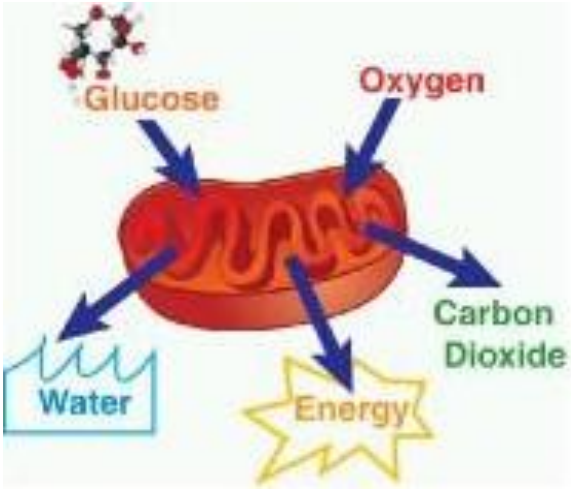
08 Respiration

#79 Respiration realeases energy from food



Respiration is the **chemical reactions** that **break down nutrient molecules** in living cells to **release energy**.

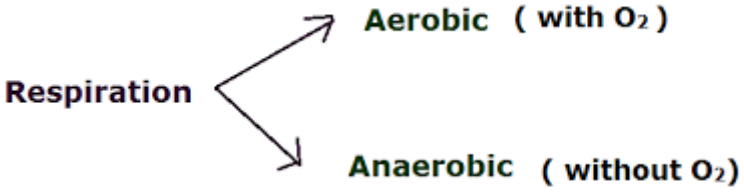
In humans, our cells need energy (ATP) for:

- muscle contraction
- making protein molecules: linking together amino acids into long chains
- cell division: to repair damaged tissues and so that we can grow
- active transport
- transmitting nerve impulses
- maintenance of constant body *t*°

All this energy comes from the food we eat. Water soluble molecules are absorbed from the intestine into the blood.

The main energy–providing nutrient: **glucose** (contains a lot of chemical energy).

There are 2 types of respiration:



Video ATP & Respiration: Crash Course Biology #7

https://www.youtube.com/watch?v=00jbG_cfGuQ

#80 Aerobic and anaerobic respiration

Respiration releases energy from food.

There are 2 kinds of respiration: **Aerobic** and **Anearobic**. The main difference between them is that aerobic respiration involves **oxygen** and anaerobic respiration does not!

A. Aerobic respiration

The release of a relatively **large amount of energy** in cells by the breakdown of food substances in the **presence of O_2**.

glucose + oxygen ⟶ carbon dioxide + water

$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$

B. Anaerobic respiration

Anaerobic respiration: the release of a relatively **small amount of energy** by the breakdown of food substances in the **absence of O_2**.

Anaerobic respiration in muscles during exercise:

glucose ⟶ lactic acid + energy

$C_6H_{12}O_6 \longrightarrow 2C_3H_6O_3$ + energy

Anaerobic respiration in yeast:

glucose ⟶ ethanol + carbon dioxide + energy

$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2$ + energy

Muscles respire anaerobically when exercising vigorously, because the blood cannot supply enough oxygen to maintain aerobic respiration. Howerver, the formation and build-up of lactic acid in muscles causes cramp (muscle fatigue).

The lactic acid that is made is transported to the liver, and later is broken down by combining it with O_2. This extra O_2 is breathed in after the exercise has stopped, and it is known as the **oxygen debt**.

Bread making

- yeast is mixed with water to activate it then added to flour to make dough

- mixture -----> warm place ------> rise

- yeast releases CO_2 ------> dough rises
* a warm t^o is important because fermentation is controlled by enzymes

- when dough is cooked, high t^o kills yeast and evaporates any formed ethanol
- air spaces are left where CO_2 was trapped

Brewing

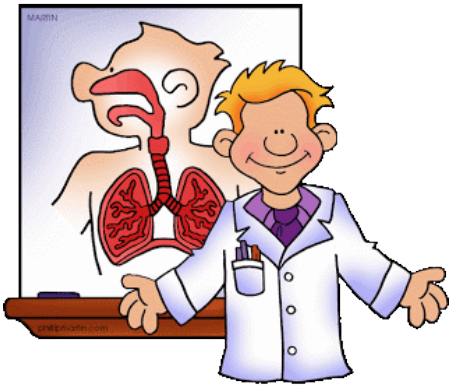
- yeast is added to a source of sugar (fruit juice or germinated barley grains) and kept in warm conditions

- fermentation (yeast respires the sugar) occurs ------> ethanol is formed making the drink alcoholic

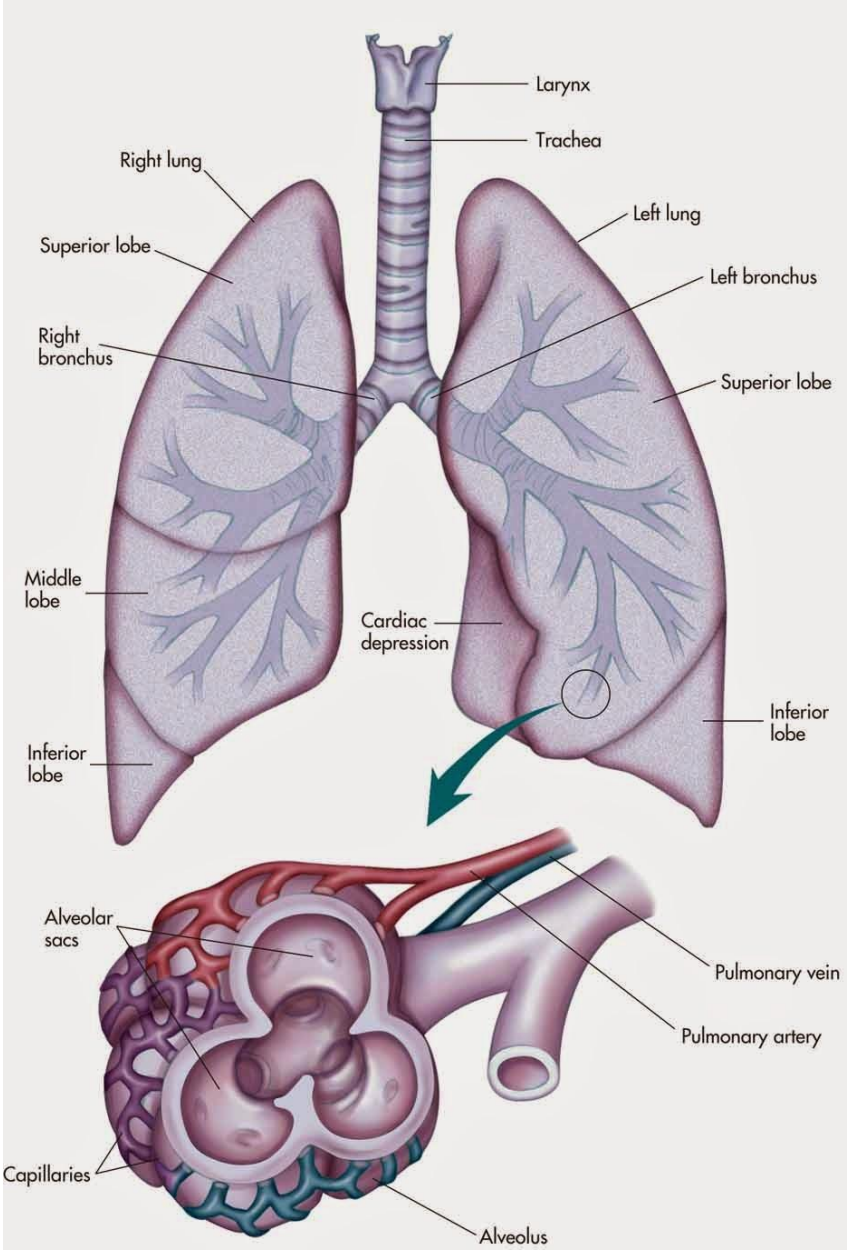
- CO_2 makes the drink fizzy + sharp flavour

#81 Gaseous exchange, role of mucus and cilia

Gas exchange usually involves **2 or more gases** transferred in **opposite** directions across a **respiratory surface**.



1. Structure of the breathing system: the larynx, trachea, bronchi, bronchioles, alveoli and associated capillaries.

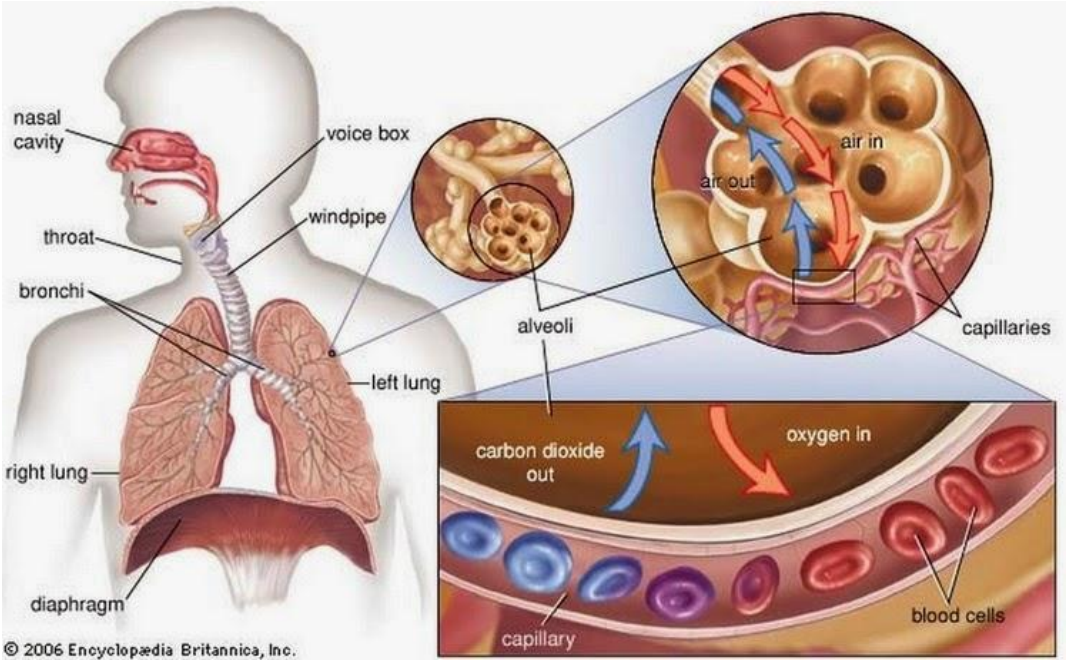


Credit: biology-forums.com

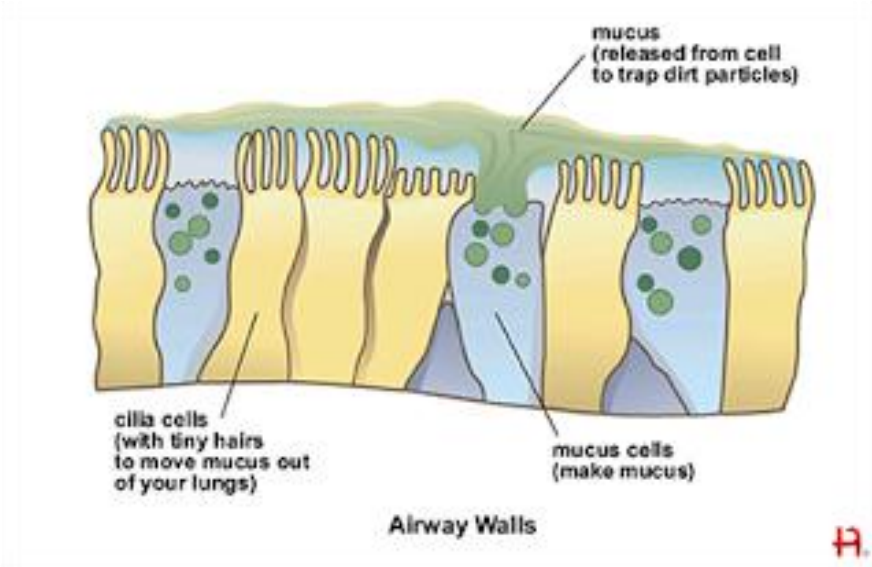
2. Gaseous exchange relies on diffusion. To be efficient, the **gaseous exchange surface** must:

- **thin** – shorter distance to diffuse
- **moist** – allow gases to dissolve
- **large surface area**
- have a **concentration gradient** across surface – maintained by movement of air and transport/ use of gas.

These features are present in gills (fish) and alveoli (lungs).



3. The role of mucus and cilia



- Inside the nose, thin turbinal bones are covered with a layer of cells. Some of which are **goblet cells**.

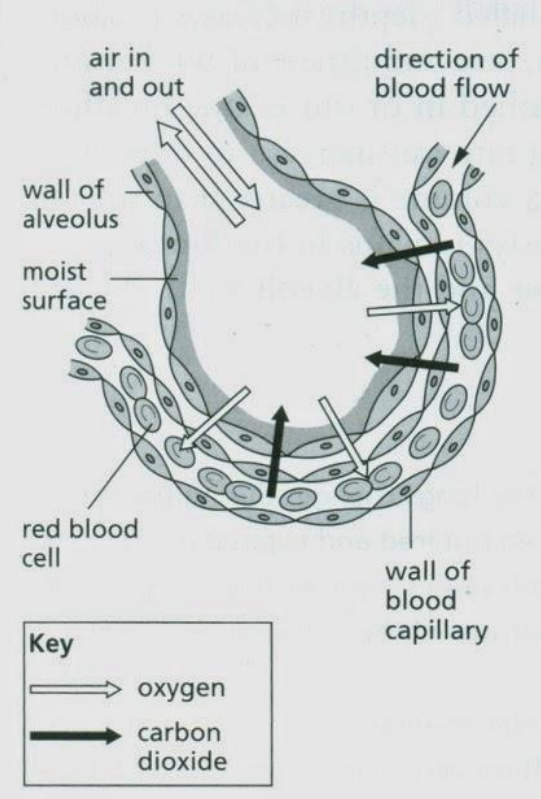
- Goblet cells produce a **liquid** (water + **mucus**) ---> evaporate ---> moisten nose.

- Cilia: tiny hair-like projections; constantly moving

- Bacteria + dust particles are **trapped** by cilia and mucus as to not move further inside the gas exchange system.

Try this

State how each feature labeled on the diagram of an alveolus makes the process of gaseous exchange efficient. [5 marks]



Answer

Wall of alveolus – one cell thick (or very thin) so that diffusion happens quickly.

Moist surface- allow O_2 to dissolve making diffusion faster.

Blood is moving – so that's concentration gradient is maintained for O_2 and CO_2

Wall of capillary – one cell thick (or very thin) so that's diffusion happens quickly.

Red blood cells – contain haemoglobin to transport O_2 away from the lungs.

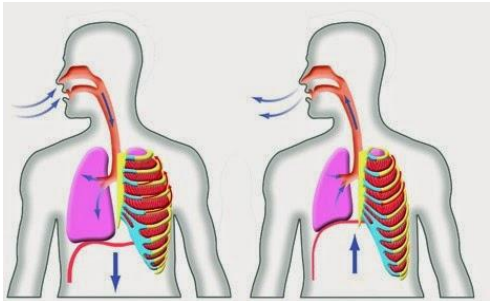
Video: Gas exchange
https://www.youtube.com/watch?v=TTkhvvs9Qkk

Video: Functions of Cilia and Goblet Cells

https://www.youtube.com/watch?v=miEEluVlemQ

#82 Inspired and expired air, blood pH and breath rate

* inspired air: air we breath in
* expired air: air we breath out



The composition of inspired and expired air

Testing for CO_2

To investigate the differences in composition between inspired and expired air, we use **limewater** because **it change colour** when the gas is bubbled through, from colourless to **milky**.

There is more CO_2 present in **expired air** ---> it makes limewater change colour more **quickly** (than inspired air).

Effects of physical activity on breathing

** tidal volume: amount of air during normal, relaxed breathing*
vital capacity; maximum amount of air breathed in or out in one breath

During normal breathing:
- depth (tidal volume) : ≈ 0.5ℓ
- rate: 12 breaths/ minute

During exercise:
- depth: ≈ 5ℓ (depending on age, sex, size & fitness of person)
- rate: over 20 breaths/ minute

The total lung volume is greater than vital capacity (some air always remains in the lungs). If not, alveoli walls would stick together, the lung would collapse.

Link between physical activity and rate and depth of breathing

- when you run, muscles in your legs use up a lot of energy.
- cells in the muscles need a lot of O_2 very quickly.
- they combine **O_2 + glucose** as fast as they can, to **release energy** for muscle construction ---> a lot of O_2 is needed
- you breath **deeper** and **faster** to get **more O_2** into your blood.
- your heart beast faster to get O_2 to the leg muscles as quickly as possible.
- a **limit** is reached - the heart and the lung can not supply O_2 to the muscles any faster.
- some extra energy (not much) is produced by **anaerobic respiration:** some glucose is broken down without combing with O_2:

Glucose ---> lactic acid + energy.

- **CO2** and **lactic acid** concentration in tissue and in the blood ↑ ---> blood **pH** ↓
- Brain sens the change ---> nerve impulses sent to the diaphragm and the intercostal **muscles**, stimulating them to **contract harder** and **more often** ---> **faster** and **deeper** breathing.

Try this

a) The composition of the air inside the lungs changes during breathing.
i) State **three** differences between inspired and expired air. [3 marks]
ii) Gaseous exchange in the alveoli causes some of the changes to the inspired air. Describe **three** features of the alveoli which assist gaseous exchange. [3 marks]

b) i) State what is meant by anaerobic respiration [2 marks]
ii)Where does anaerobic respiration occur in human? [1mark]

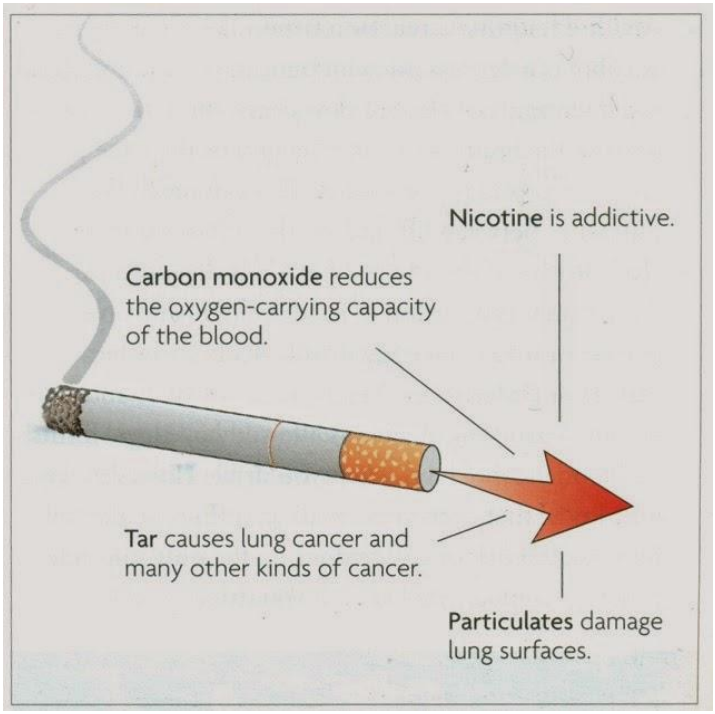
Answer
a) i) Inspired air contains more O_2, less CO_2, and less water vapor then expired air.
ii) **Three** features from:

- the wall of the alveolus is one cell thick (or very thin)
- there is a moist surface to the alveoli
- there are large number of alveoli
- the air in the alveoli is constantly being replaced.

b) i) The release of energy by cells without the use of oxygen.
ii) In muscle cells.

#83 Effects of tobacco smoke on the respiratory system

Tobacco smoke contains **irritants** and **carcinogens**.
Its 4 main toxic chemicals: **carbon monoxide, nicotine, smoke particles** and **tar.**



Carbon monoxide:
- combines with haemoglobin in RBC ---> prevents them transporting O_2.

Nicotine:
- addictive ---> continual smoking

Smoke particles:
- irritate air passages ---> inflammation + increase mucus production ---> chronic bronchitis.
- presence of smoke particles in alveoli + coughing = emphysema (breathlessness)

Tar:
- a carcinogen: increase risk of lung cancer (cell division out of control)
- lines air passages:
  - increase mucus production
  - paralysing + damaging cilia
  ---> bronchitis

Common misconceptions

Remember that only nicotine and carbon monoxide enter the blood. Tar and smoke particles do not – they stay in the lungs.

Sample question

The table shows the percentage of haemoglobin which is inactivated by CO present in the blood of taxi drivers in a city.

City taxi drivers	Percentage of Hb inactivated by CO	
Daytime drivers	Non-smokers	2.3
	Smokers	5.8
Night-time drivers	Non-smokers	1.0
	Smokers	4.4

i) Suggest two sources of the CO inhaled by these taxidrivers [2marks]

ii) Some daytime drivers have 5.8% of their Hb affected. Using information from the table, explain which source contributes most to this effect.
[2 makrs]

iii) Suggest a reason for the differences, shown in the table, between daytime and night-time drivers. [1 mark]

Studen's answer

i) 1. cigarette smoke ✓
2. breathing by passengers ×

ii) It must be cigarette smoking because non-smokers have less of their Hb affected. ✓

iii)Therer could be less car exhaust fumes, containing CO, at night. ✓

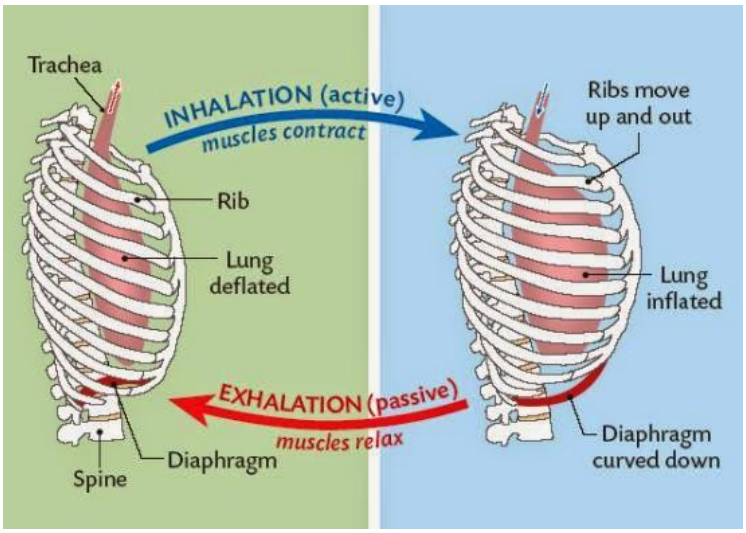
Examiner's comments

In part (i), the second answer if biologically incorrect (we breath out CO_2, not CO. The other correct answer was car exhaust gases.

In part (ii), the answer and the explanation were correct.

Part (iii) war a good answer.

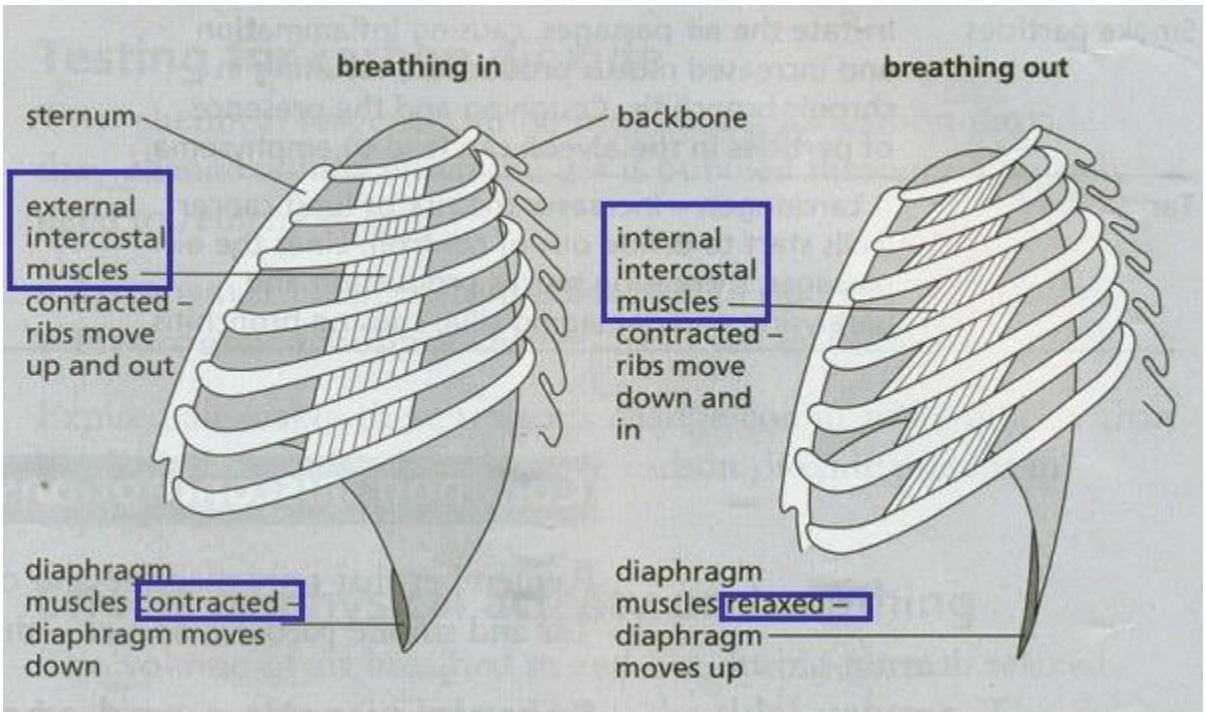
#84 Ventilation, role of intercostal muscles and diaphragm



There are 2 sets of muscles which help you to breath:
- **intercostal**: between the ribs

- **diaphragm**: a large sheet of muscle and elastic tissue, underneath the lungs and heart.

Figure below shows the relationship between intercostal muscles, diaphragm and ribcage to achieve ventilation of the lungs.



Two set of intercostal muscles are attached to the ribes. They are antogonistic.

1. Breathing in (inhaling)

- The **external intercostal muscles** contract, they move the ribcage upward and outward ---> ↑ volume of the thorax.
- The diaphragm muscles **contracts** ---> diaphragm moves **down**
- ↑ volume of the thorax
- ↓ air pressure in the thoracic cavity
- air rush **into** the lungs through the mouth or nose.

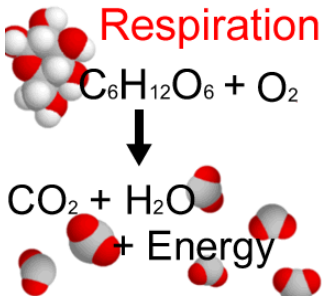
2. Breathing out (exhaling)
The opposite happens:

- The **internal intercostal muscles** contract
- The diaphragm muscles **relax** ---> diaphragm moves **up**
- ↓ volume of the thorax
- ↑ air pressure in the thoracic cavity
- air rush **out** of the lungs.

Features	**Inspiration**	**Expiration**
Intercostal muscles	**external** muscles contract	**internal** muscles contract
Ribcage moving	**upward** outward	**downward**
Diaphragm muscles	**contract**	**relax**
Diaphragm	move ↓	move ↑
Thorax volume	↑	↓
Air pressure in thorax cavity	↓ lower than air pressure outside	↑ higher than air pressure outside
air rushes	**into** the lungs	**out** of the lungs

#85 Summary of Respiration

- **Respiration** is a series of metabolic reactions that takes place in every living cell. The purpose of respiration is to **release energy** from **glucose**, so that the cell can make use of the energy.



- In **aerobic** respiration, the glucose is combined with O_2, forming CO_2 and H_2O.

- In **anaerobic** respiration, the glucose is broken down without being combined with O2. In plants and fungi, this produces alcohol and CO_2.

- In animals (including human) it produces lactic acid.

- Muscles respire aerobically when they are working so fast that they cannot be supplied with O_2 quickly enough. The lactic acid that is made is transported to the liver, and later is broken down by combining it with O_2. This extra O_2 is breathed in after the exercise has stopped, and it is known as the **oxygen debt**.

- All gas exchange **surfaces** need to be thin, have a large surface area, be kept moist, and have a good supply of O_2. In larger animals, a transport system is needed to carry away the CO_2 and bring O_2.

- The air we breath in travels down the **trachea** and **bronchi**, through the **bronchioles** and into the **alveoli**.

- Some of these tubes are lined with **goblet cells** which make mucus, and **ciliated** cells. The mucus traps dirt, bacteria and other particles and the cilia sweep the mucus up and away from the lungs.

- Air is drawn into the lungs by the contraction of the **external intercostal muscles** and the muscles in the **diaphragm**. These muscle contractions increase the volume of the thorax, which decreases the pressure. Air flows down the pressure gradient and into the lungs.

- **Tobacco smoke** contains many different substances that harm health. **Nicotine** is an addictive stimulant, and its intake increases the risk of developing heart diseases. **Tar** causes lungs and other cancers. **CO_2** reduces the ability of red blood cells to transport O_2. Smoke particles irritate the lungs and can contribute to the development of emphysema.