Blood (血液)

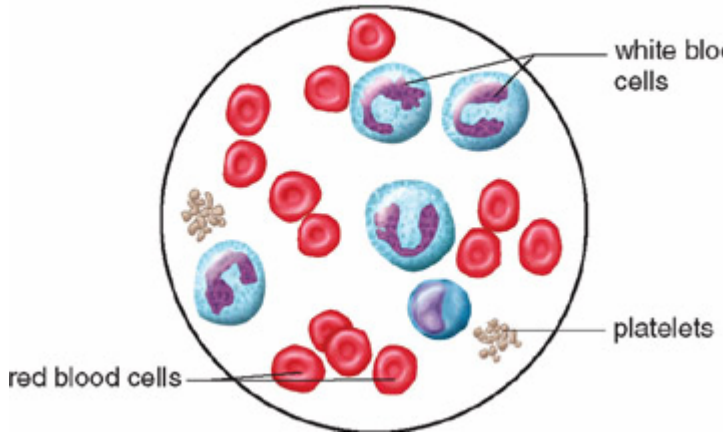
- **Fluidic tissue in our body.**
- **Blood (血液) is a part of internal environmental**
- **Blood is a result of revolution**

  Unicellualar——multicellular——extracellular fluid ——plasma + interstitial fluid
- **Internal environmental homeostasis——the most active part**

- **Functions**
  - **–Supply O_2, nutrients**
  - **–Distribute hormones**
  - **–Return metabolites, CO_2**
  - **–Buffer pH**
  - **–Buffer body temperature**
  - **–Hemostasia & defense**

Physical and chemical properties

- **Composition: plasma + cellular elements**
  - **Hematocrit value:**
    - **Male: 40-50%**
    - **Female: 37-48%**
    - **Newborn: 55%**
  - **Plasma**
    - **Water : 90%**
    - **Low MW substances : 2%**
    - **Proteins : 8%**
      - **Salt out method : albumin, globulin , fibrinogen**
      - **globulin : electrophoresis : α, β, γ**
    - **O_2 and CO_2**



Functions of plasma proteins

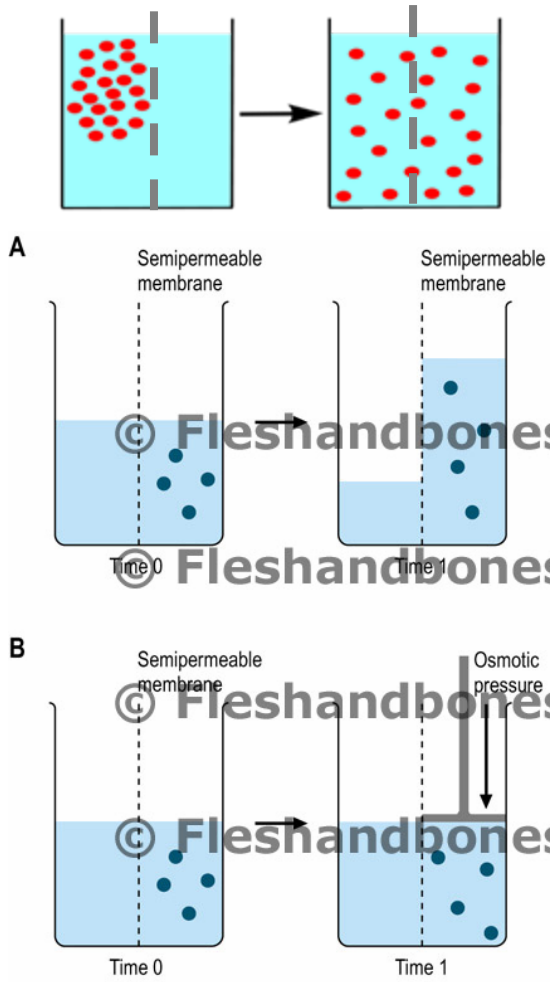
- **Transportation:**
  - **Hydrophobic —— hydrophilic**
  - **Low MW——lost in kidney**
  - **Dissociated, associated —— equilibrium (thyroid hormone)**
- **Nutrition**
- **Clotting (Coagulation), anticlotting, fibrinolysis**
- **Colloid osmotic pressure**
- **Buffer pH**
- **Immunity**

Physical and chemical properties of blood

- **Relative density :**
  - **Blood: 1.050-1.060**
  - **Plasma: 1.025-1.030**
  - **Red blood cell: 1.090-1.092**
- **Viscosity:**
  - **Blood: 4-5, plasma: 1.6-2.4**
  - **Influences: cell counts, velocity of blood flow, temperature**
- **pH: 7.35-7.45**

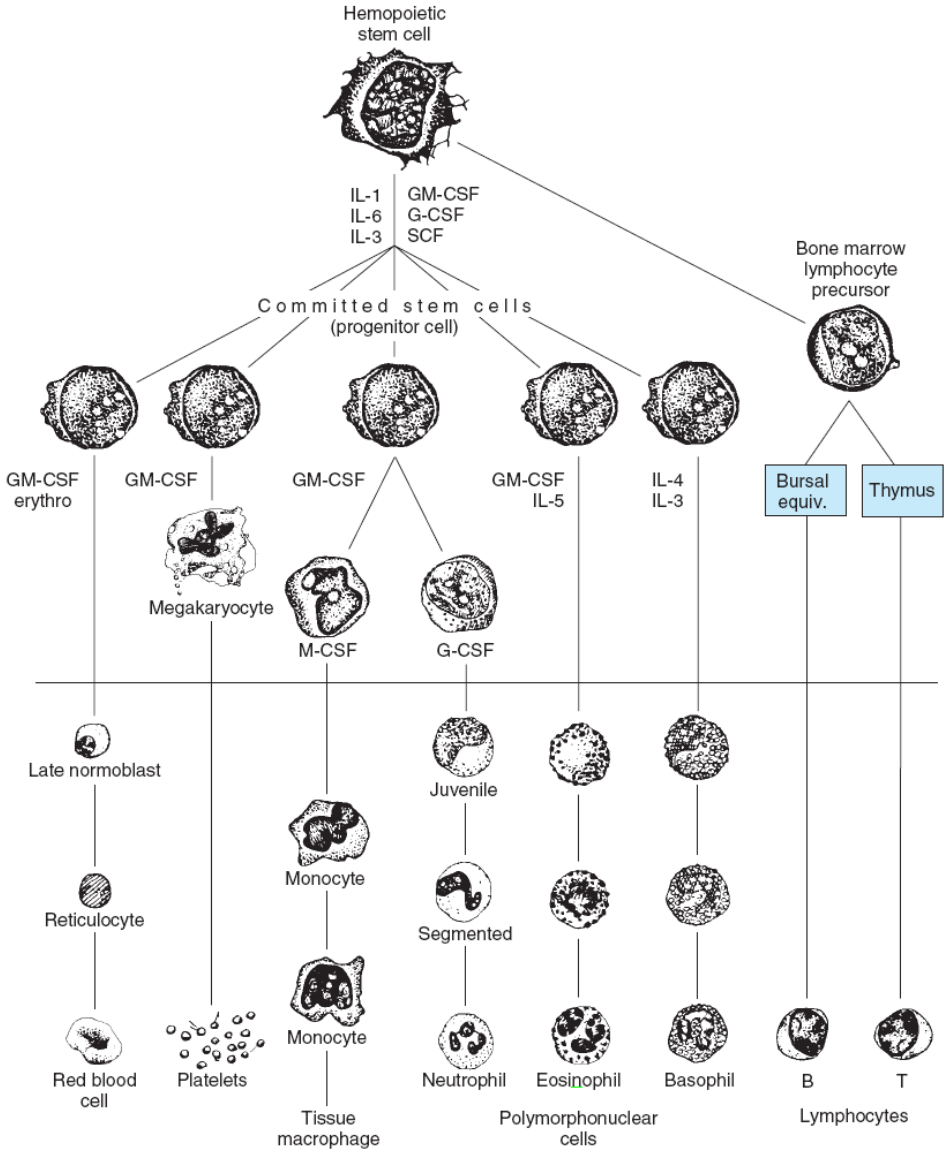
Physical and chemical properties

- **Osmotic pressure: 300 mmol/L（5330 mmHg）**
  - **Crystal osmotic pressure (晶体渗透压)**
  - **Colloid osmotic pressure (胶体渗透压):**
    - **1.5mmol/L (25mmHg)**
  - **Different significance**



Hemopoiesis

- **Place of blood cell formation**
  - **Fetus— liver, spleen**
  - **Adult—bone marrow**
- **Hemopoietic stem cell (HSCs)**
  - **Hemopoietic stem cell——committed stem cell (progenito cell)——reticulocyte——red blood cell**
- **Hemopoietic microenvironment (造血微环境)**
  - **leukemia**
  - **Aplastic anemia**



Red blood cells (erythrocyte)

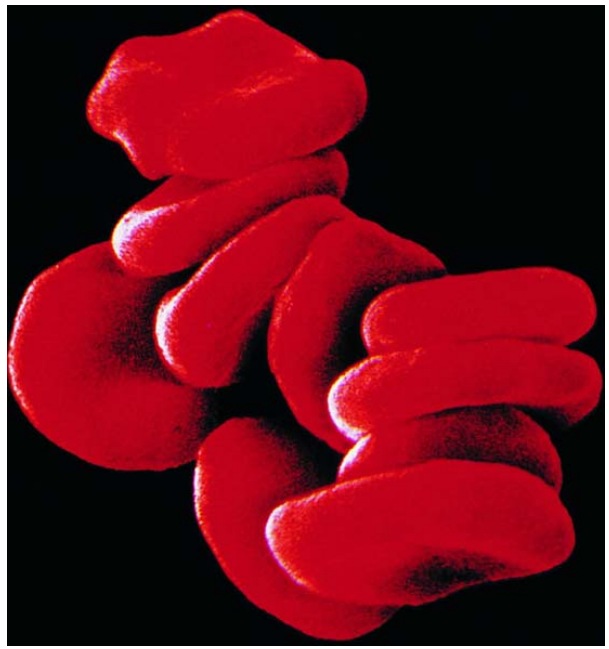
- **Biconcave disks, diameter 7-8 uM**
- **Numbers**:
  - **Male: 4-5.5 millions/ul**
  - **Female: 3.5-5 millions/ul**
  - **Newborn: 6 millions/ul**
- **Hemoglobin (血红蛋白)**:
  - **Male: 120-160 g/L**
  - **Female: 110-150 g/L**
  - **Newborn: 200 g/L**

Characters of red blood cells

- **Permeability of the cell membrane**
  - **Free: O_2, CO_2, Urea**
  - **Easy: anions**
  - **Difficult: cations**
- **Distribution of ions**：
  - **Intracellular: potassium;**
  - **Extracellular: sodium**
    - **sodium-potassium pump**
  - **Stored blood——increase in potassium concentration in plasma**

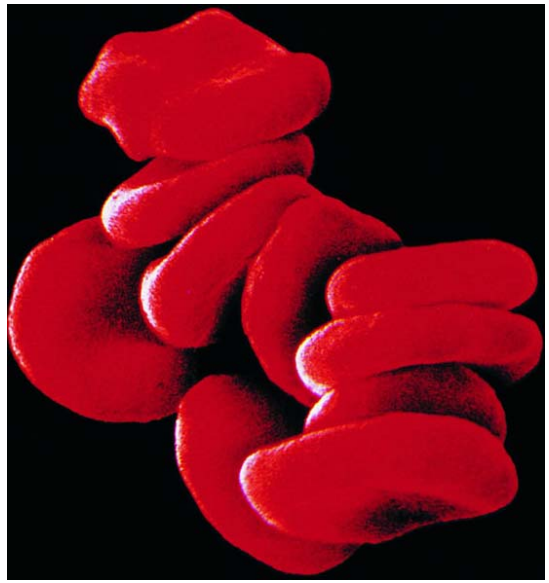
Characters of erythrocyte

- **Plastic deformation (可塑变形性):**
- **Influence factors :**
  - **Ratio of cell surface/volume**
  - **Viscosity of cytoplasm**
  - **Elasticity of cell membrane**

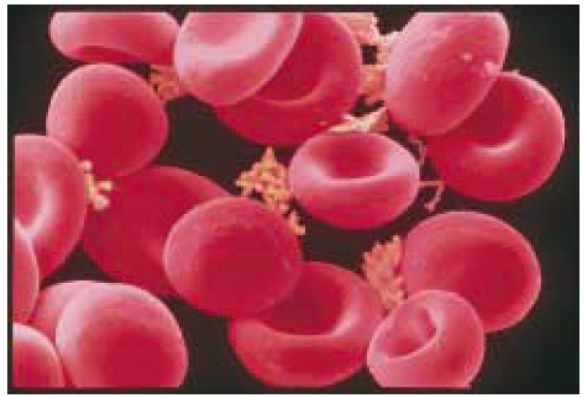


Characters of erythrocyte

- **Male: 0-15 mm/h, female: 0-20 mm/h**
- **Suspension stability (悬浮稳定性):**
- **Erythrocyte sedimentation rate (ESR)（血沉）**
- **ESR ↑ --rouleaux formation**



Characters of erythrocyte



- **Osmotic fragility（渗透脆性）**
  - **30 %——spherical**
  - **45-50 %——hemolysis（ghost cells）**

  - **0.42 % NaCl——begin to hemolysis**
  - **0.35 % NaCl——complete hemolysis**

- **Isosmotic solution（等渗溶液）**
- **Isotonic solution（等张溶液）**
  - **0.9% NaCl**
  - **1.9% Urea**

Function of red blood cell

- **Transporting O_2 and CO_2:**
  - **O_2 : 70 time;**
  - **CO_2 : 18 times**
- **Rely on intactness of cells**
- **Buffer pH**

Regulation of RBC Formation

- **Important Materials**
- **Process**
- **Regulation**

Iron

- **Daily requirement: 20-30 mg**
- **Maximal daily absorption: 1 mg**
- **Recycle:**
  - **Breakdown——release iron**
  - **Binding protein——macrophage**
  - **Transferrin—— rediculocytes**
- **Lack of iron: anemia**
- **Reasons:**
  - **Innutrition**
  - **Chronic bleeding: hemorrhoids, gastrointestinal bleeding**

Vitamin B（维生素B_{12}）

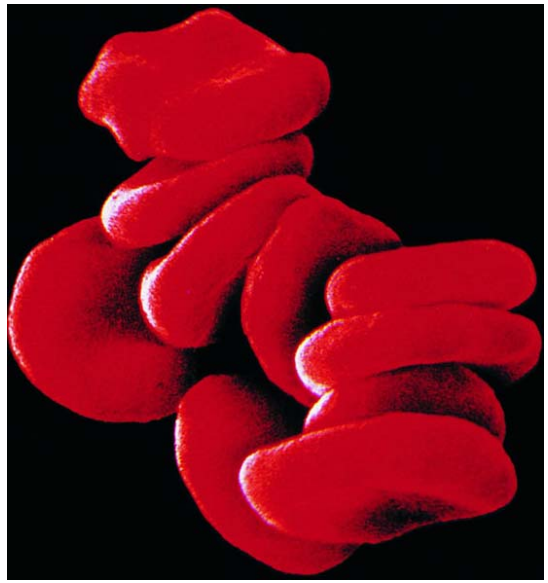
- **Source: meat**
- **Absorption: needs intrinsic factor**
- **Intrinsic factor (内因子):**
  - **Parietal cells of Gastric mucosa**
  - **Absorbed at ileum**
  - **Lack of vitamin B: anemia**
- **Daily requirement: 1-3 ug, Storage: 1000-3000 ug,**
  - **Gastrectomy**

Regulation of red blood cell formation

- **Daily renovation: 0.8%; bleeding: increase several times**
- **Regulation**：
  - **Erythropoietin (EPO)** (促红细胞生成素)
    - **kidney**
    - **Hypoxia——EPO ↑**
    - **Aplastic anemia: lack of EPO receptors**
  - **Others: androgen**

Life-span and breakdown of RBCs

- **Life-span: 120 days**
- **Breakdown**
  - **Passive**
  - **Active: macrophage**



Hemostasis （止血）

- **Functional Hemostasis**
- **Bleeding time: 1 – 3 min**

- **Processes of hemostasis**
  1. **Constriction of vessels**
  2. **Platelet thrombosis**
  3. **Fibrin complex formation – coagulation**

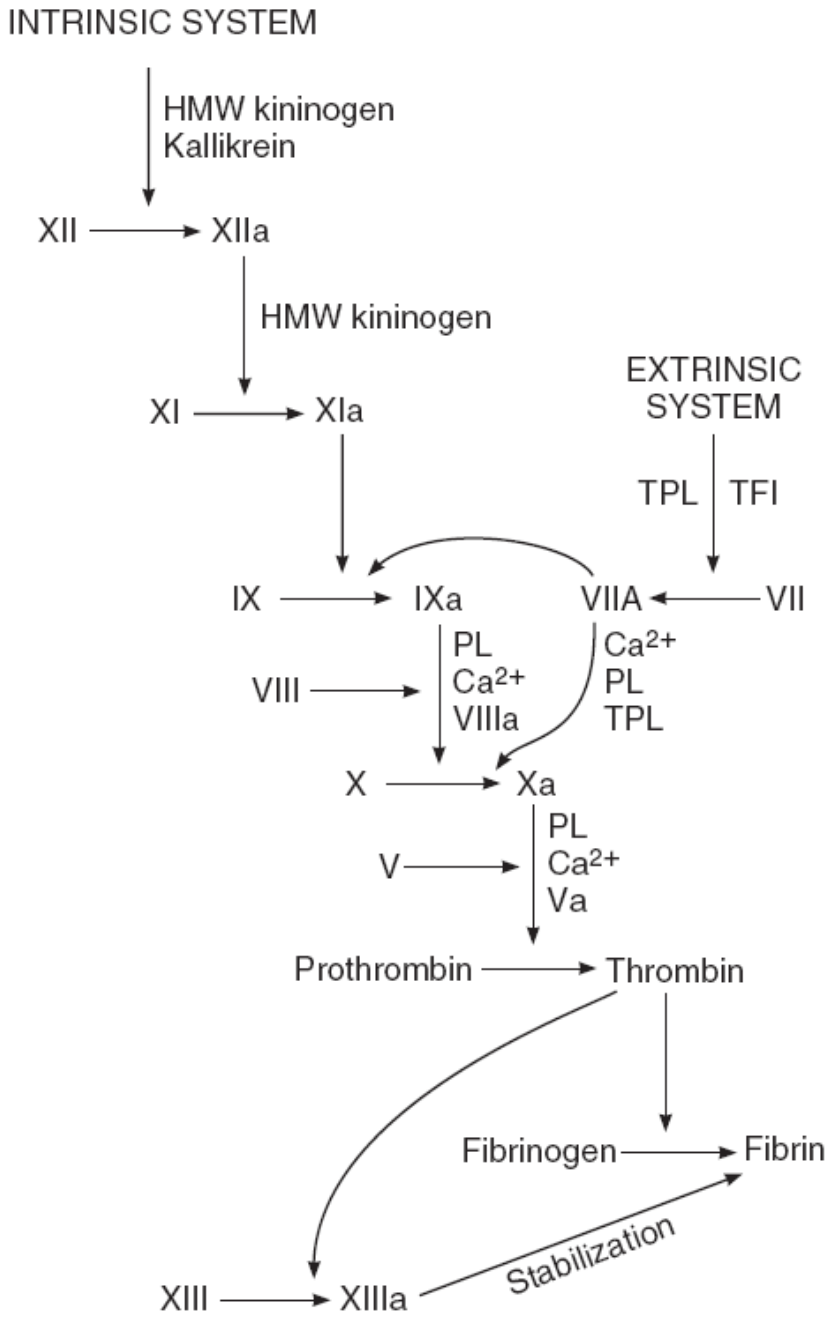
Blood coagulation

- **Blood coagulation (血液凝固): fluidic —— jellied**
- **Coagulation factor (凝血因子): all substances participate in**
  - **Proteins, except ca^{2+} and phospholipids**
  - **Exist in plasma, except tissue factors**
  - **Synthesized in liver, needs Vitamin K**
  - **Inactive zymogen**

- **Serum (血清) and Plasma (血浆)**

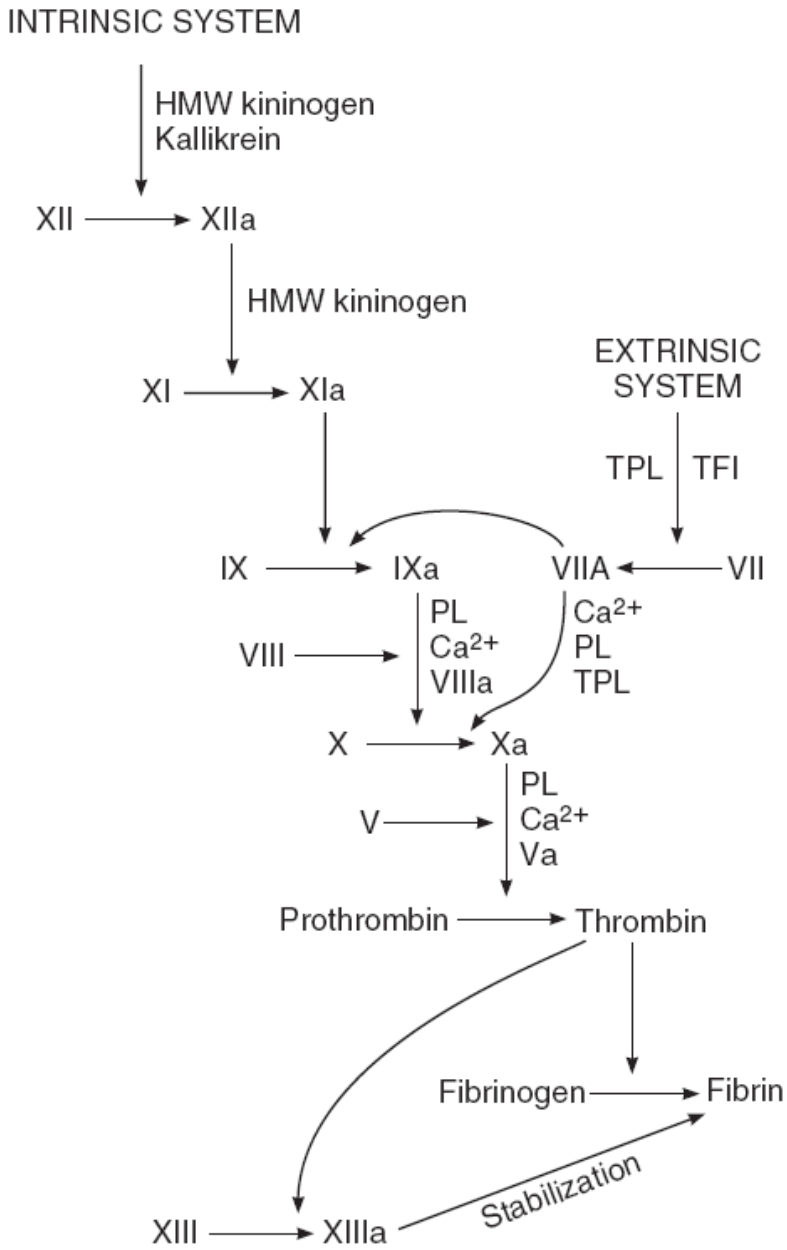
Process of coagulation

- **A series of enzymatic reactions**
- **Character:**
  - **Rapid**
  - **Sensitive**
  - **Amplified**



Coagulation pathway

- **Extrinsic pathway:**
  - **Initiate**
  - **Anchor**
- **Intrinsic pathway :**
  - **Stable**
  - **Maintain**



Anticoagulation system

1. Antithrombin III: serine protease inhibitor

Antithrombin III: arginine——serine

2. Heparin (肝素)

– **Mechanism**：

- **Binding to Antithrombin III, enhance the effect**
- **Stimulating endothelial cells producing other anticoagulation substances**

– **Natural heparin: MW 3000-57000, complex**

– **Low MW heparin: <7000, clinic use (extracorporeal circulation)**

Fibrinolysis

- **Including**:
  - **Plasminogen**
  - **Plasmin**
  - **Plasminogen activitor**
  - **Plasmin inhibitor**
- **Functions:**
  - **Breakdown fibrin, fibrinogen**
  - **Prevent clotting formation**

blood group(血型) and transfusion

- **Blood group——specific antigen on cell membrane**
- **Essence——antigen-antibody reaction**
- **Agglutination (红细胞凝集)**
- **Agglutinogen (凝集原), agglutinin(凝集素)**

Blood types

- **According to the antigens (agglutinogens) on cell surfaces**
- **1901, ABO system**
- **1995, 25 blood type systems were admitted by International Society of Blood Transfusion (ISBT)**
- **Introduce ABO system and Rh system**

ABO blood type system

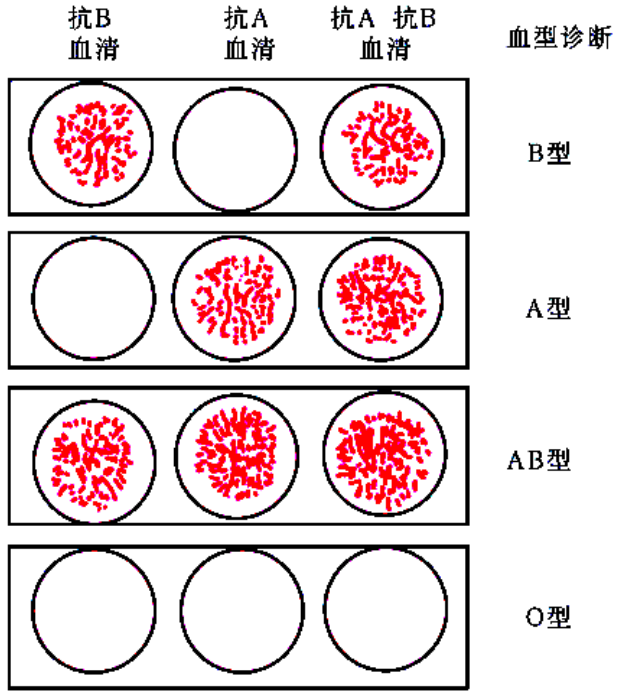
- **Blood types**
- **Inheritance**
  - **Determined by an allele on chromosome 9**
  - **Genotype (基因型)**
    - **A B: dominant**
    - **O: recessive**
  - **Phenotype (表现型)**
- **Population distribution**:
- **Blood type test**

ABO 血型的基因型和表现型

基因型	表现型
OO	O
AA, AO	A
BB, BO	B
AB	AB

A and B are dominant

O is recessive



Rh type system

- **Identification: rhesus monkey**
- **Distribution:**

- **Clinical significance**

ABO——natural antibody, IgM

Rh——no natural antibody, IgG

Blood volume

- **8% of body weight**
- **Blood volume measurement**
- **Stabilization of blood volume —— necessary for life**
- **Hemorrhage**
  - **<10% —— Compensated by regulations**
  - **10-20% —— Clinical symptoms**
  - **>30% —— Life threatening**

Principles of transfusion

- ABO must be matched
- Young woman, Rh types
- Cross-matching test
- Emergency——no preside
- “O type－universal donor?”——inadvisable
- Autotransfusion
- Component blood transfusion
  - Anemia- RBCs
  - Burned- Plasma
  - Thrombocytopenia- platelets