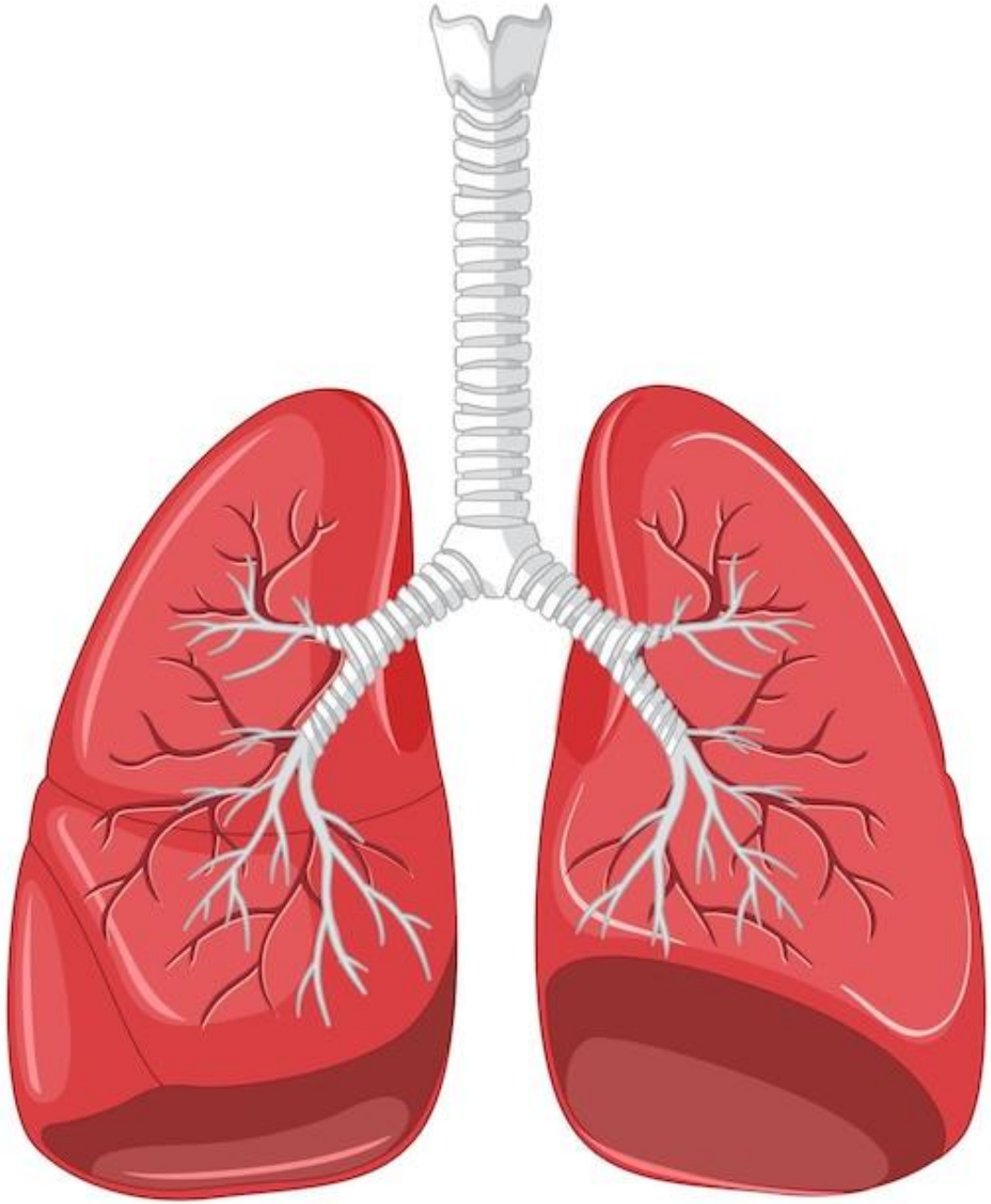
MYP 4
UNIT 3
LESSON 3

TOPIC: GAS EXCHANGE



UNIT TITLE: HOW DO ORGANISMS SUSTAIN THEMSELVES

Objectives

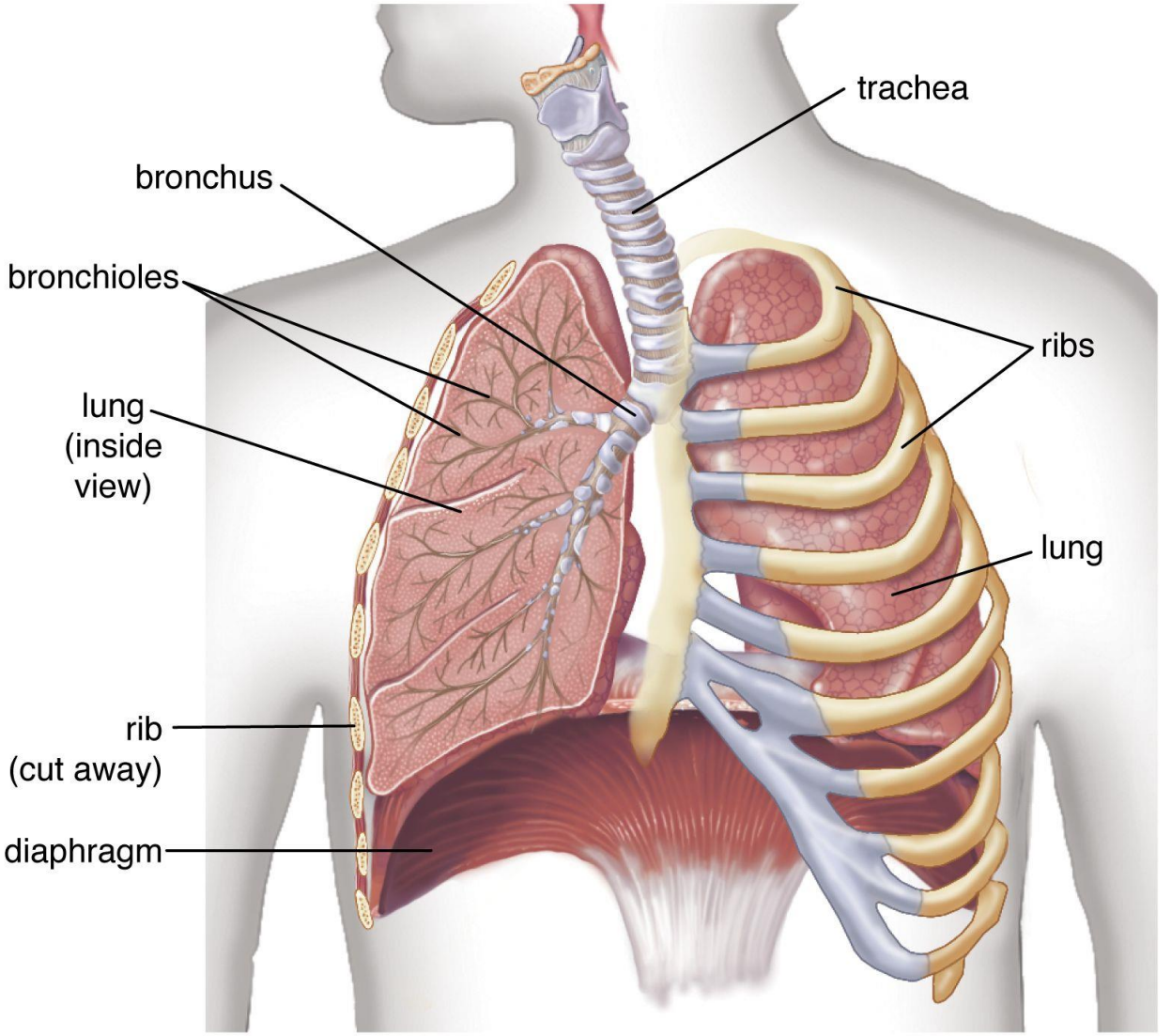
- Describe how air enters and leaves the lungs (ventilation).
- Explain how pressure changes cause inhalation and exhalation.
- Identify parts of the breathing system and their functions.
- Explain how oxygen and carbon dioxide are exchanged in the alveoli by diffusion.
- Describe at least five adaptations of the alveoli for efficient gas exchange.

Key Vocabulary

- Gas exchange
- Diffusion
- Alveoli
- Capillaries
- Diaphragm
- Intercostal muscles
- Respiration
- Concentration gradient
- Oxygen
- Carbon dioxide.

Starter quiz

- Why do we need oxygen to stay alive?
- What happens to the oxygen we breathe in?
- Where does carbon dioxide come from, and how is it removed?



Gas exchange in humans.

- All body processes need energy
- Energy comes from food
- Energy is released by **respiration**
- **Aerobic respiration needs** oxygen and produces carbon dioxide (waste)

Purpose of Gas Exchange

- Gas exchange supplies **oxygen (O_2)** to the blood for **respiration** in cells.
- It removes **carbon dioxide (CO_2)**, a waste product of respiration.
- Without a constant supply of oxygen, cells cannot release energy from glucose.

The Lungs

- Gas exchange organ in humans
- Found in the thorax (chest)
- Oxygen enters the blood
- Carbon dioxide leaves the blood

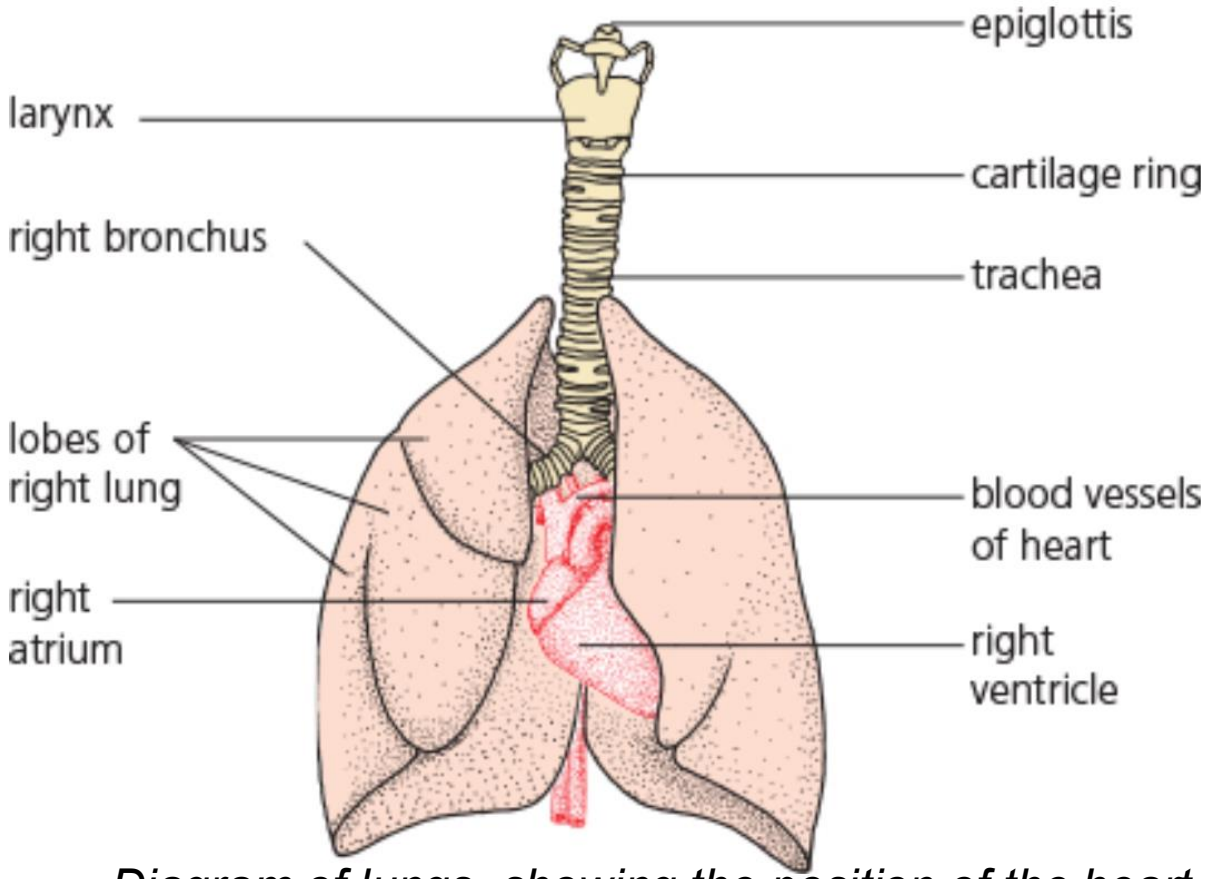


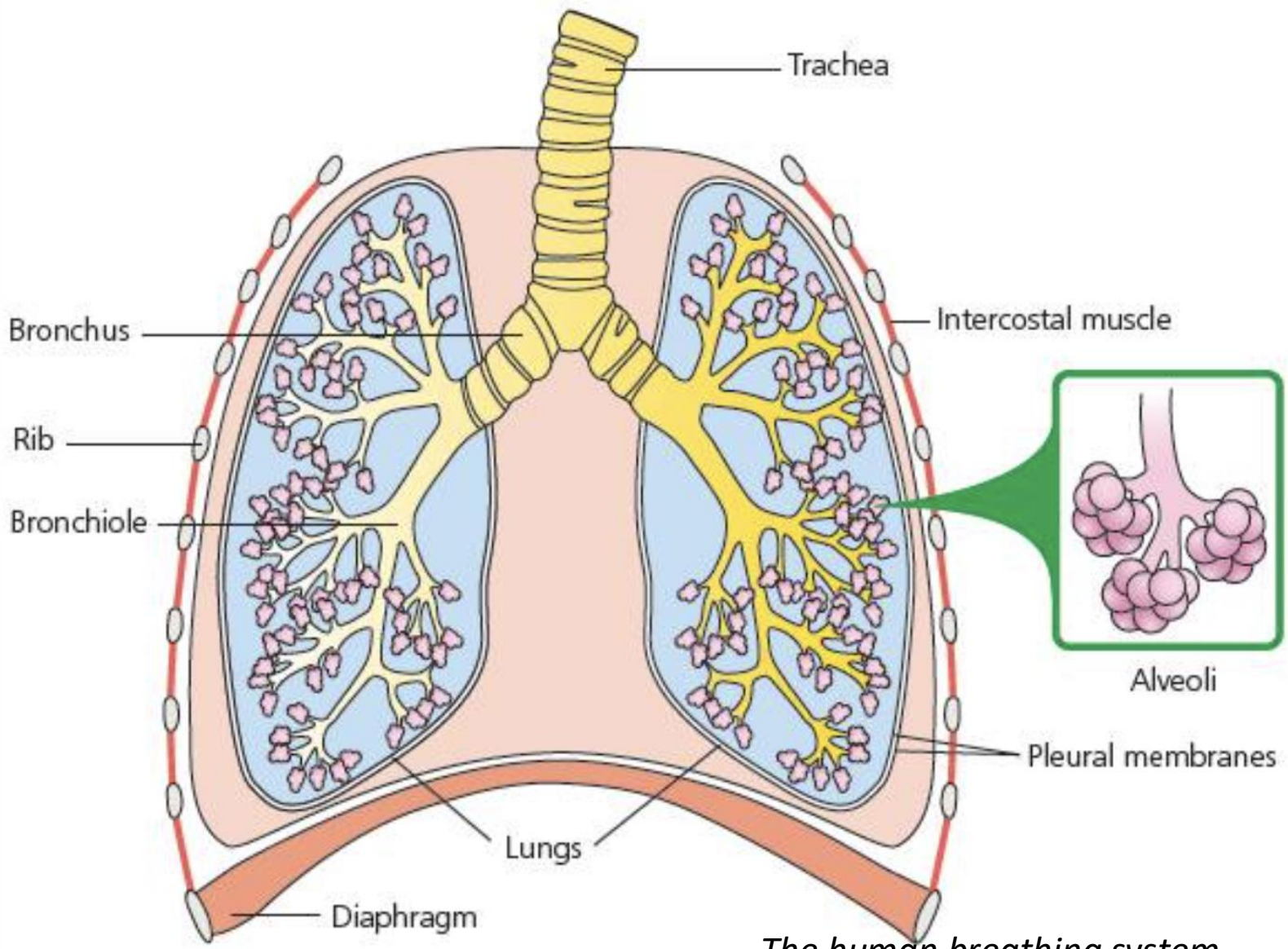
Diagram of lungs, showing the position of the heart

Lung Volumes

- Total lung capacity ≈ 5 liters
- Normal breath ≈ 500 cm^3
- Extra air during exercise ≈ 3 liters
- Residual volume ≈ 1.5 liters

Structure of the Respiratory System(Pathways of air)

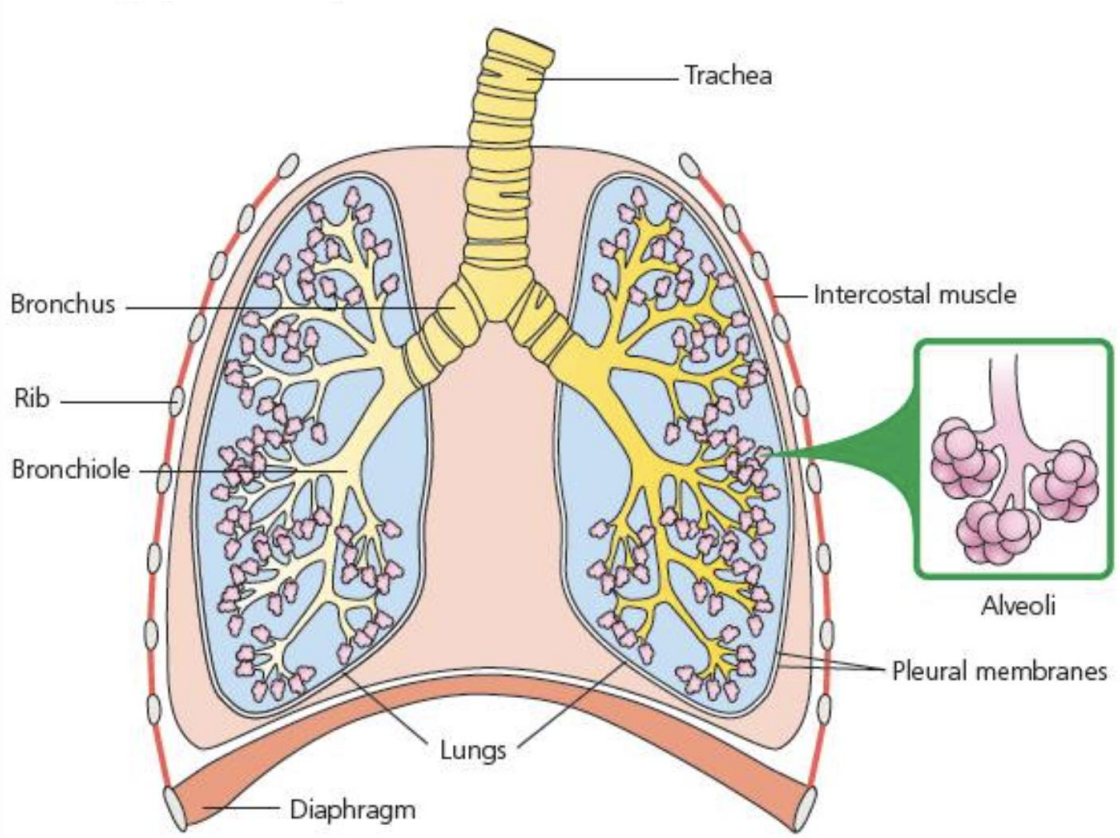
- Nasal cavity(Nose/Mouth)
- Trachea
- Bronchi
- Bronchioles
- Alveoli(air sacs)



The human breathing system

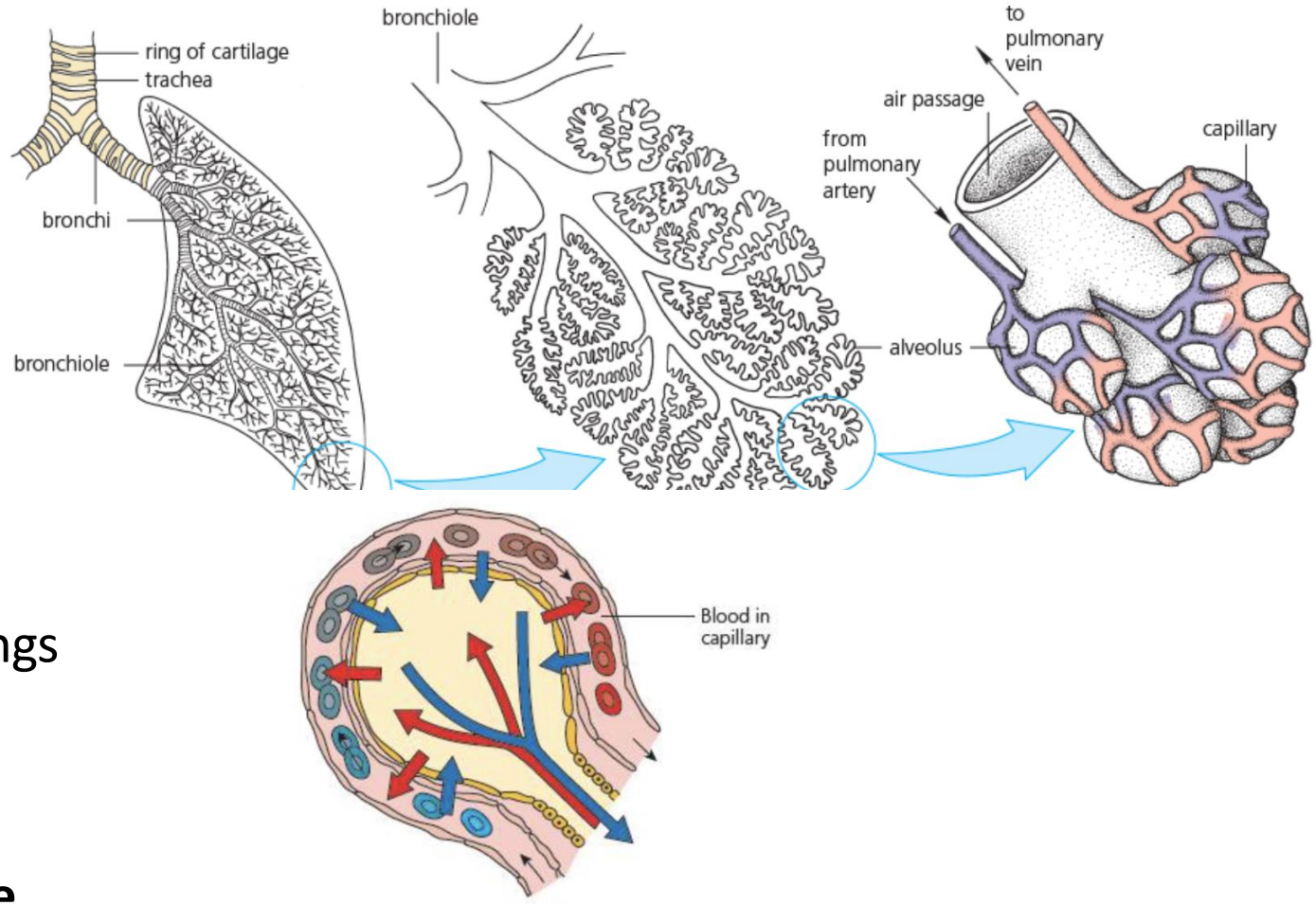
Trachea and Bronchi

- The trachea divides into two **bronchi**
- Bronchi enter the lungs and divide further
- Small branches (≈ 0.2 mm) are called **bronchioles**
- Bronchioles end in tiny air sacs called **alveoli**
- **The epiglottis** prevents food and drink from entering the trachea
- The ribcage protects the lungs.



Structure of the Alveoli and Function

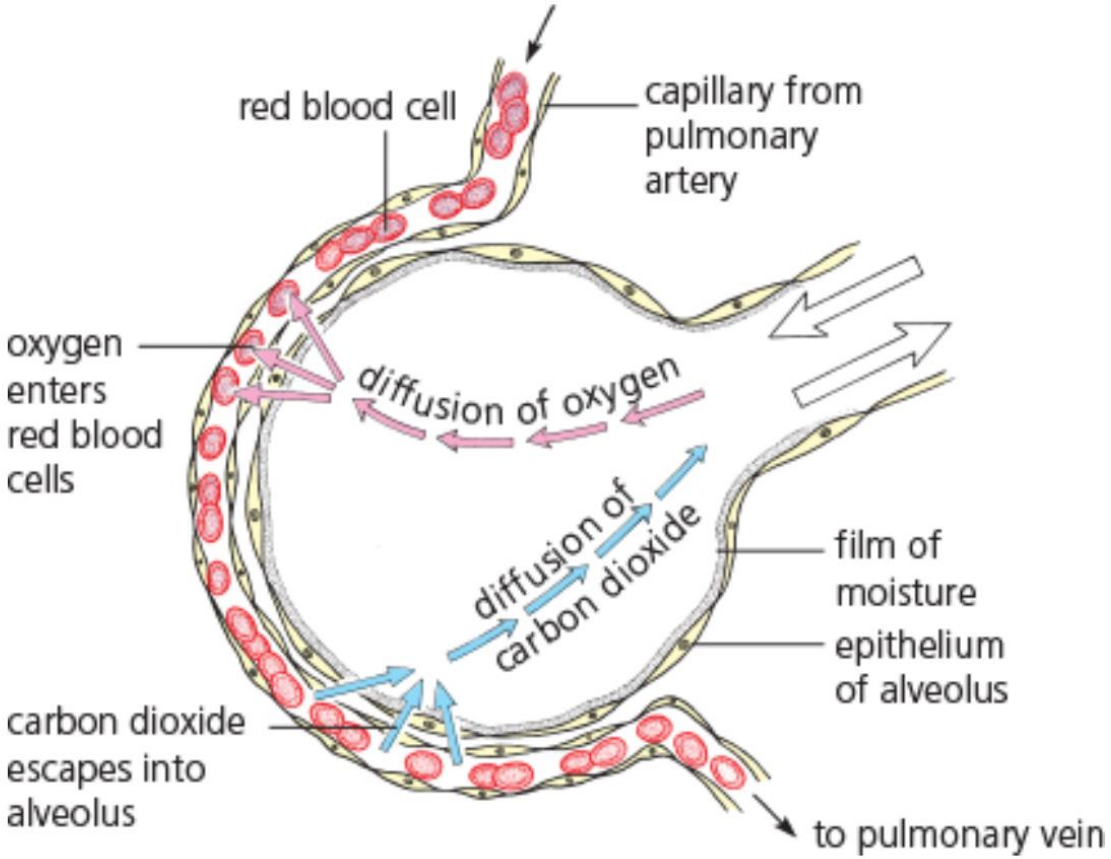
- Alveoli have **thin, elastic walls**
- The wall is **one cell thick (epithelium)**
- Surrounded by many **capillaries**
- Receive **deoxygenated blood** from the pulmonary artery
- About **350 million alveoli** in the human lungs
- Total surface area ≈ **90 m²**
- Large surface allows **efficient gas exchange**



■ **Figure 3.17** Oxygen (red arrows) diffuses into the blood at the alveolus, and carbon dioxide diffuses from blood

Gaseous Exchange

- Oxygen diffuses:
- Alveoli → blood
- Carbon dioxide diffuses:
- Blood → alveoli



Ventilation

Ventilation is the movement of air in and out of the lungs.

- Keeps oxygen level high in alveoli
- Removes carbon dioxide
- Maintains diffusion gradient
- Lungs have no muscles
- Movement caused by the ribs and the diaphragm

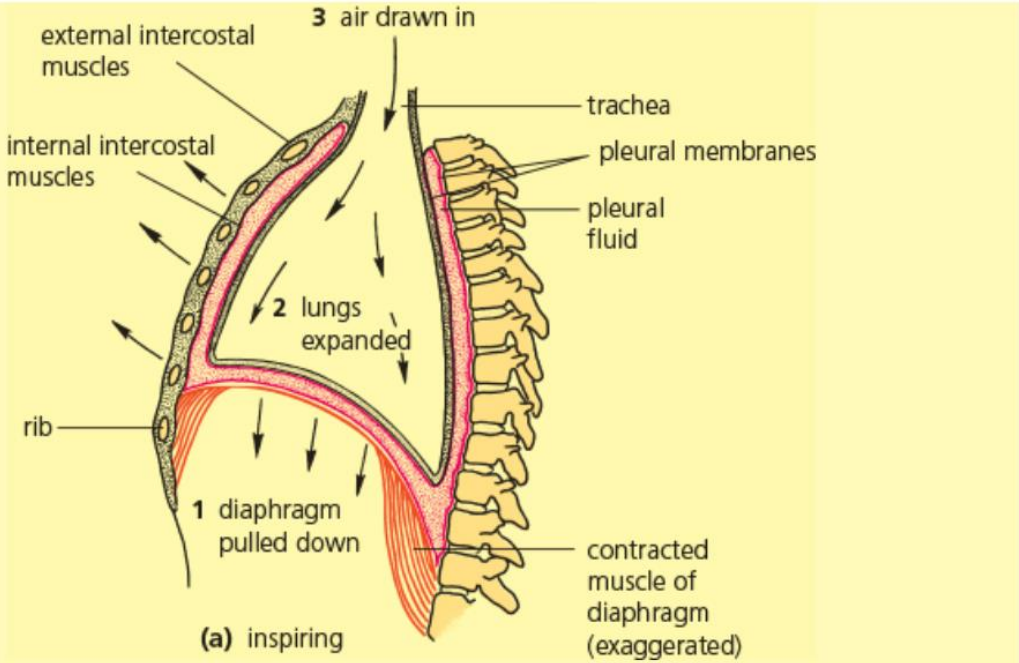
Inhalation (Breathing in)

- Intercostal muscles contract, pulling the ribs up and out.
- The diaphragm contracts and flattens (moves down).
- The volume of the thorax increases.
- The pressure inside the lungs decreases.
- Air is drawn into the lungs.
- The pleural membranes keep the lungs attached to the chest wall and make the system airtight.

Exhalation (Breathing out)

- Intercostal muscles relax, ribs move down and in.
- The diaphragm relaxes and moves up into a dome shape.
- The volume of the thorax decreases.
- The pressure inside the lungs increases.
- Air is forced out of the lungs.

- *Diagrams of the thorax to show the mechanism of breathing*



	Inhaled/%	**Exhaled/%**
oxygen	21.00	16.00
carbon dioxide	0.04	4.00
water vapour	variable	saturated

Changes in the composition of breathed air

Gas Exchange in the Alveoli

- Gas exchange occurs in the **alveoli** by **diffusion**:
- Oxygen diffuses from alveolar air (high concentration) into the blood (low concentration).
- Carbon dioxide diffuses from the blood (high concentration) into the alveoli (low concentration).
- This happens because of a **concentration gradient**.

Gas Exchange in the Alveoli

Ventilation keeps fresh air entering the alveoli, maintaining:

- High oxygen concentration
- Low carbon dioxide concentration

This allows diffusion to continue efficiently.

Adaptations of the Alveoli

The breathing system achieves:

- **Large surface area** – millions of alveoli.
- **Thin walls (one cell thick)** – short diffusion distance.
- **Moist surface** – gases dissolve easily.
- **Rich capillary network** – maintains steep concentration gradients.
- **Constant ventilation** – refreshes air continuously.

These features ensure rapid diffusion, as explained by **Fick's Law**:

Rate of diffusion increases with:

- Large surface area
- Large concentration gradient
- Small diffusion distance

Water Vapor in Exhaled Air

- Alveoli are moist
- Water evaporates into the air
- Exhaled air is saturated
- Seen as condensation on cold surfaces

Why Breathing Increases During Exercise

- Muscles respire faster
- More oxygen needed
- More carbon dioxide is produced
- The brain detects a CO_2 increase
- Breathing rate increases

Protection of the Gas Exchange System

- Air contains **pathogens** and **dust particles**
- These can damage the lungs if not removed

Goblet cells

- Found in the trachea, bronchi, and bronchioles
- Secrete **mucus**
- Mucus traps pathogens and dust
- Prevents particles from reaching alveoli

Ciliated cells

- Line the respiratory tract
- Cilia beat to **move mucus upwards**
- Mucus is swallowed into the gullet
- Keeps lungs clean and protected

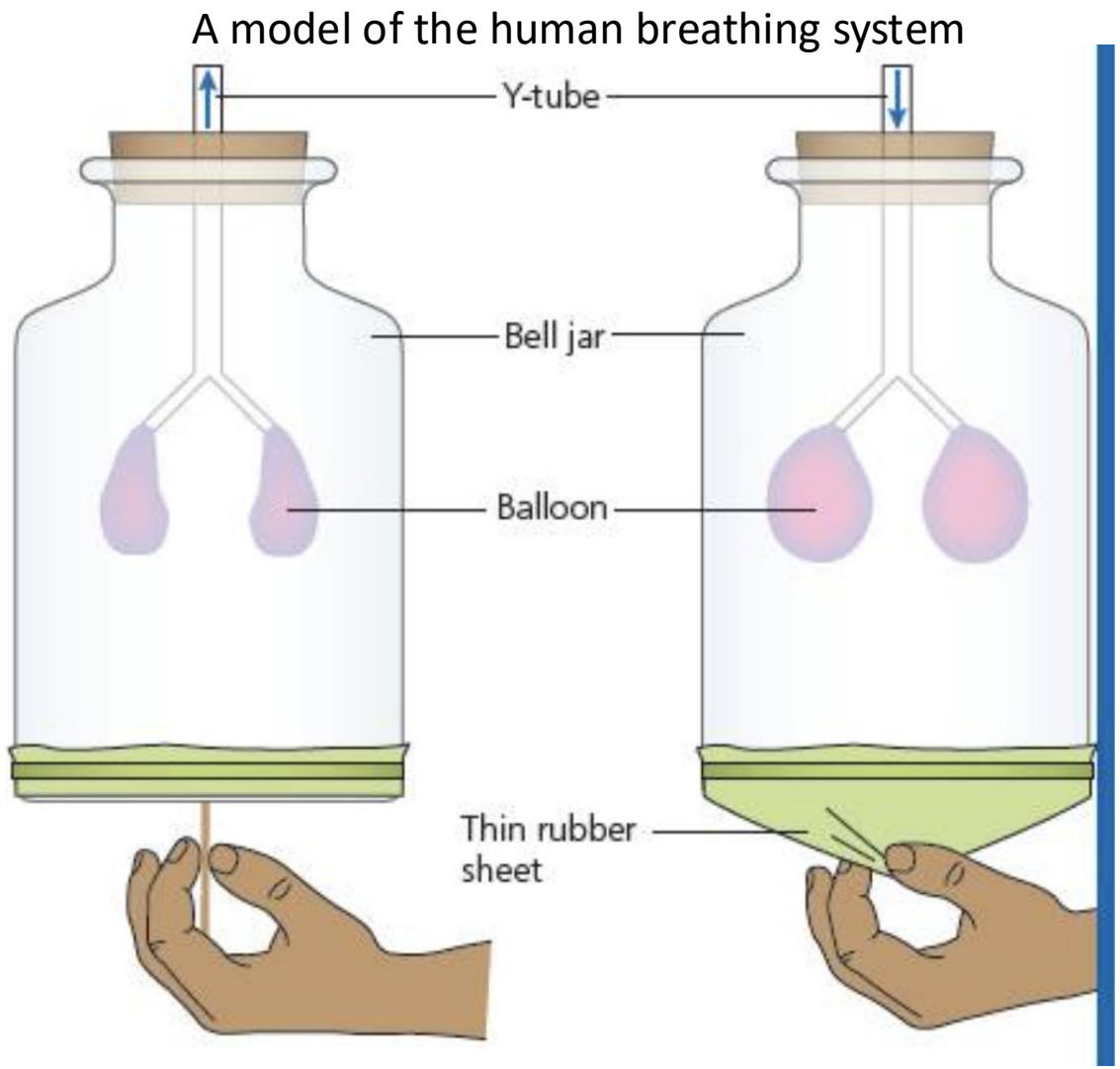
Link to Respiration and Excretion

- Oxygen is needed for **aerobic respiration** to release energy from glucose.
- Carbon dioxide is a waste product of respiration.
- Removal of carbon dioxide is an **excretion process** because it is a metabolic waste.

Model Activity: Bell Jar Lung Model

What the parts represent:

- Bell jar = Thoracic cavity
- Y-shaped tube = Trachea and bronchi
- Balloons = Lungs
- Rubber sheet = Diaphragm



Explanation:

- Pulling the rubber sheet down increases volume → pressure decreases → balloons inflate (inhalation).
- Pushing it up decreases volume → pressure increases → balloons deflate (exhalation).

Limitations of the model:

- No ribs or intercostal muscles.
- No blood supply.
- No gas diffusion shown.

Discussion Questions (Criterion A Focus)

1. Why must oxygen move into the blood?
2. How do the structure and function of alveoli support diffusion?
3. Why must carbon dioxide be removed?
4. Why do large organisms need specialized gas exchange systems?

Reference

- **Hodder Education (MYP):**
  Hodder Education. *MYP Biology by Concept*. Hodder Education, 2018.
- **Cambridge IGCSE Biology:**
  Jones, Mary, and Geoff Jones. *Cambridge IGCSE™ Biology*. 3rd ed., Cambridge University Press, 2014.