Biology Chapter 21A

The Circulatory System

cardiovascular system (also called circulatory system: made up of heart, blood, and blood vessels)

Blood - The Life of the Flesh

(adult . 6 quarts)

Components of blood:

1. blood plasma (liquid portion - about 55%)
2. blood cells
   - erythrocytes
   - leukocytes (solid portion - about 45%)
3. platelets
   - thrombocytes

blood plasma: straw-colored liquid part of the blood
   - approximately 90% water
   - 10% various dissolved substances such as: food (glucose, fats, amino acids); waste molecules (urea, uric acid); hormones; gases (O₂, CO₂, nitrogen); minerals; blood proteins

Blood proteins are not the same as protein which is a building material. Blood proteins are never used for building up (synthesizing) new cells except in the case of severe protein malnutrition. When a person has not eaten sufficient protein in many weeks, the body will use blood proteins to stay alive. As the blood proteins move out of the blood, water moves with it - causing the swollen bellies in starving people.

edema: an abnormal accumulation of fluid in cells, tissues, or cavities of the body, resulting in swelling

three basic kinds of blood proteins:

1. albumin (most plentiful): much like the white part of an egg; gives the blood a gummy texture; made in the liver; main function is to keep the proper amount of water in the blood (controls blood volume)
2. globulins: also made in liver as well as in lymph tissue, alpha and beta function is to help transport fats throughout the body and carry fat-soluble vitamins (like A, D, E, & K)
   - gamma globulin - helps protect the body from some types of diseases (antibody)
3. fibrinogen: also made in liver; helps in the clotting of blood
Plasma is important in maintaining proper blood pressure.

- consistency (too thick - blood pressure 8; too thin - blood pressure 9)
- volume (too much - blood pressure 8; too little - blood pressure 9)

If a person loses a lot of liquid as a result of an injury or a burn, the body's blood pressure falls to a critical low condition known as shock.

**intravenous infusion:** given liquid through a vein

**ERYTHROCYTES** - red blood cells
- red, biconcave discs that carry oxygen
- not really a cell - lacks a nucleus
- does not undergo mitosis
- cannot move by themselves
- most numerous of all blood cells
- in adults new ones are made in red bone marrow (before you were born they were made in spleen, liver, and red bone marrow)
- life span: 90-120 days
- old, worn out ones are broken down in liver, spleen, and bone marrow (most of the remains are recycled to form new red blood cells)
- surplus red blood cells are stored in the spleen until they are needed
- single drop of blood - 5 million red blood cells
- 130 pound adult form more than 1 billion new erythrocytes each day
- est. body contains 25 trillion lined up end to end - circle equator 4 times
- replaced at a rate of over a million each second

The cytoplasm of erythrocytes contains **hemoglobin** (about 1/3; a special iron-containing pigment which unites easily with oxygen). When hemoglobin is combined with the oxygen it is called **oxyhemoglobin**.

**anemia:** a disorder resulting from too little oxygen being transported to body cells

**LEUKOCYTES** - white blood cells
- lack hemoglobin/colorless
- about 2 times the size of red blood cells
- no definite shape
- have nuclei
- can move
- fight disease (part of the immune system)
- function like an army and like a sanitation crew
- ratio of red to white (600:1)
- produced in bone marrow and lymph nodes

**THROMBOCYTES** - platelets
- made from large cells in red bone marrow
- lacks a nucleus
- less than 1/2 the size of an erythrocyte
function in blood clotting (coagulation)

thrombus - a clot that forms within a blood vessel
embolus (EM buh lus) - a thrombus floating in the blood vessels

an embolus plugging a major artery to the brain is called a stroke
an embolus plugging vessels feeding the heart is called a coronary thrombosis (one type of heart attack)

Blood Grouping (Blood Types)

Blood types are determined by the presence or absence of certain protein molecules (called antigens [agglutinogens]) on the surface of erythrocytes.

antigens: stimulate the production of antibodies
antibodies (agglutinins): protein substances produced when foreign substances (antigens) enter the body

donor: person who gives blood
recipient: person who receives blood

When the wrong types of blood are mixed antibodies cause the erythrocytes to clump (agglutinate) and separate from the plasma. If the clumps are large enough and reach vital areas, it could kill the person.

Agglutination and coagulation are not the same
agglutination: clumping
coagulation: clotting
two blood type classifications
(1) ABO group
(2) Rh system

ABO Group
1901 by Karl Landsteiner
determined by the presence or absence of 2 antigens (A & B)

blood types: A - has antigen A
            B - has antigen B
            AB - has both antigens A and B
            O - has neither antigen

In addition to antigens, 3 of these 4 blood types also possess antibodies. The particular antibodies, however, were not present at birth but were produced between the 2nd and 8th months of life as the body responded to antigens A and B in the person's food, especially meat. Therefore if a person has type A blood, his body produces anti-B antibodies.
<table>
<thead>
<tr>
<th>Blood type</th>
<th>Antigen (in red blood cell membrane)</th>
<th>Antibody (in blood plasma)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A</td>
<td>anti-B</td>
</tr>
<tr>
<td>B</td>
<td>B</td>
<td>anti-A</td>
</tr>
<tr>
<td>AB</td>
<td>A &amp; B</td>
<td>none</td>
</tr>
<tr>
<td>O</td>
<td>none</td>
<td>anti-A and anti-B</td>
</tr>
</tbody>
</table>

most common - type O  
rare - type AB

Blood Transfusion  

<table>
<thead>
<tr>
<th>Recipients' preferred type for transfusion</th>
<th>other types used in emergencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>AB</td>
<td>AB</td>
</tr>
<tr>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

**universal recipient**: type AB  
**universal donor**: type O

The Rh System  
Named after the rhesus monkey from which the Rh antigen was first isolated in 1940.  
It too is based on the presence or absence of an antigen in the red blood cell's membrane.

**Rh types**:  
Rh+ (have the Rh antigen; 85% of population)  
Rh- (does not have the Rh antigen; 15% of population)

The Heart  
The heart has no other function than to pump blood.  
The heart is the approximate size of your clenched fist  
5½ inches long; 3½ inches wide  
weighs about 12 ounces  
contracts about 72 times per minute

Structure of the heart

**PERICARDIUM** - thin membranous sac completely enclosing the heart;  
made of tough tissue; protects heart from rubbing against the lungs and the wall of the chest; has a smooth lining that secretes a slippery liquid called **pericardial fluid**
The pericardium is a double-layered protective sac. The tough outer layer is largely composed of white fibrous connective tissue. It is firmly anchored to the diaphragm, the back of the sternum, the vertebral column, and the large blood vessels emerging from the heart. Lining the interior of the pericardium is a thin, moist membrane that closely covers the heart's surface. Between the two layers is a small amount of serous fluid (thin, watery fluid) that helps reduce friction between the pericardial membranes as the ever-active heart moves within them.

The wall of the heart consists of three distinct layers of tissues:

1. **Epicardium** (outer wall)
   - composed of connective tissue that keeps the heart muscle from becoming saturated with the pericardial fluid
   - covered by epithelial tissue, blood and lymph capillaries, nerve fibers, and fat

2. **Myocardium** (middle wall)
   - the thickest portion of the heart wall
   - the muscle tissue that contracts and pumps the blood numerous blood and lymph capillaries and nerve fibers richly supply the cardiac muscle tissue

3. **Endocardium** (inner wall)
   - this layer prevents the blood from saturating the myocardium
   - consists of epithelial and connective tissues, blood vessels, and highly specialized cardiac muscle fibers called Purkinje fibers
   - lines all of the heart chambers, covers the heart valves, and is continuous with the linings of the blood vessels that are attached to the heart

**SEPTUM** - muscular wall dividing the heart lengthwise

**HEART CHAMBERS** (four of them - two on each side)
- also called cavities

1. upper chamber - **ATRIUM** (Auricle)
   - collects the blood flowing into the heart
   - receives blood from veins
   - thin myocardium
   - right atrium: receives deoxygenated blood from body by way of the superior and inferior vena cava
   - left atrium: receives oxygenated blood from lungs by way of the pulmonary vein

2. lower chamber - **VENTRICLE**
   - forces blood into the arteries
   - thick myocardium (left 3 times thicker than the right)
   - right ventricle: pumps to lungs through pulmonary artery
   - left ventricle: pumps to the entire body through aorta
HEART VALVES - controls the flow of blood through the heart (4 of them)
(1) two are ATRIOVENTRICULAR VALVES (AV valves)
   between an atrium and a ventricle
   (a) TRICUSPID - between the right atrium and right ventricle
   (b) MITRAL (bicuspid) - between the left atrium and left ventricle
(2) two are SEMILUNAR VALVES
   control the flow of blood from ventricle to arteries
   have three cup-shaped membranes
   viewed from above they appear shaped as a half-moon
   (a) PULMONARY - between the right ventricle and the pulmonary vein
   (b) AORTIC - between the left ventricle and the aorta

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The term "heart murmur" generally describes any heart sound that differs from the usual "lubb-dubb" sound.

CORONARY ARTERIES - carry oxygen to heart muscle

The Path of Blood
Blood from the body flows into right atrium through two large veins; largest veins in the human body:

   SUPERIOR VENA CAVA - returns blood from the upper body regions
   INFERIOR VENA CAVA - returns blood from the lower body regions

   RIGHT ATRIUM
   TRICUSPID VALVE (three little triangular flaps of thin, strong fibrous tissue; AV valve)

   RIGHT VENTRICLE
   PULMONARY VALVE (semilunar)
   PULMONARY ARTERY (deoxygenated blood)
   LUNGS
   PULMONARY VEINS (oxygenated blood)
   LEFT ATRIUM
   MITRAL VALVE (similar to tricuspid - only two flaps of tissue; also called bicuspid; AV valve)

   LEFT VENTRICLE
   AORTIC VALVE (semilunar valve)

BODY

heartbeat: one complete contraction and relaxation (cardiac cycle)
   systole (SIS tuh lee): the contraction of the heart muscle
   diastole (dye AS tuh lee): the relaxation of the heart muscle
The heartbeat is controlled by the **cardiac conduction system**.
Throughout the heart are clumps and strands of specially designed cardiac muscle tissue that make up the cardiac conduction system. The purpose of these highly specialized cardiac muscle fibers is to initiate and distribute cardiac impulses throughout the myocardium. The key element of the cardiac conduction system is a bundle of self-exciting cardiac muscle fibers located high in the posterior wall of the right atrium - it is called the **sinoatrial (S-A) node** (sye no AY tree ul). The S-A node functions as the heart's natural "pacemaker" - it starts each systole and thus sets the pace, the heart's tempo. The S-A node is rhythmic; it initiates one impulse after another 70-80 times each minute.

**sinoatrial node**: the pacemaker of the heart; performs the job of starting each systole

**heart rate**: average resting heart rate is 72 beats per minute

If the heartbeat is more than 140 beats per minute, ventricular diastole may be too short for the ventricles to fill with blood. Therefore, less blood is pumped at each heartbeat, and the individual begins to tire.

A **cardiologist** (medical specialists dealing with the heart and its disorders) is able to measure the heart's ability to conduct cardiac impulses by means of an **electrocardiogram** (ECG or EKG).

**Blood Vessels and Circulations**

closed circulatory system

types of blood vessels:
1. **Arteries** - carry blood away from the heart, velocity fastest
2. **Veins** - carry blood toward the heart, equipped with valves
3. **Capillaries** - connect arteries and veins, functional units of the circulatory system, velocity slowest

arteries
arterioles
capillaries
venules
veins

As your heart beats and the left ventricle forces blood into the aorta, the elastic walls of the arteries expand. This wave of expansion moves down the aorta and along smaller arteries. As the wave passes, the elastic walls of the arteries resume their normal size.
**pulse**: dilation and rebounding of an artery  
no pulse in a vein

You can measure your pulse any place you can compress an artery against a bone or other firm tissue (radial artery in wrist, carotid artery on side of neck, brachial artery in upper arm, femoral artery in thigh)

This pressure that causes the pulse is called blood pressure.

**blood pressure**: the force exerted by blood against the inner walls of blood vessels; normal is 120/80

**systolic pressure**: the maximum arterial blood pressure achieved during the systolic phase of the cardiac cycle (heart contracting)  
normal - 120  
high - 140-150

**diastolic pressure**: the lowest arterial blood pressure that remains during the diastolic phase of the cardiac cycle (heart relaxing)  
normal - 80  
high - 90-100

**sphygmomanometer**: instrument used to measure blood pressure

high blood pressure (hypertension): when blood pressure exceeds either or both limits (140-150 &/or 90-100)

If a person's systolic blood pressure rises to 200 or higher, there is danger of an artery rupturing and causing death.

Two main divisions (or routes) of the circulatory system:

**Pulmonary circulation**: carries blood from the right ventricle to the lungs

**Systemic circulation**: carries blood from the left ventricle to all parts of the body

1. **Coronary circulation**: carries blood in and out of the myocardium

2. **Portal circulation**: flow of blood to liver

3. **Renal circulation**: flow of blood to kidneys

Know the following diseases and disorders of the circulatory system found on page 631:

- anemia
- aneurysm
- arrhythmia
- coronary thrombosis
- edema
- hemorrhage
- mononucleosis
- phlebitis
- stroke