

# Respiratory System

## Class Objectives

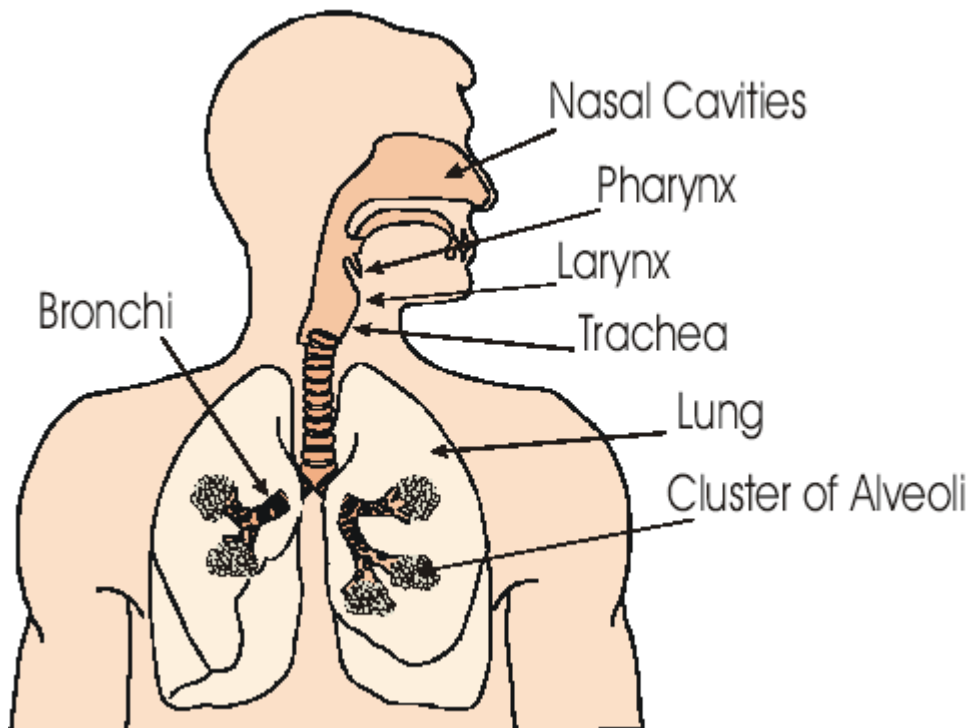
### *Student will be able to:*

1. Discuss anatomical and functional specifics of respiratory system.
2. Understand mechanics of breathing
3. Distinguish between events of respiration and define respiratory volumes and capacities.
4. Recognize the symptoms of conditions that occur from obstruction of breathing, such as: hyperventilation, hypoxia, carbon monoxide poisoning etc.

## Respiratory system: Overview and functional anatomy

A person can survive without food for 40 days, 4-5 days without water and 10 minutes without air. This alone can demonstrate how important it is for the cells to have constant supply of oxygen. Every cell in the body uses oxygen and releases carbon dioxide. How are these gases delivered to and away from the tissues? Via blood. So the cardiovascular and the respiratory systems work together to provide gas exchange.

In order for us to understand the anatomy of the respiratory system, let's follow the air particle, inhaled by a person.



## Organs of respiratory tract

### 1. *Nose*

Air enters here where it is purified by cilia, filtered of impurities, such as: dust, insects, pollen, bacteria. It is also warmed and moistened and chemically examined. Mucus secretions trap the foreign particles. Here we also have an olfactory mucosa for sense of smell. All of this debris is beaten by cilia posteriorly and swallowed, then later digested by stomach juices

### 2. *Pharynx (throat)*

The throat is a muscular passageway both for food and air. Air enters through the nasopharynx (behind nose) and travels through oropharynx (behind the mouth) and follow to the larynx. Food instead of going to larynx follows to the esophagus posteriorly.

The auditory tubes, which drain fluid from the middle ear, open into the nasopharynx. So any infections can follow back and forth.

Tonsils are also found in the pharynx.

### 3. *Larynx (voice box)*

Larynx routes air into the proper channels and plays role in speech. It is formed by eight rigid hyaline cartilages and a spoon-shaped flap of elastic cartilage, the epiglottis. The largest of the hyaline cartilages, the thyroid cartilage, which protrudes anteriorly, is commonly called the Adam's apple. If anything other than air enters the larynx, a cough reflex is triggered to expel the substance and prevent it from continuing into the lungs. This protective reflex never works when the person is unconscious, so it's not a good idea to give fluids to the unconscious person. Part of the mucous membrane in the larynx forms a pair of folds, called vocal cords, which vibrate and expel air and allow us to speak.

### 4. *Trachea*

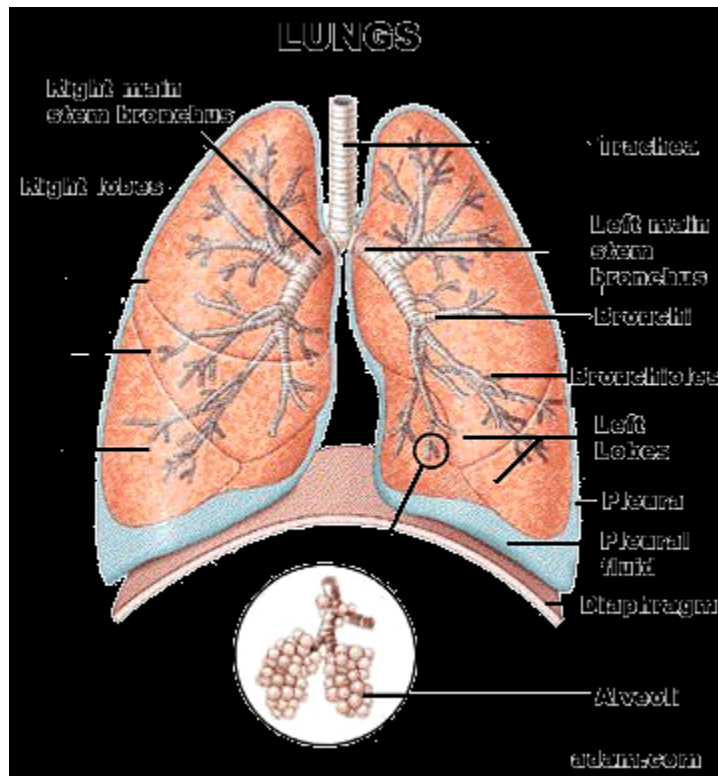
Air entering trachea, or windpipe, travels approximately 4 inches to the level of the midchest (fifth costal vertebra). Trachea is lined with ciliated mucosa. The cilia beats mucus in the upward direction, away from the lungs to the throat, where it can be swallowed or spat out.

*Smoking inhibits ciliary activity.*

The trachea is made of smooth muscle, reinforced by C-shaped rings of hyaline cartilage. These rings serve a purpose of expanding when we swallow a large particle of food.

### 5. *Bronchial tree: bronchioles*

The left and right bronchi are formed by the division of the trachea. The air follows the bronchi to the lung on each side. The further away from trachea, the more branched the bronchi is and the branches of it are called bronchioles, which ultimately leads to the alveoli.



### 6. *Lungs: alveoli*

Humidified, moistened, purified air enters lungs on each side. Lungs extend from diaphragm to just above the clavicle and lie against the ribs both anteriorly and posteriorly. Lungs are divided into lobes by fissures: right lung has three lobes, left lung has two: upper and lower lobe. Also the left lung is larger than the right one.

The surface of each lung is covered with visceral pleura and the walls of the thoracic cavity are covered by parietal pleura. There is a serous fluid between the two to prevent friction during breathing.

Lungs are elastic, they can recoil and stretch, lung compliance or distensibility is essential to normal respiration.

The terminal point for the air particle is in small grape-like sac, lined by simple squamous epithelium. They serve as the primary site of gas exchange.

The gas exchange occurs by simple diffusion through the respiratory membrane.

The surface of the respiratory area is 70 to 80 square meters, a size of a racquetball court.

The alveoli are also packed with macrophages to cleanse the lungs of bacteria and debris.

There are millions of air sacs and they make the bulk of the lungs, so lungs are mostly air spaces. They are soft and spongy and weigh about 2 ½ pounds.

## Respiratory Physiology

### *Four events collectively called respiration:*

1. Pulmonary ventilation (breathing) is a movement of the air in and out of the lungs.
2. External respiration is an exchange of air between the lungs and the blood (CO<sub>2</sub>, O<sub>2</sub>)
3. Respiratory gas transport is the transport of gases by the blood between the lungs and body cells; oxygen is transported on a hemoglobin molecule.
4. Internal respiration is the exchange of gases between the blood and body cells.

*Note: Cellular respiration is the utilization of oxygen by the body cells to break down substances such as glucose which produces energy, heat and carbon dioxide.*

The process of breathing simply relies on changes in pressure within the thoracic cavity relative to the external air pressure.

*Inhalation* occurs when the air pressure within the thoracic cavity is lower than the air pressure outside of the body.

*Exhalation* (air is forced out of the lungs) occurs when intrathoracic pressure increases, becomes higher than the atmospheric pressure.

### *Mechanics of breathing:*

1. Inspiration: physiology and musculature involved
  - 1.1. Quiet inspiration is natural and most efficient form of air intake. It is performed by diaphragm and external intercostals (pull each rib anterior and outward, also elevate sternum).
  - 1.2. Forced inspiration (during stress or exercise) is performed by contraction of diaphragm and external intercostals AND:
    - Sternocleidomastoid – elevates sternum
    - Pectoralis minor – elevates ribs
    - Scalenes
    - Pectoralis major
    - Iliocostalis thoracis
    - Serratus posterior
    - Serratus anterior
2. Expiration: physiology and musculature involved:
  - 2.1. Quiet expiration is a passive process due to relaxation of diaphragm and elastic recoil of lungs, thoracic cage and abdomen
  - 2.2. Forced expiration (during stress of exercise) is performed by:
    - Internal intercostals- pull ribs down and inward
    - Abdominal wall muscles contract to compress abdominal organs

Latissimus dorsi, serratus posterior, quadratus lumborum, longissimus assist

### ***Breathing pattern:***

- A. Quiet (diaphragmatic)
  - 1. Most energy efficient; we were designed to breath with our “bellies”
  - 2. Lowers blood pressure
  - 3. More relaxing
  - 4. Contributes to nervous system balance and emotional equilibrium
  - 5. Massages visceral organs, stimulating peristalsis and circulation
  - 6. Enhances lymphatic circulation
  - 7. Reduces pain, anxiety, asthma attacks
  
- B. Forced (upper chest)
  - 1. Requires more energy and therefore increases fatigue
  - 2. Provides poor lung ventilation
  - 3. Coincides with sympathetic nervous system stimulation
  - 4. Excess use of accessory muscles of respiration can lead to myofascial pain syndrome
  - 5. Insufficient oxygen delivery to the tissues

### **Respiratory air volumes**

- 1. Tidal volume: Volume moved into or out of the lungs during normal respiratory cycle (500 ml)
- 2. Reserve volume: Volume that can be inhaled or exhaled during forced breathing in addition to tidal volume
- 3. Vital capacity: the largest volume of air one can possibly move in and out of the lungs (depends on numerous factors including body size, posture, lung blood volume etc.)
- 4. Residual volume: volume that remains in the lungs at all times (i.e. after maximum expiration), 1200ml.
- 5. Total lung capacity: total volume of air that lungs can hold: 5800ml.

### **Control of respiration**

- 1. Neural: neurons located in the brain stem
- 2. Physical factors (exercise, movement)
- 3. Conscious control (limited)
- 4. Emotional factors (fear or pain can alter breathing pattern)
- 5. Chemical: low blood O<sub>2</sub>/ high blood CO<sub>2</sub> (controlled by chemoreceptors in large arteries)

Hypoventilation is much slower breathing than required for normal oxygen delivery; can lead to tissue damage or death.

Hyperventilation: rapid, deep respiration in need for oxygen. Lower than necessary level of CO<sub>2</sub> in blood can lead to respiratory alkalosis.

***Symptoms of hyperventilation:***

1. Deeper than required breathing
2. Tingling of hands and feet, face
3. Involuntary contraction of hands, face-muscle spasm
4. Dizziness, loss of consciousness

***How to normalize breathing in cases of hyperventilation:***

1. Explain to the person that they are hyperventilating and that they need to restore normal breathing
2. Have them breath slower, preferably into the paper bag or into their hands