Chapter 10
Lecture Outline

See separate PowerPoint slides for all figures and tables pre-inserted into PowerPoint without notes.
Respiratory System
Points to ponder

• What are the parts and functions of the upper and lower respiratory system?
• What is the mechanism for expiration and inspiration?
• How is breathing controlled by the nervous system and through chemicals?
• Where and how is exchange of gases accomplished?
• What are some common respiratory infections and disorders?
• What do you know about tobacco and health?
Overview of the respiratory system

10.1 The Respiratory System

Figure 10.1 The human respiratory tract.
What is the pathway that air follows?

- nose
- pharynx
- larynx
- trachea
- bronchus
- bronchioles
- alveoli
What constitutes the upper respiratory tract?

- **Nose**

- **Pharynx**

- **Larynx**

Figure 10.2 The upper respiratory tract.
The nose

• The nose opens at the nostrils/nares and leads into the nasal cavities.

• Hairs and mucus in the nose filter the air.

• The nasal cavity has a lot of capillaries that warm and moisten the air.

• Specialized cells act as odor receptors.

• Tear glands drain into the nasal cavities that can lead to a runny nose.
The pharynx

- The **pharynx** is a funnel-shaped cavity commonly called the throat.

- It has three portions based on location: **nasopharynx**, **oropharynx**, and **laryngopharynx**.

- **Tonsils** provide a lymphatic defense during breathing at the junction of the oral cavity and pharynx.
The larynx

• The larynx is a triangular, cartilaginous structure that passes air between the pharynx and trachea.

• It is called the voice box and houses vocal cords.

• There are two mucososal folds that make up the vocal cords with an opening in the middle called the glottis.
The larynx

Figure 10.4 The vocal cords.
What constitutes the lower respiratory tract?

- Trachea
- Bronchial tree
- Lungs

Figure 10.1 The human respiratory tract.
The trachea

• The trachea is a tube, often called the windpipe, that connects the larynx with the primary bronchi.

• It is made of connective tissue, smooth muscle, and cartilaginous rings.

• The trachea is lined with cilia and mucus that help to keep the lungs clean.
10.3 The Lower Respiratory Tract

The trachea

Figure 10.5 The cells lining the trachea.

(bottom half): © ED Reschke
The bronchial tree

• The bronchial tree starts with two main bronchi that lead from the trachea into the lungs.

• The bronchi continue to branch until they are small bronchioles about 1 mm in diameter with thinner walls.

• Bronchioles eventually lead to elongated sacs called alveoli.
The lungs

- The secondary bronchi, bronchioles, and alveoli make up the lungs.

- The right lung has three lobes while the left lung has two lobes.

- Each lobe is divided into lobules.

- Each lung is enclosed by membranes called pleura.
The alveoli

• There are 300 million alveoli in the lungs that greatly increase surface area.

• Alveoli are enveloped by blood capillaries.

• The alveoli and capillaries are one layer of epithelium to allow exchange of gases.

• Alveoli are lined with surfactant that act as a film to keep alveoli open.
10.3 The Lower Respiratory Tract

The alveoli

Figure 10.6 Pulmonary circulation to and from the lungs.
Two phases of breathing/ventilation

1. Inspiration – an active process of inhalation that brings air into the lungs

2. Expiration – a typically passive process of exhalation that expels air from the lungs
10.4 Mechanism of Breathing

Boyle’s Law

- Ventilation is governed by Boyle’s Law.

- At a constant temperature the pressure of a given quantity of gas is inversely proportional to its volume.

**Figure 10.7** The relationship between air pressure and volume.
Inspiration

• The diaphragm and intercostal muscles contract.

• The diaphragm flattens and the rib cage moves upward and outward.

• Volume of the thoracic cavity and lungs increase.

• The air pressure within the lungs decreases.

• Air flows into the lungs.
10.4 Mechanism of Breathing

**Inspiration**

Figure 10.8a The thoracic cavity during inspiration.
Expiration

- The diaphragm and intercostal muscles relax.
- The diaphragm moves upward and becomes dome-shaped.
- The rib cage moves downward and inward.
- Volume of the thoracic cavity and lungs decreases.
- The air pressure within the lungs increases.
- Air flows out of the lungs.
10.4 Mechanism of Breathing

Expiration

Figure 10.8b The thoracic cavity during expiration.

b. Expiration

- **Rib cage moves down and in.**
- **Internal intercostal muscles pull the ribs inward during forced expiration.**
- **Diaphragm relaxes and moves up.**
- **When pressure in lungs increases, air is pushed out.**

- **Air out**
Different volumes of air during breathing

- **Tidal volume** – the small amount of air that usually moves in and out with each breath

- **Vital capacity** – the maximum volume of air that can be moved in plus the maximum amount that can be moved out during one breath

- **Inspiratory and expiratory reserve volume** – the increased volume of air moving in or out of the body

- **Residual volume** – the air remaining in the lungs after exhalation
Visualizing the vital capacity

Figure 10.9 Measuring the vital capacity of the lungs.
How is breathing controlled by the nervous system?

- Nervous control
  - Respiratory control center in the brain (medulla oblongata) sends out nerve impulses to contract muscle for inspiration.
  - Sudden infant death syndrome (SIDS) is thought to occur when this center stops sending out nerve signals.
How is breathing controlled by the nervous system?

1. **Brain**: Region of the brain that automatically regulates breathing.
2. **Respiratory Center**: Region of the brain that automatically regulates breathing.
3. **Intercostal Nerves**: Stimulate the intercostal muscles to contract.
4. **External Intercostal Muscles**: Help expand the thoracic cavity by contracting.
5. **Phrenic Nerve**: Stimulates the diaphragm to contract.
6. **Diaphragm**: Helps expand the thoracic cavity by flattening when it contracts.

**Figure 10.10**: The control of breathing by the respiratory center.
How is breathing chemically controlled?

• Chemical control
  – Two sets of chemoreceptors sense the drop in pH: one set is in the brain and the other in the circulatory system.
  
  – Both are sensitive to carbon dioxide levels that change blood pH due to metabolism.
Exchange of gases in the body

- Oxygen and carbon dioxide are exchanged.
- The exchange of gases is dependent on diffusion.
- Partial pressure is the amount of pressure each gas exerts ($P_{CO_2}$ or $P_{O_2}$).
- Oxygen and carbon dioxide will diffuse from the area of higher to the area of lower partial pressure.
External respiration

- Exchange of gases between the lung alveoli and the blood capillaries.

- $P_{CO_2}$ is higher in the lung capillaries than the air, thus CO$_2$ diffuses out of the plasma into the lungs.

- The partial pressure pattern for O$_2$ is just the opposite, so O$_2$ diffuses the red blood cells in the lungs.
External respiration

**Carbon dioxide transport:**
\[ H^+ + HCO_3^- \rightarrow H_2CO_3 \xrightarrow{\text{carbonic anhydrase}} H_2O + CO_2 \]

**Oxygen transport:**
\[ \text{Hb} + O_2 \rightarrow \text{HbO}_2 \]
The movement of oxygen and carbon dioxide in the body

Figure 10.11
Movement of gases during external and internal respiration.
Internal respiration

- The exchange of gases between the blood in the capillaries outside of the lungs and the tissue fluid.

- $P_{O_2}$ is higher in the capillaries than the tissue fluid, thus $O_2$ diffuses out of the blood into the tissues.
Internal respiration

Oxyhemoglobin gives up oxygen:

\[ \text{HbO}_2 \rightarrow \text{Hb} + \text{O}_2 \]

Most CO\(_2\) is carried as a bicarbonate ion:

\[ \text{CO}_2 + \text{H}_2\text{O} \xrightarrow{\text{carbonic anhydrase}} \text{H}_2\text{CO}_3 \rightarrow \text{H}^+ + \text{HCO}_3^- \]
Upper respiratory tract infections

- **Sinusitis** – blockage of sinuses
- **Otitis media** – infection of the middle ear
- **Tonsillitis** – inflammation of the tonsils
- **Laryngitis** – infection of the larynx that leads to loss of voice
Lower respiratory tract disorders

• **Pneumonia** – infection of the lungs with thick, fluid build up

• **Tuberculosis** – bacterial infection that leads to tubercles (collections of encapsulated bacteria)

• **Pulmonary fibrosis** – lungs lose elasticity because fibrous connective tissue builds up in the lungs, usually because of inhaled particles
Lower respiratory tract disorders

- **Emphysema** – chronic, incurable disorder in which alveoli are damaged, and thus the surface area for gas exchange is reduced.

- **Asthma** – bronchial tree becomes irritated causing breathlessness, wheezing, and coughing.

- **Lung cancer** – uncontrolled cell division in the lungs that is often caused by smoking and can lead to death.
Some Diseases and Disorders of the Respiratory System

Pneumonia
Alveoli fill with pus and fluid, making gas exchange difficult.

Bronchitis
Airways are inflamed due to infection (acute) or due to an irritant (chronic). Coughing brings up mucus and pus.

Asthma
Airways are inflamed due to irritation, and bronchioles constrict due to muscle spasms.

Emphysema
Alveoli burst and fuse into enlarged air spaces. Surface area for gas exchange is reduced.

Pulmonary Tuberculosis
Tubercles encapsulate bacteria, and elasticity of lungs is reduced.

Pulmonary Fibrosis
Fibrous connective tissue builds up in lungs, reducing their elasticity.

Figure 10.12 Some diseases and disorders of the respiratory system.
Things you should know about tobacco and health

- All forms of tobacco can cause damage.

- Smoking increases a person’s chance of lung, mouth, larynx, esophagus, bladder, kidney, pancreatic, stomach, and cervix cancers.

- Smoking also increases the chance of chronic bronchitis, emphysema, heart disease, stillbirths, and harm to an unborn child.

- Passive smoke can increase a nonsmoker’s chance of pneumonia, bronchitis, and lung cancer.