Chapter 7

The Respiratory System

Goals for this Chapter:

1. Explain how the upper respiratory tract filters, moistens, and directs air.
2. Describe the composition, structure, and function of the lower respiratory system.
3. Describe how the mechanical action of breathing moves gases into and out of the lungs.
4. Explain how gases are exchanged between the respiratory system and the environment.

5. Identify factors that affect the rate of respiration.
6. Identify diseases that are associated with the respiratory system.
7. Identify technologies used to identify and treat diseases and disorders of the respiratory system.

7.1 – Structures of the Respiratory System

- Respiration actually involves a 4-stage process:

1. Breathing – the movement of air into & out of the lungs
2. External respiration – the exchange of oxygen and carbon dioxide within the lungs
3. Internal respiration – the exchange of oxygen and carbon dioxide within the blood and body tissues
4. Cellular respiration – the oxidation of glucose for energy

Respiratory Structures

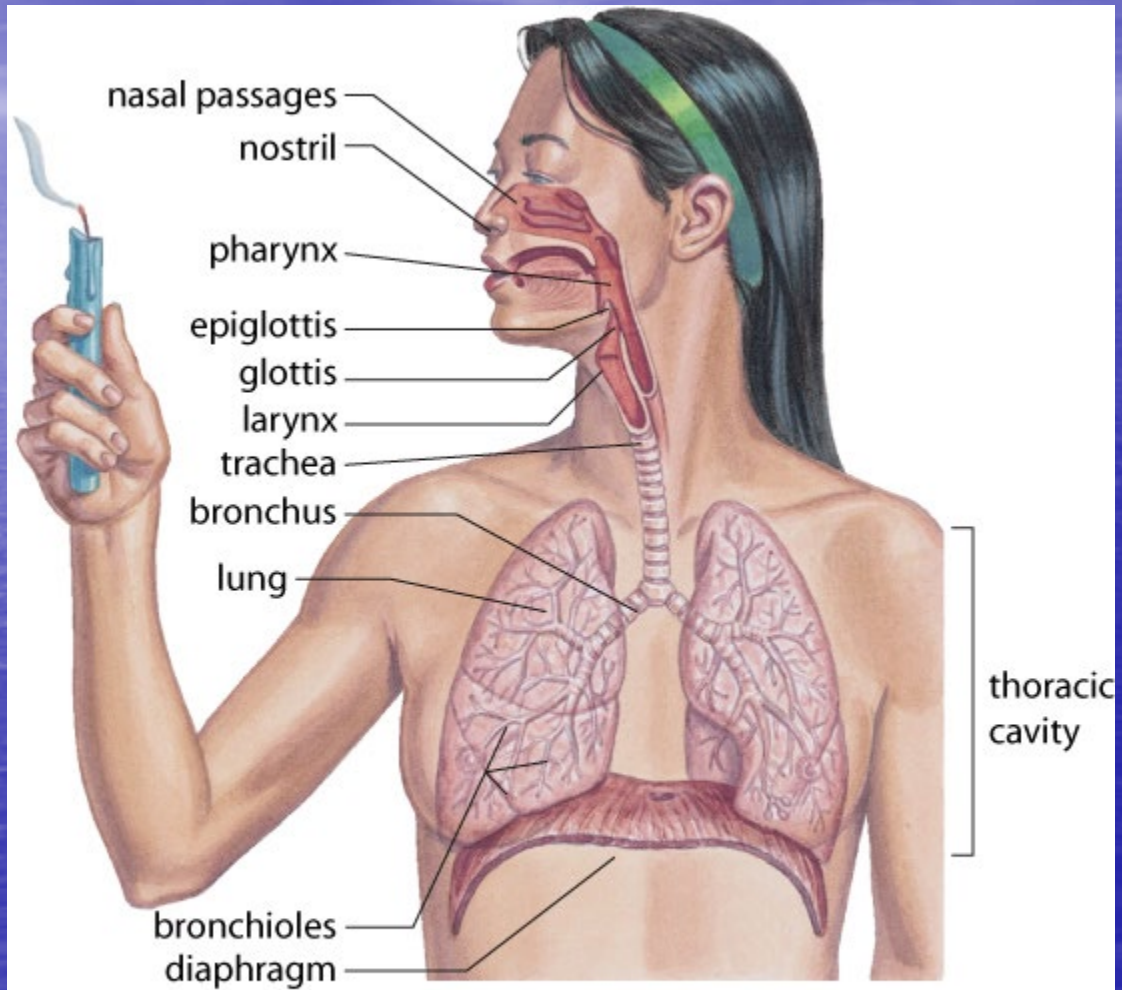
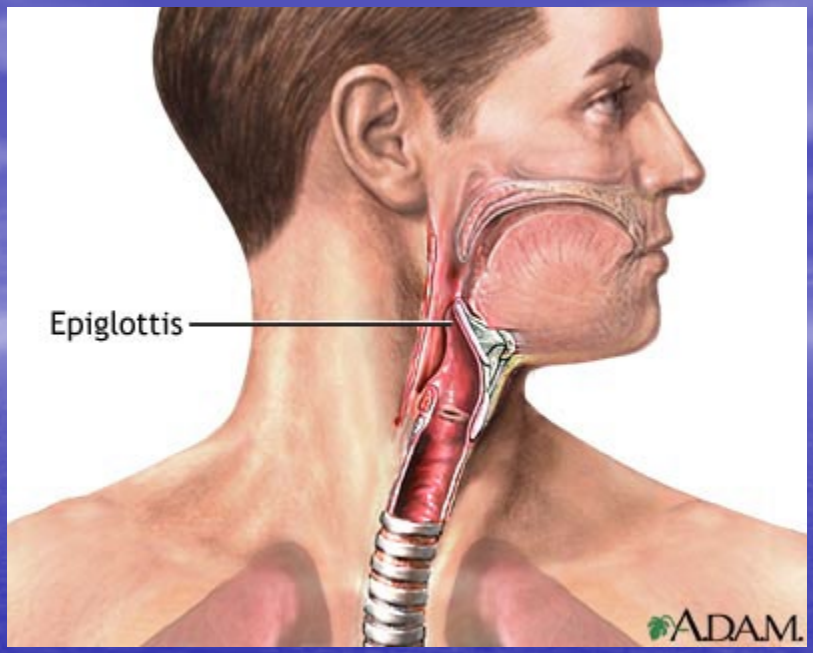


Figure 7.2 The structures of the respiratory tract provide a passageway for air to move from the external environment to deep within the lungs, where external respiration (gas exchange) occurs.

Respiratory Structures

- Air enters via the nasal cavities and mouth
- The nasal cavities contain hairs and mucus that traps particles and keeps cells moist
- At the same time, the large number of blood vessels inside the nose also warm the incoming air
- The air then travels through the pharynx, which separates the trachea (windpipe) and the esophagus

- When eating, an enlarged flap of cartilage called the epiglottis covers the trachea to prevent food from entering
- Food and drink that enter the trachea stimulates cilia that lines the respiratory tract, producing a cough



- Beyond the pharynx is the larynx, which is composed of thin sheets of elastic ligaments
- When air passes past the larynx, sounds are produced (these are the vocal cords)
- During speech, muscles contract and move these cords closer together
- Males have thicker vocal cords, which results in a deeper voice

The Lungs

- The lungs are surrounded by the pleural membrane, which attaches the lungs to the thoracic cavity
- The trachea branches into two bronchi, one for each lung
- These bronchi then continue to branch into bronchioles
- The bronchioles, unlike the bronchi and trachea, lack rings of cartilage
- Smooth muscle can change the diameter of the bronchioles

Alveoli

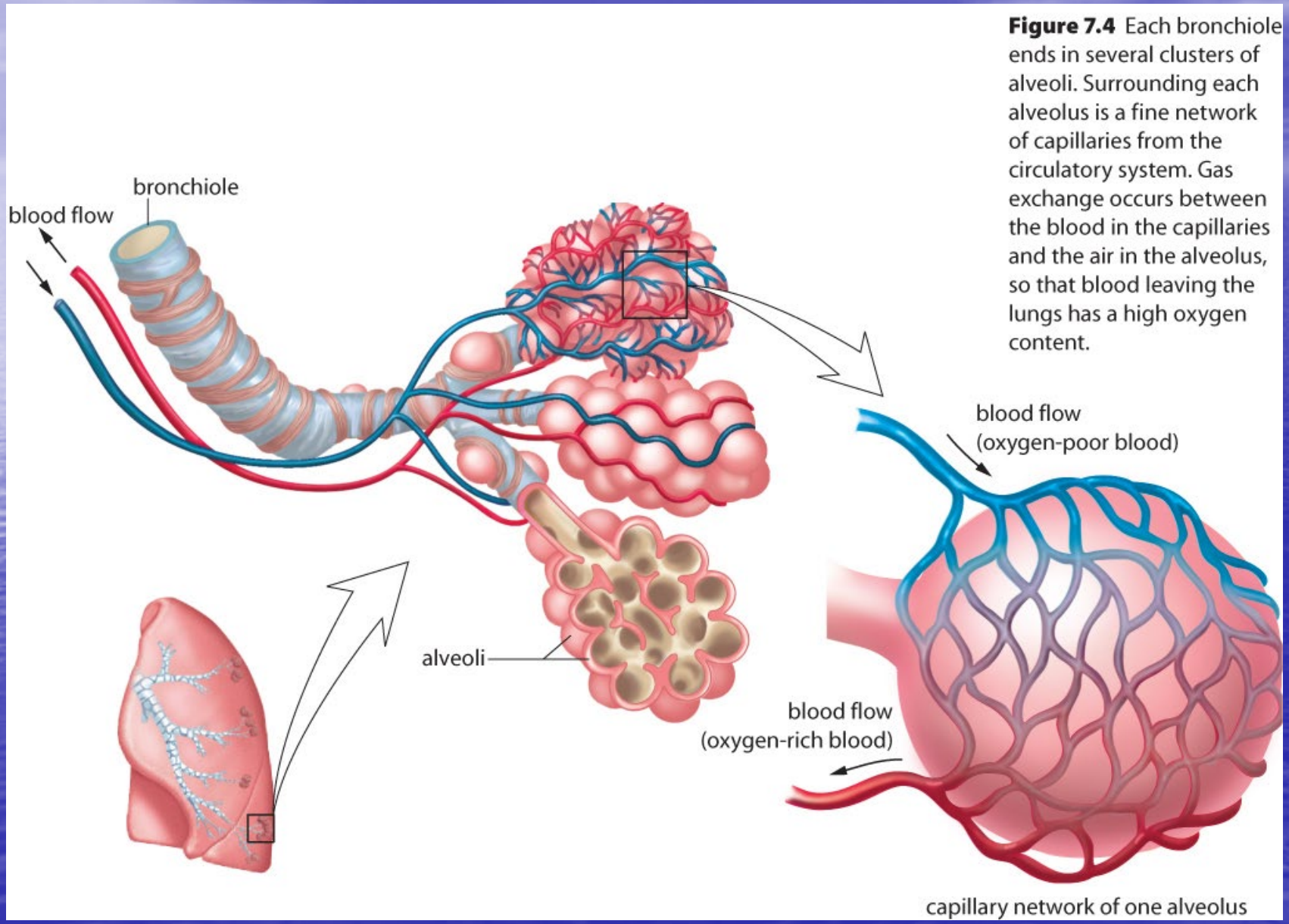


Figure 7.4 Each bronchiole ends in several clusters of alveoli. Surrounding each alveolus is a fine network of capillaries from the circulatory system. Gas exchange occurs between the blood in the capillaries and the air in the alveolus, so that blood leaving the lungs has a high oxygen content.

Gas Exchange

- The alveoli walls are very thin and are surrounded by capillaries
- Carbon dioxide and oxygen transfer between the alveoli and capillaries through diffusion
- You have about 150 million alveoli, whose total combined surface area could cover a tennis court!

Section 7.2 – Breathing and Respiration

- Recall that breathing and respiration are different
- Breathing is the mechanical action that brings air into the lungs
- Respiration is the exchange of gases

Breathing and Muscles

- Pressure differences between the chest cavity and the atmosphere move gases into and out of the lungs (atmospheric pressure is constant, but the lung pressure changes)
- Gases move from high pressure areas to low pressure areas

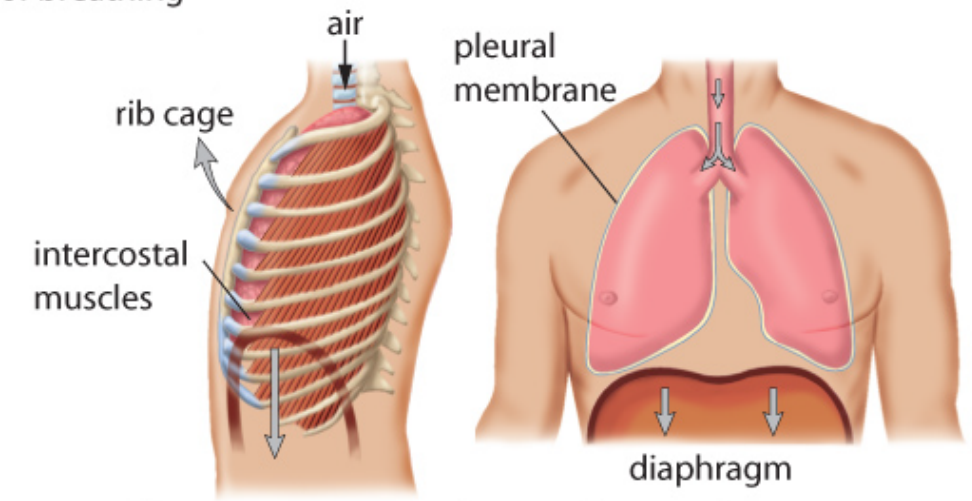
- When you inspire (breathe in), the pressure inside the lungs is lower than the outside
- When you expire (exhale), the pressure within the lungs is higher than the atmospheric pressure
- The change in lung pressure is created by changing the volume of the lungs
- The diaphragm, a band of muscle beneath the lungs, is responsible for this

- When you inhale, the diaphragm contracts and flattens, and the lungs expand
- The atmospheric pressure is now higher than the lung pressure, and air moves into the lungs
- When you exhale, the diaphragm relaxes and becomes dome-shaped
- As a result, the lung volume is reduced
- The atmospheric pressure is now lower than the lung pressure, and air moves out of the lungs

- The diaphragm is assisted by the movement of the ribs
- Between the ribs are bands of intercostal muscle
- When you inhale, these muscles pull the ribs upwards and outwards (increasing lung volume)
- When you exhale, the muscles pull the ribs inwards and downwards (decreasing lung volume)

The Mechanics of Breathing

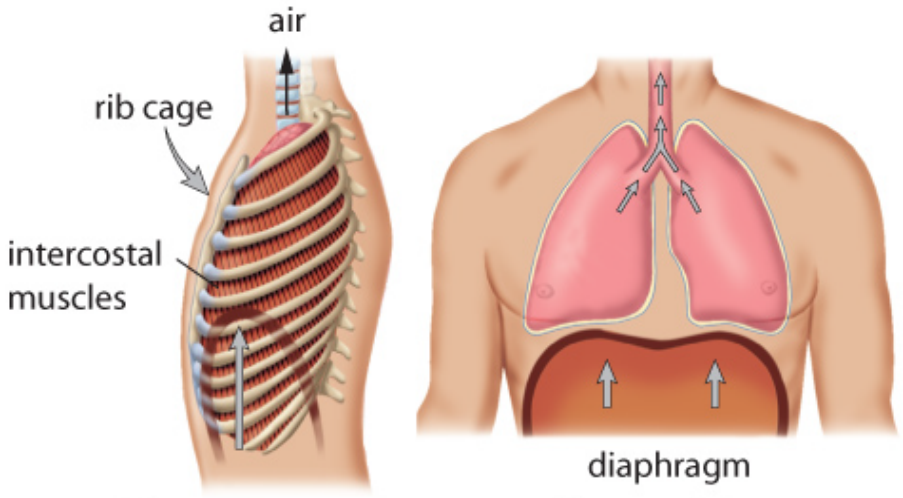
Figure 7.5 The mechanics of breathing



Rib cage moves up and out. Diaphragm contracts and moves down.

Pressure in lungs decreases, and air comes rushing in.

A **Inhalation** The intercostal muscles contract, lifting the rib cage up and out. At the same time, the diaphragm contracts and pulls downward. As the lungs expand, air moves in.



Rib cage moves down and in. Diaphragm relaxes and moves up.

Pressure in lungs increases, and air is pushed out.

B **Exhalation** The intercostal muscles relax, allowing the rib cage to return to its normal position. The diaphragm also moves upward, resuming its domed shape. As the lungs contract, air moves out.

Respiratory Volume

- You do not always use your full lung volume while breathing
- If our bodies need more oxygen, then our lungs can accommodate a greater volume of air
- The normal volume of air that is exhaled and inhaled is known as our tidal volume
- The total volume of air that our lungs can contain is known as our vital capacity

Respiratory Volume

- The volume of air that you can maximally inhale, after a normal inhale, is called the inspiratory reserve volume.
- The volume of air that you can maximally exhale, after a normal exhale, is called the expiratory reserve volume.
- The volume of air remaining in the lungs after a maximum exhale is called the residual volume.

A Spirograph:

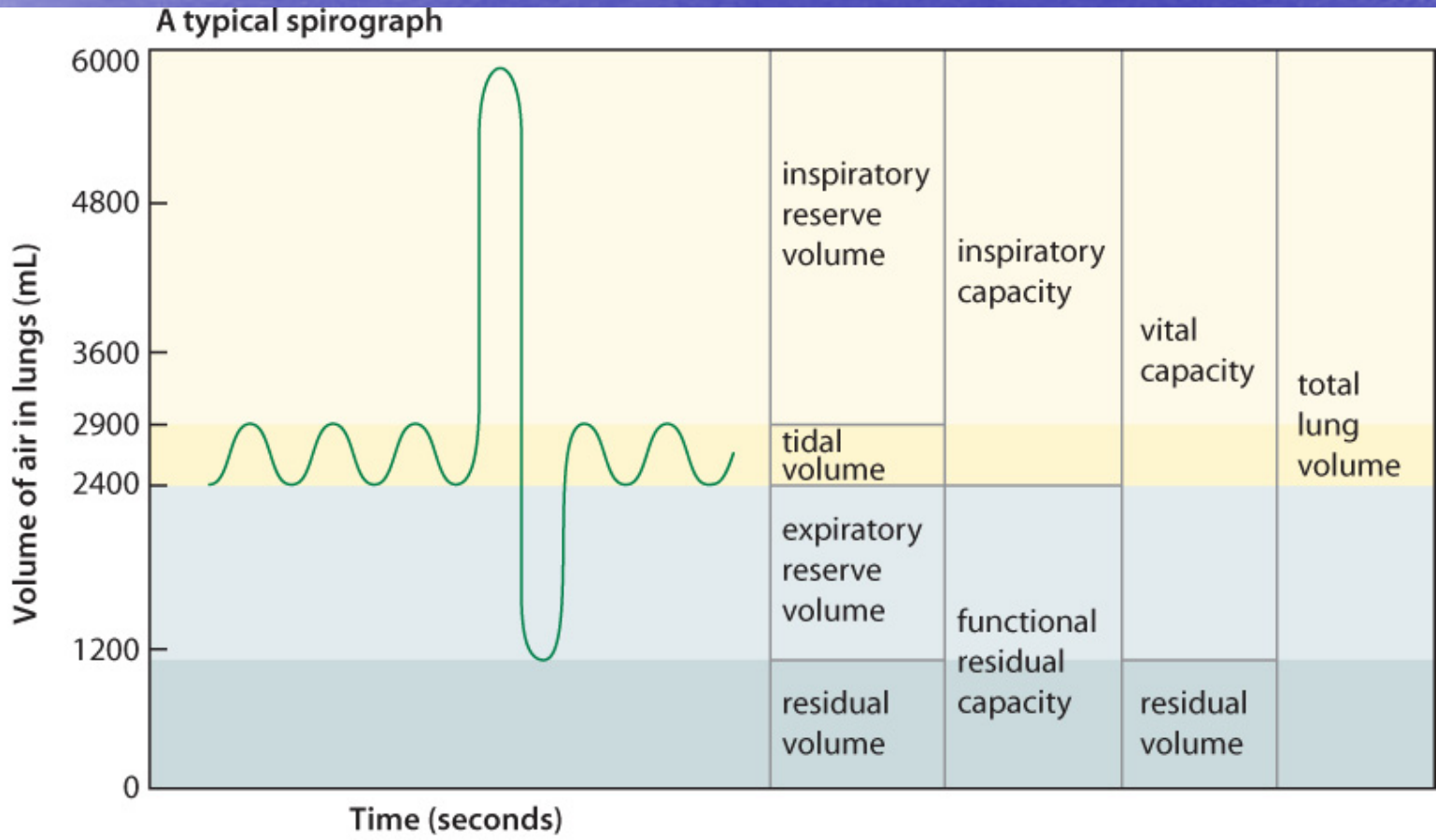
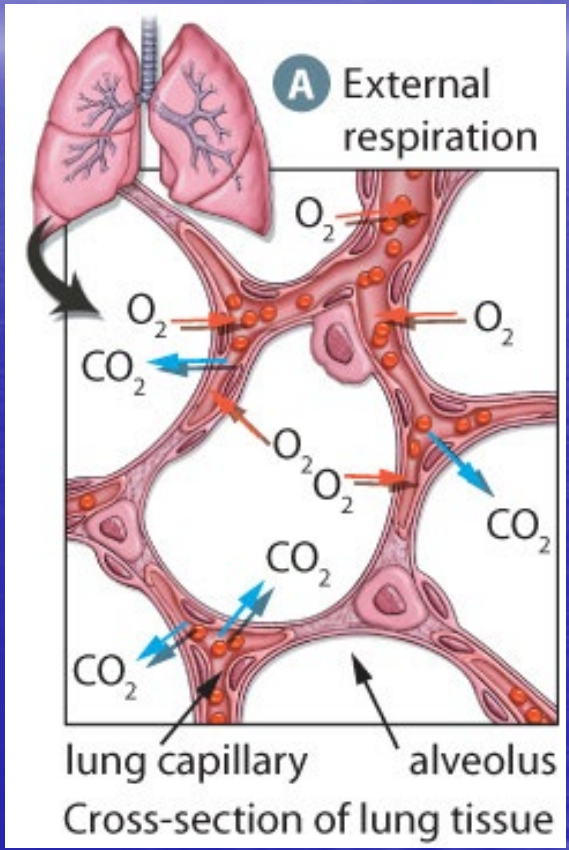


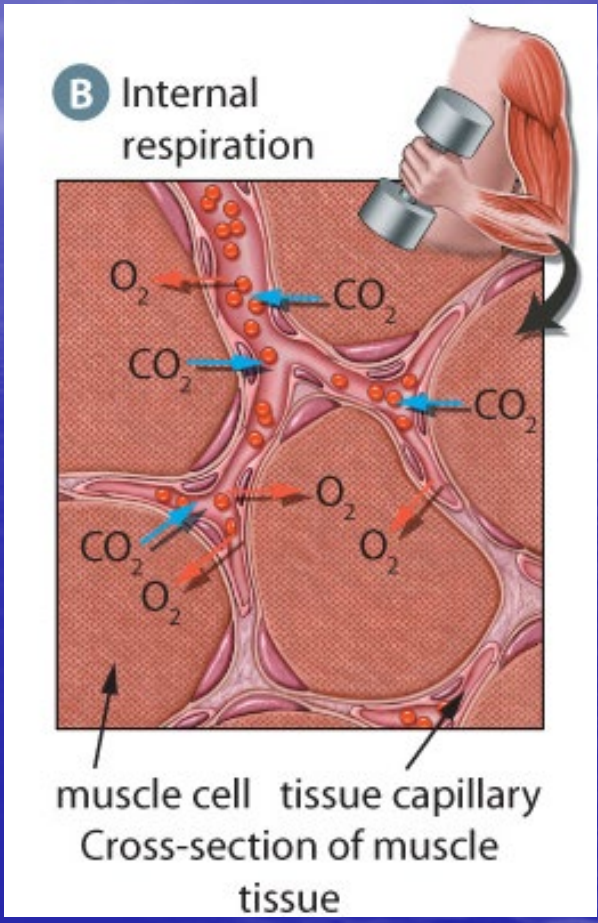
Figure 7.6 This graph shows typical values for human vital capacity: the maximum volume of air that can be moved into and out of the lungs during a single breath. The pattern of this graph is called a spirograph.

Gas Exchange

- Gases are exchanged between the air in the alveoli and the blood of the capillaries
- O_2 will diffuse out of the alveoli and into the capillary while CO_2 moves in the opposite direction
- About 30% of the O_2 transfer occurs through facilitated diffusion to increase the rate of exchange



- Within tissues, CO_2 and O_2 are also exchanged
- O_2 leaves the blood and diffuses into the tissue
- CO_2 diffuses out of the tissue and into the blood



O_2 and CO_2 Transport in the Blood

- Only 1% of O_2 in the blood is dissolved in blood plasma
- 99% of the O_2 is bonded to hemoglobin molecules
- Hemoglobin allows red blood cells to carry 70 times more oxygen than cells without hemoglobin
- You would only be able to maintain life for about 4.5 seconds without hemoglobin (we can go without oxygen for about 5 minutes!)

- CO_2 can also be transported by hemoglobin, but only about 23% of all CO_2 is carried in this fashion
- The blood plasma only carries about 7% of the CO_2
- 70% of the CO_2 in your blood is in the form of the bicarbonate (HCO_3^- ion)

Carbon Dioxide & Bicarbonate

- When CO_2 is added to water, carbonic acid (H_2CO_3) is formed
- This loses an H^+ ion, which is picked up by hemoglobin
- The remaining HCO_3^- ion remains in the blood plasma
- When the plasma reaches the lungs, the hemoglobin gives up its H^+, and the sequence reverses – CO_2 is formed and released

7.3 – Respiratory Health

- Respiratory health problems can be identified as conditions that affect either the upper respiratory tract, or the lower respiratory tract
- Many disorders are preventable – particularly those that are caused by smoking

Upper Respiratory Infections

1. Tonsillitis: This is caused by bacterial or viral infections. Typically, bacterial infections are treated with antibiotics.
2. Laryngitis: This is an inflammation of the larynx caused by infection, allergies, or straining of the voice. As a result, the vocal cords become inflamed and do not vibrate properly.

Lower Respiratory Tract Disorders

1. Bronchitis:

- This is an inflammation of the bronchi.
- It can be classified as acute (usually a bacterial infection) or chronic (caused by irritants).
- During chronic bronchitis, the cilia lining the bronchi can become damaged.
- The most common cause of chronic bronchitis is smoking.

2. Pneumonia

- A condition where the alveoli fill with fluid
- Can affect an entire lobe of the lung (lobular), or be found in small patches (bronchial)
- Lobular pneumonia is caused by bacteria and is typically more serious than viral pneumonia
- There are vaccines for bacterial pneumonia
- AIDS patients often die because of a rare bacterial form of pneumonia

3. Pleurisy

- This is a swelling of the pleura
- May be caused by infection, blood clots, or cancer
- A common symptom is a localized sharp, stabbing pain
- Treatment of pleurisy often focuses on reducing the swelling

4. Emphysema

- Emphysema is a loss of elasticity in the alveoli wall
- As a result, the surface area for absorption is reduced
- Most cases of emphysema are associated with smoking

5. Cystic Fibrosis

- Genetic condition that prevents the formation of sodium channels in cell walls
- This disrupts the water balance in the lung cells
- As a result, the normally runny mucus in the lungs becomes very thick and cannot be expelled

6. Asthma

- This is a chronic obstructive disease which reduces the diameter of the bronchi & bronchioles
- Environmental triggers and stress can often cause asthma attacks
- Bronchial dilators are used to treat asthma
- Most of these drugs are administered through inhalers which produce a mist or fine powder that contains the drug

7. Exercise Induced Bronchospasm

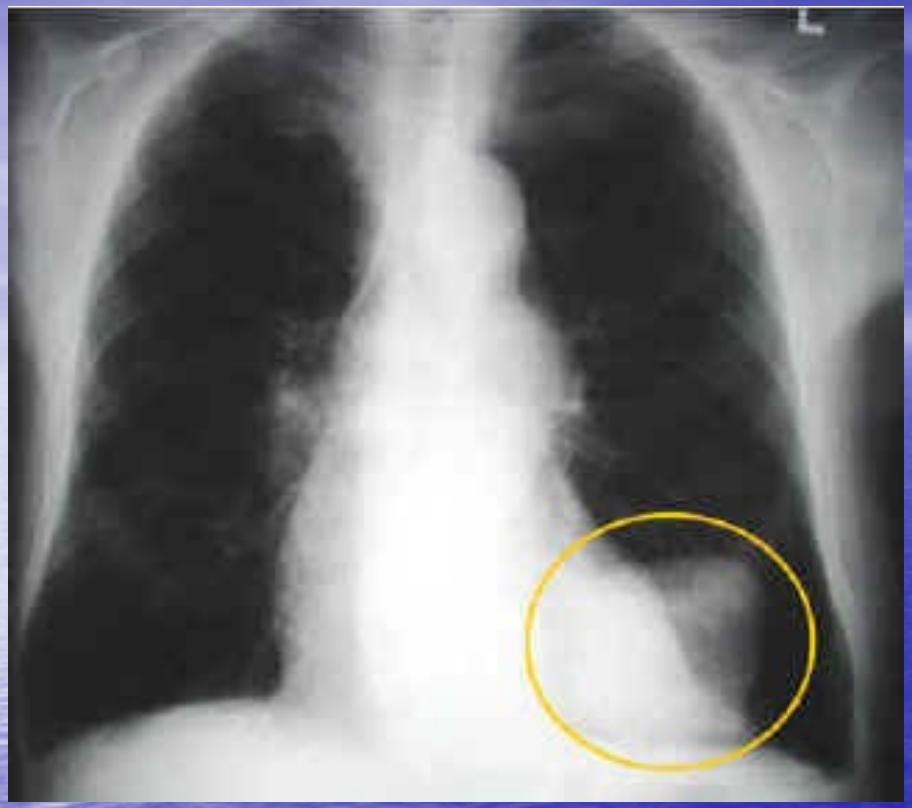
- This condition produces symptoms similar to asthma which are only brought on by exercise
- In most cases, dry, dusty and cold environments trigger this condition
- Patients with EIB can use bronchial dilators before exercise to avoid symptoms

8. Lung Cancer

- This (like all cancers) is an uncontrolled, abnormal growth of invasive cells
- The tumors that form reduce the available volume of the lung for gas exchange
- Often carcinogens (chemicals that cause cancer) trigger the production of tumors in the lungs
- Carcinogens are found in cigarette smoke, but also include asbestos and radon

Technologies for Detection and Treatment of Lung Disorders

- Diagnosis of disorders such as cancer, and some other infections (such as inhalational anthrax and tuberculosis) are typically done using X-rays and CT scans



http://www.lakeridgehealth.on.ca

- Lung Cancer

http://www.ecosur.mx/tuberculosis/Tuberculosis-4.jpg

- Tuberculosis

- DNA analysis can be used to identify if genes for cancer are present
- Cancers can be treated in several ways, including radiation therapy and chemotherapy
- In some cases, liposomes (small, hollow sacks of lipids) are filled with cancer-fighting drugs
- These liposomes follow the spread of the cancer cells and attack them before they start new growth in a new area of the body