**12. The Respiratory system**

The respiratory system consists of the nose, lungs, diaphragm and the air passages, such as the trachea, which connect them.

The respiratory system is the body's breathing equipment. Similar to the digestive system, it takes substances from outside the body (gases, particularly oxygen), circulates them through the body to cells and tissues, then excretes the excess and waste. Oxygen is the respiratory system's 'food' and carbon dioxide is its 'waste'. Breathing is the most fundamental action of the human body: we cannot live without it for more than a couple of minutes.

**TOPIC 1: STRUCTURE**

**Section 1: how oxygen enters the body: the passage of air from nose to lungs**

**WHAT IS BREATHING?**

Breathing, or external respiration, is the inhalation and exhalation of air and the gases it contains.

**HOW DO WE BREATHE?**

Through the nose and the system of passageways and organs with which it connects. The nose is the only organ of respiration that we can see. The following section explains the structure and function of the organs of the respiratory system.

**WHAT IS THE NOSE?**

The nose is an organ on the face. It acts as the first passageway for air entering the body.

**Structure:** the nose is made of cartilage and two nasal bones. It is covered with skin. both inside and out and lined with a mucous membrane that is ciliated i.e. it has microscopic hairs. The two nostrils lead into a bony nasal cavity, which has two chambers, divided by a nasal septum. The septum is made of cartilage. Thus the outside of the nose which we can see, is mostly made of cartilage whereas the inside of the nose is mostly made of bone. The nasal cavity connects to the paranasal sinuses, hollow spaces inside the bones surrounding the nose which are full of air and are also lined with mucous membrane.

**Functions:** the nose is the first organ that air enters. It has three functions:

* To work as the organ of smell
* To moisten and warm the air entering the nostrils
* To filter dust, bacteria, and other foreign matter from the air using the mucous membrane and its hairs. The mucus collects any dirt and bacteria and prevents it from passing into the lungs. The cilia push the mucus into the throat. It is then swallowed and travels to the stomach where any bacteria are neutralised by gastric acids.

**PHARYNX**

Once air has been filtered, moistened and warmed in the nose it travels to the pharynx, a tube which leads from the back of the nose and mouth and divides into the oesophagus (posteriorly) and larynx (anteriorly). It works as part of both the digestive and respiratory systems.

**Structure:** the pharynx is about 12.5cm long and made of muscular and fibrous tissue. At the back of the section of the pharynx which connects to the nose are small masses of lymphoid tissue which form the pharyngeal tonsils, or adenoids. Like the palatine tonsils (at the junction of the mouth and throat) the pharyngeal tonsils filter bacteria.

**Function:** it acts as an air passage and also warms and moistens the air.

**LARYNX**

From the pharynx, air travels down to the larynx (also known as the voice box).

**Structure:** the larynx is a tube positioned between the tongue at the back of the mouth and the trachea (the tube leading to the lungs). It is made of rings of cartilage, attached to each other by membranes and ligaments. The thyroid cartilage at the top of the larynx, which is larger in men than in women, forms the Adam's apple which is often visible in the throat.

**Function:** the larynx is a passageway for air between the pharynx and trachea. It filters bacteria, helps in voice production and warms and moistens the air.

**TRACHEA**

From the larynx, air travels to the trachea.

**Structure:** the trachea is a continuation of the larynx. It is a tube about 10cm long which runs from the front of the neck to the chest where it divides into two bronchi, tubes which lead to the lungs. The trachea is made of incomplete rings of hyaline cartilage (anteriorly) and involuntary muscle and connective tissue (posteriorly). It is lined with ciliated epithelium which contains mucus-secreting goblet cells.

**Function:** the trachea is a passageway for air between the larynx and bronchi. The goblet secretory cells in the lining secrete mucus which collects any foreign matter or bacteria and the cilia then push this up to the larynx.

**BRONCHI**

The bronchi are the branches of the respiratory tube which transport air in and out of each lung.

**Structure:** bronchi (singular: bronchus) connect the trachea to the lungs. There are two of them, one on the left and one on the right which enter the lungs at the hilum, a concave depression, where they subdivide into different branches for different lobes of the lungs. Like the trachea, they are made of hyaline cartilage, involuntary muscle and connective tissue and are lined with ciliated epithelium.

**Function:** to pass air from the trachea into the bronchioles, and thus to the lungs.

**BRONCHIOLES**

The final and finest tubes in the passage of air from the nose to the lungs are the bronchioles.

**Structure:** bronchioles are made of muscular, fibrous and elastic tissue. They become progressively smaller as they spread further into the lungs until they are no more than a single layer of flattened epithelial cells (just like blood capillaries). These microscopic tubes are called terminal bronchioles.

**Function:** bronchioles take air to the alveoli of the lungs.

**LUNGS**

The two lungs are the centre of the respiratory system. It is in these two spongy organs that gases enter and exit the blood.

**Structure:** the lungs are positioned either side of the heart; the left lung is divided into two lobes, the superior and inferior lobes, whereas the right lung is divided into three, the superior, middle and inferior. Lobes are subdivided into lobules. Lung tissue is made of bronchioles, alveoli, blood vessels, nerves, connective tissue and elastic tissue. They are covered in a special membrane called the pleura.

**Function:** lungs allow the exchange of gases into and out of the blood.

**PLEURA**

**Structure:** the pleura is a serous membrane that surrounds each lung. It has two layers, the inner, visceral layer which sticks to the lung tissue and covers the surface and the outer, parietal layer which sticks to the chest wall and the top of the diaphragm. The two layers are separated by a space called the pleural cavity which is filled with a serous fluid.

**Function:** the pleural cavity prevents friction between the two layers during respiration.

**ALVEOLI**

The exchange of gases in the lungs takes place in tiny sacs called alveoli (singular: alveolus) at the end of the terminal bronchioles.

**Structure:** alveoli are made of a thin layer of squamous epithelial cells and are surrounded by a capillary network.

**Function:** to exchange gases between the circulatory and respiratory systems. The pulmonary artery delivers deoxygenated blood to the capillary network which is then oxygenated by contact with the air in the alveoli. The oxygenated blood then leaves the lungs via the capillary network and the pulmonary veins and travels to the heart to be pumped around the body.

**MECHANISM OF RESPIRATION**

Although all of these separate tubes and passageways have individual functions, it is their function as a whole that is important i.e. to allow us, and every cell in our body, to breathe. The entrance and exit of air in and out of the body is a process known as breathing, whereas the entrance and exit of oxygen and carbon dioxide in and out of cells is known as gaseous exchange.

**WHAT IS EXTERNAL RESPIRATION?**

External respiration is the breathing in and out of air, and the diffusion of oxygen from the alveoli into the blood and carbon dioxide from the blood to the alveoli. In order to understand how the gases pass from one tissue to the next it is important to know the following physical law:

gases diffuse from a higher pressure to a lower pressure until equal pressure is achieved.

Diffusion occurs when a strong concentration of a gas comes into contact with a weak concentration of the same gas. The dissolved gas molecules will move from the strong concentration to the weak concentration until the concentration is equal on both sides. In the case of oxygen and carbon dioxide this occurs through the capillary and alveoli walls. The oxygen in the alveoli is under more pressure than the venous, deoxygenated blood in the capillaries so the oxygen passes from the alveoli (high pressure) into the capillaries (low pressure). Once the pressure in both is the same, the exchange stops. The carbon dioxide in the blood is under more pressure than the carbon dioxide in the alveoli so it diffuses through the capillary walls to the alveoli. The blood is thus oxygenated and its waste removed and it now travels back to the heart ready to be pumped round the body. The lungs then expel the carbon dioxide through the process of exhalation.

**WHAT IS INTERNAL RESPIRATION?**

Internal respiration is the diffusion of oxygen from the blood to the body cells, and of carbon dioxide from the body cells to the blood. Once blood has been oxygenated in the lungs it travels back to the heart and is then pumped round the body. When blood reaches the various cells of the body, oxygen is again transferred by diffusion: the pressure of the oxygen in the blood is high whereas the pressure of the oxygen in the cells is low, so the oxygen passes into the cells. The amount of oxygen delivered depends on how busy the cell is. For example, more oxygen will be delivered to a muscle cell when it is exercising than when it is resting. The blood delivers its oxygen and collects the carbon dioxide (pressure in the blood is lower than in the cells so the carbon dioxide passes into the blood), carrying it back to the lungs where it will be delivered to the alveoli and then exhaled.

**Oxygen's route into the body**

* Nose
* Pharynx
* Larynx
* Trachea
* Bronchi
* Bronchioles
* Alveoli
* Blood in capillaries
* Pulmonary vein
* Heart
* Aorta
* Rest of body (cells)

**HOW DOES BLOOD TRAVEL TO AND FROM THE LUNGS?**

Via the pulmonary circulation which is the movement of blood from the heart to the lungs and back.

**HOW DOES AIR GET INTO THE BODY IN THE FIRST PLACE?**

Through the same gaseous pressure principle. Air enters the respiratory system (this is known as inspiration or inhalation) when the pressure is lower inside the lungs and leaves the lungs when the pressure in the atmosphere around the body is lower (known as expiration or exhalation). But it is the action of the muscles involved in respiration that make these changes in pressure, and the movement of air, happen. The main muscle involved in the mechanics of respiration is the diaphragm which is helped by the intercostal muscles (positioned between the ribs).

**WHAT IS THE DIAPHRAGM?**

The diaphragm is a large muscle. It is positioned between the chest and abdomen and separates them from each other.

**Structure:** the diaphragm is made of a central sheet of tendon with muscle fibres towards the edges and it has three origins - posterior, lateral and anterior. When relaxed it is a dome shape; when contracted it flattens out.

**Functions:**

* **Inspiration/inhalation:** when the diaphragm contracts, it flattens out and since it forms the bottom of the chest cavity, this cavity then increases in size and volume. This lowers the pressure inside the chest. Air is thus sucked in because the pressure is lower inside the body than outside.
* **Expiration/exhalation:** when the diaphragm relaxes it becomes a dome shape and pushes up the chest cavity, thus reducing the cavity's size and volume and increasing the pressure. Air rushes out because the pressure is lower outside.
* **The diaphragm also helps with expulsive body actions:**

micturition (urine excretion)

defecation (faeces expulsion)

parturition (giving birth)

**WHAT ARE THE INTERCOSTAL MUSCLES?**

Intercostal muscles are between the ribs. These muscles aid the diaphragm in respiration. During inspiration the external intercostal muscles contract at the same time as the diaphragm, lifting the rib cage up and outwards. The flattened and lowered diaphragm and the raised ribs cause an increase in the size of the chest cavity. During expiration, the external intercostals relax allowing the ribs to fall down and inwards, helping to decrease the size of the chest cavity. Nerve impulses delivered by the intercostal nerves tell the muscles when to contract and relax.

**HOW DOES THE BODY KNOW WHEN TO BREATHE?**

Nerve cells called chemoreceptors, found in the aorta and carotid arteries (i.e. arteries which are very close to the heart) send impulses to the respiratory centre in the medulla oblongata of the brain with messages about the low levels of oxygen and high levels of carbon dioxide. When the level of carbon dioxide is too high and the level of oxygen too low a nerve impulse is sent to the diaphragm telling it to contract, thus causing inhalation. This is especially important during exercise and illness.

**THE BRAIN'S ROLE IN BREATHING**

Two centres of the brain are involved - the respiratory centre in the medulla oblongata and the pons Varolii:

* The respiratory centre stimulates inspiration and controls the depth of breathing and its regularity
* The pons Varolii stops inspiration thus provoking expiration. When the respiratory centre tells the diaphragm to contract, air is sucked into the lungs, stimulating nerve cells called stretch receptors found in the lung tissue. These receptors send impulses to the pons Varolii which then sends impulses to the diaphragm telling it to relax, thus provoking expiration.

It is important to remember that breathing is not an intermittent process! The body does not stop breathing when the correct levels of oxygen and carbon dioxide are established, although breathing slows down and speeds up depending on our level of activity and health. Cells and tissues need to breathe all the time because every bodily function and movement requires oxygen and produces carbon dioxide. Breathing is a necessary and (in a healthy person) automatic function which continues throughout life.

**WHAT DOES AIR CONTAIN**

Air that comes into the body contains approximately 21% oxygen and 0.04% carbon dioxide whereas air that leaves the body contains approximately 15% oxygen and 4% carbon dioxide. Thus, the air we exhale contains 100 times more carbon dioxide and 6% less oxygen than the air we inhale.

**TOPIC 2: DISEASES AND DISORDERS (PATHOLOGIES)**

**BRONCHITIS**

Inflammation of the bronchial tubes which causes coughing, shortness of breath and fatigue. Causes include smoking and infections.

**EMPHYSEMA**

Alveoli stretch and lose their elasticity. This prevents effective breathing, causing cough, shortness of breath, and wheezing.

**PLEURISY**

Inflammation of the pleural lining; fluid may develop in pleura. Causes localised chest pain, shortness of breath, cough.

**PNEUMONIA**

Inflammation of lung tissue caused by infection. The lungs fill with fluid. Causes cough, fever, fatigue, headache and chest pain can be fatal.

**TUBERCULOSIS**

Disease caused by bacteria, inhaled or eaten (in infected meat or milk). Symptoms include cough, night sweats and fever. BCG injections are used to vaccinate against it.

**ASTHMA**

Difficulty in exhalation, coughing and wheezing. Often caused by allergies.

**RHINITIS**

Stuffy, congested nose and sinuses. Caused by cold, flu, hay fever and sinus infections.

**HAY FEVER**

Allergic rhinitis; caused by allergy to certain pollens; symptoms include sneezing, runny nose and eyes and sometimes swelling/itching.

**SINUSITIS**

Inflammation of sinuses, often following respiratory infection; causes headaches and facial pain.

**STRESS**

Stress causes breathing rate to increase.

**COMMON COLD**

A mild viral infection involving the nose and respiratory passages (but not the lungs).

**COUGH**

A sudden noisy expulsion of air from the lungs that clears the air passages.

**INFLUENZA**

An acute contagious disease of the upper airways and lungs, caused by a virus, which rapidly spreads.

**LARYNGITIS**

An inflammation of the mucous membrane of the larynx; characterized by hoarseness or loss of voice and coughing.

**PHARYNGITIS**

A sore throat: inflammation of the pharynx.

**PULMONARY EMBOLISM**

A blockage of the pulmonary artery by foreign matter or by a blood clot.

**TONSILLITIS**

Is an infection of the tonsils and will often, but not necessarily, cause a sore throat and fever.

**COR PULMONALE**

Enlargement of the right ventricle of the heart due to disease of the lungs or of the pulmonary blood vessels.

**CHRONIC OBSTRUCTIVE AIRWAYS DISEASE (COPD)**

Refers to chronic bronchitis and emphysema, a pair of two commonly co-existing diseases of the lungs in which the airways become narrowed.

**CYSTIC FIBROSIS**

The most common congenital disease; the child's lungs, intestines and pancreas become clogged with thick mucus; caused by defect in a single gene; no cure is known.

**HYPERVENTILATION**

An increased depth and rate of breathing, greater than is demanded by the body needs; can cause dizziness and tingling of the fingers and toes and chest pain if continued.

**LUNG CANCER**

Is a disease of uncontrolled cell growth in tissues of the lung or carcinoma of the lungs; one of the commonest forms of cancer.

**PERTUSSIS**

Whooping cough: a disease of the respiratory mucous membrane.

**PNEUMOTHORAX**

An abnormal presence of air in the pleural cavity resulting in the collapse of the lung; may be spontaneous (due to injury to the chest) or induced (as a treatment for tuberculosis).

**PULMONARY FIBROSIS**

A chronic lung inflammation with progressive scarring of the alveolar walls that can lead to death.

**SARCOIDOSIS**

A chronic disease of unknown cause marked by the formation of nodules in the lungs, liver, lymph glands and salivary glands.

SEVERE ACUTE RESPIRATORY SYNDROME (SARS)

A respiratory disease of unknown etiology that apparently originated in mainland China in 2003; characterized by fever and coughing or difficulty breathing or hypoxia; can be fatal.

SNORING

Is the vibration of respiratory structures and the resulting sound, due to obstructed air movement during breathing while sleeping.

**INTERRELATIONSHIPS**

Respiratory system links to:

**Circulatory:** the circulation transports oxygen from the respiratory system to every cell of the body and transports carbon dioxide to the respiratory system to be exhaled.

**Nervous:** respiration is closely controlled by the nervous system, which indicates when inhalation or exhalation should happen. Chemoreceptors in the main arteries stimulate the nervous response of the respiratory system to begin the process of inhaling oxygen when required.

**Muscular:** the intercostal muscles and diaphragm are fundamental to the process of respiration.

**Summary**

The respiratory system

* Is a system for the exchange of gases from outside to inside the body and vice versa
* Is controlled by the nervous system