2.1 – Structure and Function of the Ventilation System

2.1.1 - List the principal structure of the ventilation system

<table>
<thead>
<tr>
<th>ORGAN</th>
<th>STRUCTURE</th>
<th>FUNCTION</th>
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<tbody>
<tr>
<td>Nasal Cavity</td>
<td>• Lined with capillaries;</td>
<td>• Warms, moistens and filters air entering the respiratory system</td>
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<tr>
<td></td>
<td>o Warms air to 37°C</td>
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<td></td>
<td>o Secrete mucus; moisten and filter air</td>
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<td></td>
<td>• Lined with cilia; filter out debris in the air</td>
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<tr>
<td>Pharynx</td>
<td>• Path that connects nasal cavity to the trachea</td>
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<tr>
<td>Epiglottis</td>
<td>• A tiny flap of connective tissue</td>
<td>• Prevents food from entering the trachea during swallowing</td>
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<td></td>
<td></td>
<td>• Prevents air from entering the stomach when breathing in</td>
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<td>Larynx</td>
<td>• Made up of cartilage</td>
<td>• To produce sound for communication</td>
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<td>• Contains the vocal cords; two highly elastic folds</td>
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<td>Trachea</td>
<td>• A hollow tube surrounded by tough, flexible C-shaped cartilage rings; lined with cilia</td>
<td>• Allows air to pass from the pharynx into the lungs</td>
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<td></td>
<td>• Lined with mucus secreting cells</td>
<td>• Cartilage rings prevent the trachea from collapsing and provide it with support</td>
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<tr>
<td><strong>Lung</strong></td>
<td>• Composed of the bronchi, bronchioles and alveoli</td>
<td>• The main organs of the respiratory system</td>
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</table>
| **Bronchi** | • Branch out of the trachea  
  o Hollow tubes surrounded by cartilage rings  
  • Lined with cilia and mucus secreting cells | • To carry the air into the lungs |
| **Bronchioles** | • Branch out of the bronchi  
  o Large bronchioles secrete mucous and are lined with cilia | • To decrease in size and carry air to the alveoli |
| **Alveoli** | • Clusters of tiny hollow air sacs; the ends of the smallest bronchioles  
  o Surrounded by an extensive network of capillaries  
  • Very small structures with very high surface area | • The sites of gas exchange |
| **Diaphragm** | • Dome-shaped sheet of muscle and tendon that serves as the main muscle of respiration and plays a vital role in the breathing process  
  • Also known as the thoracic diaphragm, it serves as an important anatomical landmark that separates the thorax, or chest, from the abdomen |
2.1.2 - Outline the functions of the conducting airways

**CONDUCTING AIRWAY** - Passageways between the ambient environments & the gas exchange units of the lungs

2 Types of Conducting Airways:

- Upper Airway
  - Nasal Cavity
  - Oral Cavity
  - Pharynx
- Lower Airway
  - Tracheobronchial Tree

Functions of the Conducting Airways:

- Conduction of air
- Warms & humidifies inspired air
- Prevents foreign materials from entering the lungs
- Serves as important area involved in speech and smell
2.1.3 - Define the terms pulmonary ventilation, total lung capacity (TLC), vital capacity (VC), tidal volume (TV), expiratory reserve volume (ERV), inspiratory reserve volume (IRV) and residual volume (RV)

**PULMONARY VENTILATION** – Inflow and outflow of air between the atmosphere and the lungs (Breathing)

**TOTAL LUNG CAPACITY (TLC)** – Volume of air in the lungs after maximum inhalation

**VITAL CAPACITY (VC)** – Maximum volume of air that can be exhaled after a maximum inhalation

**TIDAL VOLUME (TV)** – Volume of air breathed in and out in any one breath

**EXPIRATORY RESERVE VOLUME (ERV)** – Volume of air in excess of tidal volume that can be exhaled forcibly

**INSPIRATORY RESERVE VOLUME (IRV)** – Additional inspired air over and above tidal volume

**RESIDUAL VOLUME (RV)** – Volume of air still contained in the lungs after a maximal exhalation
2.1.4 - Explain the mechanics of ventilation in the human lungs

- The air in the lungs needs to be refreshed constantly
  - When you breathe, you are ventilating your lungs
    - Air is inhaled (drawn into your lungs) and then exhaled (expelled from your lungs)

- When you **inhale**, the external intercostal muscles contract and put, moving the rib cage up and out, the diaphragm contracts and lowers, the volume of the thoracic cavity increases, and air is drawn into the lungs

- Air fills the lungs because the pressure within the thoracic cavity, containing the lungs, is less than the atmospheric pressure
  - Air continues to flow until the pressure inside the lungs rises to the atmospheric pressure

- When you **exhale**, the internal intercostal muscles contract moving the rib cage down and in, the diaphragm relaxes, abdominal muscles contract, pushing the diaphragm up into a dome shape, the volume of the thoracic cavity decreases, and air is forced out of the lungs

- Air exits the lungs because the pressure within the thoracic cavity, containing the lungs, is greater than the atmospheric pressure
  - Air continues to flow until the pressure inside the lungs drops to the atmospheric pressure.

**Muscles of inhalation**

- **Sternum muscles** elevate upper ribs and sternum
- **Intercostals** elevate the ribs
- **Diaphragm flattens** increasing volume of thoracic cavity

**Muscles of exhalation**

- **Intercostals pull ribs down**
- **Abdominals compress diaphragm thus pulling it up and increasing volume of thoracic cavity**
2.1.5 - Describe nervous and chemical control of ventilation during exercise

- Respiratory centers in the brain monitor blood composition
- During exercise CO₂ levels increase
- CO₂ is produced by all active cells in the body
- It is a result of cell converting nutrients (Glucose) into energy (ATP)
- CO₂ is a byproduct of the process called aerobic cellular respiration
- CO₂ is detected by chemoreceptors in the respiratory center of the brain (Brainstem)

Ventilation increases as a direct result of increases in blood acidity levels (A low pH) due to the increased CO₂ due to the content of the blood detected by the respiratory centre. This results in an increase in rate and depth of ventilation.

Neural control of ventilation includes lung stretch receptors, muscle proprioceptors and chemoreceptors.

- Free H+ ions = More Acidity
2.1.6 - Outline the role of haemoglobin in oxygen transportation

- Almost 99% of oxygen (O2) in your blood is transported by a large, complex protein that is located in your erythrocytes (Red Blood Cells) called hemoglobin.

**Hemoglobin Molecule**

- Oxygen is one of the substances transported with the assistance of red blood cells
  - The red blood cells contain a pigment called haemoglobin, each molecule of which binds four oxygen molecules
- **Oxyhaemoglobin forms**
  - The oxygen molecules are carried to individual cells in the body tissue where they are released
    - The binding of oxygen is a reversible reaction
  
- \[ \text{Hb} + 4\text{O}_2 \rightleftharpoons \text{Hb}.4\text{O}_2 \]

- The four 'disks' in the diagram of haemoglobin are the parts of the molecule where the oxygen molecules bind, while the four folded 'sausage shapes' represent polypeptide chains

- At **high** oxygen concentrations oxyhaemoglobin forms
- At **low** oxygen concentrations oxyhaemoglobin dissociates to haemoglobin and oxygen
  - The balance can be shown by an oxygen dissociation curve for oxyhaemoglobin

### 2.1.7 - Explain the process of gaseous exchange at the alveoli

At the end of each alveolar duct there are a number of sac-like structures called alveoli, it is within these structures that surfactant is produced.

The alveoli are grouped together like a lot of interlinked caves, rather than existing as separate individual sacs.

Gas exchange is the delivery of oxygen from the lungs to the bloodstream, and the elimination of carbon dioxide from the bloodstream to the lungs. It occurs in the lungs between the alveoli and a network of tiny blood vessels called capillaries, which are located in the walls of the alveoli.
Gas exchange of oxygen and carbon dioxide takes place in the alveoli.

- Oxygen from the inhaled air diffuses through the walls of the alveoli and adjacent capillaries into the red blood cells.
- The oxygen is then carried by the blood to the body tissues.
- Carbon dioxide produced by the body's metabolism returns to the lung via the blood.
- It then diffuses across the capillary and alveolar walls into the air to be removed from the body with expiration.

**Adaptations of the Alveoli**

To maximize the efficiency of gas exchange, the alveoli have several adaptations:

- They are folded, providing a much greater surface area for gas exchange to occur.
- The walls of the alveoli are only one cell thick.
  - This makes the exchange surface very thin - shortening the diffusion distance across which gases have to move.
• Each alveolus is surrounded by blood capillaries which ensure a good blood supply
  o This is important as the blood is constantly taking oxygen away and bringing in more carbon dioxide
    ▪ Which helps to maintain the maximum concentration gradient between the blood and the air in the alveoli

• Each alveolus is ventilated, removing waste carbon dioxide and replenishing oxygen levels in the alveolar air
  o This also helps to maintain the maximum concentration gradient between the blood and the air in the alveoli