

# Physiology 441

The Blood, Chapter 11

Text: Human Physiology (Sherwood), 6<sup>th</sup> Ed.

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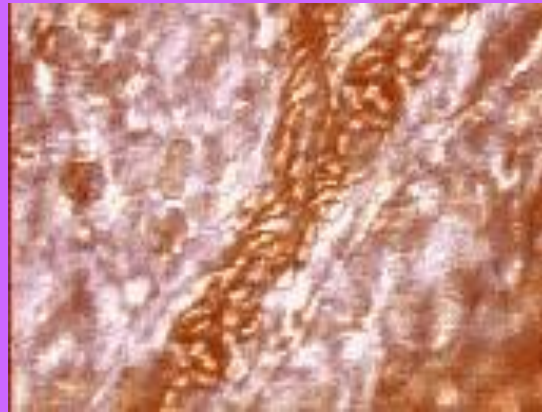
# Components of the Circulatory System

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Heart = Pump



**Blood** = Transport Medium



Blood vessel = Passageways

# Functions of Blood

## Transports:

- **Nutrients**
- **Electrolytes**
- **O<sub>2</sub> & CO<sub>2</sub>**
- **Waste Products**
- **Hormones**

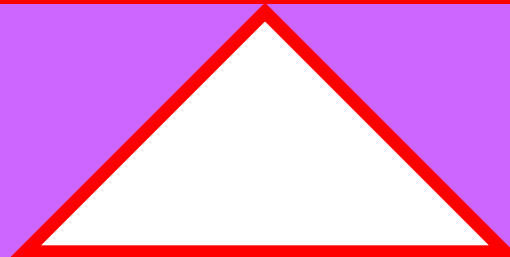
## Defense:

- **Foreign organisms**
- **Injury/infection**
- **Clotting process**
- **Body temperature**

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**Maintains**

**Homeostasis**



# Components of Blood

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**Blood is a mixture of cellular components suspended in plasma:**

- 1. Erythrocytes (RBCs)**
- 2. Leukocytes (WBCs)**
- 3. Thrombocytes (platelets)**

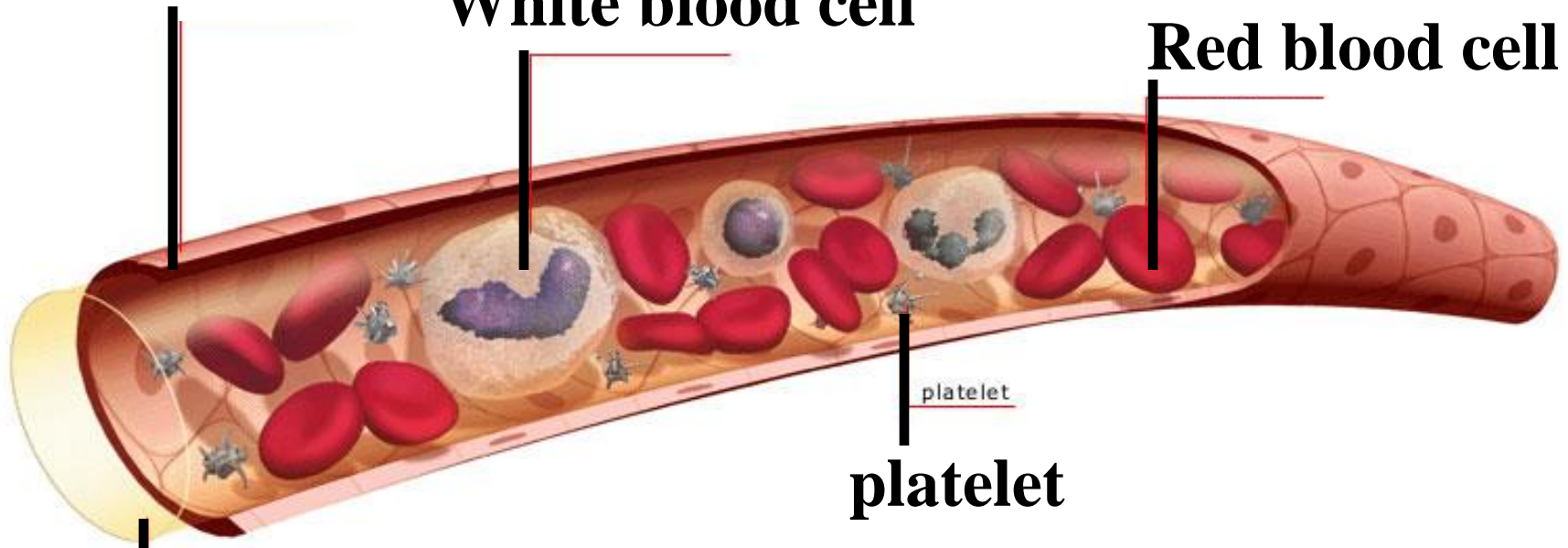
**Total Blood Volume: 8 % of body weight**

**2.75 / 5.5 liters of blood is plasma  
(remaining is the cellular portion)**

**Blood vessel**

**White blood cell**

**Red blood cell**



platelet

**platelet**

plasma

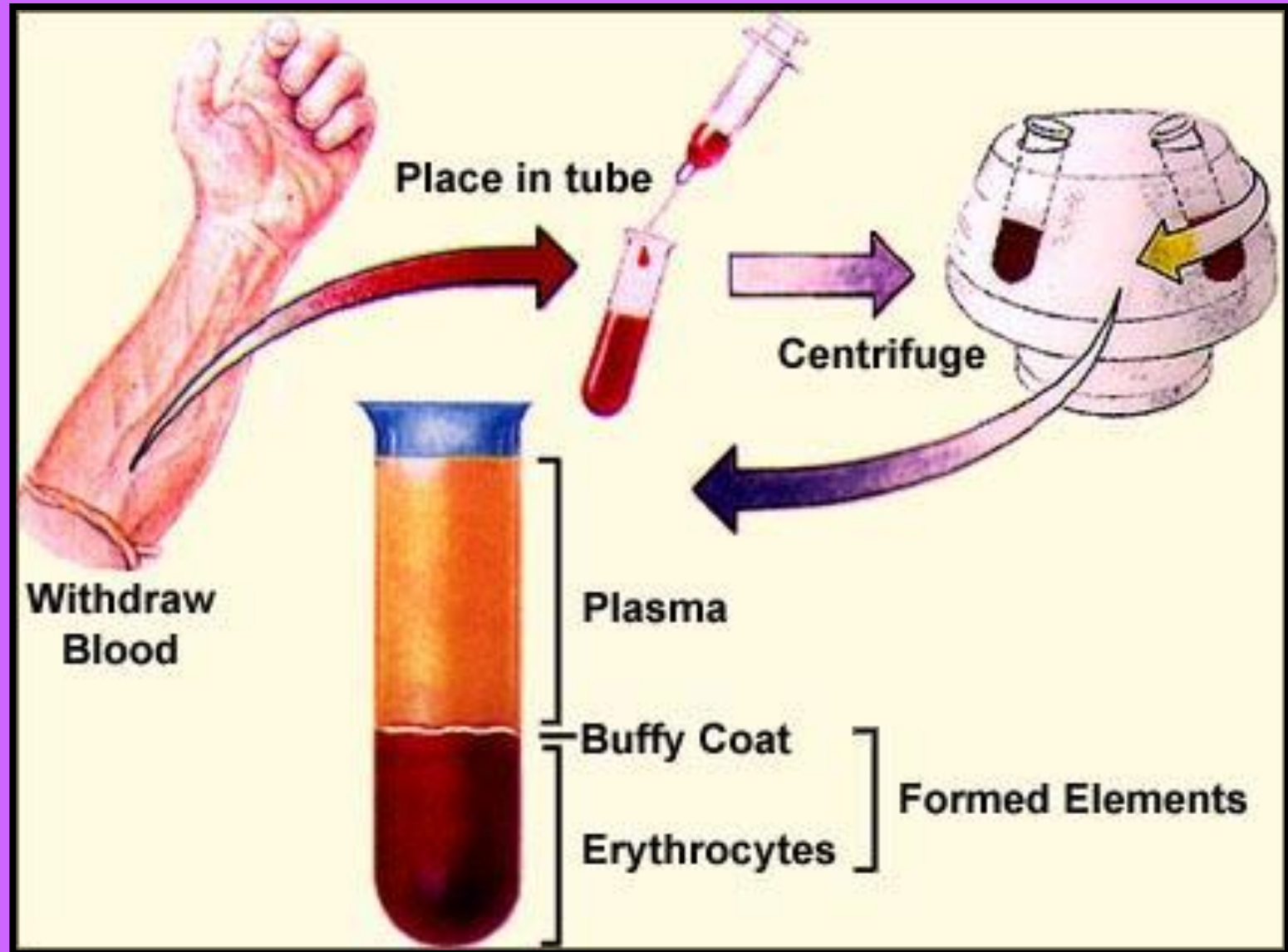
**Plasma**

# Hematocrit “Packed Cells”

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- RBCs heaviest – packed at bottom after centrifugation
- Average 45% for men / 42 % for women
- Important clinical diagnostic marker
- Anemia = Low percentage of erythrocytes
- Hematocrit – mostly RBCs b/c they are the most abundant type of blood cell (99%)
- Plasma = rest of blood not occupied by RBCs (55% of whole blood for males/ 58% for females)

# Centrifuged Blood Sample

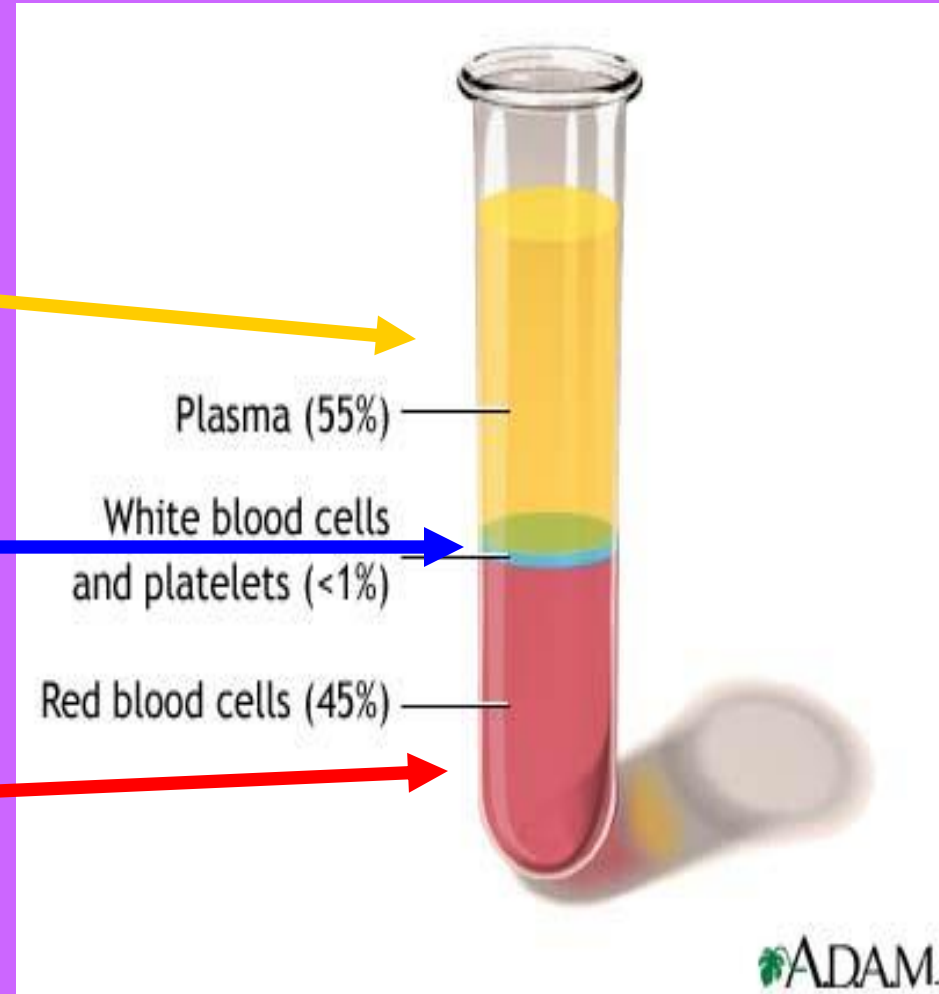


# Separation of Components

**Plasma = Less Dense**

**Platelets / WBC's**

**Hematocrit**  
**“Packed Cells”**  
**More Dense**





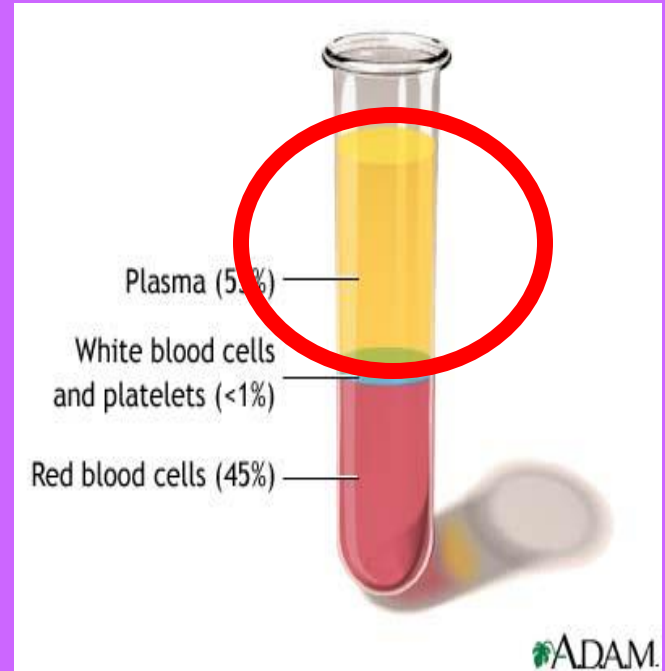
# Components of Plasma

## Blood plasma Consists of:

- Water 90%
- Plasma Proteins 6-8 %
- Electrolytes ( $\text{Na}^+$  &  $\text{Cl}^-$ ) 1%

## Other components:

- Nutrients (e.g. Glucose and amino acids)
- Hormones (e.g. Cortisol, thyroxine)
- Wastes (e.g. Urea)
- Blood gases (e.g.  $\text{CO}_2$ ,  $\text{O}_2$ )



# Functions of Plasma

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## 1. Water:

- \* Transport medium; carries heat

## 2. Electrolytes:

- \* Membrane excitability
- \* Osmotic distribution of fluid b/t ECF & ICF
- \* Buffering of pH changes

## 3. Nutrients, wastes, gases, hormones:

- No function – just being transported

## 4. Plasma Proteins (See Next Slide)

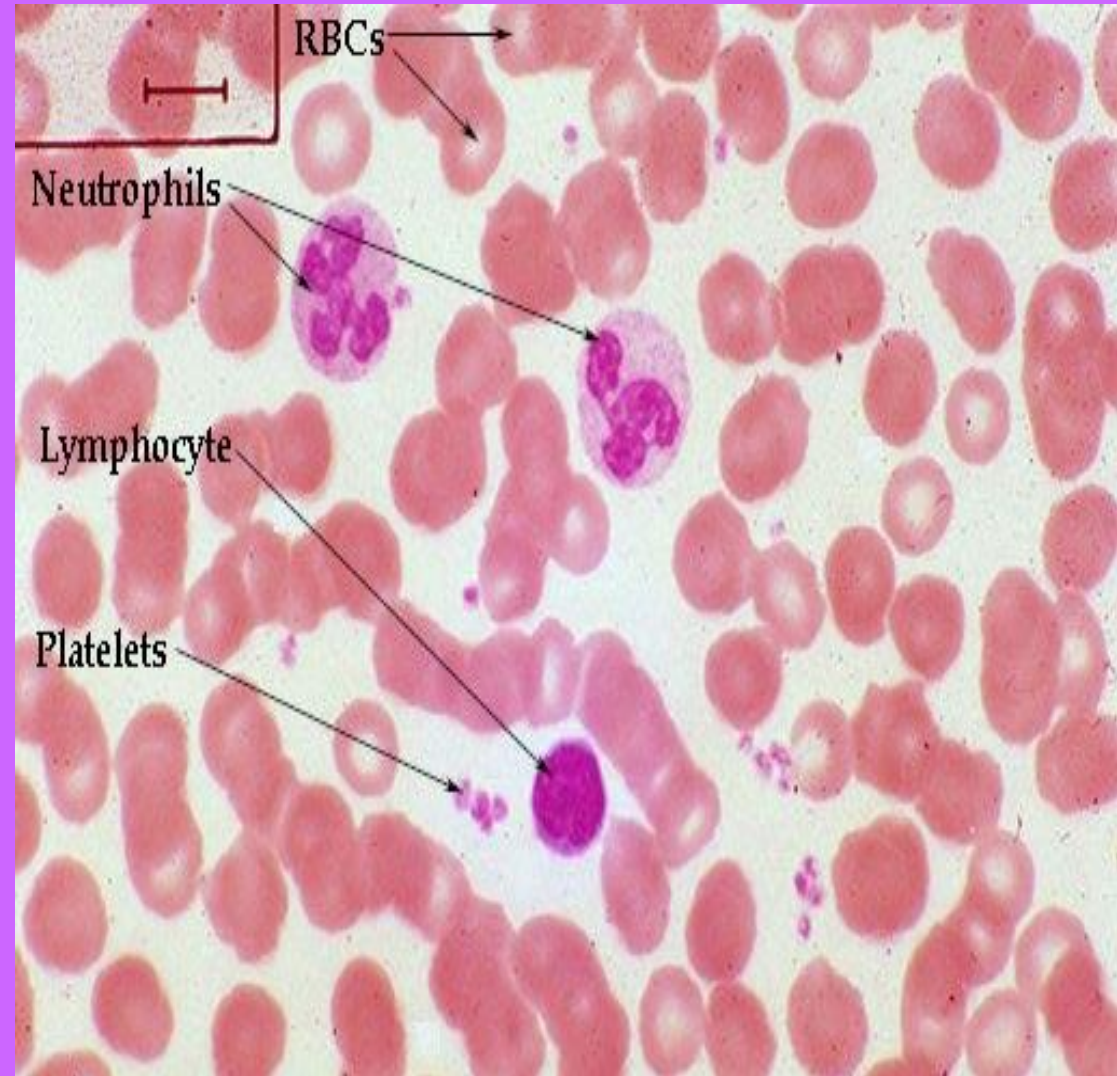
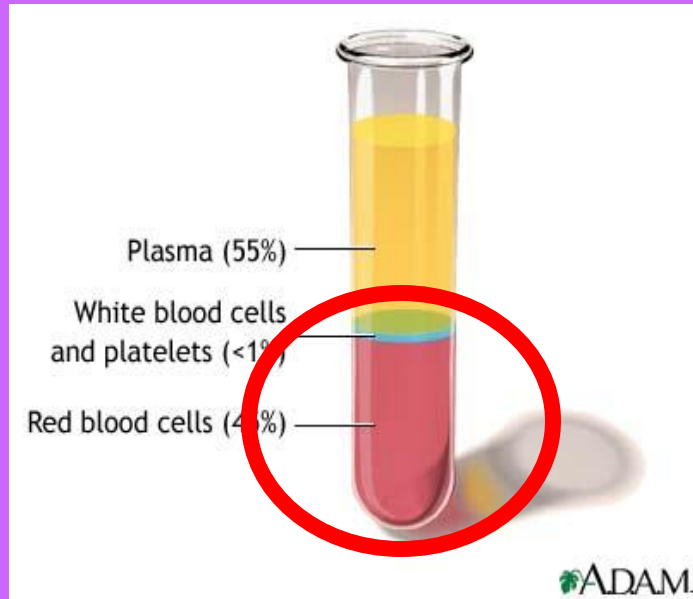
# Plasma Proteins

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Plasma Proteins: (albumins, globulins, fibrinogen)

1. Maintaining colloid osmotic balance (albumins)
2. Buffering pH changes
3. Transport of materials through blood (such as water insoluble hormones)
4. Antibodies (e.g. gamma globulins, immunoglobulins)
5. Clotting factors (e.g. fibrinogen)

# 3 Cellular Elements of Blood



**1. Red Blood Cells**

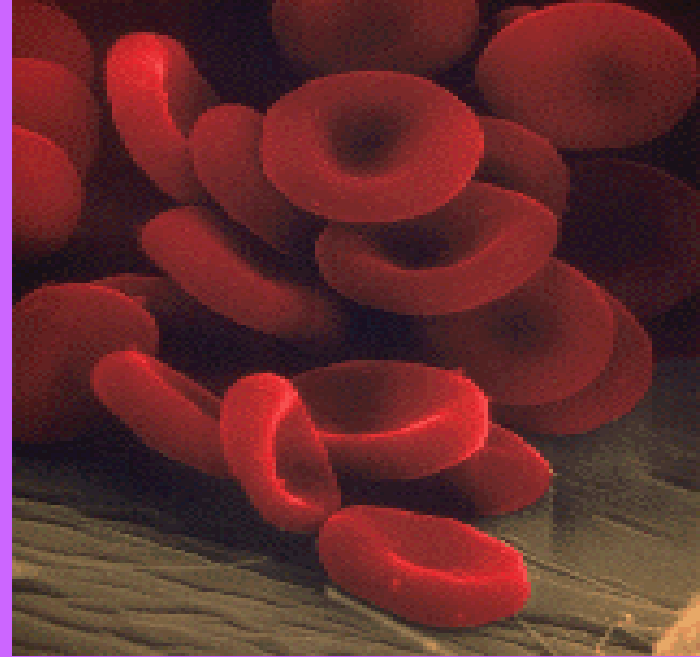
**2. White Blood Cells**

**3. Platelets**

# 1. RBC'S (Erythrocytes)

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- **Shape** - a biconcave disc with large surface area
- Can change **shape**
- **No Nucleus / organelles**
- Contains **hemoglobin**



**Primary Function = Transport oxygen** from the lungs to the cells of the body & assist with CO<sub>2</sub> removal



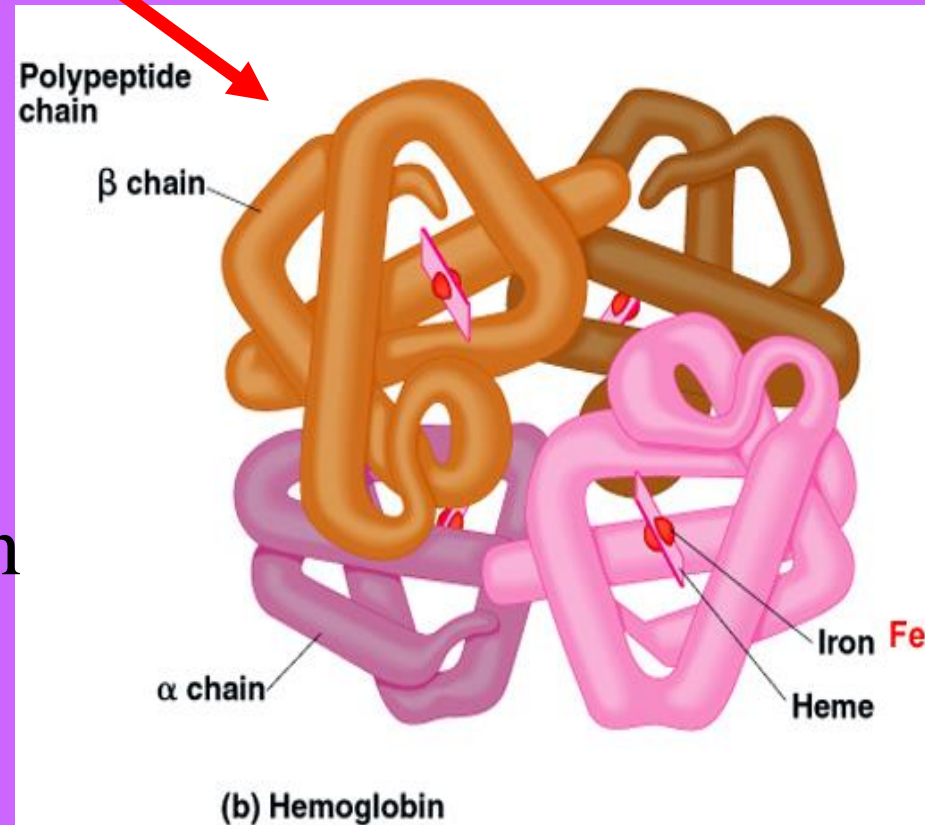
# Mechanism of Transport

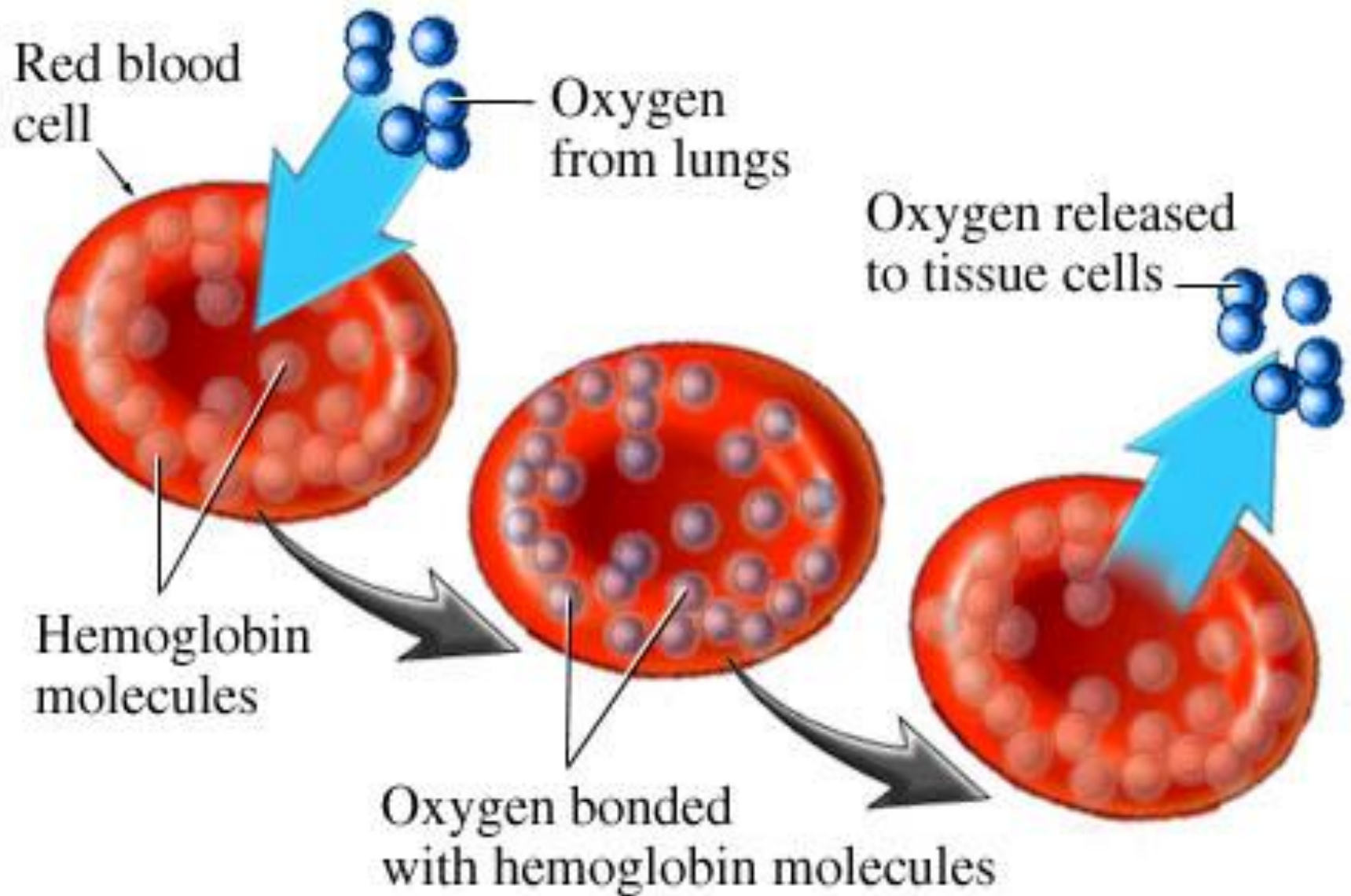


## HEMOGLOBIN

- \* 4 Heme Molecules =
- \* 4 Oxygen Molecules

- \* Oxygenated Hemoglobin  
Bright Red (systemic)
- \* Deoxygenated Hemoglobin  
Blue (venous circulation)





# RBC'S (Erythrocytes) cont...

- Lack intracellular organelles necessary for cellular repair, growth, division
- **Short Life Span** (~120 days)
  - Aged RBC
  - Fragile - prone to rupture
- **Ruptured RBC's** are destroyed in spleen
  - Phagocytic WBC's "clear the debris"





# Formation of New RBC's

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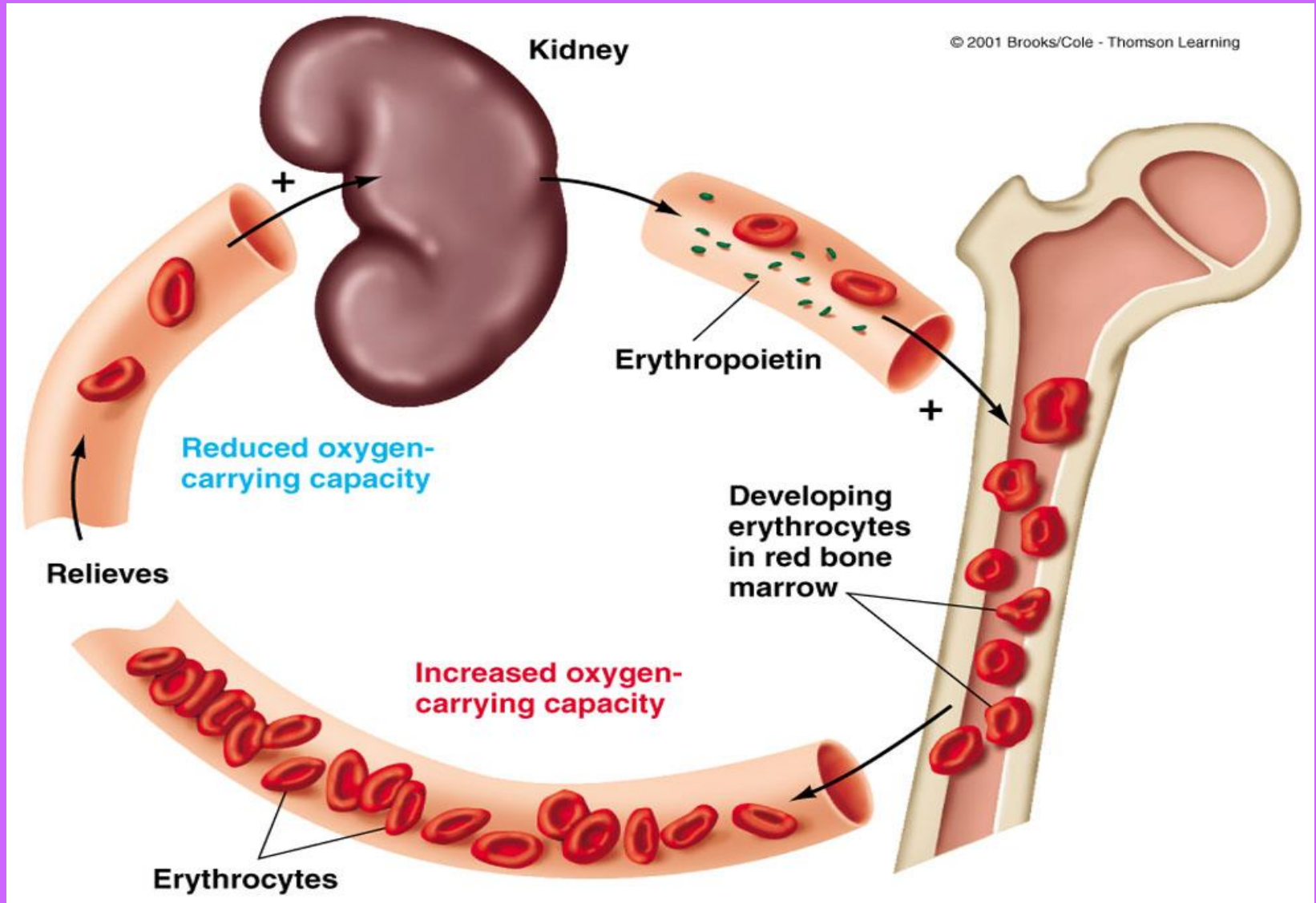
**Ruptured cells** must be replaced by new cells by a process called..... ..**Erythropoiesis**



Secretion of the hormone **erythropoietin**

New RBC's (and platelets & leukocytes) are produced in the **Bone Marrow**

# Figure 11-4

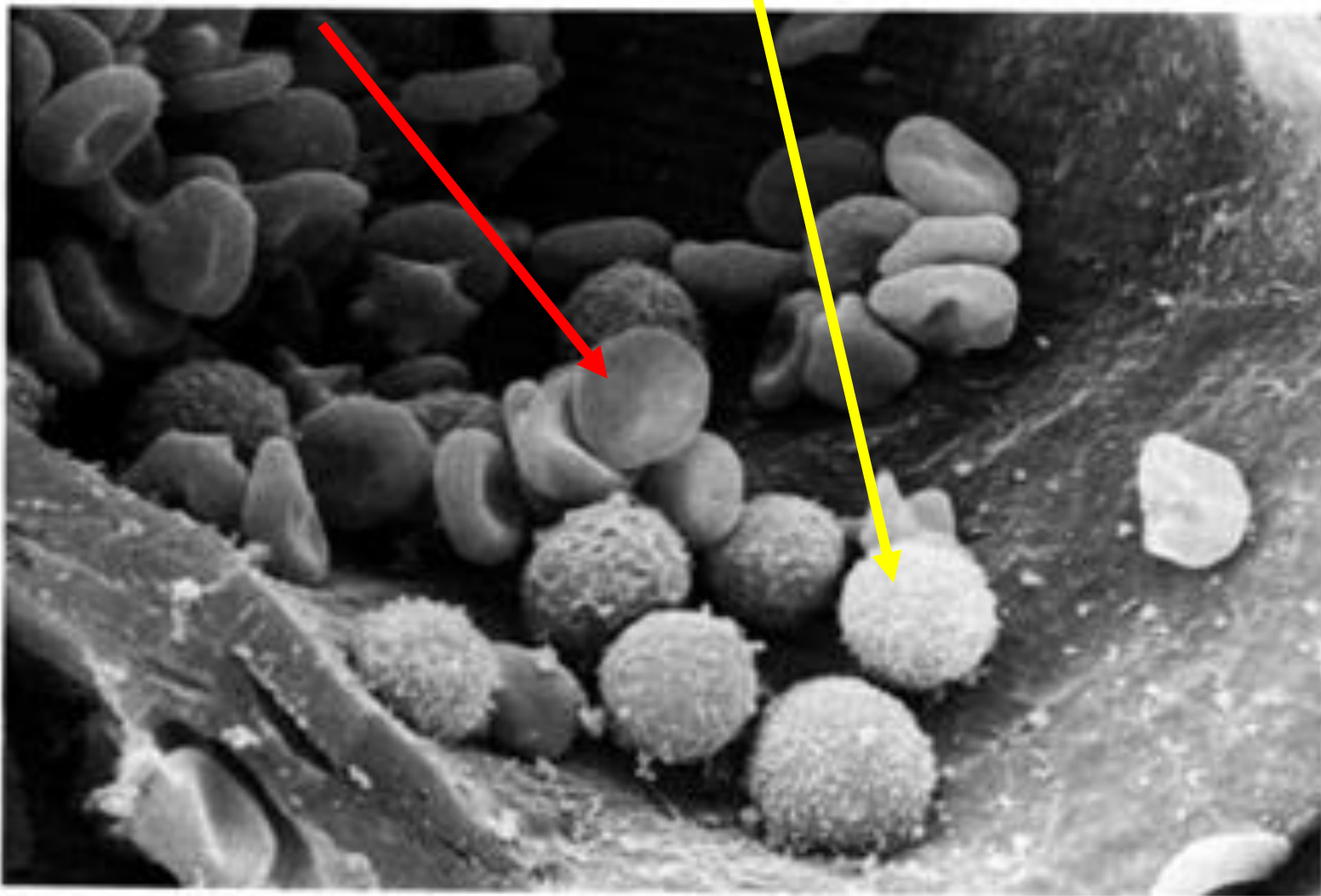


# Too few, Too many

- Anemia – low hematocrit (below-normal oxygen-carrying capacity of the blood)
  - Nutritional, pernicious, aplastic, renal, hemorrhagic, hemolytic
- Polycythemia- abnormally high hematocrit (too many RBCs in circulation)
  - Primary, secondary

**RBC's**

**WBC's**



10 μm

## 2. White Blood Cells (Leukocytes)

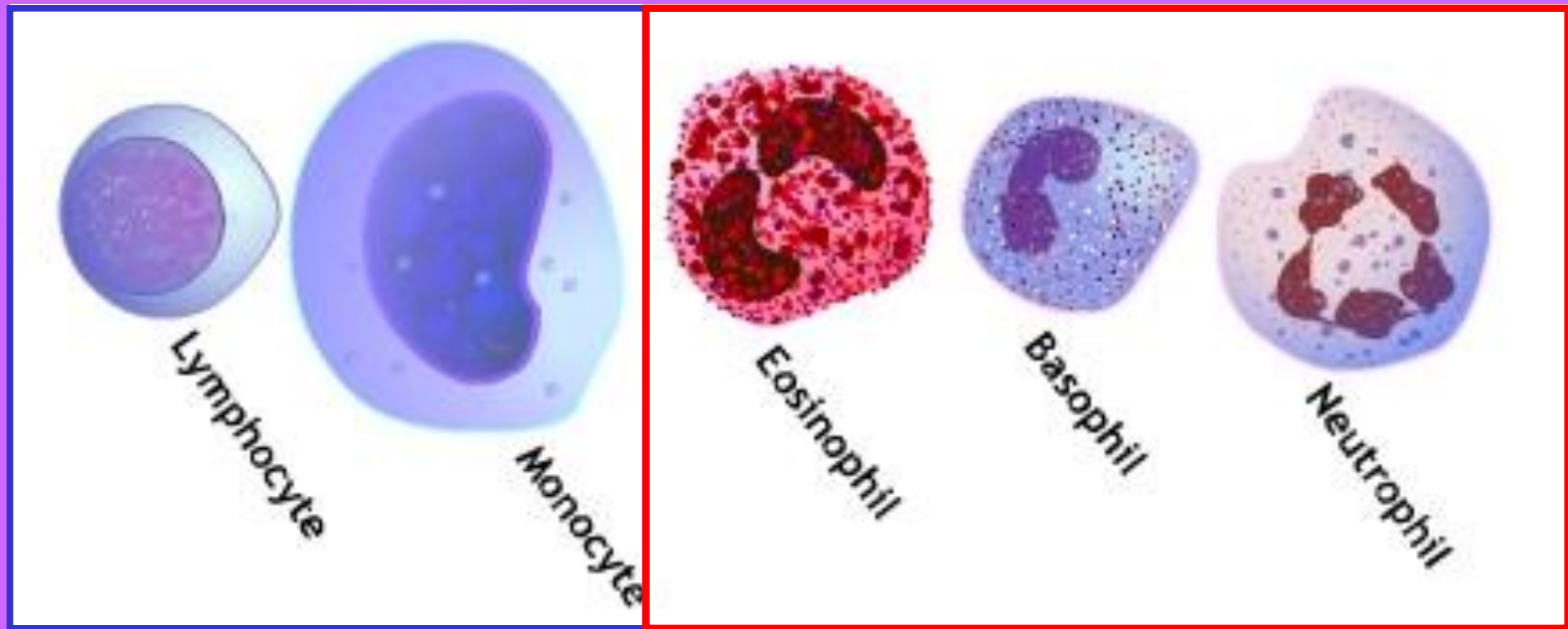
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- Mobile units of body's defense system:
- **“Seek and Destroy” Functions:**
  1. Destroy invading microorganisms
  2. Destroy abnormal cells (ie: cancer )
- **Clean up cellular debris (phagocytosis)**
  3. Assist in injury repair

# 5 - Types of WBC's

## Agranulocytes

## Granulocytes



**Each WBC has a specific function**

# Blood Cell Origin and Production

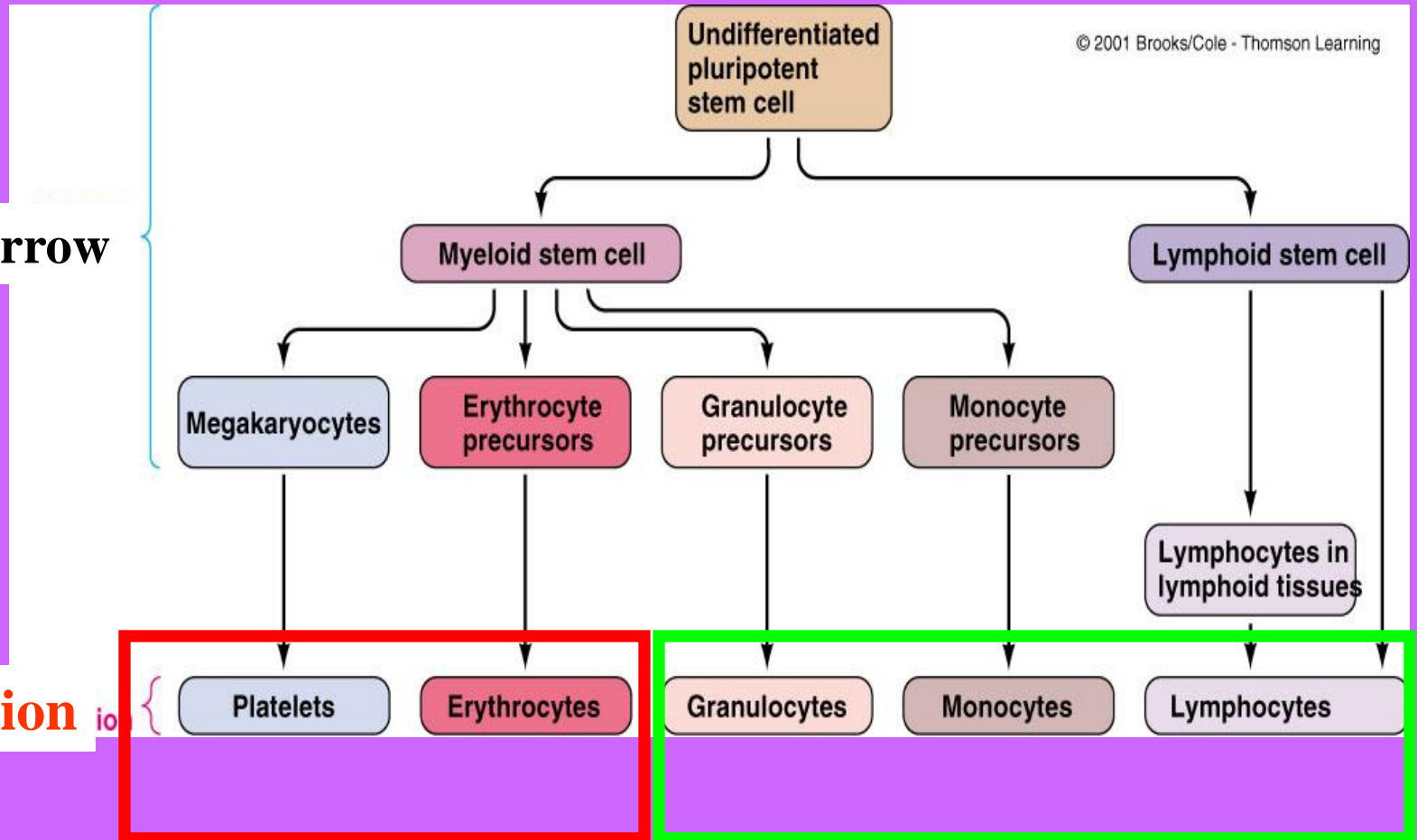


Figure 11-8

# Types of WBC's

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## Polymorphonuclear Granulocytes

**1. Neutrophils**

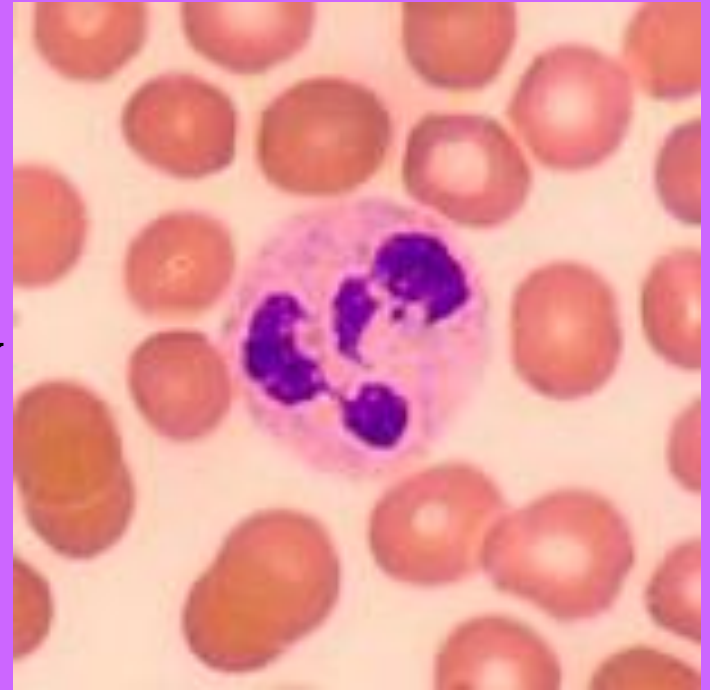
**2. Eosinophils**

**3. Basophils**



# 1. NEUTROPHILS

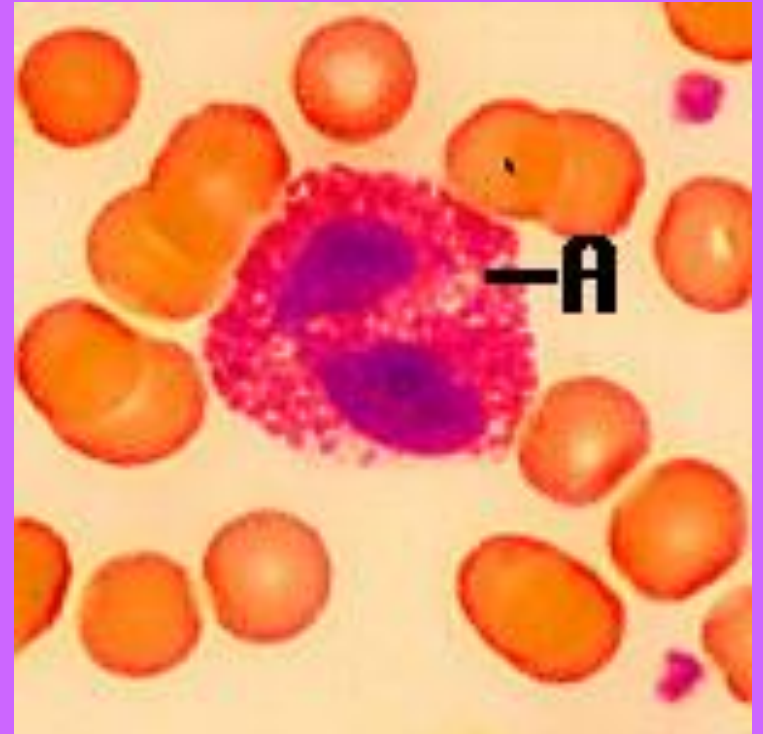
- \* **50-70% of all leukocytes (most abundant of WBC's)**
- \* **Important in inflammatory responses**
- \* **Phagocytes that engulf bacteria and Debris**



## 2. EOSINOPHILS

- \* 1-4% of the WBC's

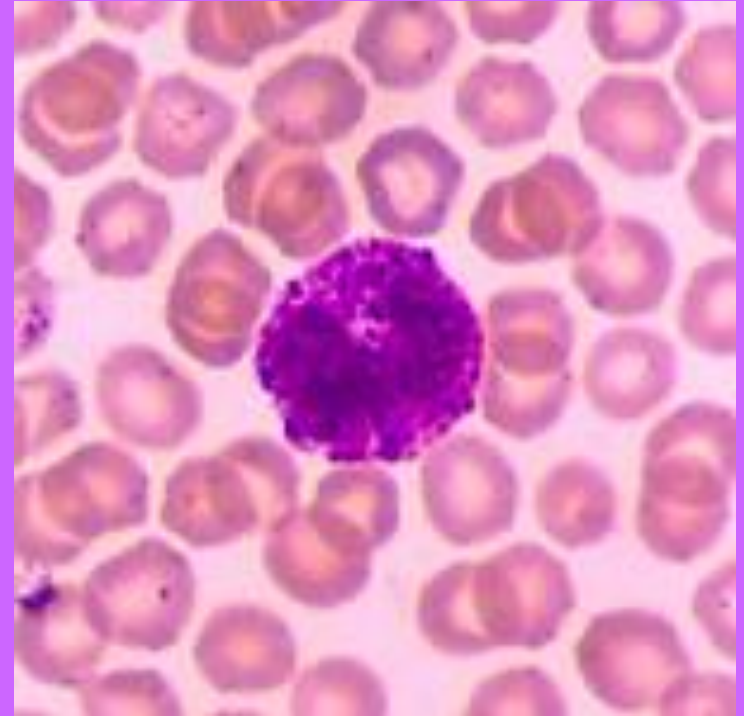
- \* Attack parasitic worms



- \* Important in allergic reactions

# 3. BASOPHILS

- \* **0.5% of the WBC's**
- \* **Release histamine and heparin**
- \* **Important in Allergic Reactions**
- \* **Heparin helps clear fat from blood**



# Types of WBC's

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## Mononuclear Agranulocytes

**4. Monocytes**

**5. Lymphocytes**

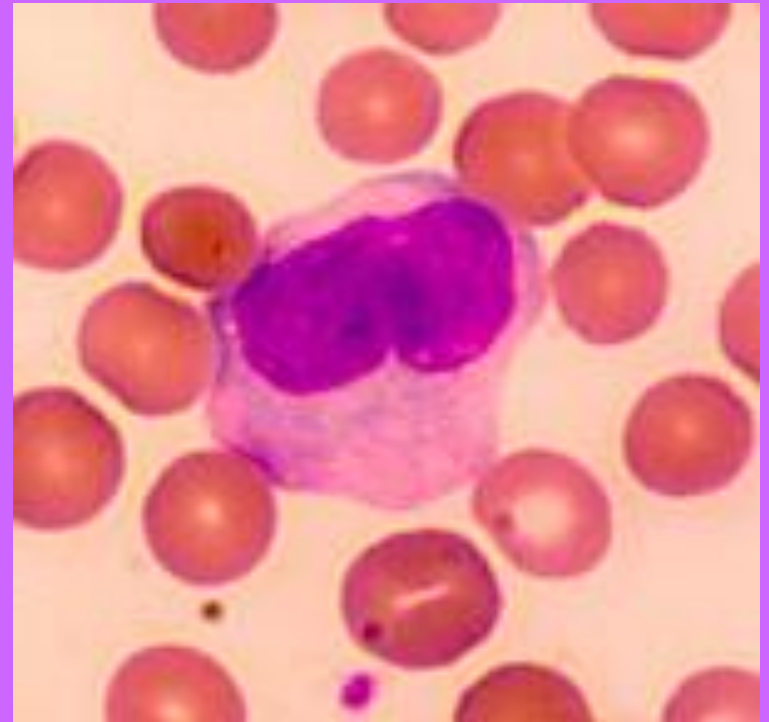
**(B and T cells)**

# 4. MONOCYTES

\* **2-6 % of the WBC's**

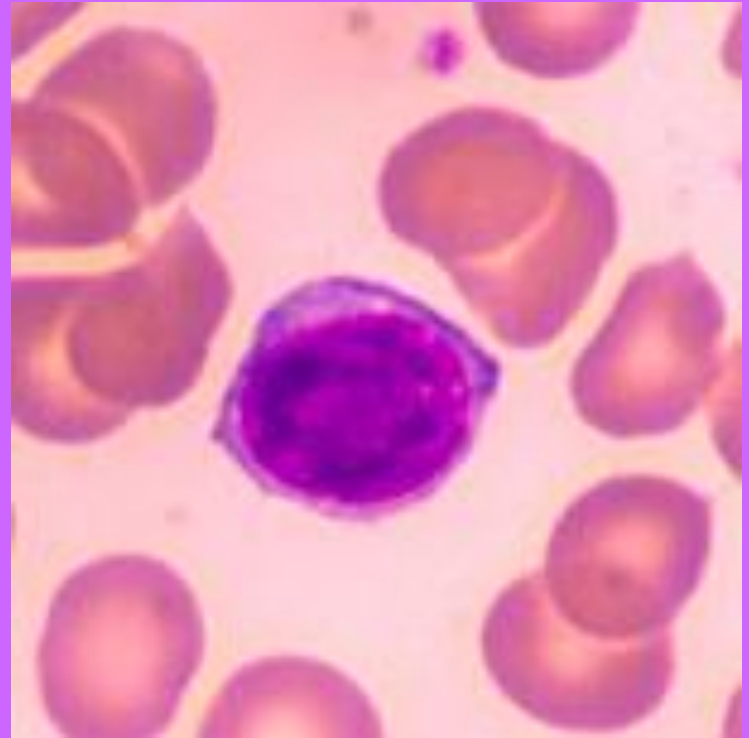
\* **Exit blood (diapedesis)  
to become macrophages**

\* **Phagocytic = defend against  
viruses and bacteria**



# 5. LYMPHOCYTES

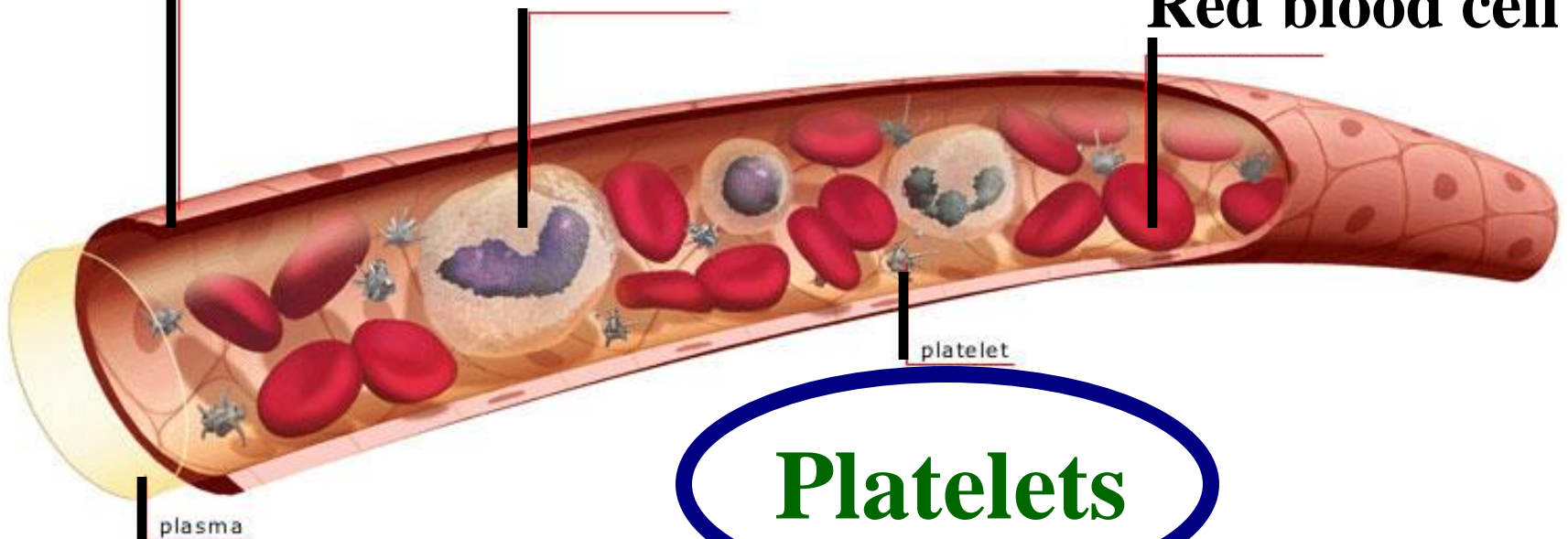
- \* **25-33 % of the WBC's**
- \* **B-lymphocytes:  
Produce Antibodies**
- \* **T-lymphocytes:  
Directly destroy virus-  
invaded cells and cancer  
cells**



**Blood vessel**

**White blood cell**

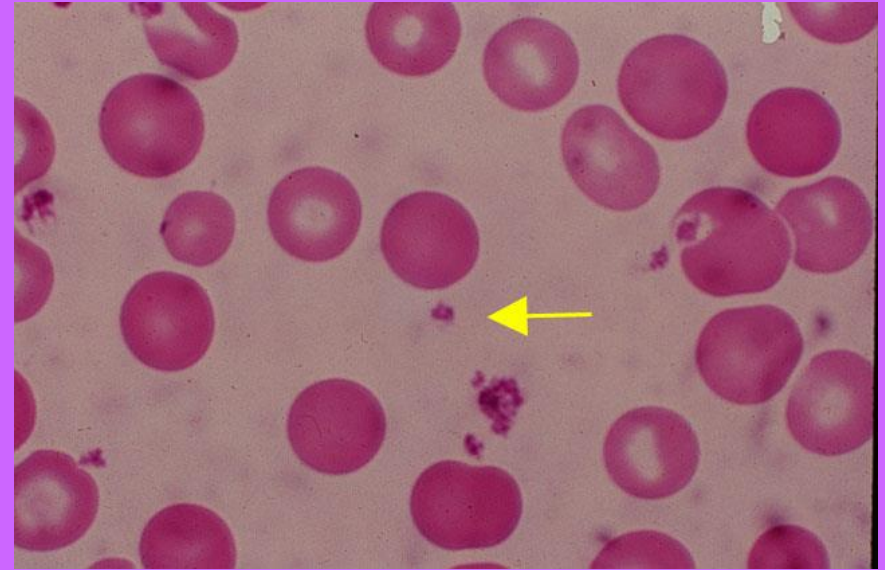
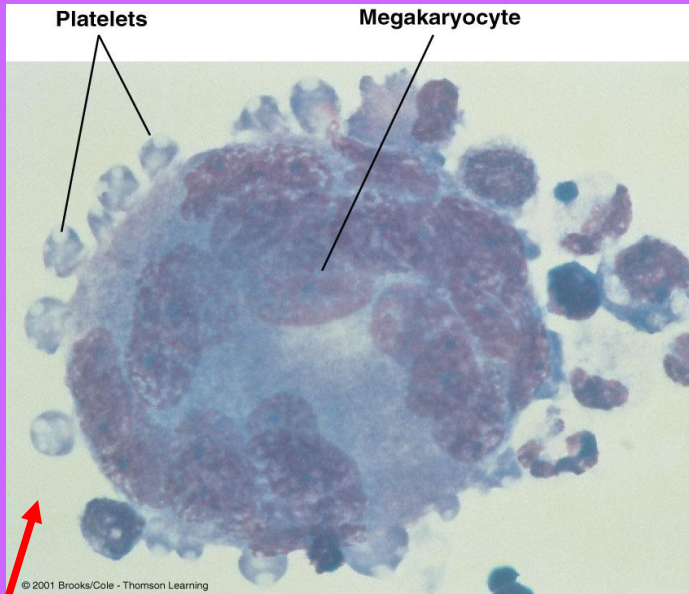
**Red blood cell**



**Plasma**

**Platelets**

# 3. Platelets (Thrombocytes)



- \* Cell fragments bound to megakaryocytes
- \* “Bud Off” and are released into the blood



# Function of Platelets

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- Stop bleeding from a damaged vessel
  - \* **Hemostasis**
- **Three Steps** involved in **Hemostasis**
  1. Vascular Spasm
  2. Formation of a platelet plug
  3. Blood coagulation (clotting)

# Steps in Hemostasis

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**\*DAMAGE TO BLOOD VESSEL** LEADS TO:

## 1. Vascular Spasm:

- **Immediate constriction** of blood vessel
- Vessel walls pressed together – become “sticky”/adherent to each other
- Minimize blood loss

# Steps in Hemostasis

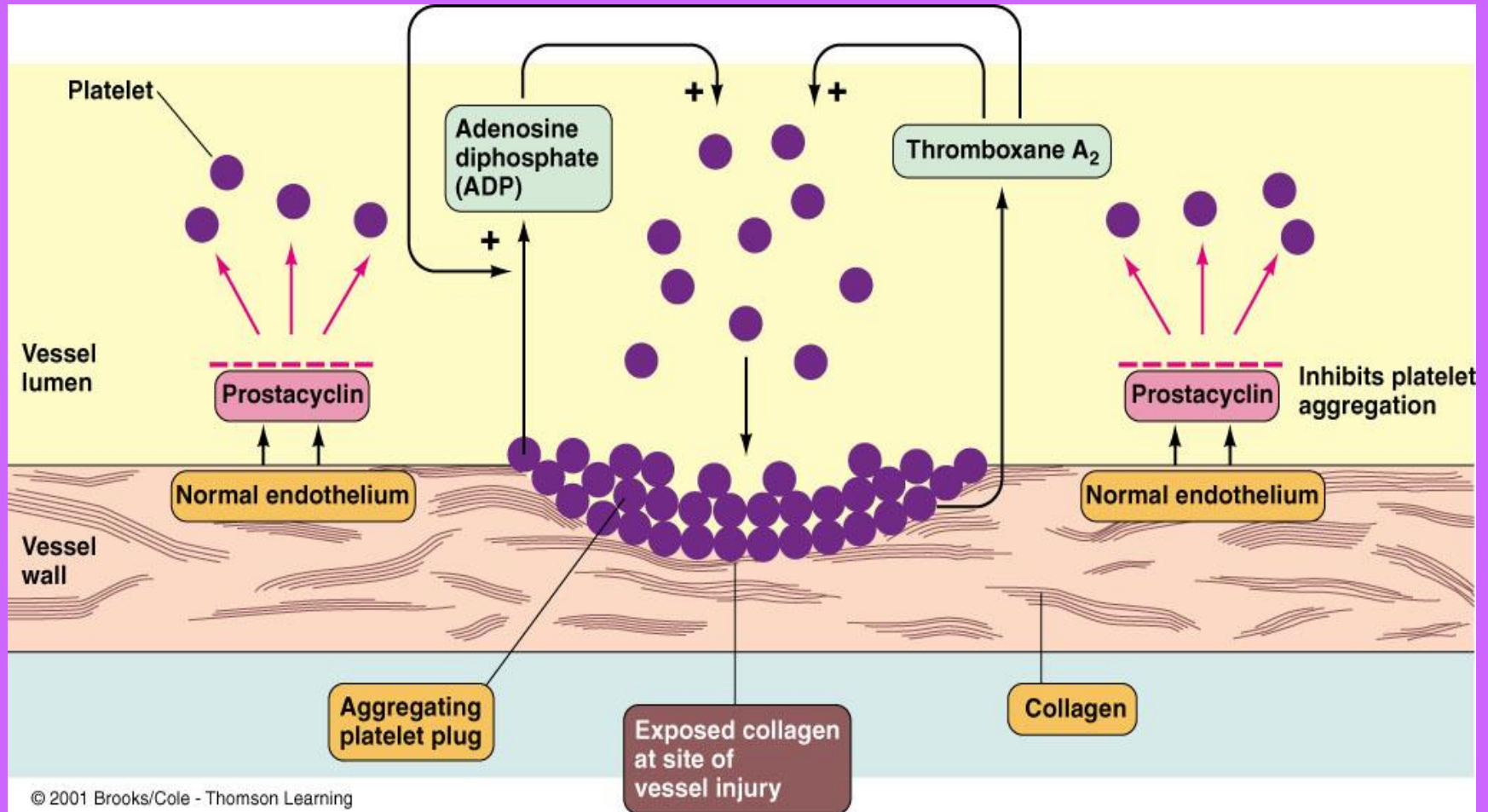
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## 2. Platelet Plug formation: (figure 11-10)

- a. **PLATELETS** attach to exposed collagen
- b. Aggregation of platelets causes release of chemical mediators (**ADP, Thromboxane A<sub>2</sub>**)
- c. **ADP** attracts more platelets
- d. **Thromboxane A<sub>2</sub>** (powerful vasoconstrictor)
  - \* promotes aggregation & more ADP

Leads to formation of **platelet plug** !

# Figure 11-10



**(+) Feedback promotes formation of platelet Plug !**

# Final Step in Hemostasis

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## 3. Blood Coagulation (clot formation):

### “Clotting Cascade”

- a. Transformation of blood from **liquid to solid**
- b. Clot reinforces the plug
- c. Multiple cascade steps in clot formation
- d. **Fibrinogen (plasma protein)**  $\xrightarrow{\text{Thrombin}}$  **Fibrin**

# Thrombin in Hemostasis

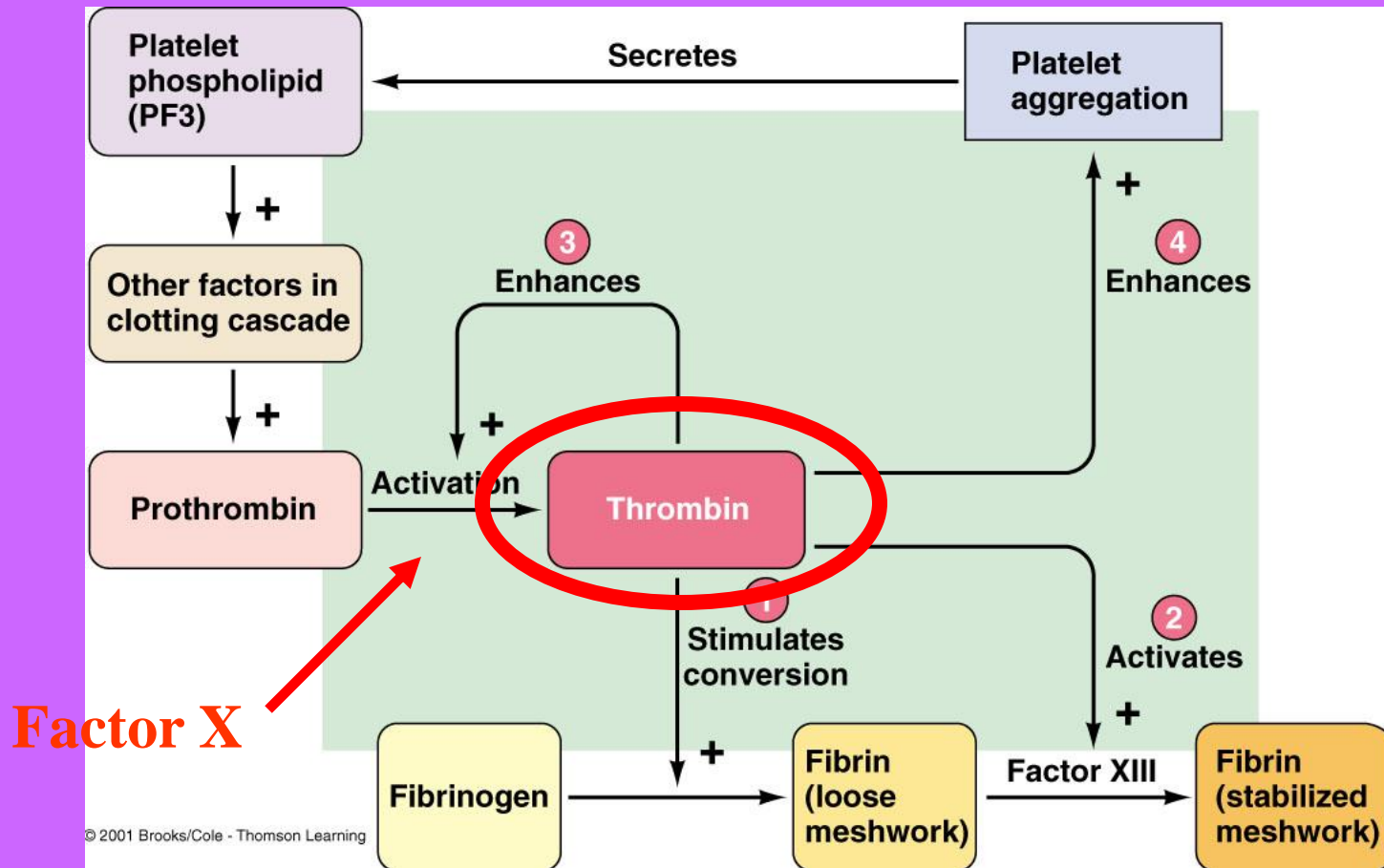


Figure 11-11

# Clotting Cascade

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- Participation of 12 different clotting factors (plasma glycoproteins)
- Factors are designated by a roman numeral
- Cascade of proteolytic reactions
- **Intrinsic pathway** / **Extrinsic pathway**
- **Common Pathway** leading to the formation of a **fibrin clot** !

### INTRINSIC PATHWAY

Damaged surface

Kininogen  
Kallikrein

XII

XII<sub>a</sub>

XI

XI<sub>a</sub>

IX

IX<sub>a</sub>

VIII<sub>a</sub>

X

**Hageman factor (XII)**

### EXTRINSIC PATHWAY

Trauma

VII<sub>a</sub>

VII

Tissue factor

Trauma

**X**

X



inactive



active

### FINAL COMMON PATHWAY

Prothrombin (II)

Thrombin (II<sub>a</sub>)

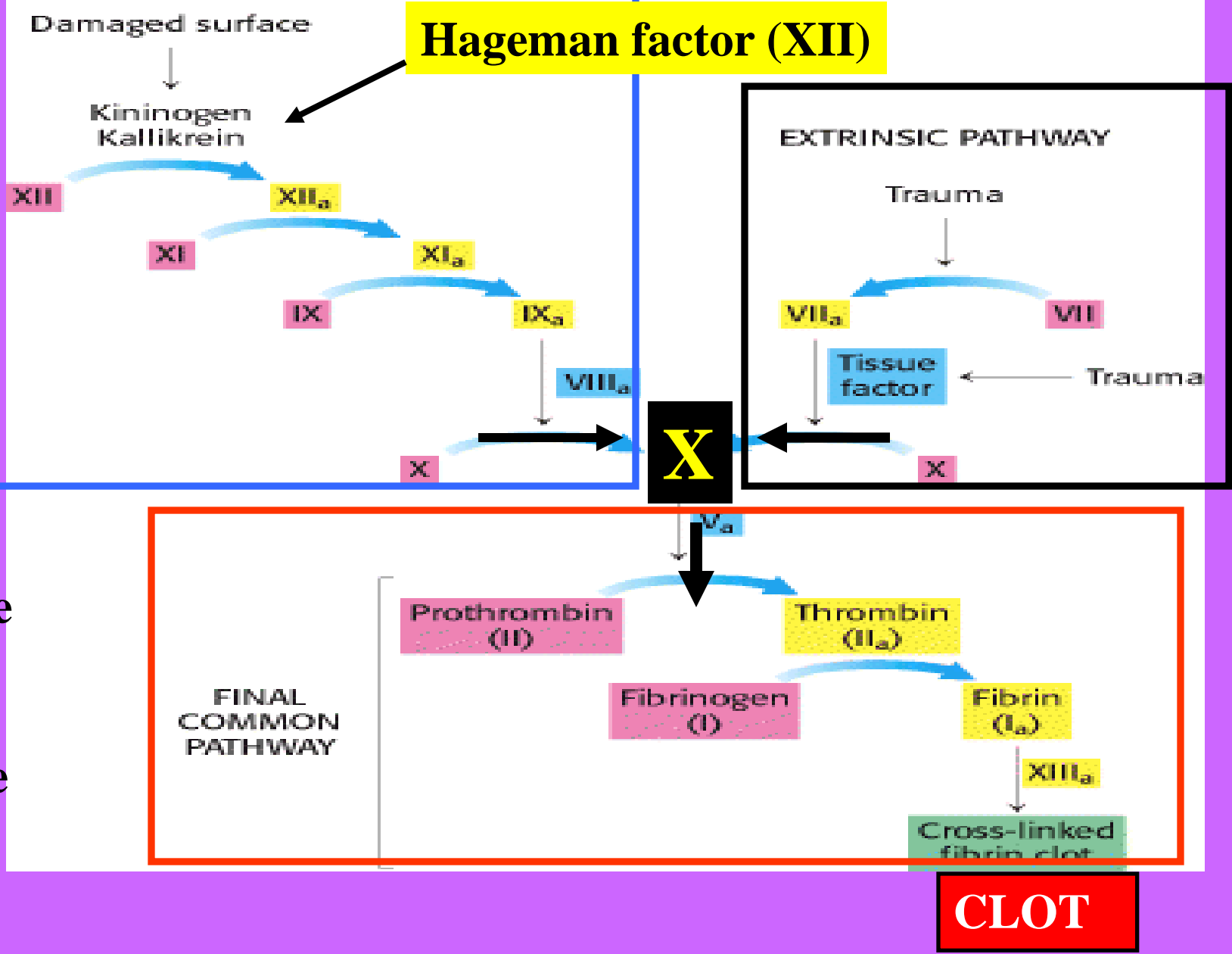
Fibrinogen (I)

Fibrin (I<sub>a</sub>)

XIII<sub>a</sub>

Cross-linked fibrin clot

**CLOT**





# Clotting Cascade

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- **Intrinsic Pathway:**
  - Stops bleeding within (**internal**) a cut vessel
  - Foreign Substance (ie: in contact with test tube)
  - Factor XII (Hageman Factor)
- **Extrinsic pathway:**
  - Clots blood that has escaped into tissues
  - Requires tissue factors **external** to blood
  - Factor III (Tissue Thromboplastin)

# Clotting Cascade

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- **Fibrin :**

- Threadlike molecule-forms the meshwork of the clot
- Entraps cellular elements of the blood forms CLOT
- Contraction of platelets pulls the damaged vessel close together:
  - Fluid squeezes out as the clot contracts (Serum)

# Clot dissolution

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- Clot is slowly dissolved by the “fibrin splitting” enzyme called **Plasmin**
- **Plasminogen** is the inactive pre-cursor that is activated by **Factor XII (Hageman Factor)** (simultaneous to clot formation)
- Plasmin gets trapped in clot and slowly dissolves it by breaking down the fibrin meshwork

**Figure 11-15**

# Clot formation:

## Too much or too little of a good thing...

- Too much:
  - Inappropriate clot formation is a thrombus (free-floating clots are emboli)
  - An enlarging thrombus narrows and can occlude vessels
- Too little:
  - Hemophilia- too little clotting- can lead to life-threatening hemorrhage (caused from lack of one of the clotting factors)
  - Thrombocyte deficiency (low platelets) can also lead to diffuse hemorrhages