# MYCT Revision

# External Respiration

**Key Understanding:**

1. Organisms take in gases from the environment, and give out gases to the environment (gas exchange).
2. Gases are exchanged when there is a diffusion gradient.
3. Ventilation maintains the diffusion gradient for gaseous exchange.
4. All respiratory systems have certain important features such as larger surface area to volume ratio, efficient transport system, thin surface, moist, good ventilation system.

# Learner outcomes (LO)

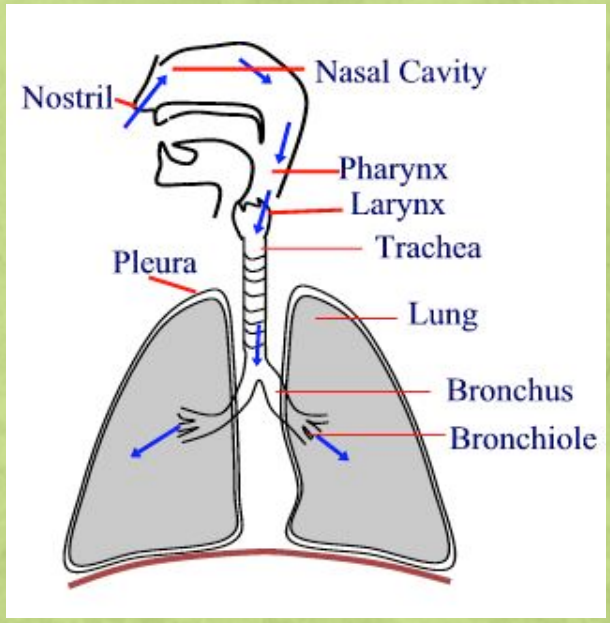
| | |
|---|---|
| 1 | Gas exchange in cells occurs by diffusion. |
| 2 | The rate of diffusion depends on the surface area of the respiratory surface, the concentration gradient and the length of the diffusion path. |
| 3 | Larger animals have specialised respiratory systems as the rate of diffusion of substances from the exterior into and out of the body of the animal is too slow to sustain life. |
| 4 | Relate the structures of the respiratory system (nose, larynx, trachea, bronchus, bronchioles, alveoli, ribs, diaphragm and intercostal muscles) to their functions. |
| 5 | Explain that the ribs, diaphragm and intercostal muscles work together to enable breathing to take place. |
| 6 | Describe the adaptations of the alveoli for efficient gaseous exchange. |
| 7 | State that the respiratory system is protected by the nasal hair, cilia and immune system. |
| 8 | State that the respiration rate is determined by the level of carbon dioxide in the blood. |
| 9 | State and account for the difference between inspired and expired air. |
| 10 | Describe how the respiratory and circulatory systems work closely together to supply the body with adequate amounts of oxygen according to the level of activity of the person. |
| 11 | Describe the advantages and disadvantages of water as a respiratory medium. |
| 12 | Describe counter current exchange in the gills of the fish and explain why it is more efficient than concurrent flow of water and blood. |
| 13 | State that breathing in of cigarette smoke as well as other irritants causes respiratory tract diseases (lung cancer, emphysema, bronchitis). |

# **LO3**: Larger animals have specialised respiratory systems as the rate of diffusion of substances from the exterior into and out of the body of the animal is too slow to sustain life

| **Passage of Air** |
| --- |
| Nostrils (nasal passages) |
| ↓ |
| Nasal cavity (nasal passages) |
| ↓ |
| Pharynx |
| ↓ |
| Larynx |
| ↓ |
| Trachea |
| ↓ |
| Left bronchus, Right bronchus |
| ↓ |
| Bronchial tubes |
| ↓ |
| Bronchioles |
| ↓ |
| Alveolus (air sac) (singular) |

Key Understanding 1:

Organisms take in gases from the environment, and give out gases to the environment (gas exchange).



# **LO4**: Relate the structures of the respiratory system (nose, larynx, trachea, bronchus, bronchioles, alveoli, ribs, diaphragm and intercostal muscles) to their functions.

| Passage of Air | Structure to function |
|---|---|
| Nostrils (nasal passages) ↓ | • Hair in **nostrils** and **mucus** in mucous membrane traps dust and foreign particles<br>• Harmful chemicals are detected by sensory cells in mucous membrane.<br>• Air is warmed and moistened before it enters the lungs. |
| Nasal cavity (nasal passages) ↓ | |
| Pharynx → Larynx ↓ | |
| Trachea ↓ | • Supported by C-shaped rings of cartilage, f(x): to ensure they are always kept open<br>• Epithelium lining bears ciliated cells and gland cells that secrete mucus, f(x): Mucus that traps dust particles and pathogens→ Ciliated cells sweep mucus into pharynx → muscus swallowed into esophagus, preventing infection of lungs. |
| Left bronchus, Right bronchus ↓ | |
| Bronchial tubes ↓ | |
| Bronchioles → Alveoli | |

**LO4**: Relate the structures of the respiratory system (nose, larynx, trachea, bronchus, bronchioles, alveoli, ribs, diaphragm and intercostal muscles) to their functions.

| Passage of Air | Structure to function |
|---|---|
| Nostrils ➔ Nasal cavity ➔ Pharynx ➔ Larynx ➔ Trachea ➔ Left & Right bronchi ➔ Bronchial tubes ➔ Bronchioles ➔ | |
| Alveoli | • Alveolar walls are only one-cell thick, f(x): rapid diffusion of gases (by shortening length of the diffusion path)<br>• Alveolus is well supplied with blood capillaries, f(x): rapid and efficient diffusion of gases (by maintaining concentration gradient)<br>• Present in large numbers (millions of alveoli), f(x): large surface area for rapid diffusion of gases<br>• Thin film of moisture on inner surface of alveoli, f(x): dissolve gases to allow for diffusion |

**LO1**: Gas exchange in cells occurs by diffusion.

**LO2**: The rate of diffusion depends on the surface area of the respiratory surface, the concentration gradient and the length of the diffusion path.

**LO3**: Describe the adaptations of the alveoli for efficient gaseous exchange.

**LO6**: State that the respiratory system is protected by the nasal hair, cilia and immune system.

# **LO4**: Relate the structures of the respiratory system (nose, larynx, trachea, bronchus, bronchioles, alveoli, ribs, diaphragm and intercostal muscles) to their functions.

| Associated structures | Structure to function |
|---|---|
| Diaphragm | A sheet of muscle that separates the thorax from the abdomen.<br>• When contracting or relaxing, it changes shape, f(x): changes the volume of the thoracic cavity, that in turn cause pressure changes, resulting in movement of air into or out of the lungs<br>• Contracts: flattens downwards, ↑ volume of thoracic cavity.<br>• Relaxes: arches upwards, ↓ volume of thoracic cavity. |
| External & Internal Intercostal muscles<br>↑<br>Work together<br>↓ | 2 sets of muscles between the ribs that are antagonistic in action.<br>• When one set of muscles contracts, the other set relaxes, f(x): cause ribs to swing upwards/downwards that changes the thoracic cavity volume, in turn causing pressure changes, resulting in movement of air into or out of the lungs<br>• External intercostal muscles contract, internal intercostal muscles relax, causing the ribs to swing upwards and outwards, increasing volume of thoracic cavity. (vice versa) |
| Ribs | 12 pairs of bones supporting the chest wall. Attached to backbone at the back and 10 pairs are attached to sternum in the front → moves sternum away or nearer to backbone in changing the thoracic cavity volume |

**LO5**: Explain that the ribs, diaphragm and intercostal muscles work together to enable breathing to take place.

## Negative Pressure Breathing

| Inhalation (Inspiration) | Exhalation (Expiration) |
| --- | --- |
| Diaphragm contracts and flattens downwards<br>AND<br>external intercostal muscles contract, while internal intercostal muscles relax, causing ribs to swing upwards and outwards | Diaphragm relaxes and arches upwards<br>AND<br>external intercostal muscles relax, while internal intercostal muscles contract, causing ribs to swing downwards and inwards |
| ↓ | ↓ |
| Thoracic cavity volume increases | Thoracic cavity volume decreases |
| ↓ | ↓ |
| Air pressure in thorax decreases | Air pressure in thorax increases |
| ↓ | ↓ |
| Air rushes into lungs down the pressure gradient | Air rushes out of lungs down the pressure gradient |

**LO10**: Describe how the respiratory and circulatory systems work closely together to supply the body with adequate amounts of oxygen according to the level of activity of the person.

1. Circulatory and respiratory systems work together to maintain a concentration gradient for diffusion of gases at the alveolus

- Movement of ribs and diaphragm contraction and relaxation results in inspiration that brings air rich in oxygen into the lungs **AND** expiration that brings air rich in carbon dioxide out of the lungs
- Circulatory system (or blood capillaries) lie close to the alveolus to bring in deoxygenated blood rich in $CO_2$ **AND** transport away oxygenated blood. (*Note the comparison in the highlighted phrases*)

**LO1**: Gas exchange in cells occurs by diffusion.

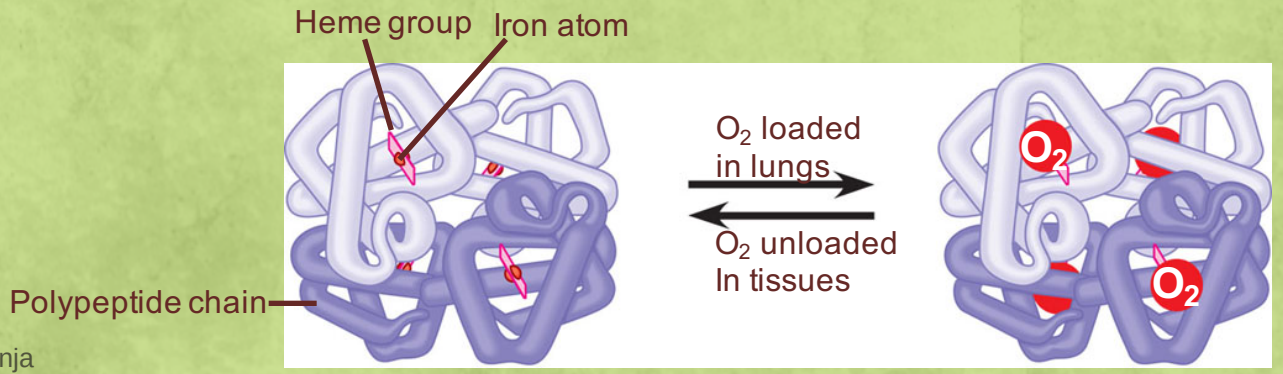
**Key understandings**: 1. Organisms take in gases from the environment, and give out gases to the environment (gas exchange). 2. Gases are exchanged when there is a diffusion gradient.

**LO10**: Describe how the respiratory and circulatory systems work closely together to supply the body with adequate amounts of oxygen according to the level of activity of the person.

2. Circulatory systems help to transport gases between the lungs and the body's cells

Transport of oxygen:

- oxygen dissolves in moisture lining inner surface of alveolus
- dissolved oxygen diffuses into blood where it binds to hemoglobin to form oxyhemoglobin in red blood cells (specifically to the $Fe^{2+}$)
- $Hb + 4O_2 \longleftrightarrow HbO_8$ (reversible)



**LO10**: Describe how the respiratory and circulatory systems work closely together to supply the body with adequate amounts of oxygen according to the level of activity of the person.

2. Circulatory systems help to transport gases between the lungs and the body's cells

Transport of carbon dioxide:

- Dissolved in plasma (5-7%)
- Bound to the amino groups of hemoglobin (15-20%) (Note: Not to the $Fe^{2+}$!)
- as bicarbonate ions in the plasma (70-80%)

$$H_2O + CO_2 \xleftrightarrow{\text{Carbonic anhydrase}} H_2CO_3 \longleftrightarrow H^+ + HCO_3^-$$

- When blood flows past the alveoli where carbon dioxide concentration is low, carbonic anhydrase catalyses the conversion of bicarbonate ions to carbon dioxide and water
- Carbon dioxide diffuses into the alveolus

**LO9**: State and account for the difference between inspired and expired air.

Inspired air

- 21% oxygen
- 0.03% carbon dioxide
- 78% nitrogen
- Water vapour variable
- Temperature variable
- Dust particles might be present

Expired air

- 16% oxygen
- 4% carbon dioxide
- 78% nitrogen
- Water vapour –saturated
- Temperature about 37C
- Dust particles little or none

Water evaporates from walls of alveoli
Heat also escapes from blood into alveolar air

**LO8**: State that the respiration rate is determined by the level of carbon dioxide in the blood.

- Breathing is automatic and controlled by the brain
- Concentration of $CO_2$ in the blood (reflected as pH change) is the **main** (not the only) stimulus for control of breathing rate
- There are sensors for changes in blood pH in the brain, aorta and carotid arteries
- Also sensors for $O_2$ levels in the aorta and carotid arteries
- Impulses sent to diaphragm and intercostal muscles to control rate of contraction

# **LO11**: Describe the advantages and disadvantages of water as a respiratory medium.

| Air as respiratory medium | Water as respiratory medium |
| --- | --- |
| Holds more oxygen than water (Advantage) | Holds less oxygen than air as oxygen isn't very soluble in water, especially in salty waters (Disadvantage) |
| Gases need to be dissolved first before they can diffuse across the respiratory surface (Disadvantage) | Respiratory surfaces are already moist and gases are already dissolved (Advantage) |

**LO12**: Describe counter current exchange in the gills of the fish and explain why it is more efficient than concurrent flow of water and blood.

- Countercurrent exchange:
  - Water flows over the gill filaments in the opposite direction of blood flow in the capillaries
  - Resulting in water **always** having a higher concentration of oxygen than the blood
  - Hence the diffusion gradient is maintained (over almost the entire length of the respiratory surface) (i.e. diffusion is constantly taking place)
  - Most of the oxygen in the water diffuses into the blood
- Concurrent exchange
  - Water flows over the gill filaments in the same direction of blood flow in the capillaries
  - Resulting in fast equilibration of oxygen concentration gradient
  - Uptake of only 50% of the oxygen in the water as diffusion stops at this oxygen concentration

Key understanding: All respiratory systems have certain important features such as large surface area to volume ratio, efficient transport system, thin surface, moist, good ventilation system.

| Structure to function | Adaptation found in human lungs | Adaptation found in fish gills |
|---|---|---|
| **1.Large surface area for gaseous exchange** | Large number of alveoli contribute to large surface area to volume ratio | Large number of finely divided gill lamellae contribute to large surface area to volume ratio |
| **2.Thin walls ensure faster rate of diffusion** | Alveoli and blood capillaries are both one cell thick | Gill lamellae is very thin |
| **3.Richly supplied with blood capillaries (continuous blood flow maintains diffusion gradient)** | Alveoli are surrounded with or supplied by numerous blood capillaries that lie close | Gill lamellae are richly supplied with blood capillaries |
| **4.Moist surface for oxygen to dissolve in order to diffuse across respiratory surface** | Layer of moisture found on the inner surface of the alveoli. | Oxygen already dissolved since respiratory medium is water |

**LO13**: State that breathing in of cigarette smoke as well as other irritants causes respiratory tract diseases (lung cancer, emphysema, bronchitis).

Cigarette contains

- > 50 carcinogens (e.g. lead, tar) that cause lung cancer
- Toxins and irritants that triggers inflammation of airway epithelium → ↑ mucus production and make cilia less motile so mucus is not swept away → mucus accumulates and blocks airway (bronchitis)
- Toxins that cause the partition walls between the alveoli to disintegrate (irreparable) → reduced surface area: volume ratio → less efficient exchange of gases (emphysema)