The Respiratory System
37–3 The Respiratory System

A. What Is Respiration?
B. The Human Respiratory System
C. Gas Exchange
D. Breathing
E. How Breathing Is Controlled
F. Diseases of the Respiratory System
What is respiration?

• Two different meanings in biology
  • On the cellular level, it is the release of energy from food molecules that occurs in mitochondria
  • On an organismal level, it is the gas exchange that occurs between the lungs and the environment
    • Sometimes referred to as breathing
    • Necessary for cellular respiration to continue
Human Respiratory System

Section 37-2

• Basic Function
  • To bring about the exchange of $O_2$ and $CO_2$ between the blood, air and tissues
  • Consists of a network of passageways that permit air to flow into and out of the lungs

• Parts
  • Nose (nasal cavity), pharynx, larynx, trachea, bronchi and lungs (which contain alveoli)
Parts of the Respiratory System

• Nasal Cavity – lined with cilia and mucous that clean, warm, and moisten the air

• Pharynx – where oral cavity and nasal cavity meet

• Trachea (windpipe) – a tube lined with cilia and mucous, surrounded by rings of cartilage for support, which branches into 2 tubes

• Bronchi – 2 tubes lined with cilia and mucous, surrounded by rings of cartilage for support, which enter the lungs and branch into many smaller tubes called bronchioles

• Bronchioles – lined with a mucous membrane, and at the end of each tube are the alveoli

• Alveoli – millions of air sacs found at the end of bronchioles; the walls are thin, moist and surrounded by capillaries
  - The functional unit of the respiratory system where gas exchange occurs
  - Gas exchange occurs through diffusion
Figure 37-13 The Respiratory System
Flowchart

Movement of Oxygen and Carbon Dioxide In and Out of the Respiratory System

Oxygen-rich air from environment → Nasal cavities → Pharynx → Trachea → Bronchi

Bronchi → Bronchioles → Oxygen and carbon dioxide exchange at alveoli → Alveoli → Bronchioles

Alveoli → Carbon dioxide-rich air to the environment

Trachea → Pharynx → Nasal cavities → Carbon dioxide-rich air to the environment
• Oxygen dissolves in the moisture on the inner surface of the alveoli and then diffuses across the capillary into the blood.
  – Once in the blood, oxygen binds to hemoglobin
    » hemoglobin increases the oxygen-carrying capacity of blood by 60 times
• Carbon dioxide diffuses in the opposite direction
• The movement of air into and out of the lungs
  – They expand and contract in response to pressure changes in the chest cavity by the rib cage and diaphragm.
• During inhalation
  – Ribs move out and up and the diaphragm moves down
    • this enlarges the chest cavity, which reduces the pressure around the lungs, which expand, so air flows to the lungs
• During exhalation
  – The ribs move in and down and the diaphragm moves up
    • The chest cavity gets smaller, creating more pressure around the lungs, so air is forced out of the lungs.
Figure 37-15 The Mechanics of Breathing

Inhalation:
- Air inhaled
- Rib cage rises
- Diaphragm

Exhalation:
- Air exhaled
- Rib cage lowers
- Diaphragm
• Breathing is not a completely voluntary or involuntary act
• The rate of breathing is controlled by the medulla oblongata
  – The brain is sensitive to the amount of CO2 in the blood.
  – When the CO2 level is high, nerve impulses from the breathing center are sent to the rib muscles and diaphragm
    » the higher the CO2 level, the stronger the impulses until you have to take a breath
• The regulation of CO2 in your blood is an example of negative feedback
Disorders of the Respiratory System

- **Bronchitis**
  - Inflammation of the bronchial linings, where air passages become narrower and filled with mucous, making breathing difficult and causing coughing

- **Asthma**
  - Allergic reaction which causes the bronchial tubes to narrow, resulting in difficulty breathing

- **Emphysema**
  - The walls of the alveoli break down, decreasing the surface area for gas exchange
  - Shortness of breath, difficulty in breathing and decreased lung capacity
Click the image to play the video segment.
Cardiovascular (Circulatory) System
1. Choose the longest vein you can see on the inner side of your wrist. Starting as close to your wrist as possible, press your thumb on the vein and slide it along the vein up your arm. Did the length of the vein remain blue?

2. Repeat this process, but in the opposite direction, moving your thumb along the vein from the far end to the end closest to your wrist. Did the length of the vein remain blue?

3. In which direction is your blood flowing in this vein? How can you tell? Can you tell where a valve is located? Explain your answer.
37–1 The Circulatory System
A. Functions of the Circulatory System
B. The Heart
   1. Circulation Through the Body
   2. Circulation Through the Heart
C. Blood Vessels
   1. Arteries
   2. Capillaries
   3. Veins
D. Blood Pressure
E. Diseases of the Circulatory System
   1. High Blood Pressure
   2. Consequences of Atherosclerosis
   3. Circulatory System Health
The majority of our cells are not in contact with the environment.
- Due to this, we can not rely on diffusion to transport materials from cell to cell.
- Most of the substances needed in one part of the body are produced in another part.

Larger organisms, including humans, have evolved circulatory systems to deal with transport of materials around larger areas.
- Our circulatory system is a closed system.
  - Our circulating fluid, blood, is contained within vessels
- The circulatory system consists of the heart, blood vessels and blood.
The heart is composed almost entirely of muscle (cardiac).
- It is a hollow organ, surrounded by a tissue known as pericardium.

It is divided into left and right sides, by a wall known as the septum.
- The septum prevents oxygen-rich blood and oxygen-poor blood from mixing.
- On either side of the septum are two chambers.
  - The upper chambers are called atria
    - They receive blood
  - The lower chambers are called ventricles
    - They pump blood out of the heart
- The atria and ventricles are separated by valves.
  - The valves prevent blood from flowing back into the atria.
Two pathways of circulation

• Pulmonary circulation
  – Blood is pumped from the heart to the lungs
• Systemic circulation
  – Blood is pumped from the heart to the rest of the body.
Oxygen-poor blood enters the right atria from the superior and inferior vena cavae. It flows into the right ventricle and is pumped into the pulmonary artery to go to the lungs. At the lungs, CO$_2$ leaves the blood and oxygen enters. The oxygen-rich blood then enters the pulmonary vein and returns to the heart. The blood flows into the left atria and then flows into the left ventricle. It is then pumped into the aorta, which carries oxygen-rich blood to the body.
Figure 37-2 The Circulatory System

Capillaries of head and arms
Superior vena cava
Capillaries of right lung
Inferior vena cava
Capillaries of abdominal organs and legs
Aorta
Pulmonary artery
Capillaries of left lung
Pulmonary vein
Superior vena cava
Figure 37-3 The Structures of the Heart

**Superior Vena Cava**
Large vein that brings oxygen-poor blood from the upper part of the body to the right atrium

**Pulmonary Veins**
Bring oxygen-rich blood from each of the lungs to the left atrium

**Pulmonary Valve**
Prevents blood from flowing back into the right ventricle after it has entered the pulmonary artery

**Tricuspid Valve**
Prevents blood from flowing back into the right atrium after it has entered the right ventricle

**Inferior Vena Cava**
Vein that brings oxygen-poor blood from the lower part of the body to the right atrium

**Aorta**
Brings oxygen-rich blood from the left ventricle to the rest of the body

**Pulmonary Arteries**
Bring oxygen-poor blood to the lungs

**Left Atrium**

**Aortic Valve**
Prevents blood from flowing back into the left ventricle after it has entered the aorta

**Mitral Valve**
Prevents blood from flowing back into the left atrium after it has entered the left ventricle

**Left Ventricle**

**Right Atrium**

**Right Ventricle**

**Septum**
Blood Vessels

Section 37-1

Three types of blood vessels

- Arteries
  - Always carry blood away from the heart
    - With the exception of the pulmonary artery, they carry oxygen-rich blood
  - They have very thick walls that help them withstand the pressure produced when the heart contracts and blood is pushed in.

- Capillaries
  - The smallest of the blood vessels
    - Only one-cell thick, so blood cells can only pass through single file.
    - All gas and nutrient exchange occurs here.

- Veins
  - Always carry blood to the heart
    - With the exception of the pulmonary vein, they carry oxygen-poor blood.
  - Contain valves, which help blood to keep moving towards the heart and prevent it from pooling.
Figure 37-5 The Three Types of Blood Vessels

Artery
- Endothelium
- Arteriole
- Connective tissue
- Smooth muscle
- Endothelium

Capillary
- Endothelium

Venule
- Endothelium
- Valve
- Vein
- Connective tissue
- Smooth muscle
- Endothelium
The force of the blood on the walls of the arteries
- Measured with a sphygmomanometer (blood pressure cuff)
- Air is pumped into the cuff until an artery is blocked.
  - When the pressure is released, the tech listens to the pulse and records two numbers
  - The first number is the systolic pressure
    - The force felt in the arteries when the ventricles contract
  - The second number is the diastolic pressure
    - The force of the blood felt in the arteries when the ventricles relax.
Parts of the Blood

- Plasma (55% of the blood)
  - A straw-colored fluid which is about 90% water and 10% dissolved gases, salts, nutrients, enzymes, hormones, waste products and plasma proteins

- Cells (45% of the blood)
  - RBC’s
    - Most numerous
      - Contain hemoglobin, which is the iron-containing protein that binds oxygen
  - WBC’s (leukocytes)
    - They are the army of the circulatory system
    - May increase dramatically when the body is fighting an infection
  - Platelets
    - Help in blood clotting by clumping together at the injury to prevent blood from flowing out of the cut
Figure 37-7 Blood

Whole Blood Sample

Sample Placed in Centrifuge

Blood Sample That Has Been Centrifuged

- Plasma
- Platelets
- White blood cells
- Red blood cells
# Types of White Blood Cells

<table>
<thead>
<tr>
<th>Cell Type</th>
<th>Function</th>
</tr>
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<tbody>
<tr>
<td>Neutrophils</td>
<td>Engulf and destroy small bacteria and foreign substances</td>
</tr>
<tr>
<td>Eosinophils</td>
<td>Attack parasites; limit inflammation associated with allergic reactions</td>
</tr>
<tr>
<td>Basophils</td>
<td>Release histamines that cause inflammation; release anticoagulants, which prevent blood clots</td>
</tr>
<tr>
<td>Monocytes</td>
<td>Give rise to leukocytes that engulf and destroy large bacteria and substances</td>
</tr>
<tr>
<td>Lymphocytes</td>
<td>Some destroy foreign cells by causing their membranes to rupture; some develop into cells that produce antibodies, which target specific foreign substances</td>
</tr>
</tbody>
</table>
Figure 37-10 Blood Clotting

**Break in Capillary Wall**
Blood vessels injured.

**Clumping of Platelets**
Platelets clump at the site and release thromboplastin. Thromboplastin converts prothrombin into thrombin..

**Clot Forms**
Thrombin converts fibrinogen into fibrin, which causes a clot. The clot prevents further loss of blood.
Diseases of the Circulatory System

- Atherosclerosis
  - Fatty deposits called plaques build up on the inner walls of the arteries
- Hypertension
  - High blood pressure
- Increases the risk of heart attack and stroke
  - Heart attack
    » Part of the heart muscle may die from lack of oxygen due to a blocked artery
    » If enough heart muscle is damaged, then a heart attack occurs
  - Stroke
    » Blood clots that form may get stuck in a blood vessel leading to a brain
    » Brain cells may become deprived of oxygen and brain function may be compromised
**Blood Transfusions**

Section 37-2

- Blood type is determined by antigens on our blood cells
  - Type A – have A antigens
  - Type B – have B antigens
  - Type AB – have A & B antigens
  - Type O – have no antigens

When blood types match, transfusions are successful

<table>
<thead>
<tr>
<th>Blood Type of Donor</th>
<th>Blood Type of Recipient</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>A</td>
<td>✔</td>
<td>X</td>
</tr>
<tr>
<td>B</td>
<td>X</td>
<td>✔</td>
</tr>
<tr>
<td>AB</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>O</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>

X = Unsuccessful transfusion

✔ = Successful transfusion
Lymphatic System

• Collects fluid lost from the blood and return it back to the circulatory system
  – Consists of a network of vessels, nodes and organs.
    • Lymph vessels – contain valves to prevents backflow
    • Spleen – main function is to destroy damaged red blood cells and platelets
    • Thymus – certain WBC’s mature here before they can function in the immune system
    • Nodes – act as filters to trap bacteria and other microorganisms
• Also plays a role in nutrient absorption
  – Helps absorb fats and fat-soluble vitamins from the intestines and carry them to the blood
Figure 37-11 The Lymphatic System

- Superior vena cava
- Lymph nodes
- Thymus
- Heart
- Thoracic duct
- Spleen
- Lymph vessels
Video 2

Human Circulation

Click the image to play the video segment.