Cardiovascular System

- **The Blood Vessels**
- The cardiovascular system has three types of blood vessels:
- the **arteries** (and arterioles), which carry blood away from the heart to the capillaries; the **capillaries,**
- which permit exchange of material with the tissues; and
- the **veins** (and venules), which return blood from the capillaries to the heart.

The cardiovascular system has three types of blood vessels:

- The arteries and arterioles, which carry blood away from the heart to the capillaries;
- the capillaries, which permit exchange of material with the tissues;
- The veins and venules , which return blood from the capillaries to the heart:.

The arterial wall has three layers (Fig. 7.2*a*).

- 1- The inner layer is a simple squamous epithelium called endothelium with a connective tissue basement membrane
- that contains elastic fibers.
- 2- The middle layer is the thickest layer and consists of smooth muscle that can contract to regulate blood flow and blood pressure.
- 3-The outer layer is fibrous connective tissue near the middle layer, but it becomes loose connective tissue at its periphery. Some

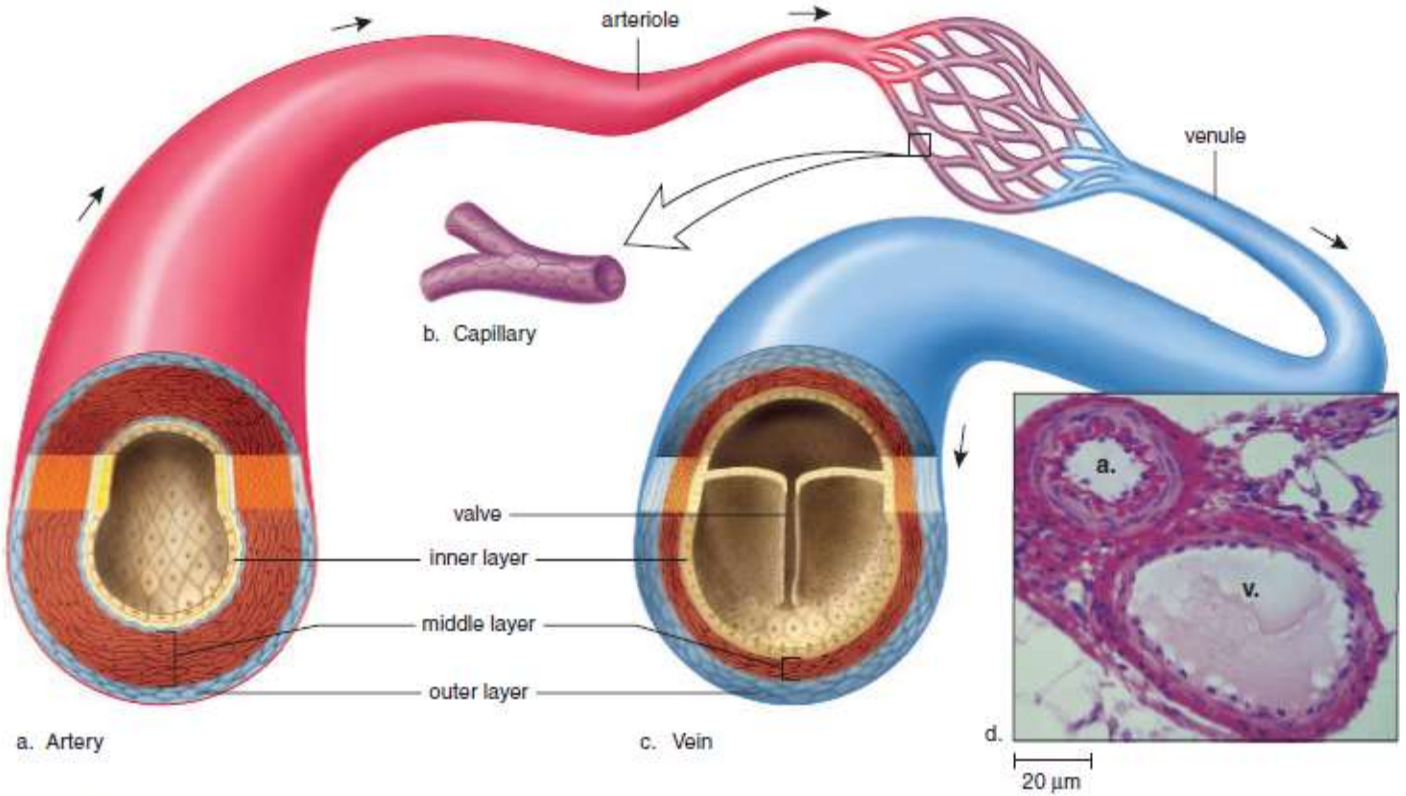


Figure 7.2 **Blood vessels.**
The walls of arteries and veins have three layers. The inner layer is composed largely of endothelium with a basement membrane that has elastic fibers; the middle layer is smooth muscle tissue; the outer layer is connective tissue (largely collagen fibers). **a.** Arteries have a thicker wall than veins because they have a larger middle layer than veins. **b.** Capillary walls are one-cell-thick endothelium. **c.** Veins are larger in diameter than arteries, so that collectively veins have a larger holding capacity than arteries. **d.** Light micrograph of an artery and a vein.

- **The Veins Venules:- are small veins that drain blood from the capillaries and then join to form a vein.**
- **The walls of venules and the veins have**
- **the same three layers as arteries,**
- **1-but there is less smooth muscle**
- **and connective tissue.**
- **2-Veins often have valves, which allow**
- **blood to flow only toward the heart when open and prevent the backward flow of blood when closed.**
- **3- The walls of veins are thinner, they can expand to a greater extent .**
- **At any one time, about 70% of the blood is in the veins. In this way, the veins act as a blood reservoir.**

a. Artery

The Heart

The **heart :** is a cone-shaped, muscular organ about the size of a fist.

It is located between the lungs directly behind the sternum (breastbone)

and is tilted so that the apex (the pointed end) is oriented to the left.

The major portion of the heart, called the myocardium,

consists largely of cardiac muscle tissue.

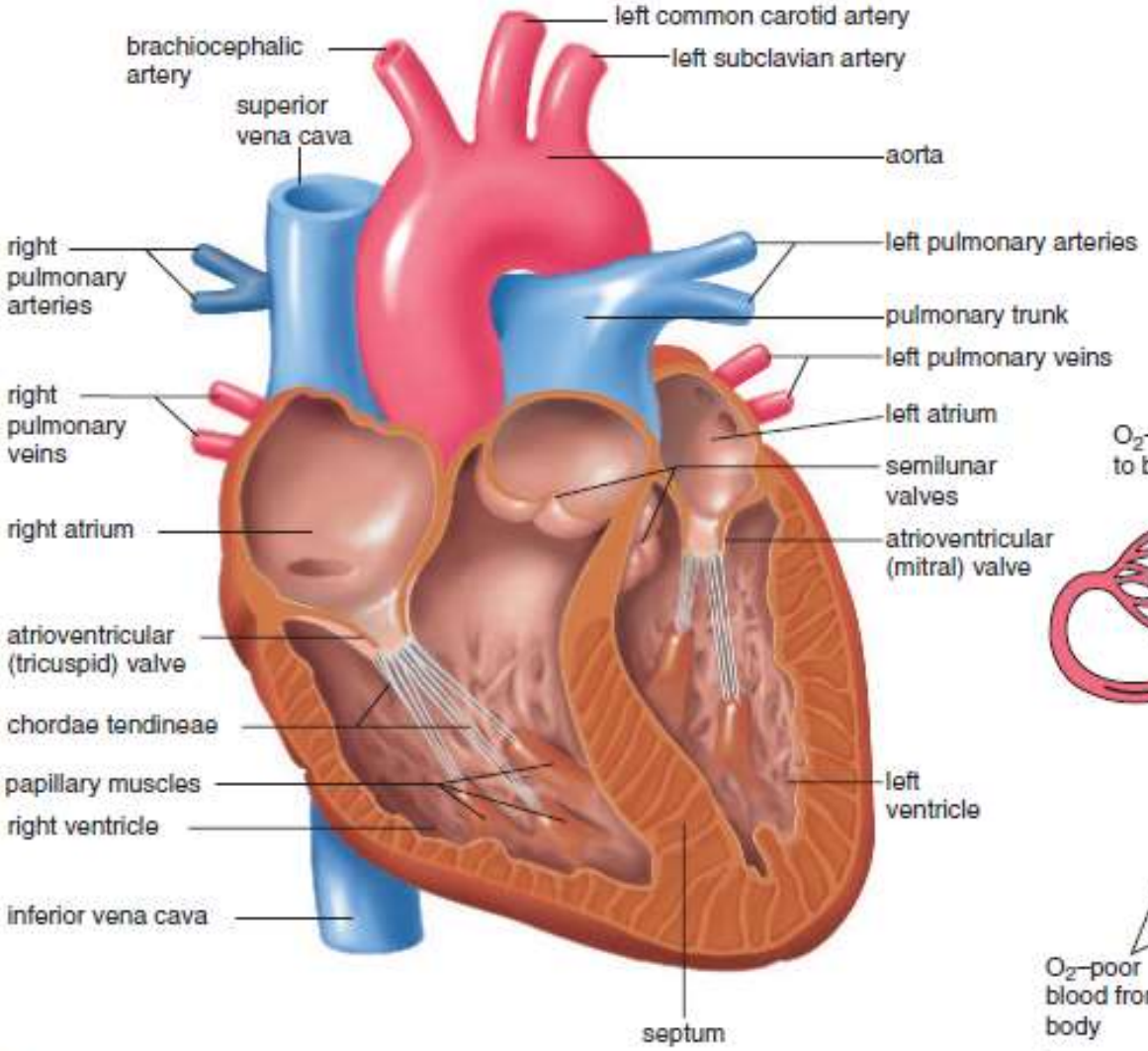
The muscle fibers of the myocardium are branched and tightly joined to one another.

The heart lies within the pericardium, a thick, membranous sac that secretes a small quantity of lubricating liquid.

The inner surface of the heart is lined with endocardium, which consists of connective tissue and endothelial tissue.

- The human heart **is a double pump;**
- **The right side pumps blood to the lungs,**
- **and the left side pumps blood to the rest of the body.**
- • **The heartbeat rate is under intrinsic and**
- **extrinsic control.**

- **The heart has four chambers.**
- **The two upper, thin walled atria (sing., atrium) have wrinkled protruding appendages called auricles.**
- **The two lower chambers are the thick-walled ventricles, which pump the blood Internally,**
- **a wall called the septum separates the heart into a right side and a left side (Fig. 7.5*a*).**



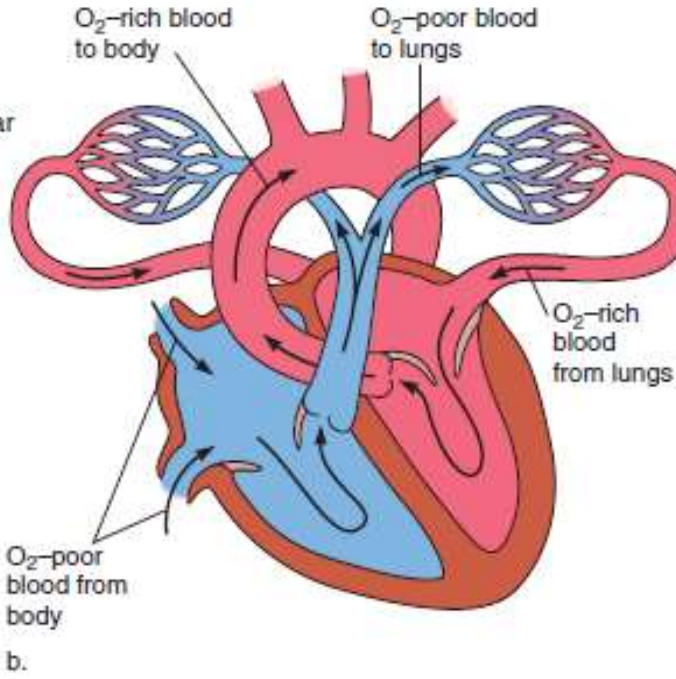


Figure 7.5 **Internal view of the heart.**

a. The heart has four valves. The atrioventricular valves allow blood to pass from the atria to the ventricles, and the semilunar valves allow bloo to pass out of the heart. **b.** This diagrammatic representation of the heart allows you to trace the path of the blood through the heart.

- **The heart has four valves, which direct the flow of blood and prevent its backward movement.**
- **1. The two valves that lie between the atrium and the ventricles**
- **are called the atrioventricular valves.**
- **a-The atrioventricular valve on the right side is called the tricuspid valve because it has three flaps, or cusps.**
- **b-The atrioventricular valve on the left side is called the bicuspid (or mitral) valve because it has two flaps.**
- **2-The remaining two valves are the semilunar valves, whose flaps resemble half-moons, between the ventricles and their attached vessels.**
- **a-The pulmonary semilunar valve lies between the right ventricle and the pulmonarytrunk.**

b-The aortic semilunar valve lies between the left ventricle and the aorta.

Passage of Blood Through the Heart

We can trace the path of blood through the heart

- • **The superior vena cava and the inferior vena cava, which carry O2-poor blood, enter the right atrium.**
- • **The right atrium sends blood through an atrio ventricular valve (the tricuspid valve) to the right ventricle.**
- • **The right ventricle sends blood through the pulmonary semilunar valve into the pulmonary trunk.**
- **The pulmonary trunk divides into two pulmonary arteries, which go to the lungs. Four pulmonary veins, which carry O2-rich blood, enter the left atrium.**
- • **The left atrium sends blood through an atrio ventricular valve (the bicuspid or mitral valve) to the left ventricle.**
- • **The left ventricle sends blood through the aortic semilunar valve into the aorta to the body parts**

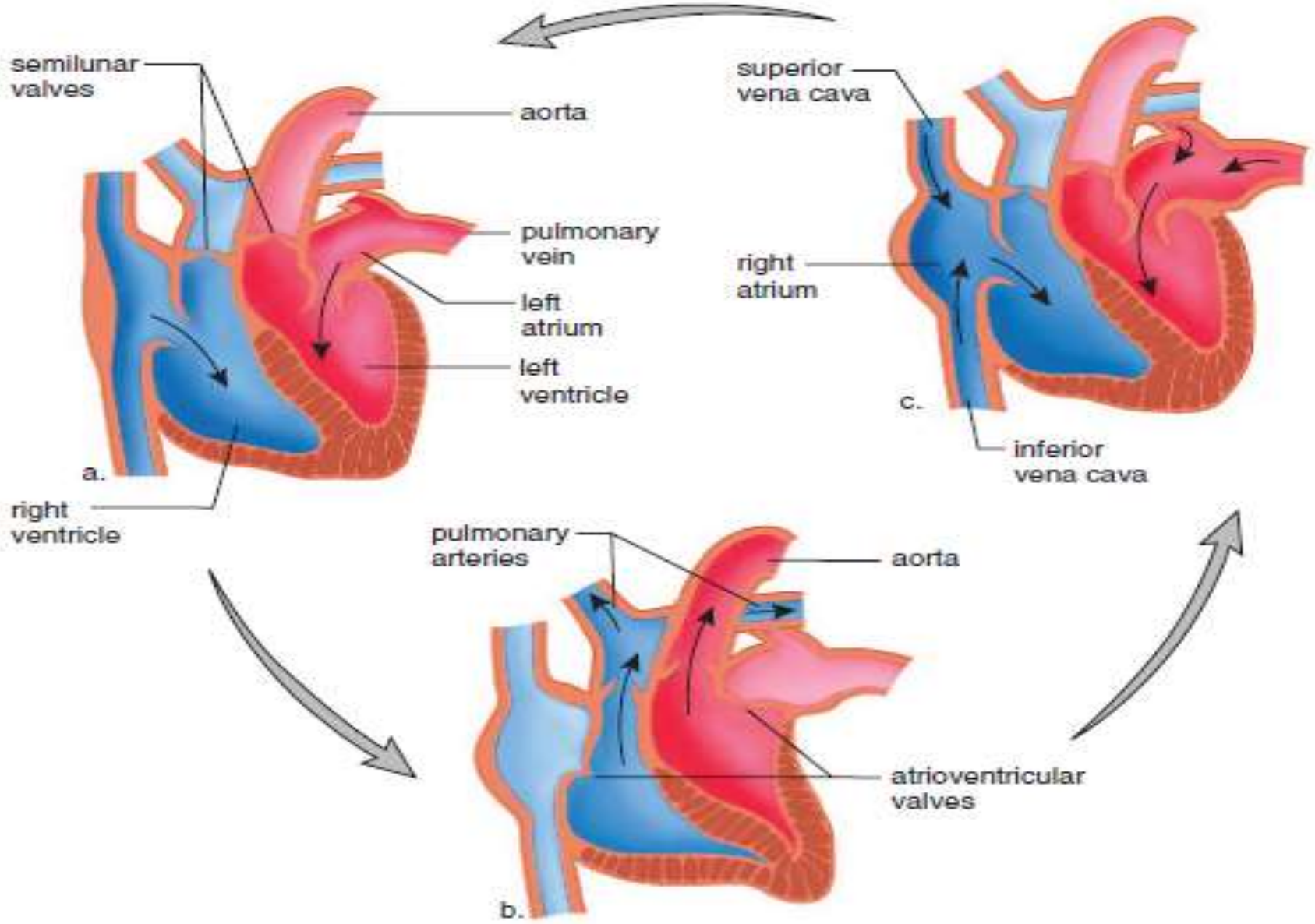


Figure 7.6 **Stages in the cardiac cycle.**

a. When the atria contract, the ventricles are relaxed and filling with blood. **b.** When the ventricles contra atrioventricular valves are closed, the semilunar valves are open, and the blood is pumped into the pulm trunk and aorta. **c.** When the heart is relaxed, both the atria and the ventricles are filling with blood.

The Heartbeat

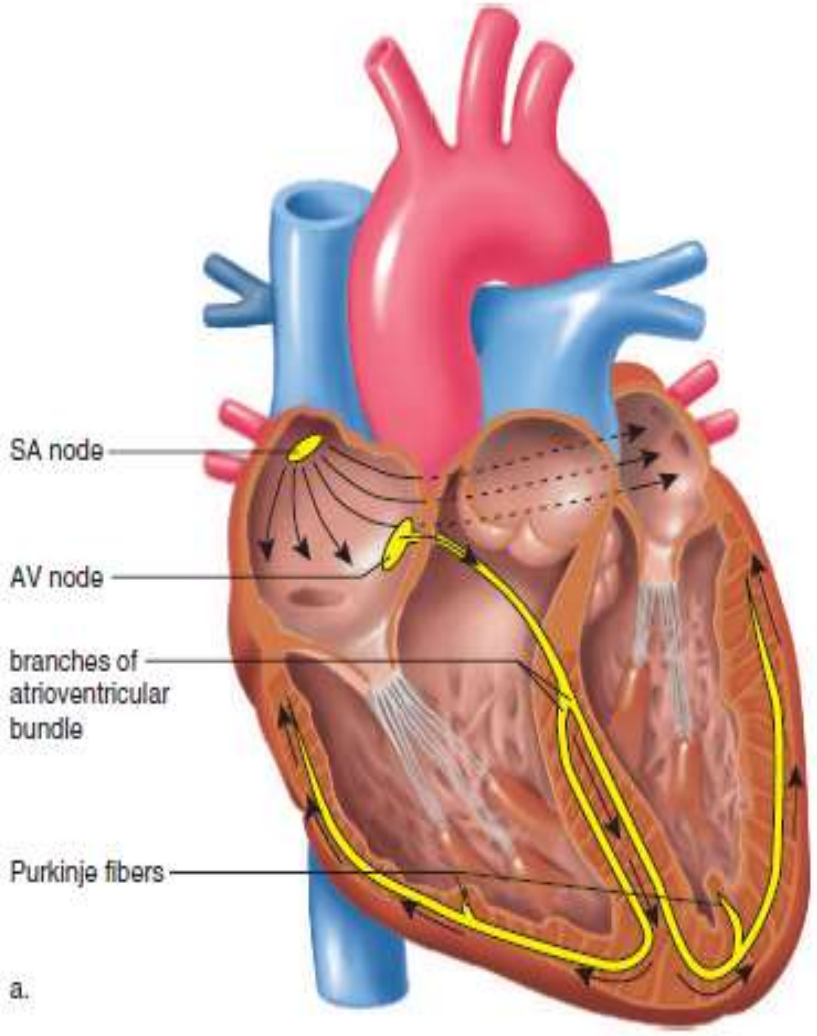
Each heartbeat is called a **cardiac cycle** (Fig. 7.6). When the heart beats, first the two atria contract at the same time; then the two ventricles contract at the same time. Then all chambers relax. The word **systole** refers to contraction of heart muscle, and the word **diastole** refers to relaxation of heart muscle. The heart contracts, or beats, about 70 times a minute, and each heartbeat lasts about 0.85 second.

Time	*Atria*	*Ventricles*
0.15 sec	Systole	Diastole
0.30 sec	Diastole	Systole
0.40 sec	Diastole	Diastole

A normal adult rate at rest can vary from 60 to 80 beats per minute.

When the heart beats, the familiar "lub-dup" sound occurs. The longer and lower-pitched "lub" is caused by vibrations occurring when the atrioventricular valves close due to ventricular contraction. The shorter and sharper "dup" is heard when the semilunar valves close due to back pressure of blood in the arteries. A heart murmur, or a

trical current for a short period of time. Then the SA node may be able to reestablish a coordinated beat.



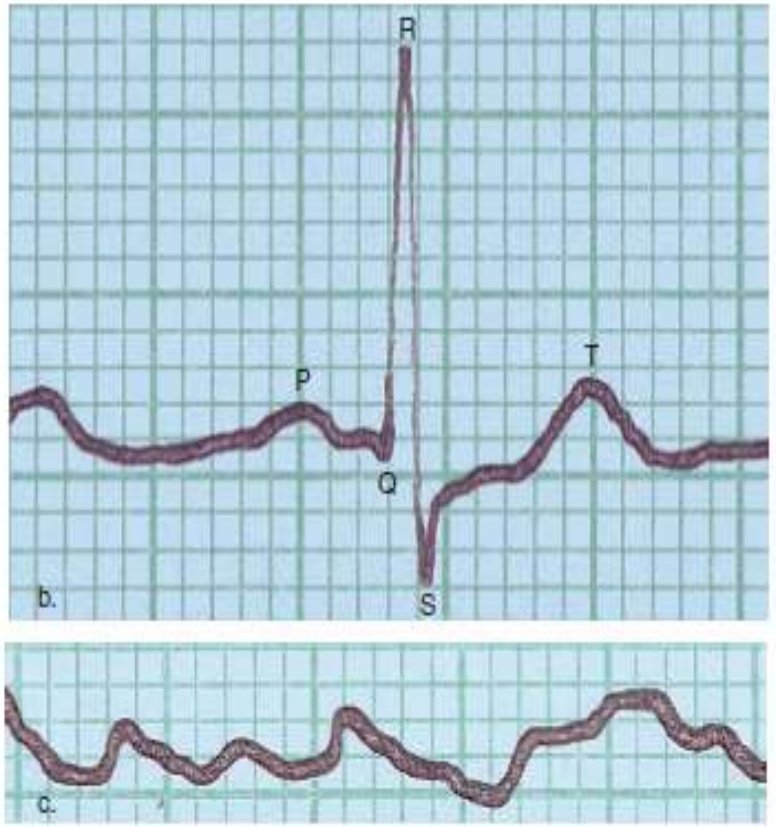


Figure 7.7 **Conduction system of the heart.**

a. The SA node sends out a stimulus, which causes the atria to contract. When this stimulus reaches the AV node, it signals the ventricles to contract. Impulses pass down the two branches of the atrioventricular bundle to the Purkinje fibers, and thereafter the ventricles contract. **b.** A normal ECG indicates that the heart is functioning properly. The P wave occurs just prior to atrial contraction; the QRS complex occurs just prior to ventricular contraction; and the T wave occurs when the ventricles are recovering from contraction. **c.** Ventricular fibrillation produces an irregular electrocardiogram due to irregular stimulation of the ventricles.

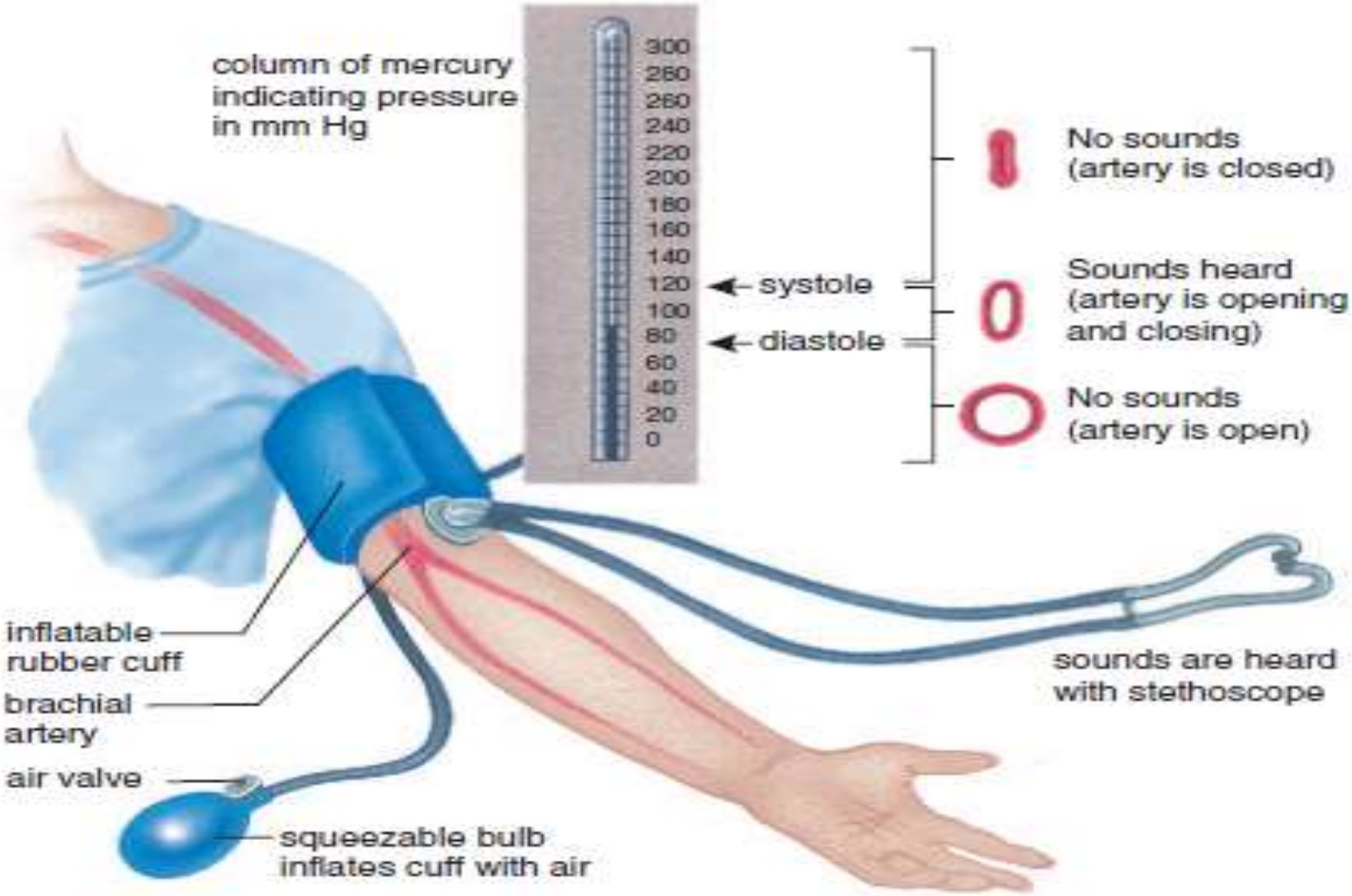
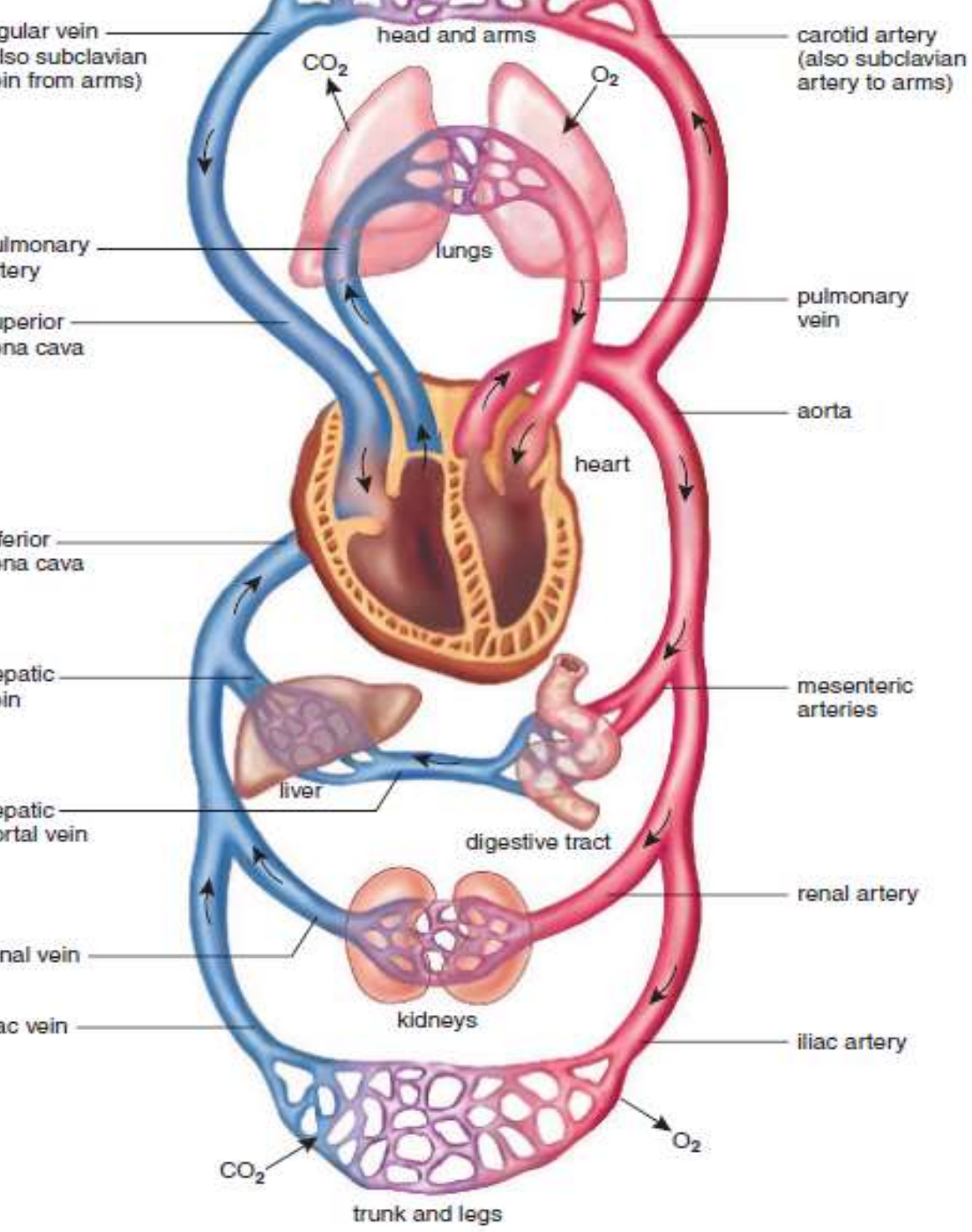
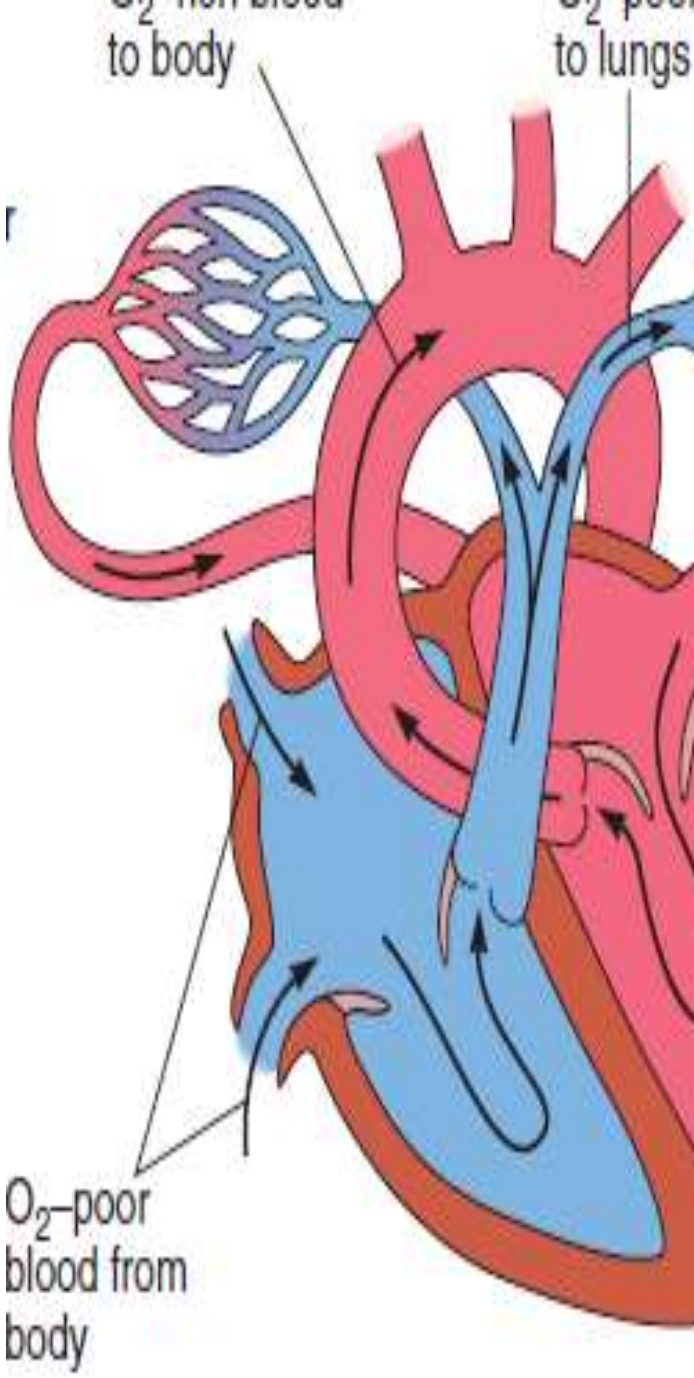


Figure 7.9 **Use of a sphygmomanometer.**
The technician inflates the cuff with air, gradually reduces the pressure, and listens with a stethoscope for the sounds that indicate blood is moving past the cuff in an artery. This is systolic blood pressure. The pressure in the cuff is further reduced until no sound is heard, indicating that blood is flowing freely


gular vein
lso subclavian
in from arms)
head and arms
carotid artery
(also subclavian
artery to arms)
CO_2
O_2
lmonary
tery
lungs
perior
na cava
pulmonary
vein
aorta
heart
ferior
na cava
epatic
in
mesenteric
arteries
liver
epatic
rtal vein
digestive tract
renal artery
nal vein
ac vein
kidneys
iliac artery
O_2
CO_2
trunk and legs


to body
to lungs
O_2–poor
blood from
body

- **Blood**

The boon marrow produce different types of cells

Blood is composed of cells and a fluid containing many inorga
organic molecules.

Red blood cells are very abundant in blood and function in oxyg
transport.

The White Blood Cells: There are several types of white blood
each type has a specific function in defending the body against
Platelets are fragments of larger cells that function in blood clo

Platelets: (thrombocytes)

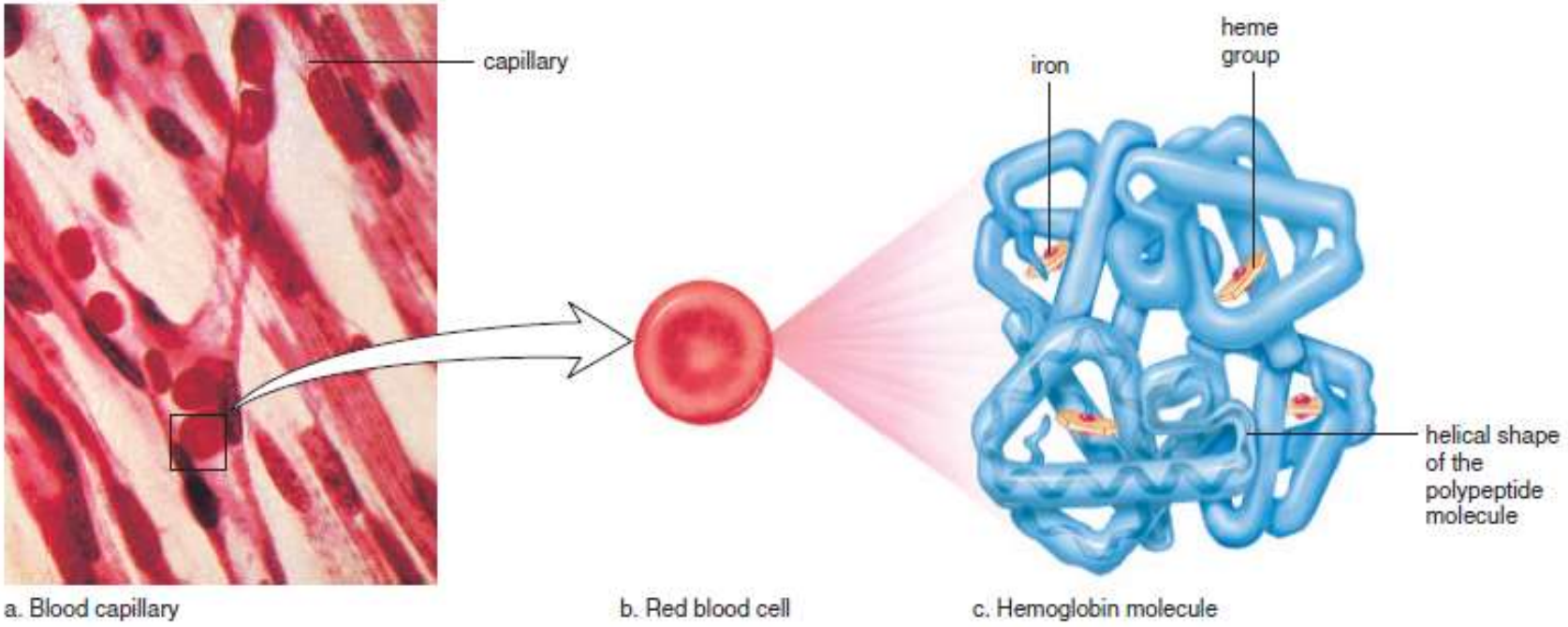
Plasma

Plasma is over 90% water and contains a variety
of proteins and other molecules.

6.1 The Red Blood Cells

Red blood cells (erythrocytes) are small, biconcave disks that lack a nucleus when mature. They occur in great quantity; there are 4 to 6 million red blood cells per mm^3 of whole blood. The absence of a nucleus provides more space for hemoglobin. **Hemoglobin** is called a respiratory pigment because it carries oxygen, and is red. A red blood cell contains about 200 million hemoglobin molecules. If this much hemoglobin were suspended within the plasma rather than enclosed within the cells, blood would be so viscous that the heart would have difficulty pumping it. In a hemoglobin molecule, the iron portion of hemoglobin carries oxygen, a molecule that cells require for cellular respiration (Fig. 6.3c). The equation for oxygenation of hemoglobin is usually written as

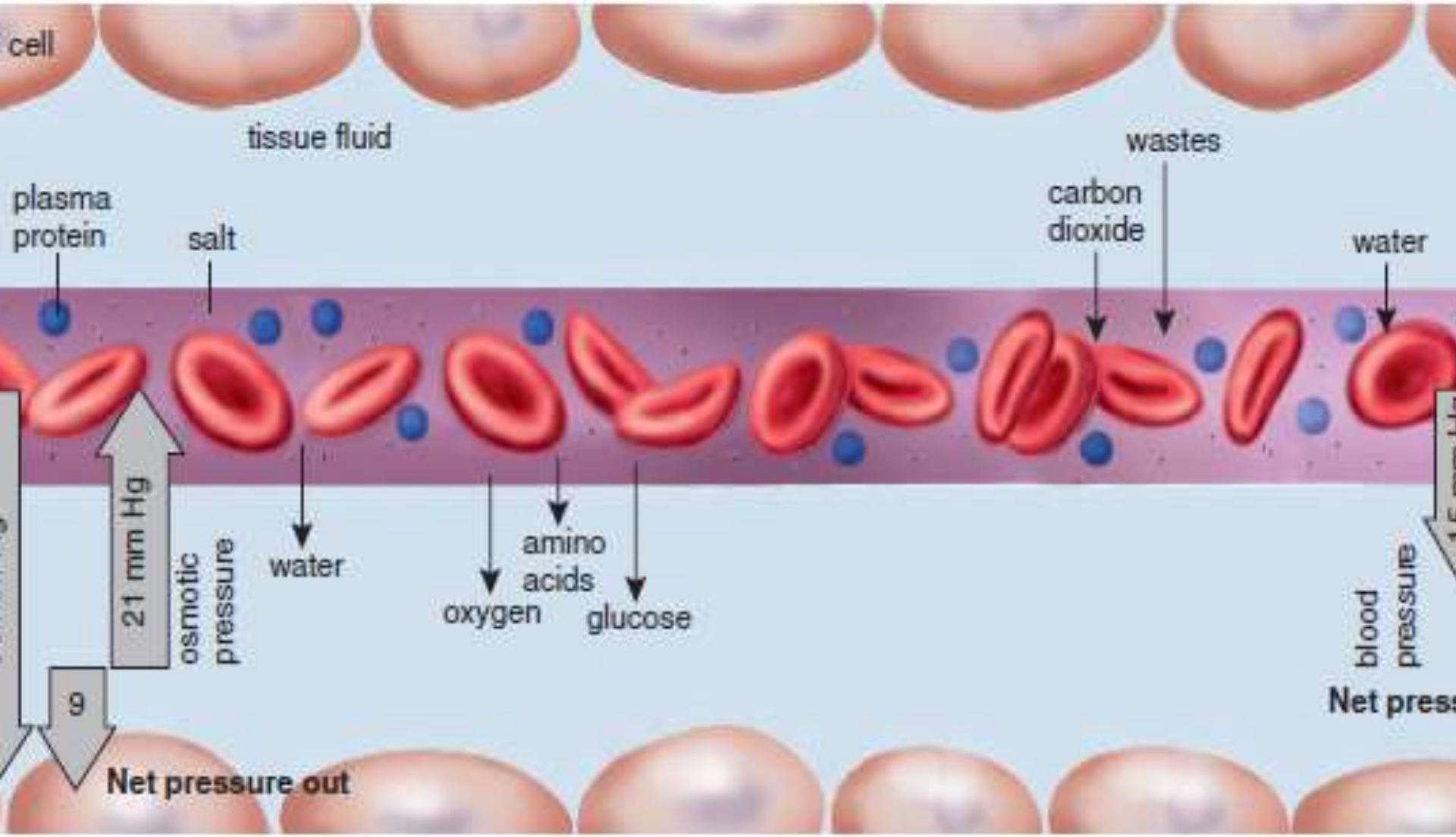
$$Hb + O_2 \underset{\text{tissues}}{\overset{\text{lungs}}{\rightleftharpoons}} HbO_2$$



a. Blood capillary

b. Red blood cell

c. Hemoglobin molecule



apillary exchange.

of a capillary, the blood pressure is higher than the osmotic pressure; therefore, water (H_2O) tends to
xygen (O_2) and carbon dioxide (CO_2) follow their concentration gradients. At the venous end of a capi
blood pressure; therefore, water tends to enter the bloodstream.

blood cells are produced in the red
of all bones, but in adults, produc-
occurs in the red bone marrow of
es, ribs, sternum, vertebrae, and

cells, including erythrocytes, are
special red bone marrow cells
ls (Fig. 6.4). A **stem cell** is ever ca-
ing and producing new cells that
nto specific types of cells. As red
ure, they lose their nucleus and ac-
bin. Possibly because they lack a
ood cells live only about 120 days.
ed blood cells are destroyed in the
een, where they are engulfed by
It is estimated that about 2 million
s are destroyed per second, and
qual number must be produced to
ood cell count in balance.
blood cells are broken down, the
released. The globin portion of
n is broken down into its compo-
ds, which are recycled by the body.
overed and is returned to the bone

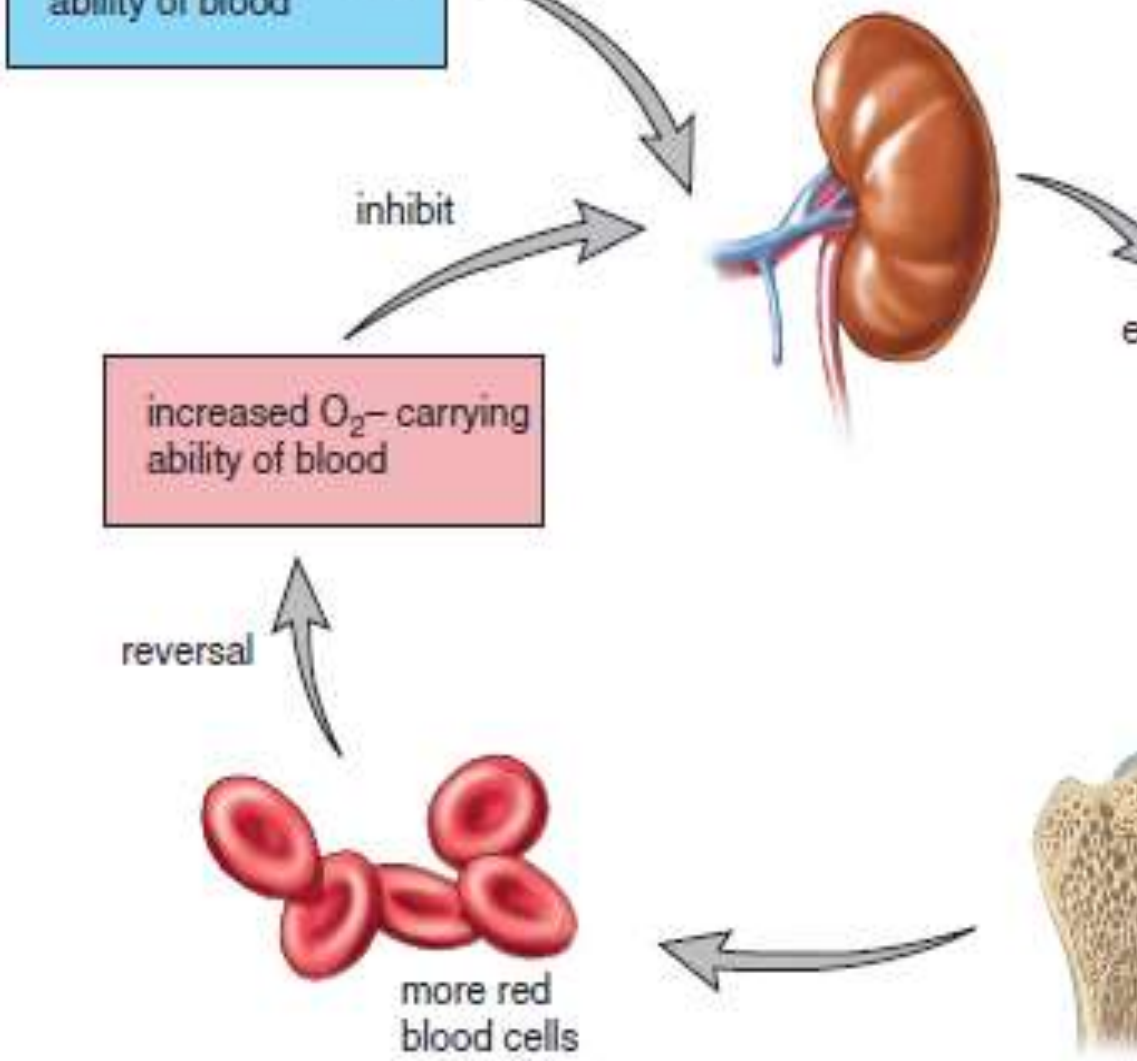
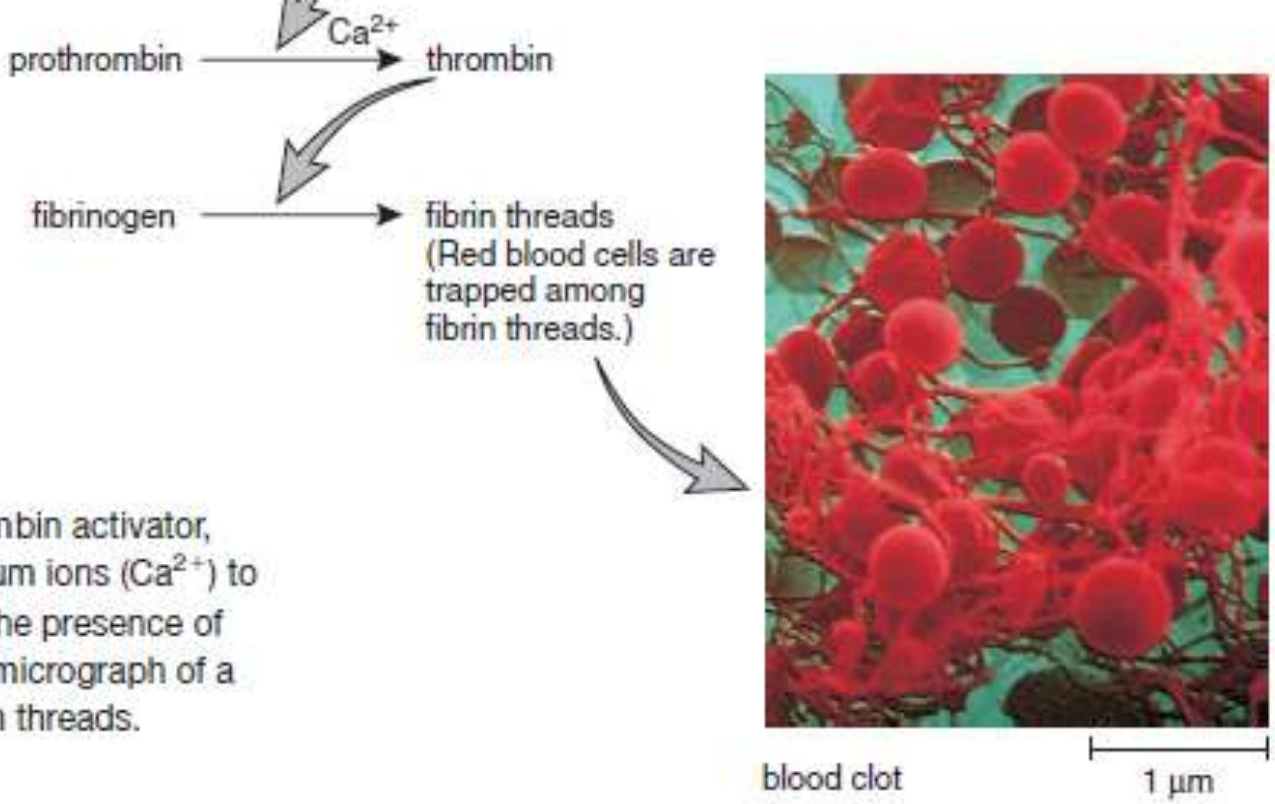


Figure 6.5 Action of erythropoietin.
The kidneys release increased amounts of erythropoietin whene
capacity of the blood is reduced. Erythropoietin stimulates the r
speed up its production of red blood cells, which carry oxygen.
carrying capacity of the blood is sufficient to support normal ce
kidneys cut back on their production of erythropoietin.



ood clotting.
ged tissue cells release prothrombin activator,
rombin in the presence of calcium ions (Ca^{2+}) to
Thrombin acts on fibrinogen in the presence of
threads. The scanning electron micrograph of a
d blood cells caught in the fibrin threads.

Clotting

bocytes) result from fragmentation of cer-
lled **megakaryocytes,** in the red bone mar-
produced at a rate of 200 billion a day, and
ns 150,000–300,000 per mm^3. These formed
olved in the process of blood **clotting,** or

d vessel in the body is damaged, platelets
of the puncture and seal the break if it is not

Table 6.1 Body Fluids Related to Blood

Name	Composition
Blood	Formed elements and plasma
Plasma	Liquid portion of blood
Serum	Plasma minus fibrinogen
Tissue fluid	Plasma minus most proteins
Lymph	Tissue fluid within lymphatic vessels

Bright-red to dark-purple biconcave disks without nuclei		(7–8% of plasma)	pressure and pH	
		Albumin	Maintain blood volume and pressure	
Fight infection	Red bone marrow	Globulins	Transport; fight infection	
		Fibrinogen	Clotting	
10–12 μm in diameter Spherical cells with lobed nuclei; large, irregularly shaped, deep-blue granules in cytoplasm; release histamine which promotes blood flow to injured tissues		Salts (less than 1% of plasma)	Maintain blood osmotic pressure and pH; aid metabolism	Absorbe intestine
10–14 μm in diameter Spherical cells with bilobed nuclei; coarse, deep-red, uniformly sized granules in cytoplasm; phagocytize antigen-antibody complexes and allergens		Gases Oxygen Carbon dioxide	 Cellular respiration End product of metabolism	 Lungs Tissues
10–14 μm in diameter Spherical cells with multilobed nuclei; fine, pink granules in cytoplasm; phagocytize pathogens		Nutrients Lipids Glucose Amino acids	Food for cells	Absorbe intestine
		Nitrogenous wastes Urea Uric acid	Excretion by kidneys	Liver
5–17 μm in diameter (average 9–10 μm) Spherical cells with large round nuclei; responsible for specific immunity		Other Hormones, vitamins, etc.	Aid metabolism	Varied
10–24 μm in diameter Large spherical cells with kidney-shaped, round, or lobed nuclei; become macrophages which phagocytize pathogens and cellular debris				

- with Wright's stain

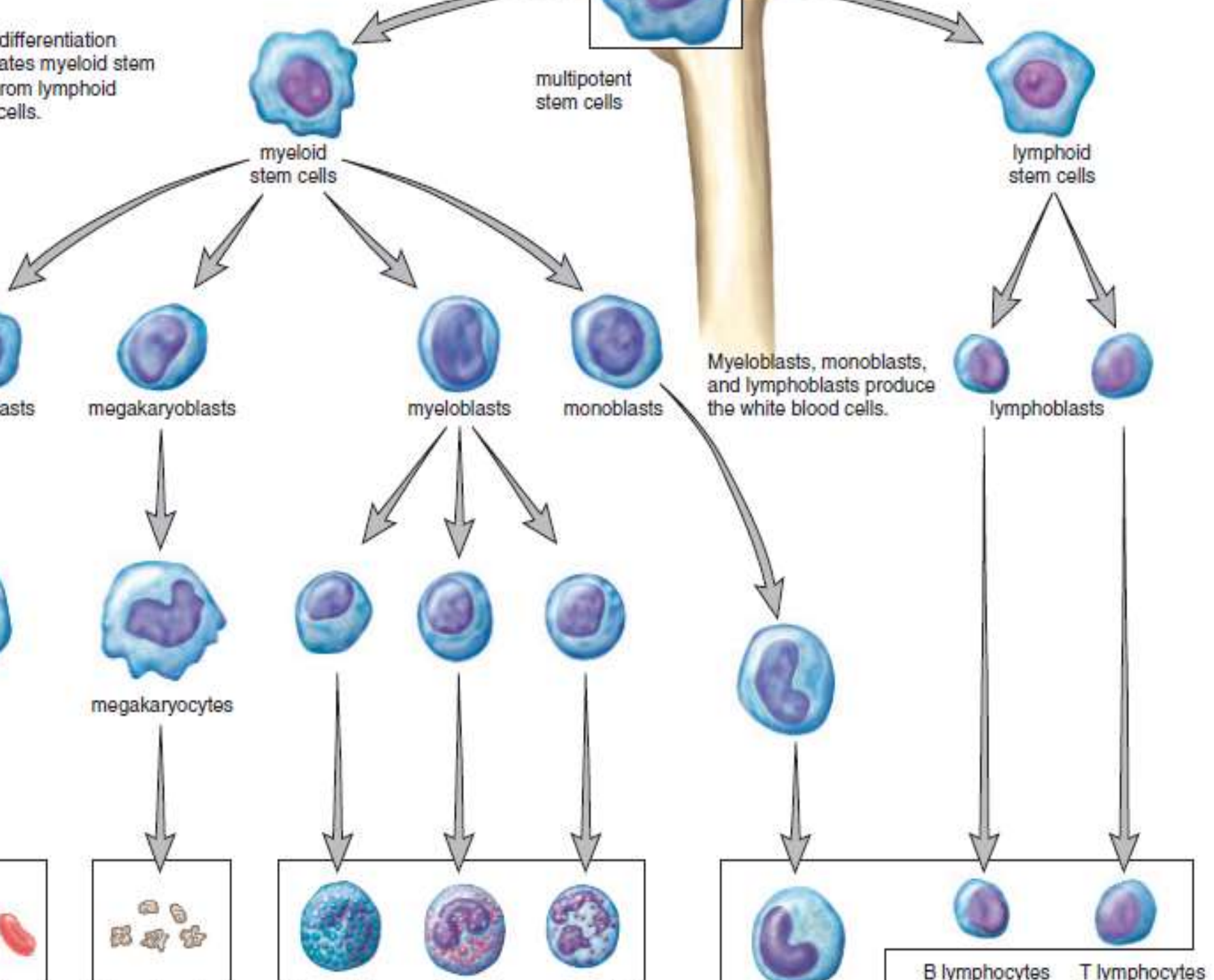
The boon marrow produce different types of cells

The Red Blood Cells :-function in oxygen transport.

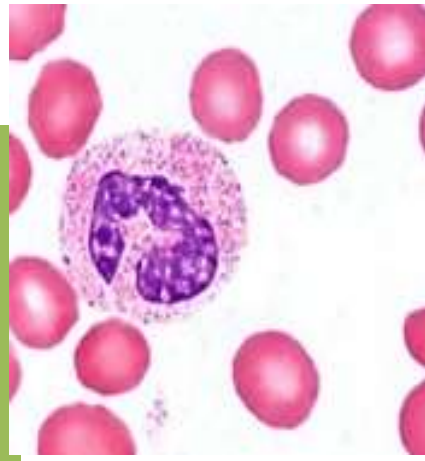
The White Blood Cells: There are several types each type has a specific function in defending the body against disease.

Platelets (thrombocytes):

are fragments of larger cells that function in blood clotting :

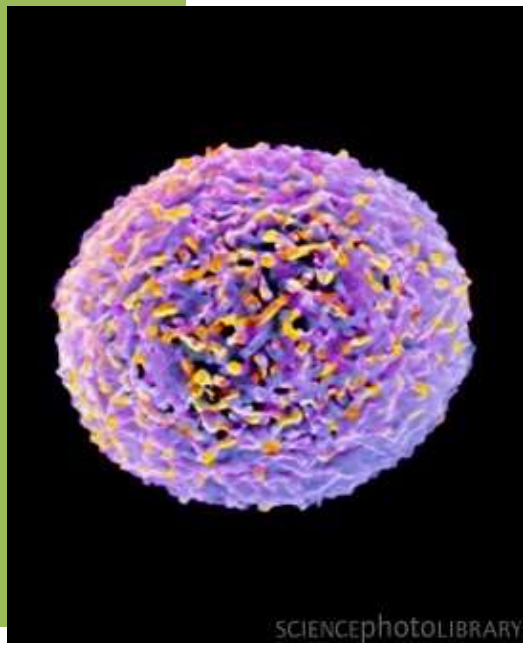

differentiation
ates myeloid stem
rom lymphoid
cells.
multipotent
stem cells
myeloid
stem cells
lymphoid
stem cells
asts
megakaryoblasts
myeloblasts
monoblasts
Myeloblasts, monoblasts,
and lymphoblasts produce
the white blood cells.
lymphoblasts
megakaryocytes
B lymphocytes
T lymphocytes

Neutrophils

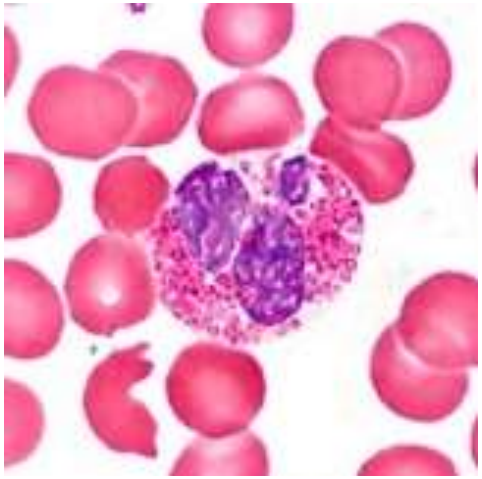


- Large cells (10-20 microns); only live about 2-3 days
- 90% of granulocytes are neutrophils
- Neutral staining cytoplasmic granules containing enzymes

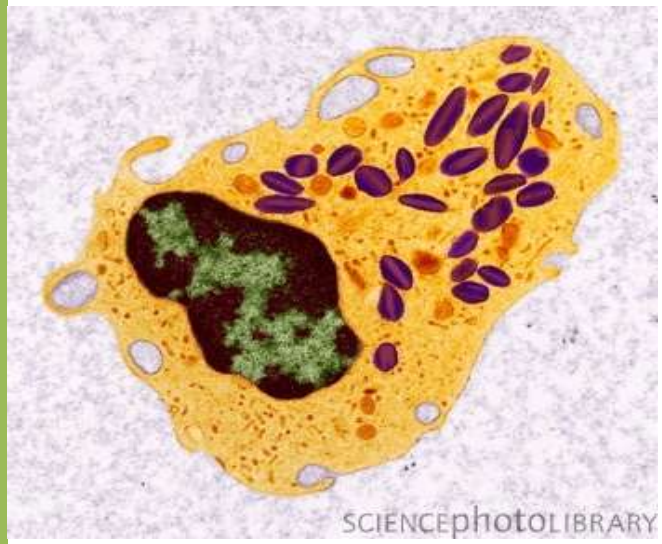
  e.g. lysozyme
- Phagocytic, kill bacteria by microbicidal mechanisms
- Most important cell in non-viral infections



Eosinophi

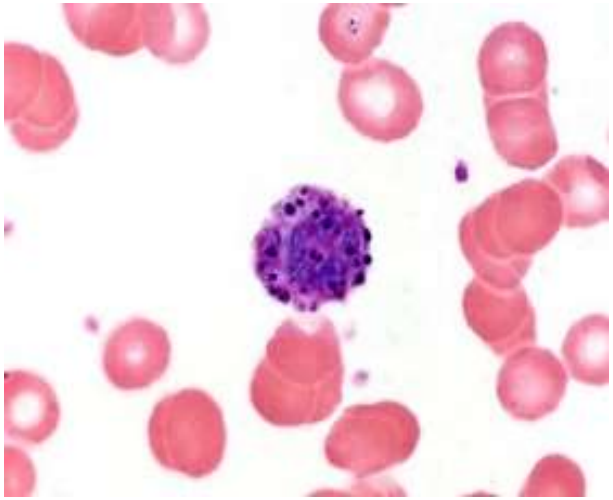


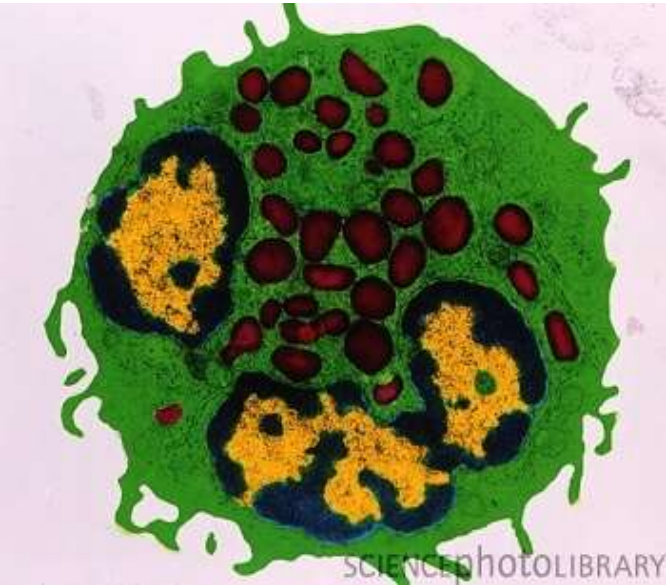
- Contain prominent granules, which stain red with eosin
- Granules contain a crystalline core cytotoxic for parasites; EOSINOPHIL BASIC PROTEIN
- Important in immunity to helminth infections
- Phagocytic, though this is not a major function



Basophils

- **<0.2% white blood cells, only go into tissues during inflammation**
- **When stimulated, release substances that promote inflammation**
- **Important in allergy**
- **Not thought to phagocytose**





Monocytes and macrophages

Monocytes

- in blood 1-2 days
- Mononuclear leukocytes
- Phagocytic

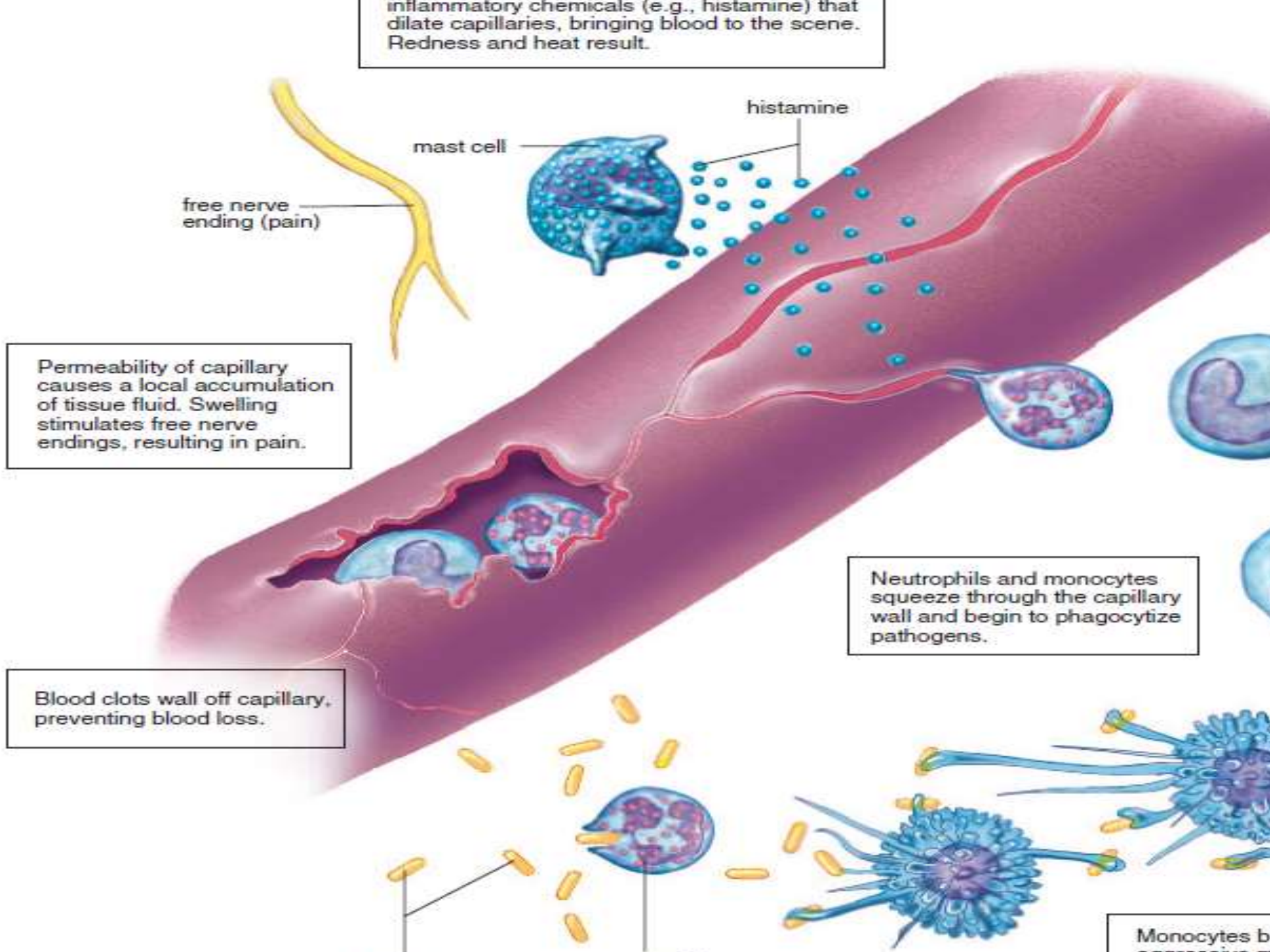
Macrophages

- MCs in tissues = macrophages (MΦ)
- Up to 10x larger than MCs
- can live months or years
- Characteristics of macrophages depend on tissue e.g. Kupffer cells in liver, microglia of brain
- Phagocytic (like neutrophils and eosinophils), adherent

Monocytes and macrophages

- **MCs and MΦs have a variety of microbicidal mechanisms including enzymes**
- **MCs and MΦs have secrete a huge array of growth factors, chemicals and activation factors**
- **Can be identified by certain molecules on the surface (CD14 & CD15 on MCs)**
- **Good at engulfing ‘foreign’ material and ‘showing ‘ it to other cells of the immune system**

inflammatory chemicals (e.g., histamine) that dilate capillaries, bringing blood to the scene. Redness and heat result.



Permeability of capillary causes a local accumulation of tissue fluid. Swelling stimulates free nerve endings, resulting in pain.

Neutrophils and monocytes squeeze through the capillary wall and begin to phagocytize pathogens.

Blood clots wall off capillary, preventing blood loss.

Monocytes b

Lymphoid progenitor cell

- Gives rise to Lymphocytes
- 20-30% peripheral blood white cells
- 6-10um in diameter with large nucleus, small halo of ytoplasm

- Upon stimulation by Ag become EFFECTOR CELLS or EMORY CELLS

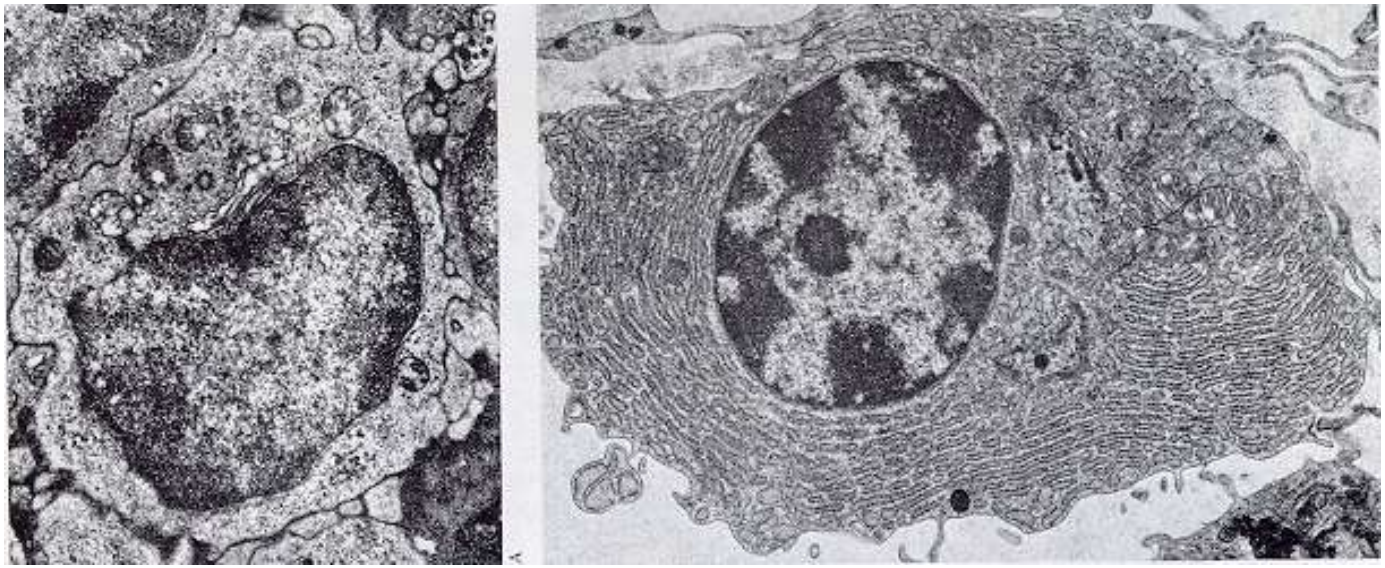
- 2 main types: T cells and B cells

T-lymphocytes and B-lymphocytes)

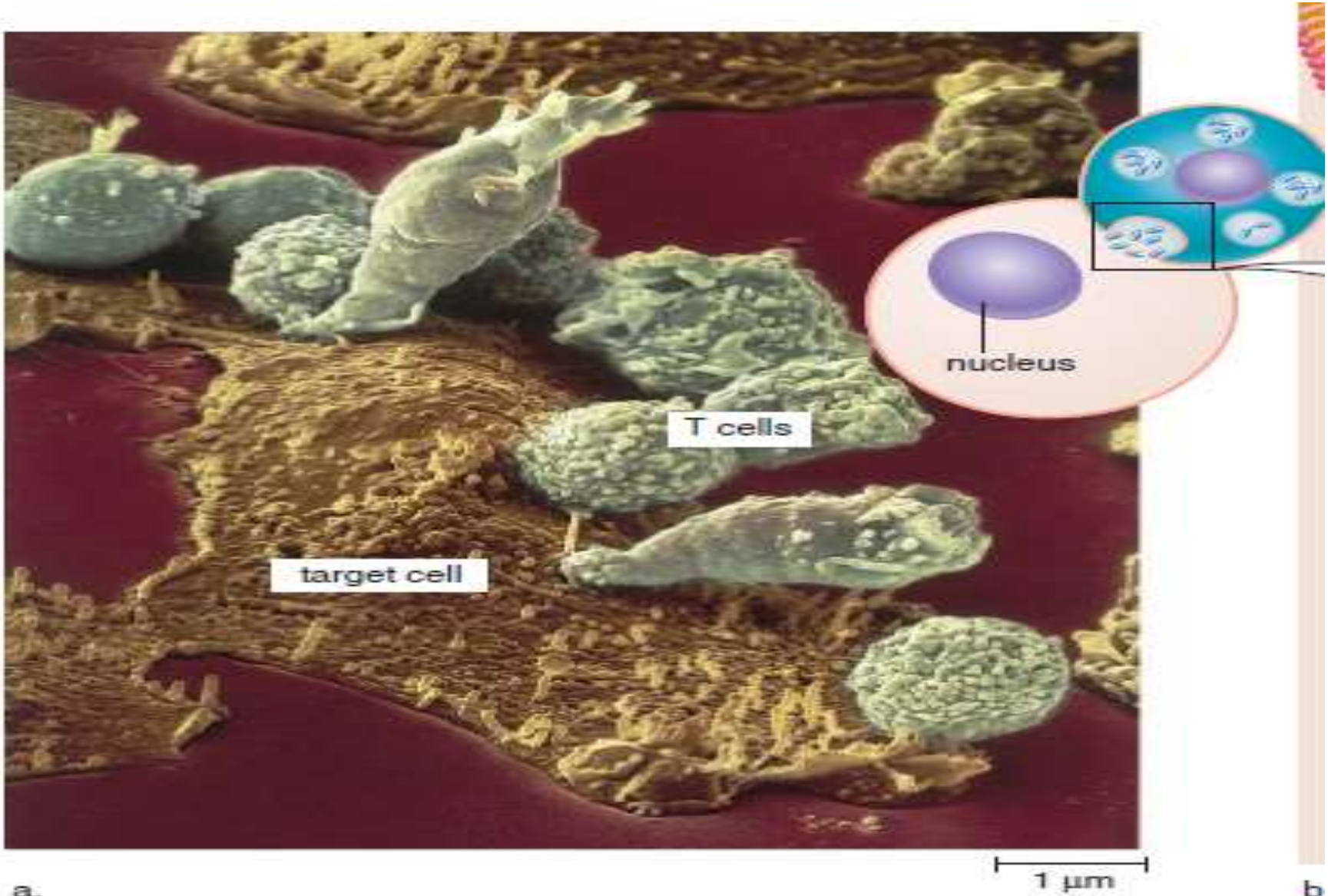
- Early developmental stage, cells pass to Thymus – become T ells or stay in Bone marrow – become B cells

B Lymphocytes (B cells)

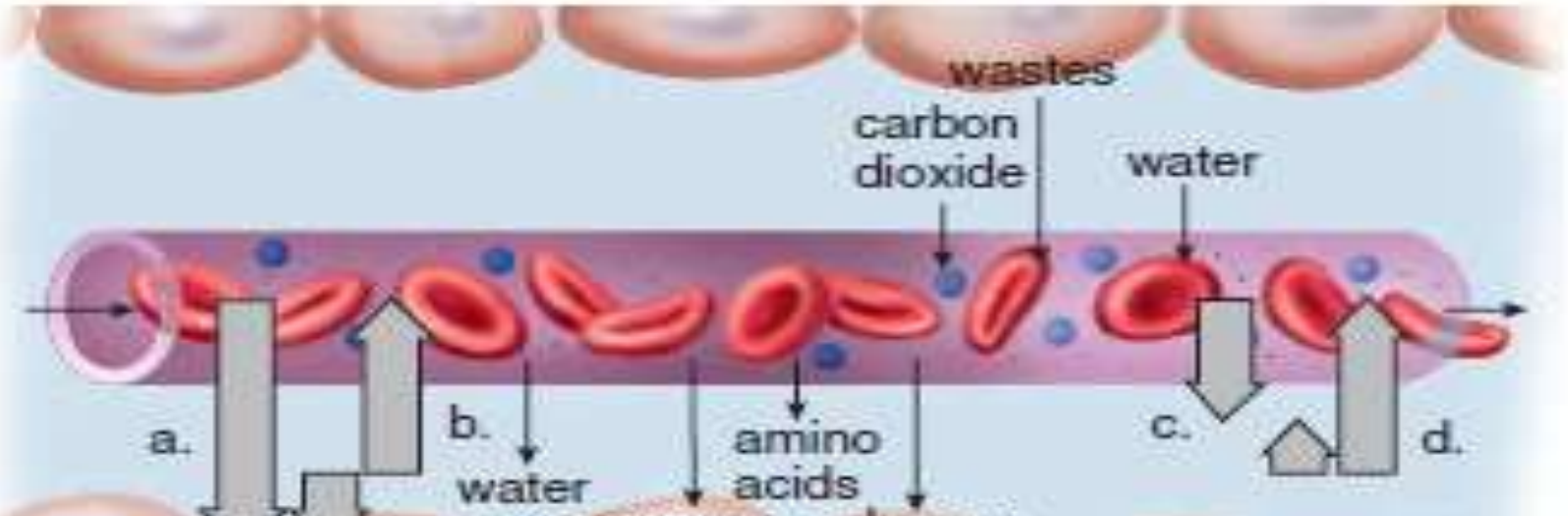
- **Have immunoglobulin/antibody anchored in cell membrane (mIg) to form the B cell antigen receptor (BCR)**
- **When activated differentiate into Plasma cells and secrete antibody or memory cells**



a. The scanning electron micrograph shows cytotoxic T cells attacking and destroying a cancer cell.



8. B lymphocytes produce _____ that react with antigens.
9. A person with type AB blood has _____ antibodies in the plasma.
0. Match the key terms to these definitions:
   a. _____ Iron-containing protein in red blood cells that combines with and transports oxygen.
   b. _____ Clumping of cells, particularly red blood cells involved in an antigen-antibody reaction.
   c. _____ Liquid portion of blood.
   d. _____ Cell fragment that is necessary to blood clotting.
   e. _____ Plasma protein that is converted to thrombin during the steps of blood clotting.
1. Label arrows as either blood pressure or osmotic pressure.



THANK YOU

Will MEET IN NEW LECTURE