WJEC (Wales) Biology GCSE

Topic 1.2: Respiration and the Respiratory System

Notes

('Higher Tier only' in **bold**)

Cellular respiration

Respiration is a series of enzyme-controlled reactions that release energy (**in the form of ATP**) from the breakdown of organic compounds (e.g. glucose). It involves a sequence of exothermic chemical reactions occurring in the mitochondria and cytoplasm of cells.

Respiration is important because a constant supply of energy is required for many essential processes in living cells e.g. movement, homeostasis and active transport.

There are two types of respiration: **aerobic** and **anaerobic**.

Aerobic respiration

Aerobic respiration releases energy from the breakdown of glucose in the **presence of oxygen**:

glucose + oxygen → carbon dioxide + water (+ energy)

Anaerobic respiration

Anaerobic respiration takes place without oxygen (e.g. during vigorous exercise) and releases energy from the partial breakdown of glucose. In animal cells, lactic acid is produced:

glucose → lactic acid (+ energy)

Anaerobic respiration produces an 'oxygen debt' due to lactic acid build-up. To 'repay' this, extra oxygen must be taken in after anaerobic respiration to break down lactic acid in the liver.

Comparison

Aerobic respiration	Anaerobic respiration
Presence of oxygen	Lack of oxygen
Complete breakdown of glucose	**Incomplete breakdown of glucose**
More efficient - produces 32 ATP	**Less efficient - produces 2 ATP**
Produces carbon dioxide, water, ATP	Produces lactic acid, ATP (animal cells)

The respiratory system

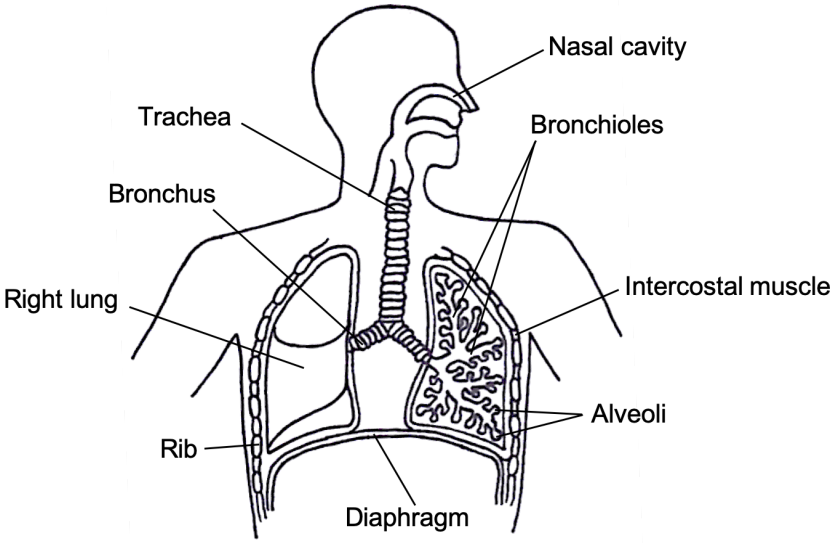
The need for a respiratory system

Unlike smaller organisms, large multicellular organisms require a respiratory system because:

- Small SA/V ratio
- Diffusion insufficient to provide all cells with the required O_2 and to remove all CO_2

Structure of the respiratory system

Pathway of gas through the respiratory system:
nose → trachea → bronchi → bronchioles → alveoli → capillaries



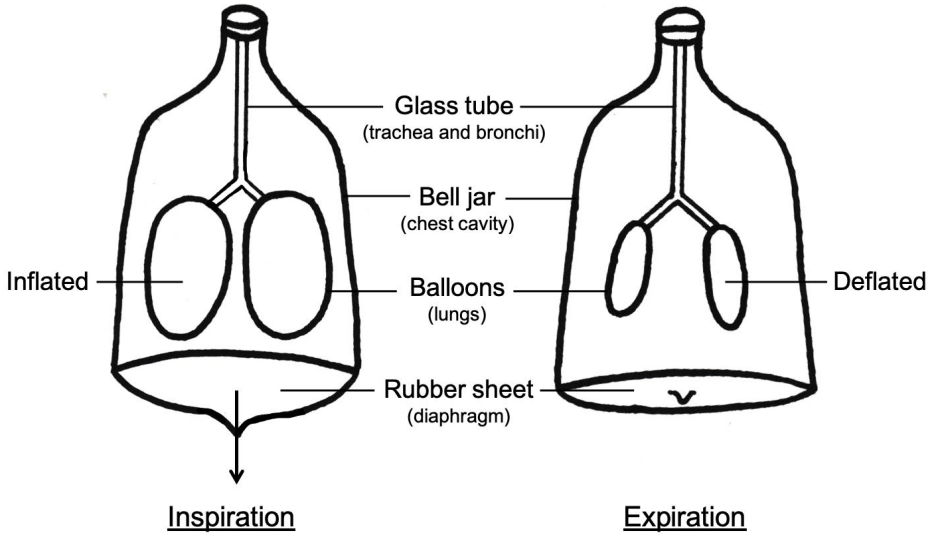
Cells lining the surface of the respiratory tract produce mucus. This is sticky and traps harmful substances and organisms, preventing entry into the lungs. Ciliated epithelial cells found lining the respiratory tract move in a synchronised wave to beat mucus up to the back of the throat where it is swallowed. This protects the lungs from infection.

Ventilation

Ventilation is the movement of fresh air into the lungs and stale air out of the lungs via inspiration (breathing in) and expiration (breathing out). The processes of inspiration and expiration are outlined in the table below:

Inspiration	Expiration
Ribs move up and out	Ribs move down and in
Diaphragm contracts and flattens	Diaphragm relaxes and reverts to dome shape
Volume of thorax increases	Volume of thorax decreases
Thoracic pressure falls below air pressure	Thoracic pressure rises above air pressure
Air moves into trachea	Air moves out of trachea

A bell jar model can be used as a model of ventilation.



As the rubber sheet is drawn down during inspiration, the volume of the bell jar increases and its pressure falls below air pressure. Air moves into the glass tube and balloons causing inflation.

Limitations of the bell jar model:

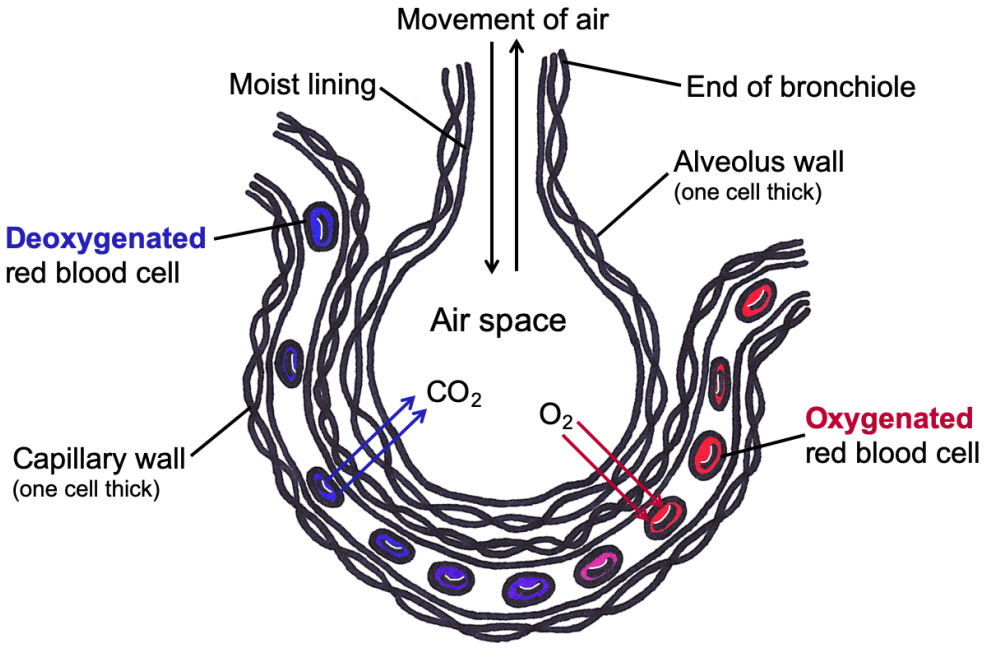
Thorax	Bell jar model
Thoracic cavity filled with pleural fluid	Bell jar filled with air
Cartilage in trachea flexible	Glass tube rigid
Diaphragm flattens	Rubber sheet drawn downwards

Lungs composed of many alveoli	Balloons empty
Ribs move to change thoracic cavity volume	Bell jar does not move

Alveoli

The alveoli are a cluster of air sacs found in the lungs where gas exchange occurs:

- O_2 diffuses from air in the alveoli into blood in the capillaries
- CO_2 diffuses from blood in the capillaries into air in the alveoli



Alveoli are adapted for gas exchange:

- Large surface area
- Surrounded by a network of capillaries giving a good blood supply
- Rapid blood flow maintains a steep concentration gradient
- Thin wall gives a short diffusion distance
- Walls covered by thin, moist film, allowing gases to dissolve and increasing diffusion rate

Composition of inspired and expired air

Gas	% of inspired air	% of expired air
Oxygen	21	16
Carbon dioxide	0.04	4
Nitrogen	79	79
Water vapour	variable	1

To test for the presence of CO_2, bubble gas through **lime water**. CO_2 turns lime water **milky**.

The effects of smoking on the respiratory system

Several chemicals found in tobacco smoke cause damage to the respiratory system. The effects of each are described in the table below:

Chemical	Effect
Carcinogens	Chemicals that increase the risk of cancer, e.g. lung, oesophagus, mouth
Tar	Sticky substance deposited in the airways. Stimulates mucus production. Paralyses the cilia, preventing mucus from being swept away. Mucus contains microorganisms and dirt builds. Leads to smoker's cough.
Nicotine	Addictive. Increases heart rate. Directly damages lungs.
Carbon monoxide	Binds with haemoglobin in red blood cells irreversibly, reducing the oxygen-carrying capacity of the blood.

Damage to the alveoli walls and loss of elasticity in the alveoli can lead to emphysema, a lung condition resulting in breathing difficulties.