Respiratory System

Learning Outcome C8, C9 & C10

Learning Outcome C8

- Analyse the functional interrelationships of the structures of the respiratory system

Student Achievement Indicators

Students who have fully met this learning outcome are able to:

- Identify and give functions for each of the following:
  - ✓ nasal cavity
  - ✓ pharynx
  - ✓ larynx
  - ✓ trachea
  - ✓ bronchi
  - ✓ bronchioles
  - ✓ alveoli
  - ✓ diaphragm and ribs
  - ✓ pleural membranes
  - ✓ thoracic cavity
- Explain the roles of cilia and mucus in the respiratory tract
- Explain the relationship between the structure and function of alveoli

Learning Outcome C9

- Analyse the functional interrelationships of the structures of the respiratory system

Student Achievement Indicators

Students who have fully met this learning outcome are able to:

- Describe the interactions of the following structures in the breathing process:
  - ✓ respiratory centre in the medulla oblongata
  - ✓ lungs
  - ✓ pleural membranes
  - ✓ diaphragm
  - ✓ intercostal (rib) muscles
  - ✓ stretch receptors
- Compare the processes of inhalation and exhalation
- Explain the roles of carbon dioxide and hydrogen ions in stimulating the respiratory centre in the medulla oblongata
- Explain the roles of oxygen, carbon dioxide , and hydrogen ions in stimulating carotid and aortic bodies

Learning Outcome C10

- Analyse internal and external respiration

Student Achievement Indicators

Students who have fully met this learning outcome are able to:

- Describe the exchange of carbon dioxide and oxygen during internal and external respiration, including:
  - ✓ location of exchange
  - ✓ conditions that favour exchange (e.g., pH, temperature)
- Explain the roles of oxyhemoglobin, carbaminohemoglobin, reduced hemoglobin, bicarbonate ions, and carbonic anhydrase in the transport of carbon dioxide and oxygen in the blood
- Write the chemical equations for internal and external respiration

The Respiratory Tract

Primary Function: allows oxygen from air to enter the blood and CO_2 from the blood to exit into the air

1. Inspiration (AKA inhalation)
   - ✓ Breathing in, air is conducted towards the lungs by a series of cavities, tubes and openings.
2. Expiration (AKA exhalation)
   - ✓ Breathing out, air is conducted away from the lungs.

The Respiratory Tract

3. Ventilation (AKA breathing)
   - ✓ Includes inspiration and expiration

- The respiratory and cardiovascular system work together to allow:
  - ✓ External Respiration: exchange of gases (CO_2 and O_2) between air and blood
  - ✓ Transport of gases to and from the lungs and tissues
  - ✓ Internal Respiration: exchange of gases between blood and tissue fluid.

The Respiratory Tract

- Air is cleansed by coarse hairs inside the nostrils and by cilia and mucus within the nasal cavity.
- Air is warmed by heat, which is given off by the blood vessels lying close to the surface of the lining of the airways.
- The air is moistened by the wet surfaces of these passages.
- As air moves out during expiration it cools and loses moisture.
- As the air cools it deposits its moisture on the lining of the trachea and nose.
- This may cause the nose to drip as a result of condensation.
- The air still retains so much moisture that on a cold day it condenses and forms a small cloud upon expiration.

Upper Respiratory Tract

- Has three parts:

1. *Nose (AKA nasal cavities)*
   - ✓ Only external portion of the respiratory tract
   - ✓ Air enters nose through external openings; the nostrils
   - ✓ The nose contains two nasal cavities; which are separated by a septum composed of cartilage and bone.
   - ✓ Mucous membranes line the nasal cavities, these membranes warm/moisten air.
   - ✓ Odor receptors are located on cilia that are high in the recesses of the nasal cavities.
   - ✓ The tear (lacrimal) glands drain into the nasal cavity, this is the reason why you receive a runny nose when you cry.
   - ✓ The nasal cavities are located near the sinuses, which are air-filled spaces that help reduce the weight of the skull
   - ✓ The hard and soft palates separate the nasal cavities from the mouth.

Upper Respiratory Tract

2. *Pharynx*
   - ✓ Connects the nasal and oral cavities to the larynx
   - ✓ Composed of three parts:

a. Nasopharynx: where the nasal cavities open behind the soft palate

b. Orthopharynx: where the mouth opens into the pharynx

c. Laryngopharynx: opens into the larynx.

Upper Respiratory Tract

- Tonsils are located at the junction between the mouth and pharynx.
- Tonsils are made up of lymphatic tissue containing lymphocytes, that function as part of the immune system that protects against the invasion of inhaled bacteria and viruses.
- Both the larynx and trachea are normally open; allowing air to pass but the esophagus is normally closed until a person swallow.

Upper Respiratory Tract

3. *Larynx*
   - ✓ Cartilaginous structure between pharynx and trachea
   - ✓ Known as a voice box, because it houses the vocal cords
   - ✓ The vocal cords are mucosal folds supported by elastic ligaments.
   - ✓ The slit between the vocal cords is an opening called the glottis.
   - ✓ When air is expelled past the vocal cords through the glottis the vocal cords vibrate producing sounds.
   - ✓ Pitch of the voice is regulated by changing the tension of the vocal cords.
   - ✓ The greater the tension, the narrower the glottis which results in a higher pitch
   - ✓ Loudness/intensity of voice depends on the amplitude (size) of the vibrations.
   - ✓ When food is swallowed, the larynx moves upward against the epiglottis, which is a flap of tissue that prevents food from passing into the larynx.

Lower Respiratory Tract

- Has three parts:

1. *Trachea (AKA windpipe)*
   - ✓ Connects larynx to primary bronchi
   - ✓ Lies above the esophagus and is help open by C-shaped cartilaginous rings.
   - ✓ The open part of the C-shaped rings face the esophagus, this allows the esophagus to expand during swallowing.
   - ✓ Epithelial cells line the trachea; which have projected cilia.
   - ✓ The cilia keep the lungs clean by sweeping mucus and debris towards the pharynx
   - ✓ Smoking destroys these cilia, and toxins can build up in the lungs.

Lower Respiratory Tract

2. *The Bronichial Tree*
   - ✓ The trachea divides into left and right primary bronchi
   - ✓ Each bronchi leads to a lung
   - ✓ Bronchi resemble the trachea in terms of structure but as the bronchi divide and subdivide their walls become thinner and the small rings of cartilage are no longer present.
   - ✓ Each bronchiole leads to an air sac known as an alveoli

Lower Respiratory Tract

3. *Lungs*
   - ✓ A pair of cone-shaped organs that occupy the thoracic cavity
   - ✓ The right lung has three lobes and the left lung has two lobes, this allows room for the heart.
   - ✓ Loves are divided into lobules, and each lobule has a bronchiole with many alveoli.
   - ✓ The apex of the lungs is narrow, while the base is broad and curves to fit the dome-shaped diaphragm.
   - ✓ The diaphragm is a muscle that separates the thoracic and abdominal cavities.

Inspiration & Expiration

- There is a continuous flow of air form the pharynx to the alveolus.
- The lungs lie within the sealed off thoracic cavity.
- The ribs attach to the vertebral column and to the sternum, which forms the top and the sides of the thoracic cavity.
- The diaphragm and connective tissue form the floor of the thoracic cavity.
- The lungs adhere to the thoracic wall by way of the pleura.
- Normally any space between the two pleurae is minimal due to the surface tension of the fluid between them.

Inspiration

- Active phase of respiration, diaphragm and external intercostal muscles contract
- Diaphragm lower and contracts, which the intercostal muscles move the ribcage upward and outward
- Following contraction the volume of the thoracic cavity is larger.
- As the thoracic cavity increase the lungs expand
- This causes the air pressure within the alveoli to decrease, creating a partial vacuum.
- Alveolar pressure is now less than atmospheric pressure outside the lungs, so air will naturally flow from outside the body into the alveoli.
- Air moves lungs because the lungs are already open, air does not force the lungs open.
- The creation of this partial vacuum in the alveoli causes air to be brought into the lungs.

Expiration

- Passive part of respiration
- Elastic properties of thoracic walls and lungs cause them to recoil
- Lungs recoil because the surface tension of the fluid lining the alveoli tend to close them.
- During expiration, the abdominal organs press up against the diaphragm and the rib cage moves in and downward.
- When breathing is deeper, a more rapid expiration may occur.
- Forces the ribcage to move downward and inward
- Also when the abdominal wall muscles contract they push on the viscera which pushes on the diaphragm.
- This causes increased pressure in the thoracic cavity, which expels air.

Control of Ventilation

- The respiratory centre is located in the medulla oblongata and it controls the rhythm of ventilation.
- Causes inspiration to occur by sending impulses to the diaphragm by way of the phrenic nerve
- When the respiratory center stops sending neuronal signals to the diaphragm and the rib cage, the diaphragm relaxes and resumes its dome-shape.
- Expiration can now occur (passive).
- Respiratory center controls rate and depth of breathing but its activity can also be influenced by nervous input and chemical input.
- Following forced inhalation, stretch receptors in the alveolar walls initiate inhibitory nerve impulses that travel via the vagas nerve from the inflated lungs to the respiratory center.
- This stops the respiratory center from sending out nerve impulses.

Chemical Input

- The respiratory centre is directly sensitive to the level of CO_2 and H^+ in the blood.
- When the levels rise the respiratory center increase the rate and depth of breathing.
- The respiratory center is not affected directly by low O_2 level.
- Chemoreceptors in the carotid bodies which are located in the carotid arteries located in the aorta are sensitive to level of O_2 in the blood.
- When the concentration of oxygen decreases, these chemoreceptors communicate with the respiratory center and the rate and depth of breathing increases.

Mechanisms of Breathing

- Breathing can be measured by a spirometer, it records the volume of air exchanged during normal and deep breathing.

Respiratory Volumes

- Normally when we are relaxed only a small amount of air move in and out with each breath
- This small amount of air is known as tidal volume (approx. 500 mL).
- It is possible to increase the amount of air you inhale, and therefore the amount of exhaled by breathing deeply.
- The maximum amount of air that can be moved in plus the maximum amount of air that can be moved out in a single breath is known as vital capacity.
- To increase vital capacity, you much increase the amount of air you breathe in, as well as the amount of air you breathe out.
- You can increase inspiration by expanding lungs and lowering your diaphragm.
- Forced inspiration increases volume of air beyond tidal volume by about 2900 mL, and this is known as the inspiratory reserve volume.
- You can increase the amount of air expired by contracting abdominal muscles and the inner intercostal muscles.

Respiratory Volumes

- This is the expiratory reserve volume (approx. 1400 mL).
- In average adults only 70% of tidal volume actually reaches the alveoli and 30% remains in the airway.
- The airways are not used for gas exchange, therefore this is known as dead-space air.
- If you breathe deeply and slowly a larger portion of inhaled air can reach the lungs.
- Residual Volume: is the volume of air that remains in the lungs even after exhalation. This air is not useful for gas exchange because it is depleted of O_2.