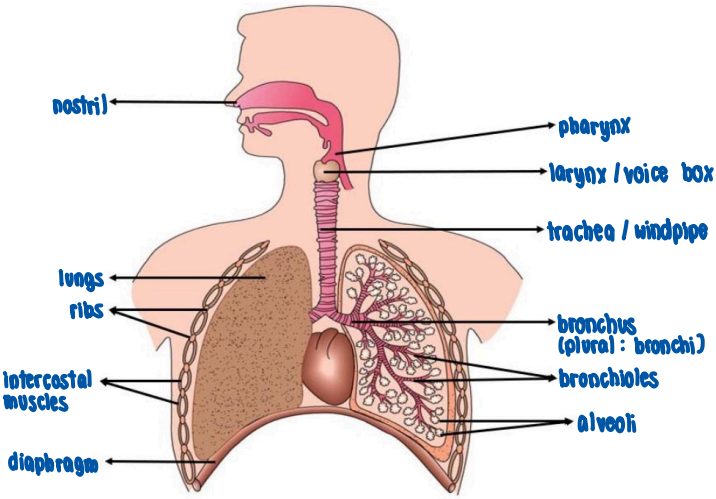
respiration in humans



PARTS OF THE RESPIRATORY SYSTEM

① nose and nostrils

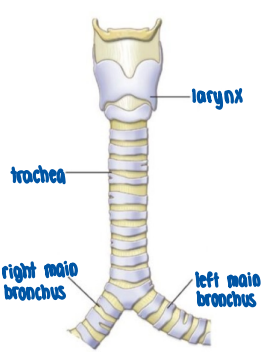
- air enters through the nostrils
- walls of nostrils have nasal hair and mucous membranes that produce mucus

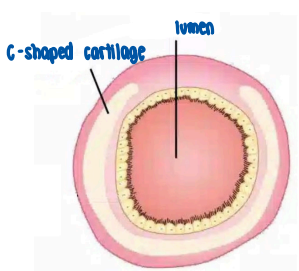
FUNCTION

- hairs and mucus trap dust, foreign particles
- mucus warms and moistens air
- sensory cells in mucous membrane detects harmful chemicals

② trachea

- airway that lies in front of the oesophagus
- trachea is supported by C-shaped rings of cartilage to ensure that the trachea is always kept open





cross-section view

route taken by air as we inhale:

through nostrils
↓
pharynx
↓
larynx
↓
trachea
↓
bronchus / bronchus
↓ / ↓
bronchioles / bronchioles
↓ / ↓
alveoli / alveoli

③ bronchi & bronchioles

- the trachea branches into two tubes called the bronchi
- each bronchus branches repeatedly and ends in numerous bronchioles
- each bronchiole ends in a cluster of air sacs called alveoli where gaseous exchange takes place

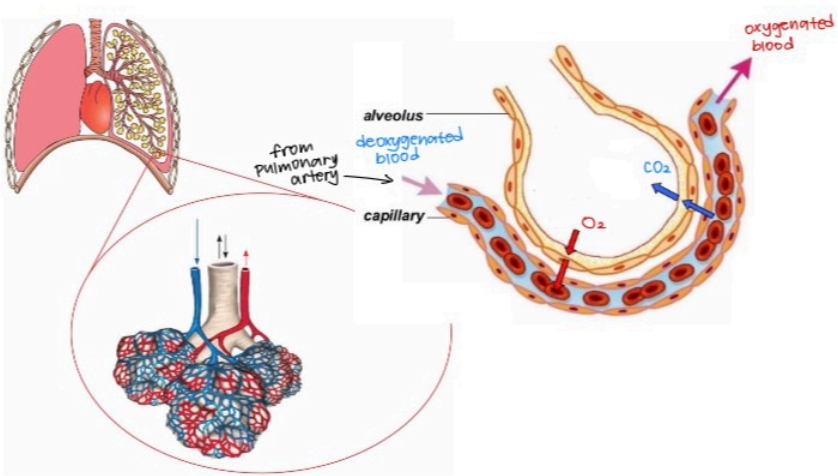
④ epithelium of trachea and bronchi

- the membrane in the inner wall of the lumen of the trachea and bronchi is called the epithelium
- consists of 2 types of cells
  1. gland cells — secrete mucus that traps dust particles & bacteria in the air passage
  2. ciliated cells — have cilia, which sweep the mucus containing dust particles in bronchi and trachea into the pharynx

can be coughed out through the pharynx or be swallowed into the oesophagus

⑤ alveoli

- the sites of gas exchange
- numerous alveoli are found in the lungs
  each alveolus is surrounded by a network of blood capillaries



GAS EXCHANGE AT THE ALVEOLI

- gas exchange at the alveoli occurs by diffusion
- blood flowing to the lungs has a lower concentration of oxygen and a higher concentration of carbon dioxide than atmospheric air entering the lungs
- a concentration gradient for oxygen and carbon dioxide is set up between the blood in the capillaries and air in the alveolus

ADAPTATIONS OF THE LUNGS & ALVEOLI FOR EFFICIENT GASEOUS EXCHANGE

- lungs
  - there are numerous alveoli in the lungs, which provides a large surface area to volume ratio for more efficient gaseous exchange
- alveoli
  - thin, one-cell thick walls
    - ↳ provides a short diffusion distance for gases, ensuring more efficient diffusion of gases in and out of alveoli
  - thin film of moisture in inner walls of alveoli
    - ↳ allows gases to dissolve in it
  - each alveolus is surrounded by network of blood capillaries
    - ↳ continuous flow of blood maintains concentration gradient of gases
      - -maintains higher concentration of oxygen in alveoli than in blood
      - -maintains lower concentration of carbon dioxide in alveoli than in blood
    - ↳ allows more efficient diffusion of gases in and out of alveoli

HOW IS OXYGEN ABSORBED FROM THE LUNGS INTO BLOOD AND INTO CELLS OF TISSUES?

1. alveolar air contains a higher concentration of oxygen than the blood plasma
2. oxygen dissolves in the thin film of moisture in the inner wall of the alveolus and then diffuse into blood capillaries
3. oxygen combines reversibly with haemoglobin in red blood cells to form oxyhaemoglobin
4. when blood passes through oxygen-poor tissues, the oxyhaemoglobin releases oxygen
5. which will diffuse through the walls of the blood capillaries into the cells of the tissues

BREATHING

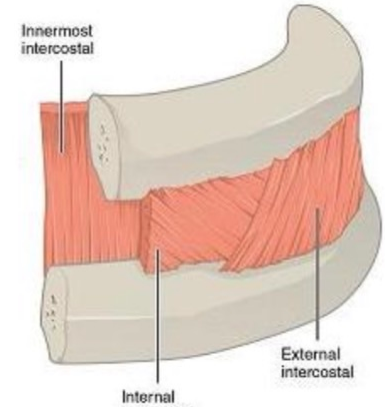
- part of the gas exchange process
- refers to the muscular contractions and movement of the ribs which result in air moving in and out of the lungs
- breathing movements consist of 2 phases:
  1. taking in of air called inhalation or inspiration
  2. giving out of air called exhalation or expiration

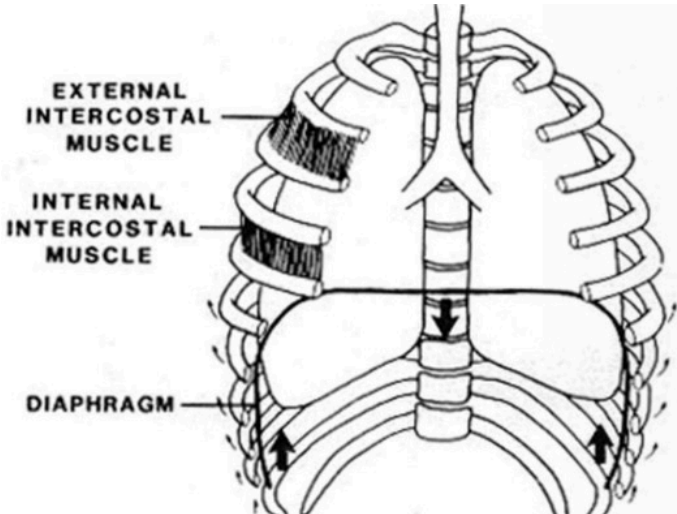
STRUCTURES WITHIN THE THORACIC CAVITY

- the thoracic cavity is the space in the body that is protected by the rib cage, as well as the associated skin and muscles
- 2 sets of intercostal muscles can be found between the ribs
- the intercostal muscles and the diaphragm at the rib cage enable the change in volume of the thoracic cavity

⑥ intercostal muscles

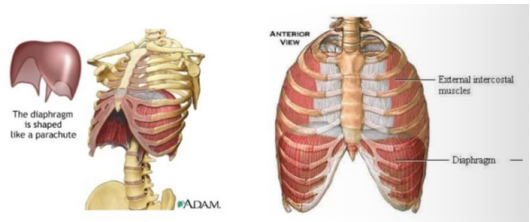
- external intercostal muscles and internal intercostal muscles are found between the ribs
  - ↳ they are antagonistic muscles





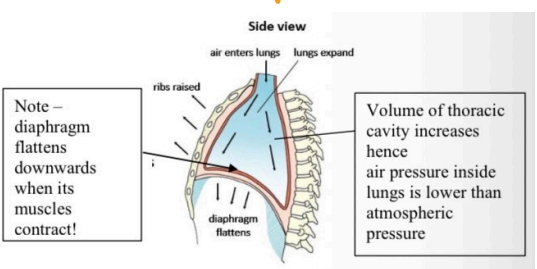
① diaphragm

- found below thorax
- made up of a dome-shaped sheet of diaphragm muscles
- when diaphragm muscles contract, diaphragm flattens downwards
- when diaphragm muscles relax, diaphragm arches upwards and becomes dome-shaped



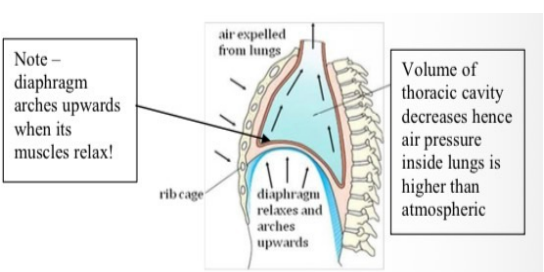
BREATHING IN – INSPIRATION

- diaphragm muscles contract, diaphragm flattens downwards
- external intercostal muscles contract, internal intercostal muscles relax
  ribs swing upwards and inwards
- volume of thoracic cavity increases
  - ↳ decreases air pressure in the lungs
  - ↳ atmospheric pressure is now higher than the pressure within the lungs
  - ↳ causes air from the atmosphere to be forced into the lungs



BREATHING OUT – EXPIRATION

- diaphragm muscles relax, diaphragm arches upwards and becomes dome-shaped
  external intercostal muscles relax, internal intercostal muscles contract
- ribs swing downwards and inwards
- volume of thoracic cavity decreases
  - ↳ increases air pressure in the lungs
  - ↳ atmospheric pressure is now lower than the pressure within the lungs
  - ↳ this causes the air in lungs to be forced out of the lungs



SMOKING & EFFECTS OF TOBACCO SMOKE

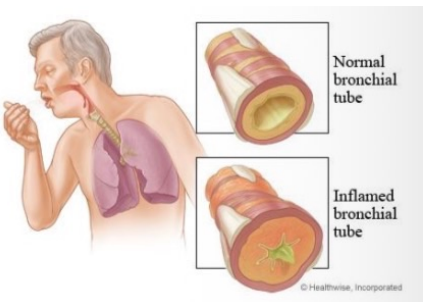
major toxic components of tobacco smoke	
nicotine	• nicotine is an addictive drug, that causes addiction to smoking • nicotine increases the chances of blood clot in blood vessels, increasing the risk of coronary heart disease • nicotine causes the release of the hormone, adrenaline, which increases heart rate and blood pressure
carbon monoxide	carbon monoxide binds irreversibly with haemoglobin in red blood cells to form carboxyhaemoglobin ↳ reduces the ability of haemoglobin to bind to oxygen and reduces the efficiency of oxygen transport • carbon monoxide also increases the risk of coronary heart disease
tar	• tar paralyses cilia in air passages • mucus cannot be swept up in air passage, so particles in mucus cannot be removed ↳ this can lead to violent and persistent coughing (chronic bronchitis) • tar contains cancer-causing chemicals that cause uncontrolled cell division in the lungs, increasing the risk of lung cancer
irritant particles	paralyse cilia lining in the air passages • increase risk of chronic bronchitis and emphysema

DISEASES ASSOCIATED WITH SMOKING

1. chronic bronchitis

prolonged exposure to irritant particles in tobacco smoke leads to:

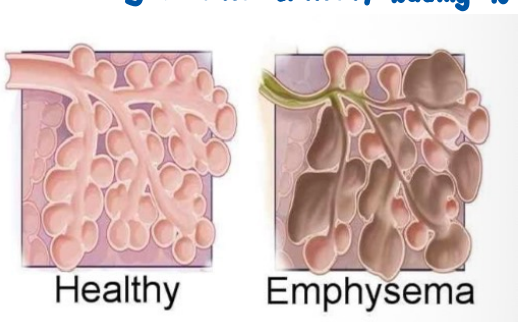
- epithelium lining of air passages become inflammed, excessive mucus secreted by epithelium
- cilia on the epithelium paralysed
  - ↳ mucus and dust particles cannot be removed
- air passage becomes blocked and breathing becomes difficult
- persistent and violent coughing to clear air passages



2. emphysema

long-term persistent and violent coughing may lead to emphysema

- partition walls between alveoli break down because of the force from the coughing
- this results in decreased surface area for gaseous exchange
- the lungs lose their elasticity and become inflated with air
- breathing becomes difficult, leading to wheezing and severe breathlessness



3. lung cancer

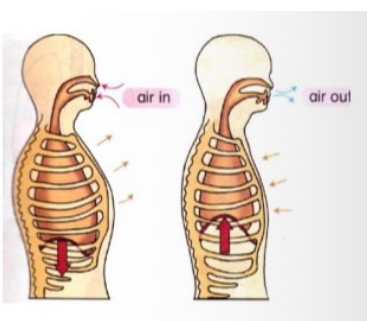
carcinogens (substances that can cause cancer) in tobacco smoke can cause mutations in the DNA in lung cells

- this causes lung cancer, which is a result of uncontrolled division of cells in the lungs, producing lumps of tissues (tumors) in lungs

RESPIRATION

- the oxidation of food substances with the release of energy in living cells
- 2 types of respiration
  1) aerobic respiration (requires oxygen)
  2) anaerobic respiration (does not require oxygen)

  both types utilise glucose as a respiratory substrate
- respiration vs breathing
  1) respiration and breathing are different but related processes
  2) respiration: oxidation of food molecules within living cells to release energy
  3) breathing: exchange of gases between the body and the surroundings
  4) oxygen required for aerobic respiration is taken in when we breathe in; carbon dioxide produced is given out when we breathe out



AEROBIC RESPIRATION

↳ breakdown of food substances in the presence of oxygen with the release of a large amount of energy

occurs in the mitochondria

- during respiration, glucose is oxidised, producing carbon dioxide and water, and releasing a large amount of energy

glucose + oxygen ⟶ carbon dioxide + water

ANAEROBIC RESPIRATION

↳ breakdown of food substances in the absence of oxygen

- anaerobic respiration takes place in the cytoplasm of the cell
- anaerobic respiration is less efficient than aerobic respiration; less energy is released during anaerobic respiration
- in humans, anaerobic respiration can happen in muscle cells during vigorous exercise
  in muscle cells, this process produces lactic acid and releases a small amount of energy

glucose → lactic acid

AEROBIC & ANAEROBIC RESPIRATION IN HUMANS

there are more vigorous muscular contractions during exercise

- more energy is required for more vigorous muscular contractions
- so, a higher rate of aerobic respiration takes place in muscle cells
  1) glucose is oxidised at a higher rate to release energy at a higher rate

breathing rate increases:

1) oxygen is taken in at a higher rate, so that aerobic respiration can take place at a higher rate, for more efficient release of energy
2) carbon dioxide is also removed from the body at a higher rate

- heart rate increases:
  1) so oxygen and glucose can be pumped to the muscles at a higher rate
  2) this allows higher rate of aerobic respiration in muscle cells, to release energy faster

} during exercise

AEROBIC & ANAEROBIC RESPIRATION IN HUMANS

- during intense or long periods of vigorous exercise, oxygen supplied to muscles is not enough to meet the oxygen demand
- amount of oxygen taken in is less than amount of oxygen required, leading to an oxygen debt

↓

the amount of oxygen required to convert all the lactic acid accumulated back to glucose

- there is insufficient oxygen taken in for aerobic respiration to take place fast enough to release the large amount of energy required
- anaerobic respiration takes place in the muscles, in the absence of oxygen to release the extra energy required
- lactic acid is produced and small amount of energy is released in the process

when max. rate of aerobic respiration is taking place but more energy is required

AEROBIC & ANAEROBIC RESPIRATION IN HUMANS

- body needs to rest
- lactic acid is gradually removed from muscles and transported to the liver to be oxidised to glucose
- breathing rate continues to be high for some time
  1) provides sufficient oxygen to muscle cells to repay oxygen debt
  2) provides oxygen to oxidise lactic acid into glucose in the liver
- when all lactic acid has been converted, the oxygen debt is repaid

after a race