The Immune System and Gas Exchange

Section 11.4 and Chapter 10
Review: Function of Blood Cells

- Red blood cells
- Platelets
- Blood Cells
- Granulocytes
- White blood cells
- Agranulocytes

- Release (clot digesting enzyme)
- (anticoagulant)
- and (inflammation)

- Phagocytosis of large particles
Function of the Immune System

What is the function of the immune system?
Function of the Immune System

What is the function of the immune system?

The roles of the immune system can be summarized in the following statements:

- Recognize healthy body cells and harmful foreign invaders or damaged and irregular cells.
- Attack and destroy invaders
- Destroy and remove damaged, infected, or irregular cells
- Remember previous infections, and respond quickly to repeated exposures
Function of the Immune System

We have already discussed a few topics related to immunity.

Which types of blood cells are mostly responsible for protecting the body against disease?

Where are lymphocytes found in the body?
Review of Terms

Define the following terms:

Antigen:

Antibody:
Review of Terms

Define the following terms:

**Antigen:** Any substance that can cause an immune response. Proteins and other large molecules on the surface of bacteria, viruses, and cancer cells can all act as antigens.

**Antibody:** These are Y-shaped molecules produced by lymphocytes which can bind to antigens. Antibodies are very specific; most will bind only to a single antigen molecule.
One Role of Antigens

Where have we seen antigens already?

Blood types!

Our red blood cells carry antigens, which our immune system recognizes as "self", or belonging to our own bodies.

Not everyone carries the same antigens...the antigens on your blood cells determine your blood type.

In human blood, there are three antigens which combine to determine blood type.
# Blood Types

What are the three possible antigens that can be found on RBCs?

<table>
<thead>
<tr>
<th>Antigen A</th>
<th>Antigen B</th>
<th>Rh Antigen</th>
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</table>

These antigens allow for eight blood types in humans.

If your blood carries the A or B antigen, that letter is included in your blood type.

Rh is different...if you carry the Rh antigen, you add "+" to your blood type.  
If you *don't* carry the Rh antigen, you add - to your blood type.
Blood Types

Your blood also carries *antibodies*.

You will carry the antibodies which will recognize and bind to any blood cells which carry antigens you *don't* have.

In other words, if your blood doesn't carry the Antigen B, you *will* have the *anti-B antibody*. Your immune system releases antibodies which will bind to this antigen, causing the blood to "clump".
Blood Types

So, you can only receive a blood transfusion from a blood type which does not carry antigens that you produce antibodies for ... in other words, it cannot carry any antigens that your own blood doesn't have.

However, the blood does not have to have all of the same antigens as your blood.
To determine blood type, blood samples have each of the three antibodies added to it.

The antibodies which cause a clumping reaction indicate which antigens are present.

For example, type B+ blood caused reacted with the Anti-B and Anti-Rh antibodies, but not with the Anti-A antibody.
# Blood Types

Complete the following table:

<table>
<thead>
<tr>
<th>Blood Type</th>
<th>Antigens Carried</th>
<th>Antibodies in blood</th>
<th>Safe Transfusions</th>
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</thead>
<tbody>
<tr>
<td>A+</td>
<td>A, RH</td>
<td>B</td>
<td>A+, A−, O+, O−</td>
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<tr>
<td>A−</td>
<td>A</td>
<td>B, RH</td>
<td>A−, O−</td>
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<td>B+</td>
<td>B, RH</td>
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<td>B+, B−, O+, O−</td>
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<tr>
<td>B−</td>
<td>B</td>
<td>A, RH</td>
<td>B−, O−</td>
</tr>
<tr>
<td>AB+</td>
<td>A, B, RH</td>
<td>—</td>
<td>All (Universal Recipient)</td>
</tr>
<tr>
<td>AB−</td>
<td>AB</td>
<td>RH</td>
<td>A−, B−, AB−, O−</td>
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<tr>
<td>O+</td>
<td>RH</td>
<td>A, B</td>
<td>O+, O−</td>
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<tr>
<td>O−</td>
<td>—</td>
<td>A, B, RH</td>
<td>O− (Universal Donor)</td>
</tr>
</tbody>
</table>
Think You Understand Blood Typing?

See if you can keep patients alive in the

Blood Typing Game
Read pages 382-384, up to the section titled "Cellular Immunity and Antibody Immunity"

Carefully examine the diagram of the bodies defense systems shown in Figure 11.26 on page 383.

Define the following terms:
Immunity; pathogens; phagocytosis

Answer the following questions:
1) What are the three lines of defense the body uses to fight off invaders?
2) What is the difference between a pathogen and an antigen?
3) How are the non-specific defenses different from the specific immune system?
4) What is the difference between T-lymphocytes and B-lymphocytes?
Lines of Defense

The body has three major lines of defense against invaders. The first two are called *non-specific* defenses, because they are able to react to a wide range of pathogens.

The first line of defense is the *physical and chemical barriers* which prevent pathogens from entering the body at all.

List the physical and chemical barriers:

- Skin
- Sweat, skin oils
- Mucus lining digestive path & airways
- Nose hairs
- Ear hairs
- Tears
- Stomach acid
First Line of Defense

**Skin** *(waterproof *keratin* layer)*

**Skin oils and sweat** *(contain *bactericides* that is slightly acidic)*

**Mucus lining** of respiratory and digestive pathways *(saliva, *cilia* lining the trachea, etc.)*

**Stomach acid**

Also *tears*, *nose and ear hair*, *urine*.
The first line of defense also includes the phagocytic leucocytes.

There are three major types.
Name them, and distinguish between them:

- **Neutrophils** (small particles)
- **Monocytes** (large particles)
- **Macrophages** (develop from monocytes)
The second line of defense involves *inflammation*. This is a response to the presence of pathogens attacking body cells.

Body cells which are under attack, and basophils attracted to the site, release *histamine*. This increases blood flow to the area, and attracts phagocytes (neutrophils, monocytes, and macrophages).
Macrophages are giant white blood cells which ingest large amounts of pathogens and damaged tissue.

Inflammation has several symptoms, such as redness, warmth, swelling, and soreness, all related to the increased blood flow in the area of attack.

How does histamine increase blood flow? (What physical response does it cause to happen?)
Second Line of Defense

How does increased blood flow contribute to all of these symptoms?

Swelling: As vessel expands, pores enlarge, and more plasma enters interstitial spaces.

Redness: More blood near surface.

Heat: Increased blood flow carries more heat to the area.

Soreness: Increased interstitial fluid buildup causes pressure on nerve endings, makes area more sensitive to pain.
Interstitial fluid containing live and dead pathogens and dead white blood cells forms pus at the site of infection. The pus will drain from the body, or be reabsorbed into the lymph where lymph nodes remove the dead material.

If the pathogen is a virus, infected cells will also release the protein interferon, which signals neighboring cells to create enzymes to prevent viral reproduction.
Third Line of Defense: Specific Defenses

The third Line of Defence is the *immune response* which uses the macrophages and lymphocytes to attack and destroy foreign material in the body.

The system is based on the presence of *antigens* which are proteins or carbohydrates on the cell membranes of foreign cells. Antigens indicate to the immune system that these cells do not belong.

The reason this system is called *specific* is that the immune system must be able to recognize a specific antigen to respond, and produce the correct antibodies to fight that pathogen.
Third Line of Defense: Specific Defenses

The two major types of lymphocytes involved in the immune response are B Cells and T Cells, which are produced in bone marrow.

View Animation of T-Cell and B-Cell Formation
B Cells and T Cells

Where do T-Cells mature?
Thymus → Lymph Nodes

What is T-Cell immunity called?
Cellular

Where do B-Cells mature?
Bone marrow → Lymph nodes

What is B-Cell immunity called?
Antibody (Humoral)
Antibodies are Y-shaped proteins made up of 2 heavy and 2 light polypeptides. The binding site which recognizes antigens are designed specifically for each one...most antibodies can only bind to one type of antigen.

Fortunately, your body produces many different antibodies, so it is able to respond and destroy almost any antigen it finds.
Review pages 382-384, and read pages 384-385 in your text.

Use this information to create flow-chart type diagrams, including illustrations, of the steps in both cellular immunity and antigen immunity. (Use a full page for each map; note that some of the initial steps will be the same.)

Then, answer the following questions:

1) What is the difference in the types of pathogens that cellular and antibody immunity respond to?

2) How do memory T and B cells help provide immunity against future infections?
Group Work

Each student will be assigned a letter, either A or C.

The 'A's are responsible for  *Antibody Immunity*.

The 'C's are responsible for  *Cellular Immunity*.

All Antibodies move to the  *right side* of the room.

All Cellulars move to the  *left side* of the room.
Assign each member of the group a number from 1-5. Remember your *number* and your *letter*.

Now, get into groups with your numbers.

There should be 4-6 people per group.
Group Work

Your assignment:

• One member of each group will take three sheets of chart paper and two markers
• We will move to the bio lab area, with each number group staying together (all the 1s, all the 2s, etc.)
• Each group will split into two sections, Antibodies and Cellulairs
• Each section (of two or three people) will use the chart paper to outline the steps in their immune response (15 minutes)
• Each group will come back together, and the sections will review their process with the other group members. (15 minutes)
• Groups will write any questions or problems they are having with the processes to bring back to class (5 minutes)
• Return to class, being sure to bring all materials with you
Return to class:

- One group volunteer to present their maps to the class

- Questions on the processes?

- Use SMART Board to outline steps in both processes
The Human Respiratory System

Class Outline for Thursday

• Take introductory notes on respiratory system

• View animations related to respiration

• Read section from book, and complete assignment

• Homework: review immune response and intro to respiratory system for Friday

*(Note: I will review the steps in cellular and antibody immunity with the class on Friday)*
Gas exchange is the physical method that organisms use to obtain oxygen from their surroundings and remove carbon dioxide.

Oxygen is needed for aerobic respiration.

The respiratory surface is the physical location of gas exchange in the organism.

What is the respiratory surface in humans?

LUNGS
Requirements of a Respiratory System

A respiratory surface has several requirements to be effective.

1. *The surface area must be large.*
   A larger surface area increases the amount of diffusion; the area must be large enough to supply the organism's needs

2. *The surface must be moist.*
   O₂ and CO₂ must be dissolved in a liquid before they can diffuse

3. *The surface must be in contact with a supply of O₂*
   There must be oxygen available, and a way to remove CO₂

4. *The surface must be thin.*
   Diffusion occurs faster through a thin surface
Requirements of a Respiratory System

5. In most multicellular organisms, the respiratory surface must be in contact with a transport system. Not all the cells are in contact with the outside environment. Therefore a transport system is needed to deliver $O_2$ and remove $CO_2$.

What is the transport system in humans?

Circulatory system...the heart and blood vessels
Stages in Gas Exchange

Gas exchange can be divided into several distinct phases.

1. **Breathing** This includes *inspiration*, or *inhaling* (taking air into the lungs) and *expiration*, or *exhaling* (forcing air out of the lungs).

2. **External Respiration** Exchange of oxygen and carbon dioxide between the air in the lungs and the blood.

3. **Internal Respiration** Exchange of oxygen and carbon dioxide between the blood and cells in body tissues.

4. **Cellular Respiration** Chemical reactions that break down glucose to release energy; these reactions use oxygen and produce carbon dioxide.
Stages in Gas Exchange

Animation: Breathing

Click the link to view the breathing process.
Structures of the Respiratory Tract

You should be able to identify and describe the structure and function of all major parts of the respiratory tract.

1) **Nose**  
Air enters the nose through 2 nostrils.  
Hairs help remove particles from the air  
(dust, pollen, etc.)

2) **Nasal cavity (a.k.a. sinuses, nasal passages)**  
The walls of the nasal passages, and the rest of the airway, are lined with *mucous membranes*. Some cells secrete mucus and others have *cilia*. The lining holds many capillaries. This serves three functions:  
a) Moistens the air  
b) Warms the air  
c) Traps foreign material such as bacteria and dust  
This prevents damage to lung tissue by the cold air.
3) **Pharynx**  
The back of the throat, behind the mouth and nasal cavity. The pharynx contains many other openings, such as the Eustachian tubes (connected to the ears), oral cavity, esophagus, and trachea.

4) **Trachea**  
aka the *windpipe*. Leads from the pharynx into the chest (*thoracic*) cavity. Contains “U” shaped cartilage rings in its wall to keep it open. Approx. 12 cm long by 2.5 cm wide. The trachea is lined with a *ciliated mucous membrane* to move mucus and trapped debris up and out into the pharynx.

* Tobacco smoke (*just one cigarette!*) will stop the cilia for *20 minutes* and increase the amount of mucus present. This causes coughing and increases the risk of respiratory infection.
Animations

Healthy Cilia

Unhealthy Cilia

Click the links to view the breathing process.
5) **Larynx** (a.k.a. *Adam’s apple* or *voice box*)

Found at the top of the trachea, the larynx is made mainly of cartilage and some small bones. A pair of membranes (*vocal cords*) stretch across the larynx and vibrate as air flows over them. By controlling the amount of air and the vibrations of the vocal cords, humans can control the loudness and pitch of their voice.

The *epiglottis* at the top of the larynx is a muscular flap which prevents food from entering the trachea during sallowing.
6) **Bronchi**  The trachea divides in the middle of the chest into two smaller cartilage ringed tubes called *bronchi*, each leading to one of the lungs. The bronchi are lined with a ciliated mucous membrane.

7) **Bronchial tubes**  Inside the lung, each bronchi divides into a tree-like network of smaller and thinner tubes called *bronchial tubes*.

8) **Bronchioles**  The bronchial tubes divide to form even smaller and thinner tubes called *bronchioles.*

*This is similar to arteries branching into arterioles and then capillaries.*
9) **Alveoli**  
(Singular: alveolus) At the end of each bronchiole, there is a grape-like cluster of cavities called *alveoli*. There are approximately 300 million, with a total surface area of 70 m², or about the size of a classroom! Each alveolus is surrounded by a network of capillaries.

The alveoli are the actual respiratory surface where gas exchange takes place.
## Structures of the Respiratory Tract

Additional structures you should be aware of:

<table>
<thead>
<tr>
<th><strong>Diaphragm</strong></th>
<th>This thin sheet of muscle forms the floor of the chest cavity and is involved in breathing.</th>
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</thead>
<tbody>
<tr>
<td><strong>Ribs</strong></td>
<td>This portion of the skeletal system protects the chest cavity, and along with intercostal muscles is involved in breathing</td>
</tr>
<tr>
<td><strong>Pleura</strong></td>
<td>This two layered membrane completely encloses each lung; one layer covers the lung, the other is in contact with the diaphragm and other chest cavity organs. The pleura maintain a thin fluid layer inside, to make movement of the lungs easier within the chest cavity.</td>
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</tbody>
</table>
Animation: Structures of the Respiratory Tract

Click the link to view the breathing process.
Label the Structures of the Respiratory System

1. nasopharynx
2. oropharynx
3. larynx
4. trachea
5. bronchi
6. bronchial tubes
7. bronchioles
8. diaphragm
9. epiglottis
10. capillaries
11. nasal passages
12. larynx
13. trachea
14. alveoli
Homework

Read pages 332-342 in your text, and answer the following questions:

#1-3 and 5 on page 337, and #1 on page 342
Breathing is controlled by two sets of muscles, the **diaphragm** and the **intercostal muscles**.

The diaphragm is the layer of muscle separating the **thoracic cavity** (chest region, containing the heart and lungs) from the **abdominal cavity** (lower torso, containing the digestive organs, kidneys, etc.)

The intercostal muscles are the layer of muscle between and beneath the ribs.
When we **inhale**, the diaphragm and intercostal muscles contract. (Contracting the diaphragm pulls the muscle sheet *downward*.)

At the same time, the intercostal muscles contract, pulling the ribs *upward and outward*.

All of this *increases* the space in the thoracic cavity, reducing pressure. As a result, air outside, which is under higher pressure, flows into the lungs.

**Animation**
The Mechanics of Breathing

When we **exhale**, the diaphragm and intercostal muscles relax. (Relaxing the diaphragm allows the abdominal muscles to push internal organs in and up, forcing the diaphragm's muscle sheet *upward*.)

At the same time, the intercostal muscles relax, and the ribs move *downward* and *inward*.

All of this *decreases* the space in the thoracic cavity, increasing pressure. As a result, air outside the lungs are under lower pressure, and flows out of the lungs.

**Animation**
External Respiration

External respiration involves the gas exchange which occurs in the alveoli.

Because blood entering the lungs is low in oxygen, there is a higher O₂ concentration (or pressure) in the air. Oxygen crosses from the alveolar spaces into the capillaries, where it enters the blood and is picked up by red blood cells and carried by hemoglobin.

When four oxygen molecules bind with hemoglobin, it forms a molecule of oxyhemoglobin.
At the same time, carbon dioxide diffuses out of the blood and into the alveoli. This is because the concentration of CO$_2$ is higher in the blood than in the air.

Where does the CO$_2$ come from?

It is a product of cell respiration!
Control of Breathing

The normal rate of breathing is **12-25 breaths per minute**. This can be controlled somewhat, but is generally under involuntary control by the respiratory center in the brain.

Several of the larger arteries (including the aorta) have **chemoreceptors** which measure the amount of \( \text{O}_2 \) and \( \text{CO}_2 \) in the blood, and relay messages to the respiratory center in the brain.

High \( \text{CO}_2 \) in the blood causes the brain to send signals which increase breathing rate. High \( \text{O}_2 \) levels in the blood cause the brain to send signals to decrease breathing rate. The presence of **lactic acid** in the blood (due to exercise) will also increase breathing rate.
Control of Breathing

Under what conditions would you expect the levels of CO$_2$ in your blood to increase?

Where would lactic acid in the blood come from?
Internal Respiration

As blood leaves the lungs and is sent to other parts of the body it passes through sets of capillaries that lie near all body cells.

The blood has a high concentration of oxygen and the body cells have a high concentration of carbon dioxide. Diffusion occurs between the blood and body cells:

* Oxygen diffuses into the interstitial fluid, then into body cells
* CO2 diffuses out of the cells, and into the blood

Most of the carbon dioxide carried in the blood is actually combined with water molecules in the blood to form carbonic acid (H2CO3), which then breaks down into H+ and HCO3- ions.
Why Hemoglobin and Carbonic Acid?

Can you think of a reason why the body would transport oxygen and carbon dioxide using oxyhemoglobin and carbonic acid?
Lung Capacity

Read pages 340-341, and explain the meaning of the following terms:

- Tidal volume
- Inspiratory reserve volume
- Expiratory reserve volume
- Vital capacity
- Residual volume
Lung Capacity

**Tidal volume:** Volume of air taken in or expelled during a normal breath.

**Inspiratory reserve volume:** Amount extra you could inhale.

**Expiratory reserve volume:** Amount extra you could exhale.

**Vital capacity:** Total volume of air you could move in or out of your lungs.

**Residual volume:** Amount of air left in lungs and airways even after exhaling as much as you can.
Asthma

Animation: Asthma
Homework

Read Section 10.3 in your text (pages 343-348)

Create a table outlining the common respiratory diseases described in this section (lung cancer, pneumonia, bronchitis, asthma, and emphysema). Include the headings shown below:

<table>
<thead>
<tr>
<th>Disease</th>
<th>Cause</th>
<th>Physical Effect on Lungs</th>
<th>Treatment</th>
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Title: Nov 28-8:48 AM (70 of 91)
<table>
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<th>Disease</th>
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Title: Nov 28-8:48 AM (73 of 91)
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Cellular Immunity
Cellular Immunity
Cellular Immunity
Antibody Immunity
Antibody Immunity
Review Cellular and Antibody immunity.

Read Section 10.1 (pages 332 - 337) in your text.

Complete Questions #1-3 and 5 on page 337
Immunity Manipulative

Title: Nov 29-2:26 PM (91 of 91)