

# Lecture 7

January-17-11  
4:32 PM

## Biology 2A03

### Lecture 7 Circulation I

1. Which statement regarding intracellular receptors is false:

- A) They bind lipophobic ligands on the cell surface
- B) They act as transcription factors
- C) They bind lipophilic ligands in the cytosol
- D) They evoke changes in synthesis of a protein

Ans: A

2. Second messengers of signal transduction pathways:

- A) Can amplify the signal from the first messenger
- B) Act as chemical relays from the plasma membrane to the biochemical machinery inside the cell
- C) Bind to the receptor ligand binding site
- D) Both A and B
- E) none of the above are correct

Ans: D

Multicellular cells are surrounded by other cells (i.e. deep within tissue)

All the other cells around them are producing wastes/intaking nutrients, and so there is less of a driving force for both

Diffusion would not be sufficient

That is not to say diffusion does not happen - it does - but it occurs between the blood and the cells

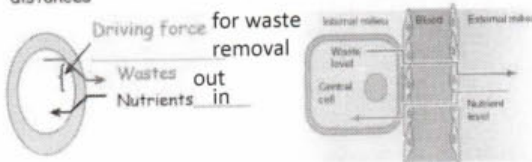
#### The Circulation

Why have a circulatory system?

Diffusion times ( $t$ ) are proportional to the distance ( $x$ )<sup>2</sup> over which diffusion occurs.

Diffusion gradients for nutrients or wastes can decrease over large distances

Diffusion doesn't occur quickly enough to transport things from one area to another



Unicellular organism

Multicellular organism

Diffusion sufficient

Diffusion is NOT sufficient

We need a circulatory system so we can constantly removing waste products and constantly deliver nutrients, and keep those diffusion gradients relatively large

## Circulatory Systems

A fast convection system = rapidly circulating fluids between surfaces that equilibrate external milieu and cells deep inside organisms

1<sup>st</sup> role = distribution of dissolved gases and molecules for nutrition, growth and repair

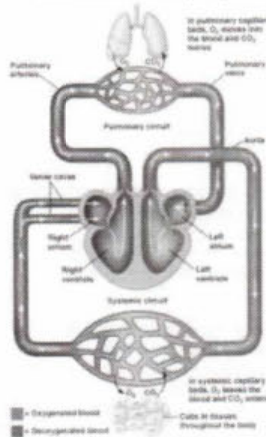
2<sup>nd</sup> role =

- 1) fast chemical signalling
- 2) dissipating heat
- 3) inflammatory and host defence against microorganisms

System consists of:

- 1) A Convective medium = blood (communication system - connects) e.g. chemical messengers
- 2) Plumbing = blood vessels (regulates blood pressure and blood distribution)
- 3) A Pump = heart (sensory and endocrine functions)

### The Circulatory System



Composed of 2 circuits

#### 1. Pulmonary circulation

Picks up O<sub>2</sub> lungs  
Low Pressure system (20mmHg)

Right Ventricle → lungs  
→ Left Atrium

#### 2. Systemic circulation

Delivers O<sub>2</sub> to organs and tissues (except lungs)  
High Pressure system (100mmHg)

Left Ventricle → Organs and tissues  
→ Right Atrium

Both have an arterial (blood away from heart) and a venous component (returns blood to heart)

Bloodflow equal to each ~5L/min Fig 14-2

Blood never has 0 oxygen content - it is just depleted of it

*circ. btw heart & lung*  
*space btw alveoli & capillaries where O<sub>2</sub> can be picked up*

*circ. that supplies blood to all the body except to the lungs*

Blood - 1) plasma & 2) cells (erythrocytes, leukocytes, platelets)

#### 1) Plasma

Composed of:

-ISF and plasma values close to each other -Except that proteins > in the plasma	}	water ~92%	
		proteins ~7%	(60% of plasma proteins) Albumin, antibodies, hormones, fibrinogen
		Electrolytes (ions)	Major Cation: Na <sup>+</sup> (145mM) Major Anions: Cl <sup>-</sup> (100-140mM) HCO <sub>3</sub> <sup>-</sup> (24mM)
		gases	O <sub>2</sub> , CO <sub>2</sub> , N <sub>2</sub>
		nutrients	Glucose, lipids, amino acids
		wastes	Urea, ammonia, lactate

Albumin (the major protein) maintains the osmolarity of the blood

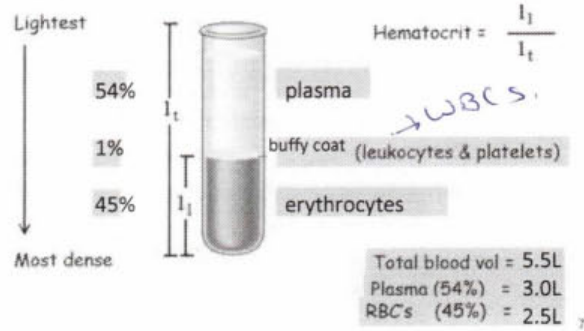
Fibrinogen is an important component of blood clotting

Capillary wall very permeable to H<sub>2</sub>O and most plasma components except protein See Table 16-1

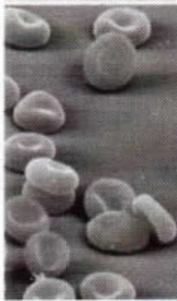
Ratio of volume occupied by packed RBCs to the volume of the whole blood as measured by a hematocrit

### Hematocrit

The fraction of blood composed of red blood cells (erythrocytes)  
Can be measured after blood centrifuged in a microhematocrit tube



### 2) Blood Cells -

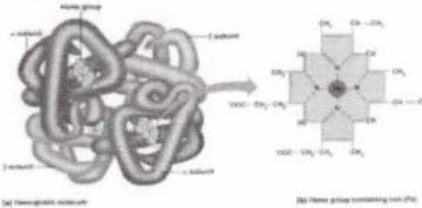


#### 1. Red blood cells (erythrocytes)

- most abundant cell in the blood
- Major function to transport  $O_2$  from lungs and  $CO_2$  formed in tissues
- In mammals do not contain a nucleus or other organelles
- Contain large amounts of hemoglobin (85% of protein content) for carrying  $O_2$  (and some  $CO_2$ )
- and the enzyme carbonic anhydrase important for  $CO_2$  transport

- Shape of cells important for rapid  $O_2$  and  $CO_2$  diffusion:
- Biconcave disk - thicker on the edges than in the middle
- Provides a high surface area/volume and gives the greatest flexibility

$280 \times 10^6$  Hb molecules per RBC



Hb is a tetramer (M.W. ~ 68,000), composed of 4 similar units

Each unit consists of a "heme" ring structure, which binds & a polypeptide chain (globin) which binds  $CO_2$ ,  $H^+$ , phosphates, etc.

Hb exhibits the property of allosteric modulation = "binding at one site on a molecule affects binding at a second site, usually by changing the shape of the molecule."

Regulation of erythrocyte production

Blood components are under tight reflex (homeostatic) control

Red blood cell production occurs primarily in bone marrow

Have relatively short (120 days) life span (compared to other vertebrates)

- Approximately 1% recycled per day,
- breakdown occurs in spleen and liver

Product = bilirubin (yellow in colour)

Production (erythropoiesis) is primarily regulated by the hormone erythropoietin (EPO) secreted by specialized cells in the kidney

Increased release triggered by decreased O<sub>2</sub> delivery to the kidney

Fig 16-4<sup>10</sup>

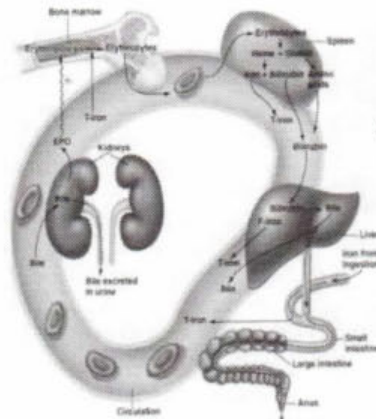


Fig 16-4

Regulation of erythrocyte production

↓ O<sub>2</sub> delivery to kidneys

↑ EPO secretion by kidneys

↑ Plasma EPO

↑ Production of rbc in bone marrow

↑ Blood Hb (hemoglobin)

↑ Blood O<sub>2</sub> carrying capacity

↑ Restoration of O<sub>2</sub> delivery

Increase in hemoglobin causes an increase in blood O<sub>2</sub> carrying capacity

The prodn of RBCs by the stem cells in the bone marrow

a pigment in the bile that forms a product of hemoglobin

Can occur thru anemia, decrease in blood flow to kidney, or systemic hypoxia (whole body hypoxia fr. a lung disease or being in env w/ low O<sub>2</sub>)

hypoxia = O<sub>2</sub> deficiency

The breakdown of erythrocytes releases bilirubin which goes to liver

boosting the # of RBCs in the bloodstream

Ways to increase red blood cells

High altitude: Low O<sub>2</sub> stimulates production

Blood doping: Previously stored rbc reinfused

Synthetic EPO

Epo: 3-4 weeks for hormone to clear the system

Definitions

Polycythemia: Hematocrit (rbc's) is too high  
Makes bloodflow more difficult = increased viscosity (resistance to flow)

Anemia: Low ability for blood to carry O<sub>2</sub>  
1) Low RBCs 2) Low HB per RBC 3) both

Chronic high altitude -- high level of hematocrit, makes heart work harder *disease*

types of WBCs

"Buffy coat"

2. Leukocytes - eosinophils, basophils, neutrophils, ~~monocytes,~~ ~~lymphocytes~~

monocytes, lymphocytes

- Produced in bone marrow and lymphoid tissue.
- Defense and cleanup functions

3. Blood platelets - important in hemostasis - (maintaining blood volume)

- Formed by the breakdown of WBCs
- Involved in blood clotting
- Form a "platelet plug" - prevention from bleeding to death

Both of these types are cells are much less numerous in the blood than RBC's

13

The fundamental law of the circulation

Q (w/ dot on top)  
= cardiac output

(Like Ohm's Law)

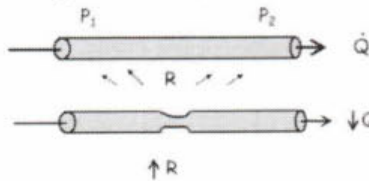
$$\dot{Q} \text{ (or } F) = \frac{\Delta P}{R}$$

$\Delta P$  = pressure difference between 2 points in the circulatory system  
P = force/area exerted by blood - generated by heart contractions

R = friction that impedes flow *Not measured directly but calculated*

Internal (Viscosity)

External (Interaction w. vessel wall)



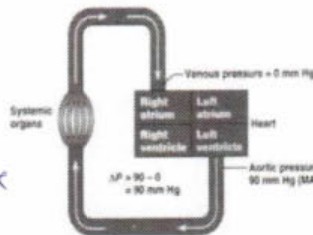
Increase resistance by decreasing radius

14

The fundamental law of the circulation - Pressure

$$\dot{Q} \text{ (or } F) = \frac{\Delta P}{R} \quad \dots \text{where,}$$

Spends 1/3 of the time contracting and 2/3 of time relaxing  
 systole  
 diastole



$$\begin{aligned} \Delta P &= \text{MAP} - \text{CVP} \\ &= 90 - 0 \text{ mmHg} \\ &= \frac{1 \text{ Systolic } P + 2 \text{ Diastolic } P}{3} \end{aligned}$$

MAP a weighted average of time spent in each phase

MAP is the overall pressure driving blood into tissues

MAP = mean arterial pressure  
CVP = central venous pressure

Fig 15-2

the avg. arterial pressure during a single cardiac cycle

reflects the amt. of blood returning to the heart & the ability of the heart to pump the blood into the arterial system