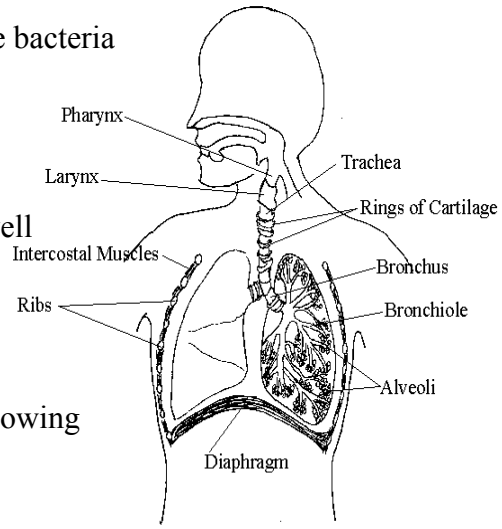
Breathing System

Functions
Effective absorption of O_2 from the air and excretion of CO_2 to the air (= **gas exchange)**

Remember Fick's Law : *Diffusion* α $\frac{\textit{surface area x concentration difference}}{\textit{distance}}$

Structure

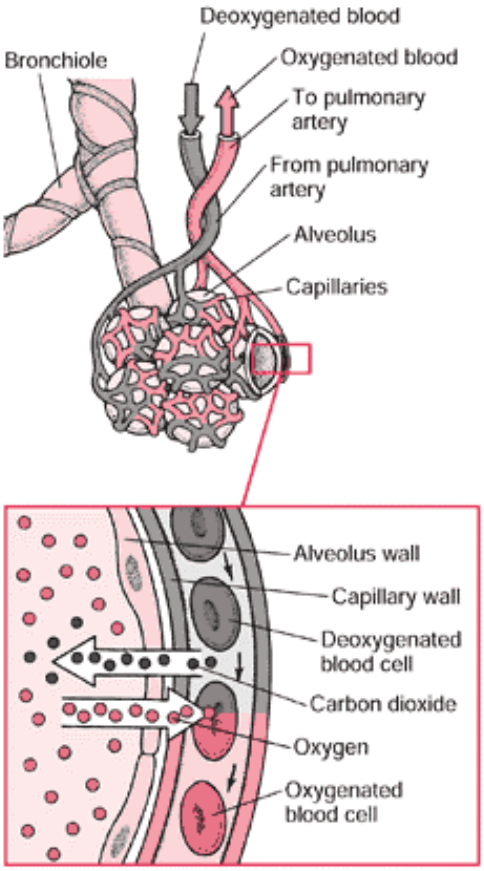
Nasal Cavity
- hairs and mucus trap much of the dust and small particles like bacteria
- the wet surface moistens the air
- the rich blood supply warms the air



Mouth Cavity
Air entering via the mouth is not cleaned, moistened or warmed as well

Epiglottis
- protects the trachea against the entry of food and drink by
- a reflex action
- the opening of trachea is closed by the epiglottis during swallowing

Trachea
- a channel for air to flow to and from the bronchi
- its mucus lining traps dust and bacteria
- the beating of cilia on its surface move the mucus to the pharynx for swallowing
- the C-shaped rings of cartilage support the wall of the trachea keeping it permanently open
- **Bronchus -** one goes to each lung - similar in structure to the trachea but narrower



Bronchioles (many branches)
- a narrow open tube for air to flow in and out of the alveoli
- inflammation = **bronchitis**

Alveoli
- Sites of gas exchange in close extensive contact with blood capillaries
- Large Surface Area: ($90m^2$) from 700 million alveoli.
- Good blood supply

Pleural Membranes
- surround and protect the lungs, lining the thoracic cavity
- 'glues' the lungs to the chest wall and diaphragm
- permits smooth moving of lungs across chest wall and diaphragm during breathing

Ribs
- protective bony cage around the lungs and heart;
- play a role in breathing (**intercostal muscles)**

Diaphragm

- a broad sheet of muscle between the thoracic and abdominal cavities
- its contraction is responsible for 75% of the air drawn into the lungs

Intercostal Muscles

- changes the shape and volume of the rib cage during breathing
- **external intercostals contract** to breathe in – '**inspiration'**
- **internal intercostals contract** during forced breathing out – **'expiration'**
- responsible for 25% of the inspired air

Inspired and Expired Air Comparison			
Gas + %	*Inspired Air*	*Expired Air*	*Alteration*
Nitrogen	78%	76%	No real change.
Oxygen	20.8%	15.3%	Reduced by about a quarter
Carbon Dioxide	0.04%	4.2%	Increased by about a hundred and five times
Water Vapour	1.2%	6.1%	Increased about five times
Note: > 250cm^3/day of water is lost from the body due to breathing.			

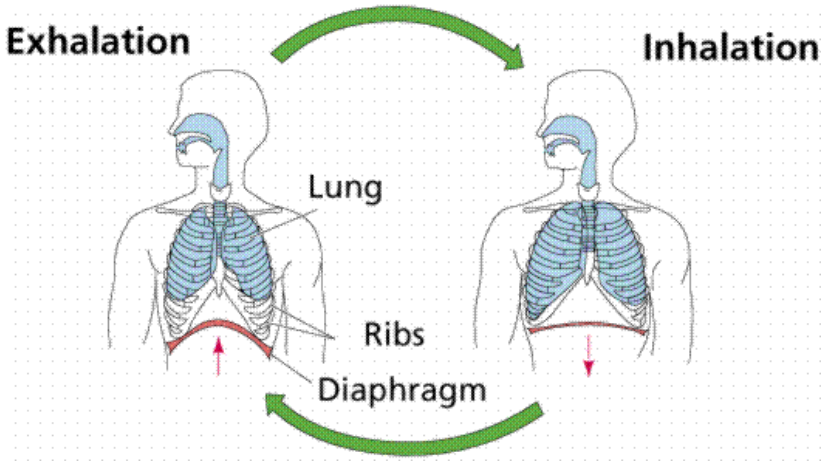
The Breathing Mechanism

Inspiration

- An active process because it involves muscle contraction.
- The diaphragm and external intercostal muscles contract.
- The contracting diaphragm flattens and stretches the elastic lungs downward.
- The contracting intercostals pull the ribcage up and out causing the elastic lungs to stretch.
- The expansion of air causes a drop in air pressure in the lungs.
- The air in the lungs is at a lower pressure than the air outside, so air enters the lungs.

Expiration

- A passive process because it does not involve muscle contraction.
- The diaphragm relaxes, and the internal intercostal muscles contract (forced breathing).
- The lungs recoil elastically reducing their volume – a passive process.
- The volume of air in the lungs decreases causing an increase in the air pressure.
- Air flows from higher to lower pressure so the air flows out of the lungs.
- **Note**: the elastic recoil of the lungs pulls up the adhering diaphragm and ribcage.

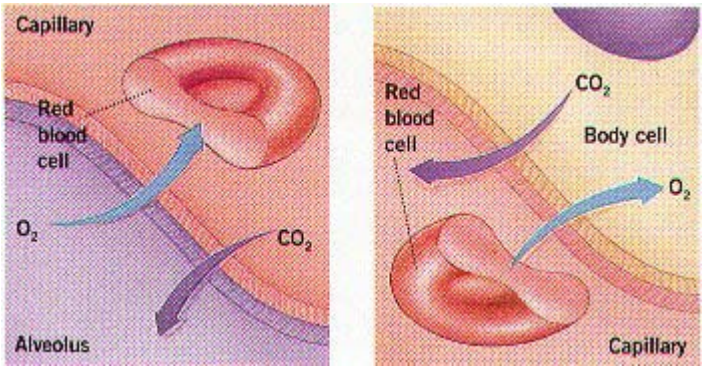


Carbon Dioxide and Breathing

- Carbon dioxide blood level controls the rate and depth of breathing.
- Normal breathing is controlled subconsciously by the medulla oblongata in the brain.
- ↑ in blood CO_2 stimulates the medulla, sending nerve impulses to the breathing muscles.
- The diaphragm and external intercostal muscles contract , so air is breathed in.
- Nervous feedback from the inflating alveoli causes the medulla to switch off its stimulation.
- Inspiration stops and the lungs recoil causing expiration.
- Rapidly rising levels of CO_2 increase the rate of breathing.
- Exercise increases the production of CO_2 leading to an increase in the breathing rate.

Gas Exchange Adaptations

- Gas exchange is by diffusion so these adaptations enhance diffusion. (**Fick's Law**)
- **Large surface area**: 90m^2 — 700 million alveoli
- **Good blood supply** - 40 billion capillaries.
- **Permeable surfaces**: the cell membranes are freely permeable to O_2 and CO_2.
- **Thin walls**: the distance between the air and the blood is two cells wide.
- **RBC's only just fit capillaries** thus distance for diffusion minimised
- **Moist surface of alveoli**: enhances the uptake of O_2.



- **Elastic alveoli walls**: efficient filling with air and recoil enhances emptying.
- **Slow capillary blood flow**: time for complete oxygenation and excretion of CO_2.