Chapter 10
The Respiratory System

Why do we breathe?

- Cells carry out the reactions of cellular respiration in order to produce ATP. ATP is used by the cells for energy.
- All organisms need energy, therefore all organisms carry out cellular respiration.
- The energy needed to produce ATP comes from glucose. As we saw in the previous slides, glucose is produced by photosynthesis.
- The equation for cellular respiration is:
  \[ C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 36 \text{ ATP} \]
- How do we get this oxygen, and get rid of the CO₂?
Respiration

- Respiratory surface – any surface across which gases are exchanged for the purpose of respiration
- In humans, the respiratory surface is contained in the lungs. They are internal in order to keep the respiratory surface moist.
- Breathing – the taking in and releasing of air in and out of the lungs
- Inspiration: taking air in
- Expiration: the act of breathing out
- External respiration – the exchange of oxygen and carbon dioxide between the air and blood
- Internal respiration – the exchange of oxygen and carbon dioxide between the blood and the cells of the surrounding tissue
- Cellular respiration – the complex series of chemical reactions that may take place mainly in the mitochondria of cells

Function of the respiratory system

- Gas exchange
  - CO₂ must be able to leave each cell
  - O₂ must be able to enter each cell
- Diffusion
  - What types of diffusion are involved?
- How are these gases transported to all the cells in the body?
The Lung

Three Basic Elements
Moist surface area
Means of forcing air to come in contact with lung surface
Circulatory system to carry the gases between lungs and other cells

Respiratory Tract
Parts of the Human Respiratory System

- 1. **Nostrils** – openings in the nose where air enters. As well, the lining of the nostrils helps warm and moisten air and it also filters it.
- 2. **Pharynx** – structure located just behind the mouth that connects the mouth and nasal cavity to the larynx and esophagus. Also known as the throat.
- 3. **Larynx** – a structure within the upper respiratory tract that contains the vocal cords. Also known as the “voice box”.

- 4. **Trachea** – tube that carries air from the nasal passages or mouth to the lungs. Also known as the “windpipe”.
- 5. **Bronchi** – the passageways that branch from the trachea into the lungs. One bronchus carries air to each lung.
- 6. **Bronchioles** – the passageways that branch from the bronchi into the separate lobes of the lungs. The bronchioles divide into smaller and smaller passageways that carry air into all portions of the lungs.
Parts of the Human Respiratory System

7. **Alveoli** – the gas exchange structures within the lungs. Alveoli are tiny air pockets with walls made of a membrane a single cell thick. Respiratory gases are exchanged across these cell membrane walls.

8. **Diaphragm** – a muscle layer that forms the floor of the thoracic cavity. The contraction of the diaphragm contributes to inspiration by increasing the volume of the thoracic cavity.

9. **Pleura** – the membranes that envelop the lungs. Each lung is encased in two separate by a thin layer in fluid.

10. **Intercostal Muscles** – muscles of the rib cage. These muscles help to expand and contract the rib cage and play an important role in breathing.
External Respiration

• External respiration takes place in the lungs. The exchange of oxygen and carbon dioxide occurs across cell membranes. The alveoli and adjacent capillaries each have walls which are only one cell thick, so diffusion is easy. Carbon dioxide diffuses from the blood to the lungs, and oxygen from the lungs to the blood.
The Mechanics of Breathing – inhalation (inspiration)

- **Inhalation**
- During inhalation, the intercostal muscles contract which causes the rib cage to lift up and out. As well, the diaphragm contracts and pulls down.
- These two things cause the pressure inside the chest cavity to drop compared to the outside. As a result, air rushes in to fill the lungs.

Mechanics - Inhalation
The Mechanics of Breathing – exhalation (expiration)

- **Exhalation**
  - The intercostals muscles relax and the ribs move back to their normal position. As well, the diaphragm relaxes and moves back up
  - These two things cause the pressure inside the chest cavity to be greater than outside, so air is forced out of the lungs
  - Note that the lungs are not active in taking in air or pushing it out; the lungs are essentially empty sacs
Comparison of Inhaled vs. Exhaled Air

<table>
<thead>
<tr>
<th></th>
<th>Inhaled Air</th>
<th>Exhaled Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen</td>
<td>~ 21%</td>
<td>~ 16.5%</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>~ 0.04%</td>
<td>~ 4.5%</td>
</tr>
<tr>
<td>Nitrogen and other gases</td>
<td>~ 79%</td>
<td>~ 79%</td>
</tr>
</tbody>
</table>

Lung Capacity

- Under normal conditions, your regular breathing does not use up the full capacity of the lungs.
- **tidal volume**: the volume of air inhaled and exhaled in a normal breathing movement
- **inspiratory reserve volume**: the additional volume of air that can be taken in beyond a regular or tidal inhalation
- **expiratory reserve volume**: the additional volume that can be forced out of the lungs beyond a regular or tidal exhalation
Lung Capacity

- **vital capacity**: the total volume of gas that can be moved into and out of the lungs
- Vital capacity = tidal volume + inspiratory reserve + expiratory reserve
- **residual volume**: the amount of gas that remains in the lungs and the passageways of the respiratory system even after a full exhalation.
- **Respiratory efficiency**: rate at which oxygen can be transferred from the respiratory surface to the internal transport system or tissues of an animal.
Respiratory Diseases

- **Lung Cancer**
  - Lung cancer: uncontrolled and invasive group of abnormal cells in the lungs
  - Carcinoma: malignant tumour
  - Carcinogen: a cancer-causing agent
  - Death not usually caused by difficulty breathing, but the cancer spread to other parts of the body
  - 87% of lung cancer caused by cigarette smoking, 12% by radon exposure

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Respiratory Diseases

- **Pneumonia**
  - Pneumonia: disease of the lungs that causes the alveoli in the lungs to inflame and fill with liquid. This impairs their ability to take in oxygen, so body cells become starved
  - 2 types:
    - i. lobar – affects a lobe of the lung
    - ii. bronchial – affects patches in both lungs
  - Pneumonia can be caused by bacterial infections or viral infections. Bacterial infections tend to be more serious
Respiratory Diseases

• Asthma
  • → Asthma: chronic obstructive lung disease that can develop at any age, characterized by extreme sensitivity of the lungs to certain triggers that cause airways to react and become obstructed
  • → Asthma can be mild or severe, and in some cases can lead to death
  • → In asthma attacks, the airways of the lungs swell, the bronchial muscles tighten and increased mucus is secreted in the airway.
  • → Common triggers for asthma attacks include colds, exercise, exposure to pollen, tobacco smoke, cold air, dust, and so on.
  • → Medications used to treat asthma include anti-inflammatory agents and bronchodilators

Respiratory Diseases

• Chronic Bronchitis
  • → Chronic bronchitis: common obstructive respiratory disorder in which airways are inflamed and filled with mucus. Commonly, a cough brings up mucus and infection is likely to occur
  • → Most common cause is smoking
Respiratory Diseases

- Emphysema
  - Emphysema: chronic, obstructive incurable respiratory disease where the alveoli are distended and their walls become so damaged that the surface available for gas exchange is reduced and less oxygen is available to the brain and tissues
  - Only treatment for emphysema is reducing or eliminating smoking, exercise, some medications, and supplemental oxygen.