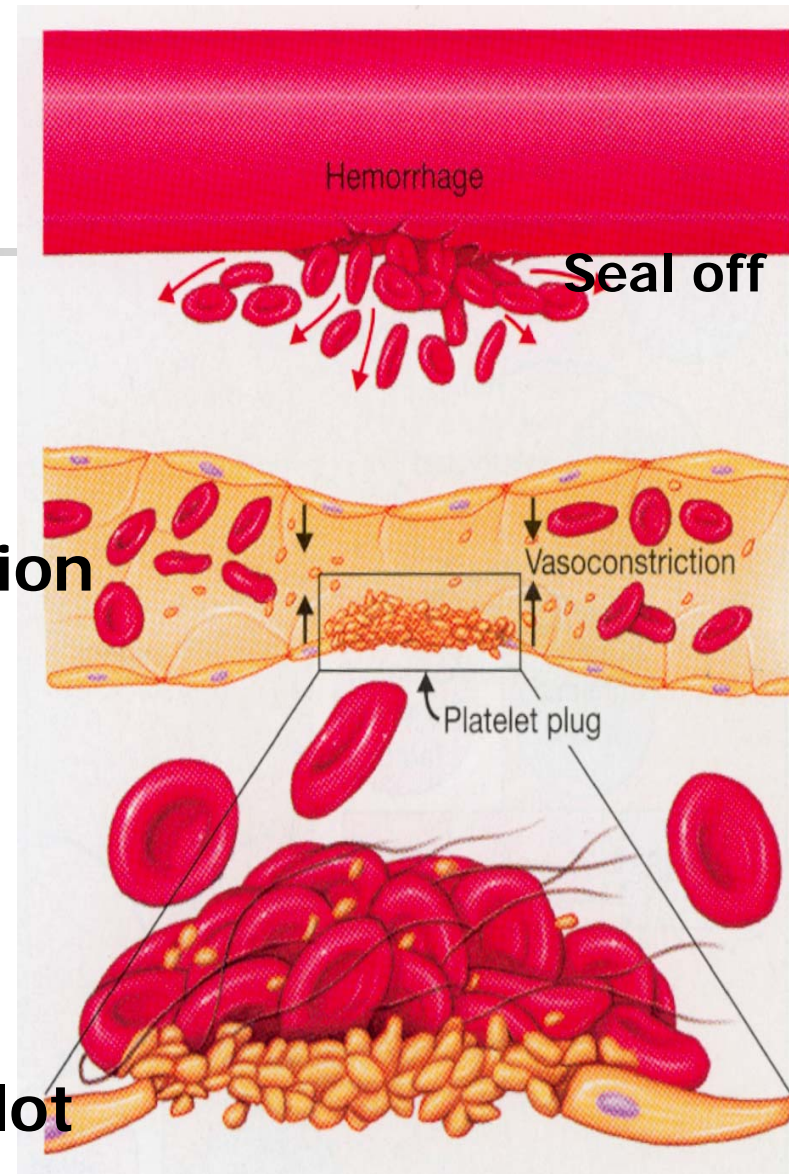
Vascular smooth muscle contraction

- Platelet plug Formation

Adhesion/release/aggregation

-Blood coagulation (clot)

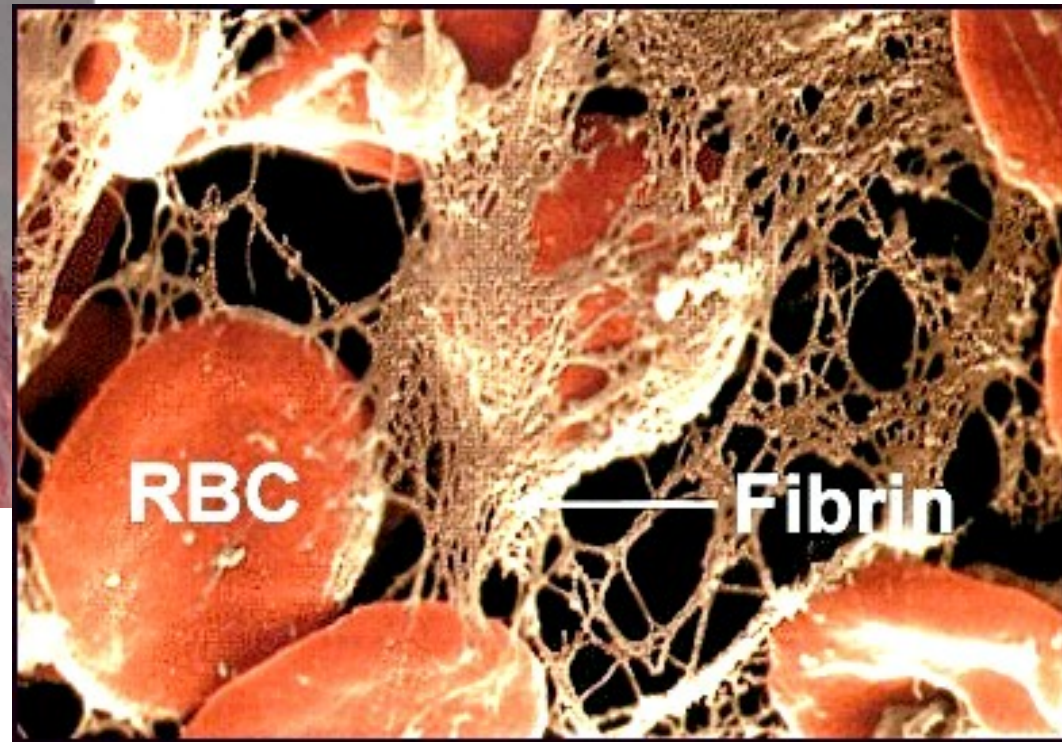
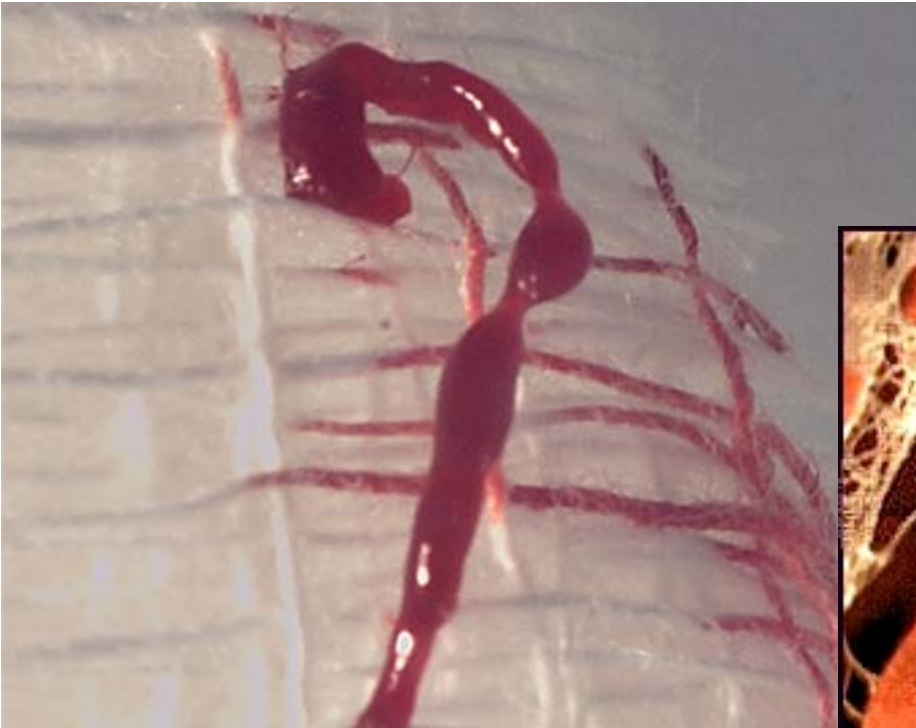
Conversion of plug to definitive clot





Blood Coagulation

**Soluble fibrinogen
---insoluble fibrin**





Clotting/coagulation factors

International nomenclature:

- I-XIII (VI excluded)

Prekallikrein (PK)

High-molecular weight kininogen (HMWK)

- Most are proteins (IV excluded)
- Found in fresh plasma (III excluded)
- Most are synthesized in the liver

- **Factor I** **Fibrinogen**
- **Factor II** **Prothrombin/thrombinogen**
- **Factor III** **Tissue thromboplastin (Tissue factor)**
- **Factor IV** **Calcium**
- **Factor V**
- **Factor VII**
- **Factor VIII** **Antihemophilic factor**
- **Factor IX**
- **Factor X**
- **Factor XI**
- **Factor XII**
- **Factor XIII** **Fibrin-stabilizing factor**
- **PK** **prekallikrein**
- **HMWK (HK)** **High-molecular-weight kininogen**



■ Classification

(1) **Substrate:** I

(2) **Zymogen of serine protease**

II, VII, IX, X, XI, XII, XIII, PK

F II \longrightarrow F II_a activated

(3) **Cofactors:** **III, IV, V, VIII, HK**



Vit K-dependent factor

II, VII, IX, X

γ - carboxyglutamate on N-terminal

**Vit K deficiency resulted in hemorrhagic
tendency**

a cascade of reactions in which inactive enzymes are activated, and the activated enzymes in turn activate other inactive enzymes.

Process of coagulation (1964)

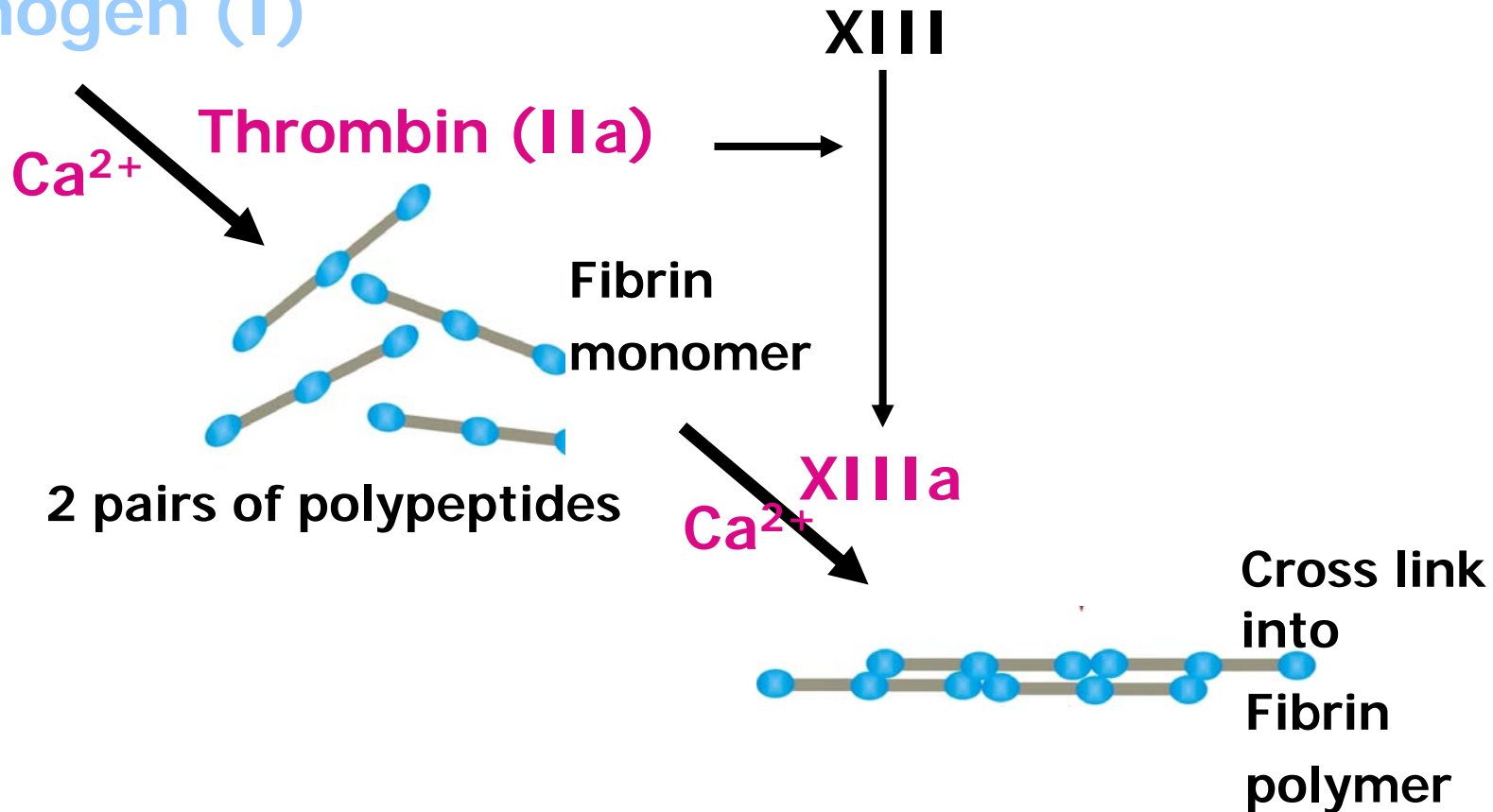
1、 **Prothrombinase Complex**

2、 **Prothrombin (II)** → **Thrombin (IIa)**

3、 **Fibrinogen (I)** → **Fibrin**

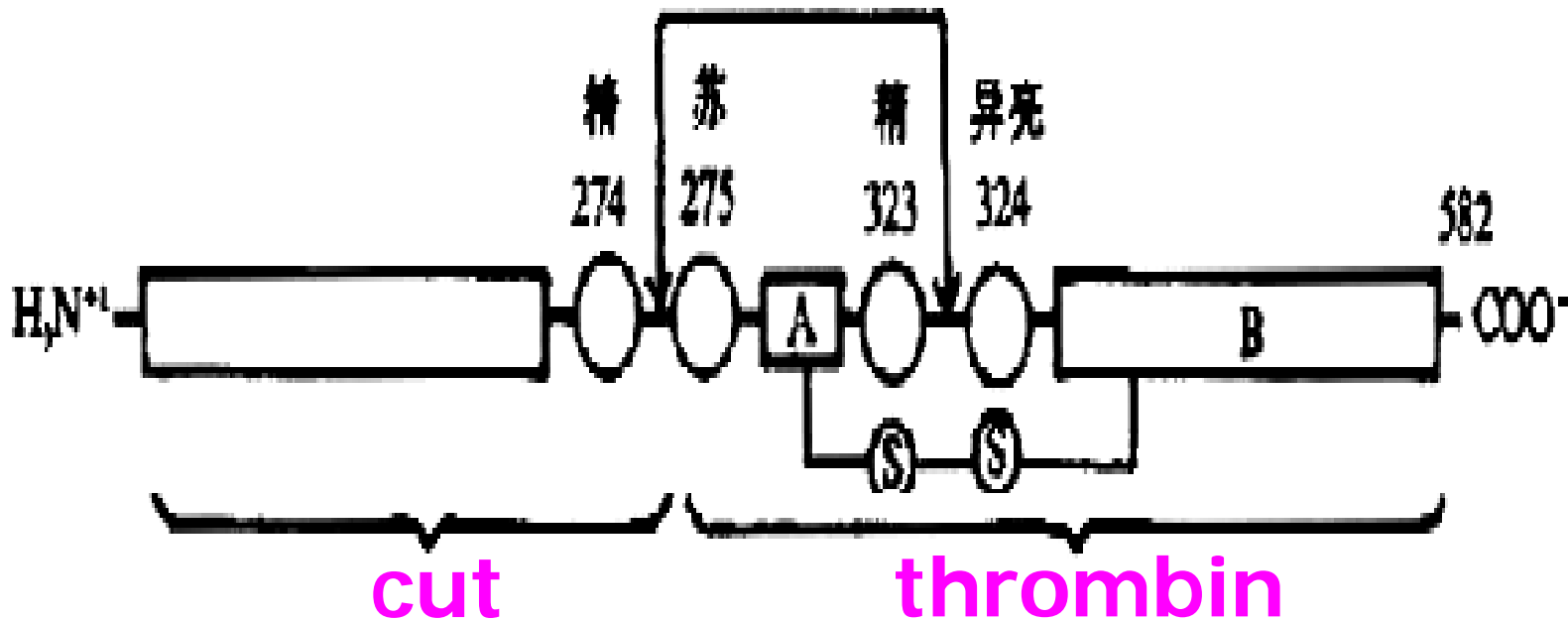
■ Formation of fibrin

Fibrinogen (I)



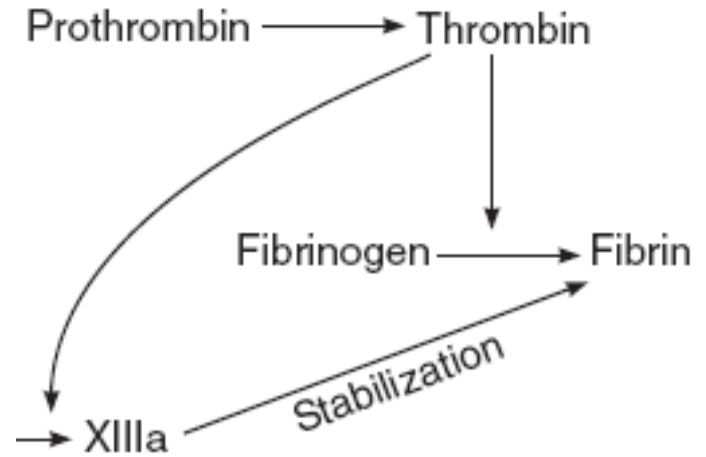
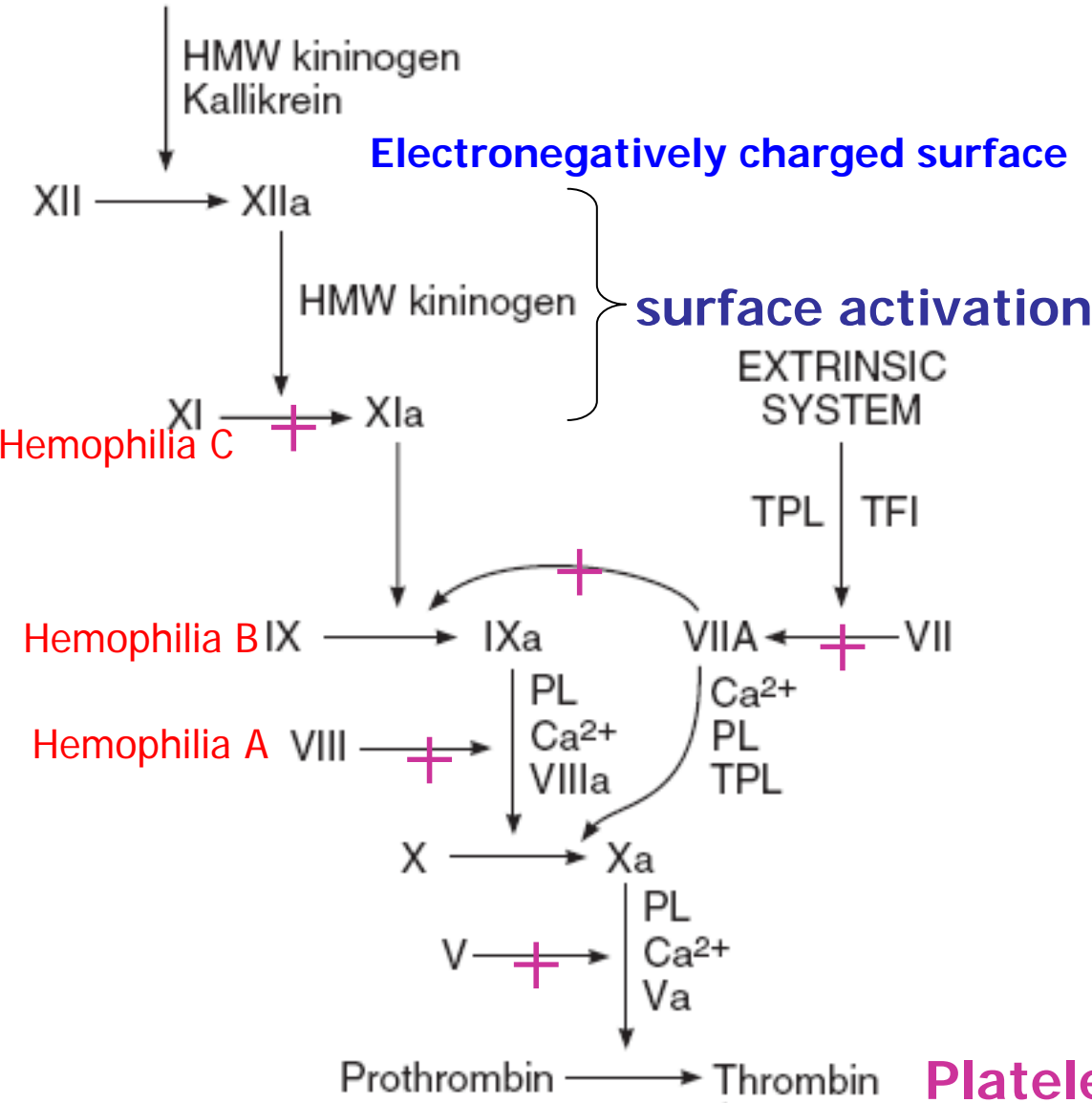
■ Formation of thrombin

Prothrombinase Complex
Xa-Va-Ca²⁺-Phospholipid(PL)



Clotting Cascade

INTRINSIC SYSTEM



PL: phospholipid

TPL: Tissue thromboplastin (tissue factor)



Intrinsic/extrinsic pathways

- **Extrinsic: initiate**

Intrinsic: amplify & maintain

- **Interaction:**

(1) VIIa-TF complex activate IX

(2) Xa activate VII

(3) IIa activate V, VIII, XI



Functions of platelet in hemostasis

- Release 5-HT, TXA₂
- Platelet plug
- Release clotting factors (fibrinogen)
- Provide phospholipids (PL) surface
- Blood clot retraction
- Absorption clotting factors



三、Anticoagulation system

Anticoagulation by endothelial cells

- Barrier
- Excrete heparitin sulfate proteoglycan/
Antithrombin/thrombomodulin(TM)/TFPI
- Excrete prostacyclin (PGI_2)/nitric oxide (NO)
- Excrete tissue-plasminogen activator (t-PA)



Anticoagulant

1. Serine protease inhibitor

(II, VII, IX, X, XI, XII, XIII, PK)

2. Protein C system

3. Tissue factor pathway inhibitor (TFPI)

4. Heparin



1. Serine protease inhibitor

- **Antithrombin (AT)**

- produced by liver / capillary endothelial cells
- inactivate **IIa**, IXa, Xa, XIa, XIIa
- AT- heparitin sulfate proteoglycan complex
- heparin as co-factor (>2000 fold)



2. Protein C system

PC, PS, thrombomodulin, inhibitors of PC&PS

- **PC (activated by thrombin-thrombomodulin complex)**
 - Inactivated VIIIa, Va
 - PS acts as cofactor
 - Inactivated t-PA inhibitors



3. Tissue factor pathway inhibitor

- Produced by capillary endothelial cells
- Main anticoagulant in vivo
- Inactivate VIIa-TF complex **in the presence of Xa**

Bind to Xa first, then inactive VIIa-TF complex



4. Heparin

- Lung、 heart、 liver、 muscle
almost none in plasma
- **Anti-coagulative mechanism**
 - Enhance AT activity (main)
 - Stimulate the release of TFPI



Coagulation- anticoagulation

- **Tepid gauz**
Promote surface activation
- **Anticoagulative tubes**
oxalate/citrate/EDTA to remove Ca^{2+}
- **Blood sample for transfusion**
citric sodium
- **Extracorporeal circulation**
heparin

四、Fibrinolytic system

plasminogen activator (PA)

Fibrinolysis inhibitors

1、 Plasminogen $\xrightarrow{\quad}$ Plasmin

2、 Fibrin $\xrightarrow{\quad}$ Fibrin fragments

Decomposition/colliquation



Component of fibrinolytic system

- 1. Plasminogen**
- 2. Plasmin**
- 3. Plasminogen activator**
- 4. Fibrinolysis inhibitors**



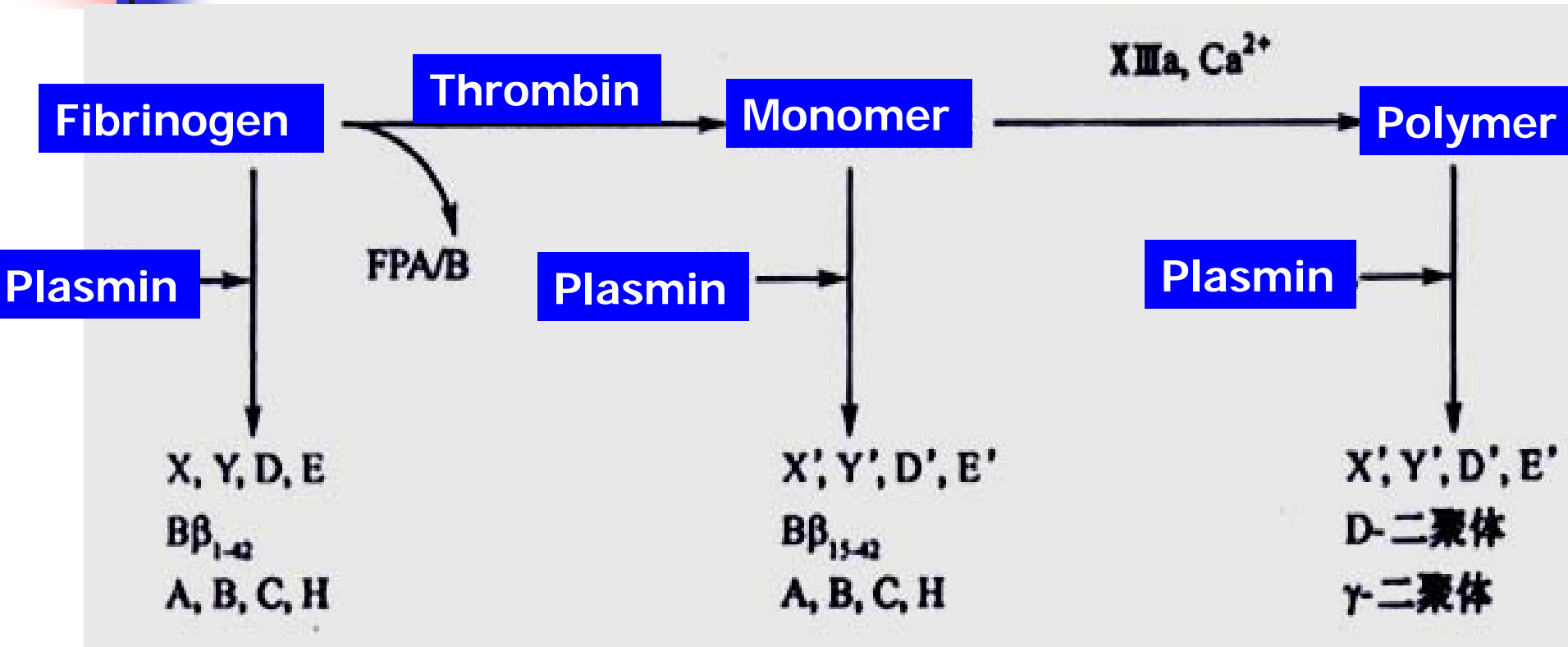
1、 Plasminogen activation

Plasminogen activators

- **Tissue-type (t-PA) : capillary endothelial cells**
- **Urokinase-type (u-PA): epithelial cells in kidney**
- **From blood: XIIa, kallikrein**
- **Drugs: Streptokinase-a bacterial enzyme**

Urokinase used for myocardial infarction

2、 Degradation of fibrin/ fibrinogen



Fibrin degradation products



Fibrinolysis inhibitors

(1) Plasminogen activator Inhibitor-1

(PAI-1)

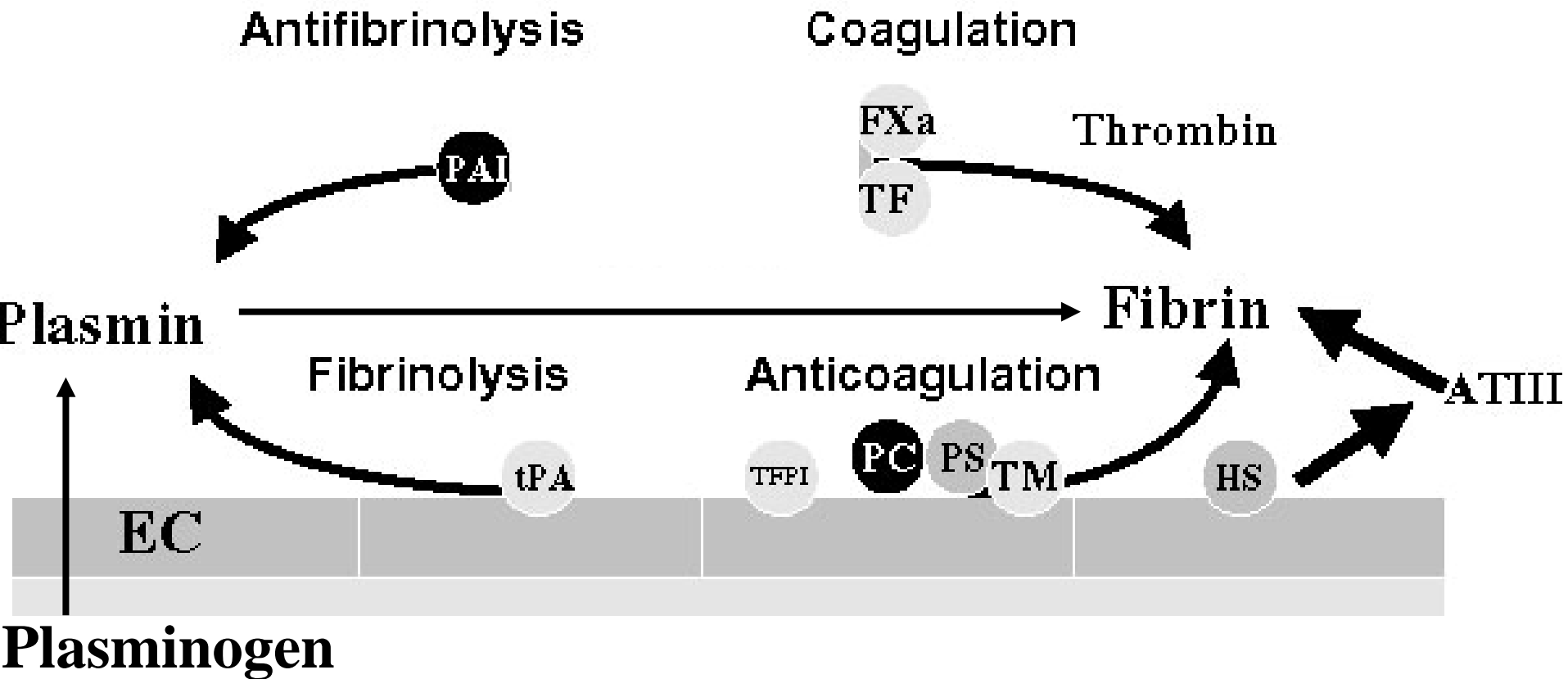
- **Capillary endothelial cells, hepatocytes**
- **Inactivate t-PA/u-PA**



(2) α 2 - antiplasmin

- Main Fibrinolysis inhibitor in vivo**
- hepatocytes**
- Inactivate plasmin**

Balance





Key points:

- **Physiological characteristics of RBC**
 - ✓ Suspension stability/ Osmotic fragility
- **Physiological characteristics of platelets**
- **Hemostasis**
 - ✓ Intrinsic pathways
 - ✓ extrinsic pathways
 - ✓ Fibrinolytic system

The end

