GASEOUS EXCHANGE

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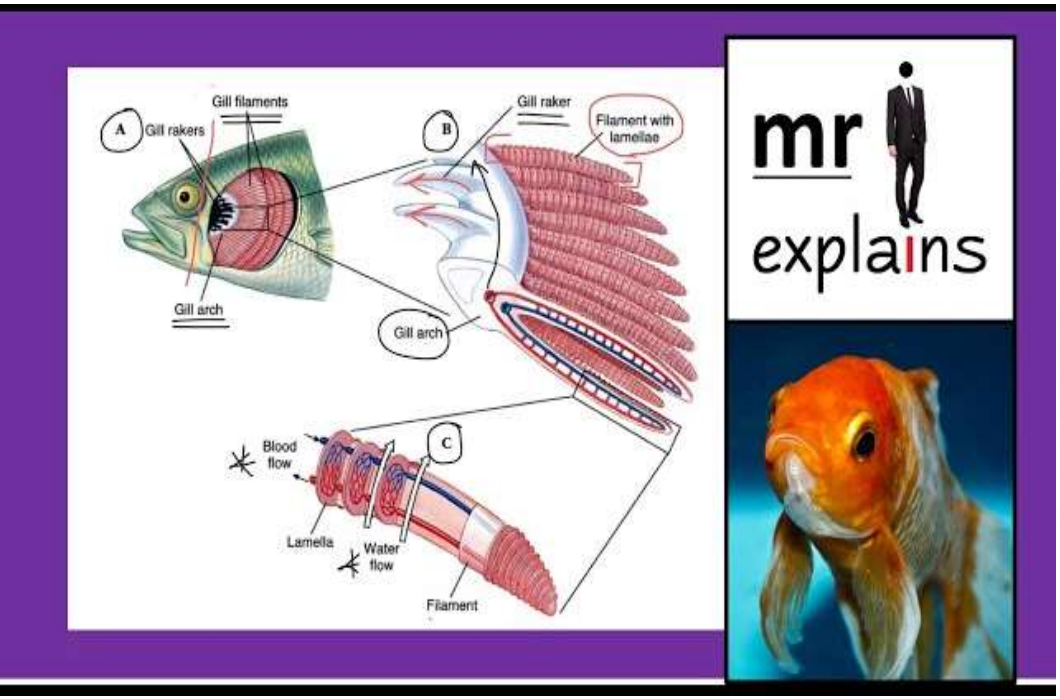
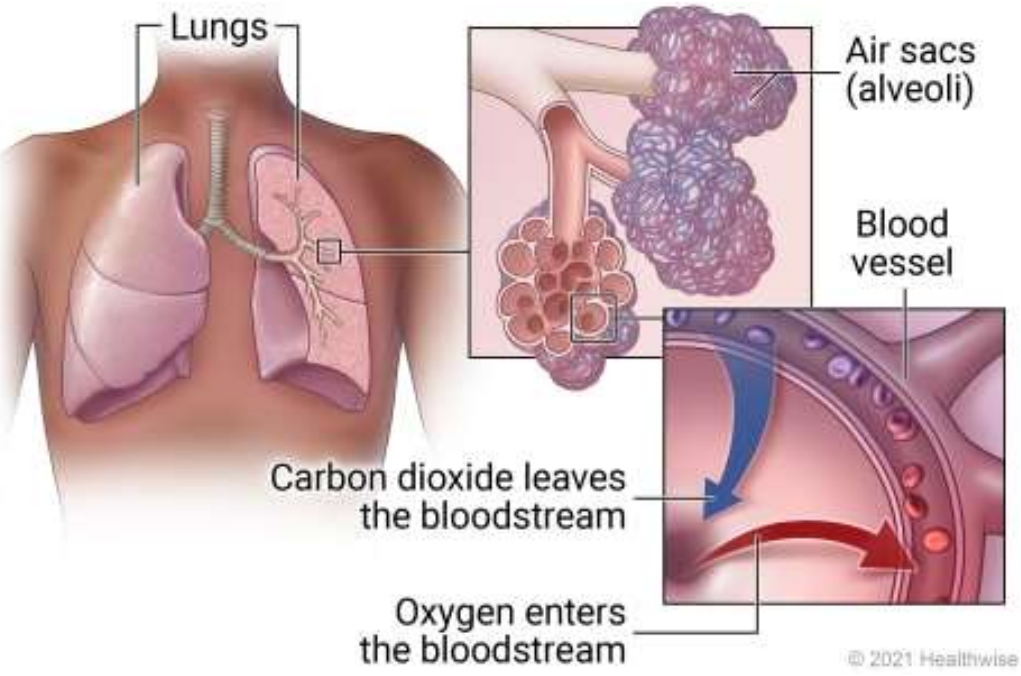
0708838163- 0779031329

COMPETENCY

- The learners knows the functions of, and is able to recognize the similarities and differences of gas exchange surfaces in different organisms.





LEARNING OUTCOMES

A learner should be able to;

- Appreciate the need for gaseous exchange system in multicellular organisms.(u)
- Identify adaptations of gas exchange surfaces. (u)
- Understand the structure of the human respiratory system, and explain the mechanisms of gaseous exchange in humans.(u, s)
- Determine and understand the variation in the percentage composition of gases in inhaled and exhaled air. (s, u)
- understand the dangers of smoking and air pollution to gas exchange surfaces in the lungs. (u, v/a)
- Know the causes, symptoms and treatment of diseases (bronchitis, emphysema, lung cancer, throat cancer and chronic cough) associated with respiratory organs in humans (k, u)

MEANING OF GASEOUS EXCHANGE

- QTN

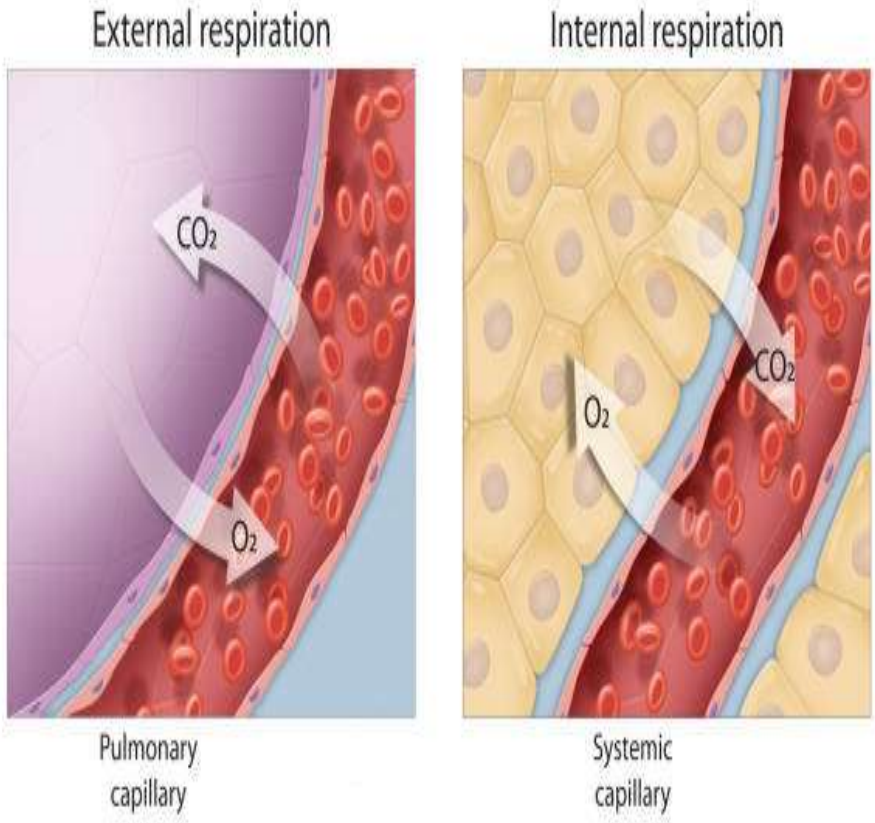
In your groups, discuss the meaning of the term gaseous exchange.

NOTE

- Refers to the diffusion of gases across the cell membrane

INTRODUCTION.

- This is the ***exchange of respiratory gases between the organism and the environment.***
- It **takes place across specialized surfaces** called **respiratory surfaces**.
- Gaseous exchange **helps an organism to get rid of CO_2** produced during respiration within cells and at the same time **obtain oxygen needed for aerobic respiration** to occur.



GASEOUS EXCHANGE IN PLANTS

- Plants ***do not have a special respiratory surface*** for exchange of gases.
- The gases enter the tissues through openings called **stomata in leaves** and **lenticels in roots and stems**.
- The exchange of the gases takes place by **diffusion** where gases circulate in the plant tissues by simple diffusion due to large intercellular spaces between the cells that make air movement faster.
- For example, if there is a deficit of oxygen in any part of the plant, oxygen will diffuse into the part from the surrounding air.
- Like ways, if there is a surplus of carbon dioxide, carbon dioxide will diffuse out to the air.

WHY PLANTS DON'T NEED RESPIRATORY ORGANS

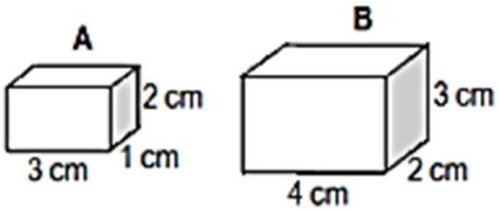
- They **utilize CO2 produced by the plant cells for photosynthesis** thus preventing its accumulation.
- Plants **produce oxygen as a bi-product** of photosynthesis which is **then used in respiration.**
- Plants have **numerous stomata and lenticels** that **allow faster diffusion of gases to the tissues.**
- • They have large intercellular spaces between cells that allow faster circulation of gases to cells.
- • They have low demand for oxygen due to their **low metabolic rate** because **they are less active** since they are immobile.

GASEOUS EXCHANGE IN SIMPLE ORGANISMS

- Small organisms like amoeba, paramecium, hydra and jellyfish **have a large surface**

area to volume ratio.

- In such organisms, **gaseous exchange takes place over the whole-body surface**. Because of their small body volume, **diffusion alone is enough to transport oxygen and carbon dioxide into, around and out of their bodies**.
- Larger organisms such as insects and vertebrates have **a small surface area to volume ratio**.
- In these organisms, gaseous exchange takes place in a specialized region of the body known as a respiratory surface. The respiratory surface is part of the respiratory organ. It is the actual site where gaseous exchange takes place.



Box A is smaller than box B. We can work out the surface area to volume ratio of each box to prove that smaller objects have a larger surface area to volume ration than big ones.

Box A

Total surface area.

$A = 2(2X1) + 2(3X2) + 2(1X3)$

$A = 4 + 12 + 6$

$A = 22\ cm^2$

Volume of A

$V = L \times W \times H$

$V = 3 \times 1 \times 2$

$V = 6\ cm^3$

Surface area to volume ratio of A

$= \frac{22}{6}$

$= 3.67$

Box B

Total surface area.

$A = 2(3X2) + 2(2X4) + 2(3X4)$

$A = 12 + 16 + 24$

$A = 52\ cm^2$

Volume of B

$V = L \times W \times H$

$V = 4 \times 2 \times 3$

$V = 24\ cm^3$

Surface area to volume ratio of B

$= \frac{52}{24}$

$= 2.3$

- The surface area to volume ratio of A is larger than that of B.

- Therefore, ***the surface area to volume ratio of smaller organisms is larger than that of larger organisms.*** This ***facilitates a faster rate of diffusion of respiratory gases*** to all body tissues.
- Most of these organisms are single celled and some have only one layer of cells.
- Larger organisms on the other hand have **a smaller surface area to volume ratio.**
- This ***reduces the rate of diffusion*** and ***diffusion alone cannot meet the respiratory demands of their large bodies***. They also have a large diffusion distance because they have very many layers of cells.
- Due to this, large organisms have developed mechanisms, which reduce on the diffusion distance and increase the surface area to volume ratio.

QTN

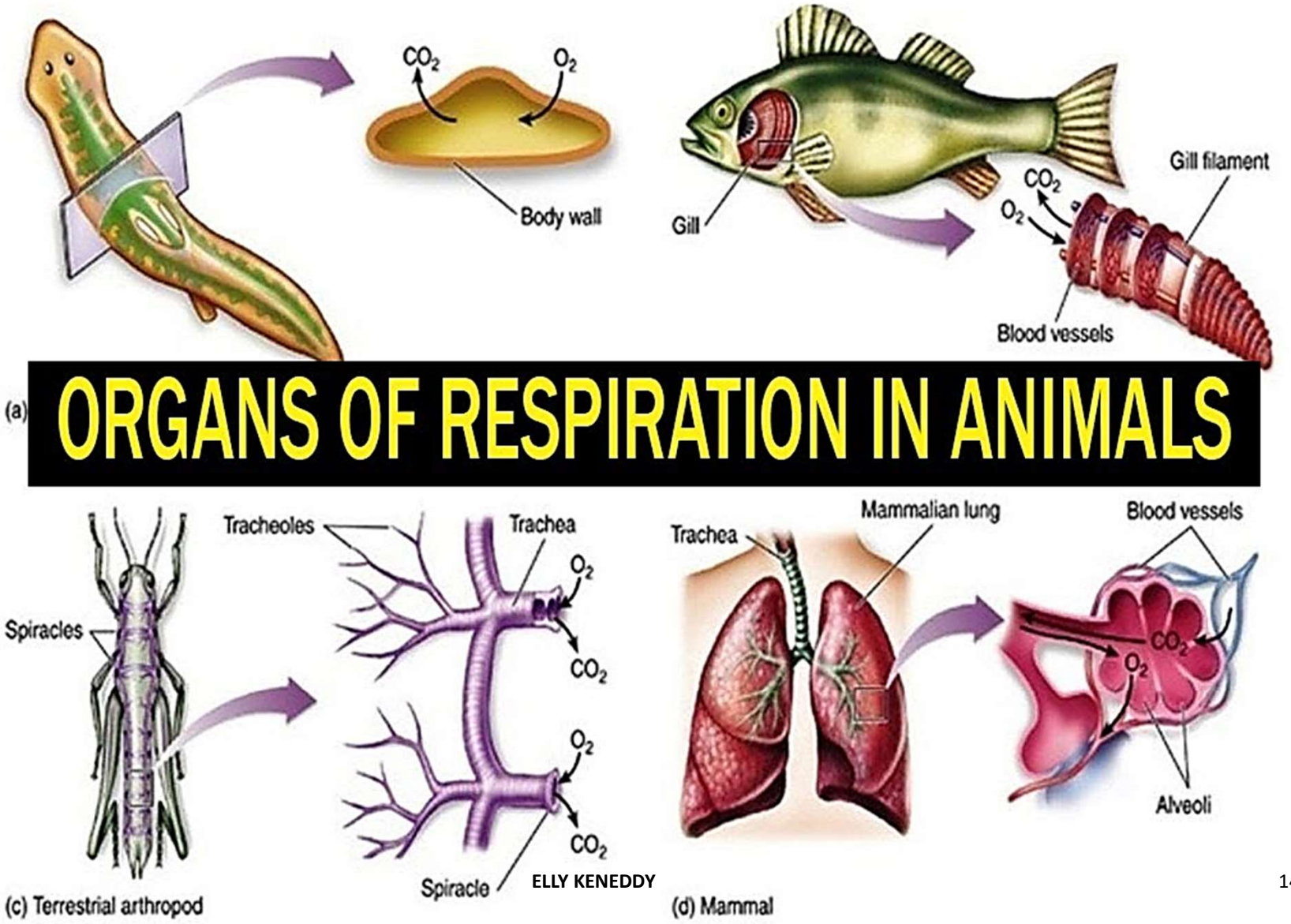
- Why do multicellular organisms need a gaseous exchange system?

NOTE

- Large organisms have large bodies, with small surface area to volume ratio, therefore diffusion alone is not enough to supply gases, needed by their highly active bodies.
- Large organisms also have their cells far away from their respiratory surfaces that diffusion alone would cause a delay in exchange and removal of respiratory gases.
- Small organisms have small bodies , with large surface area to volume ratio making diffusion alone to be enough so supply and and remove respiratory gases.

RESPIRATORY SURFACES AND CORRESPONDING RESPIRATORY ORGANS

Animal	Respiratory organ	Respiratory surface
Amphibians	Lungs	Alveolus
	Skin	Skin surface
	Buccal cavity	Buccal cavity epithelium
Fish	Gills	Gill filaments
Insects	Tracheal system	Tracheoles
Mammals	Lungs	Alveolus
Tadpoles	Gills	Gill filaments


ORGANS OF RESPIRATION IN ANIMALS
(a)
CO_2
O_2
Body wall
Gill
Gill filament
CO_2
O_2
Blood vessels
Spiracles
Tracheoles
Trachea
O_2
CO_2
O_2
CO_2
Spiracle
(c) Terrestrial arthropod
Trachea
Mammalian lung
Blood vessels
CO_2
O_2
Alveoli
(d) Mammal

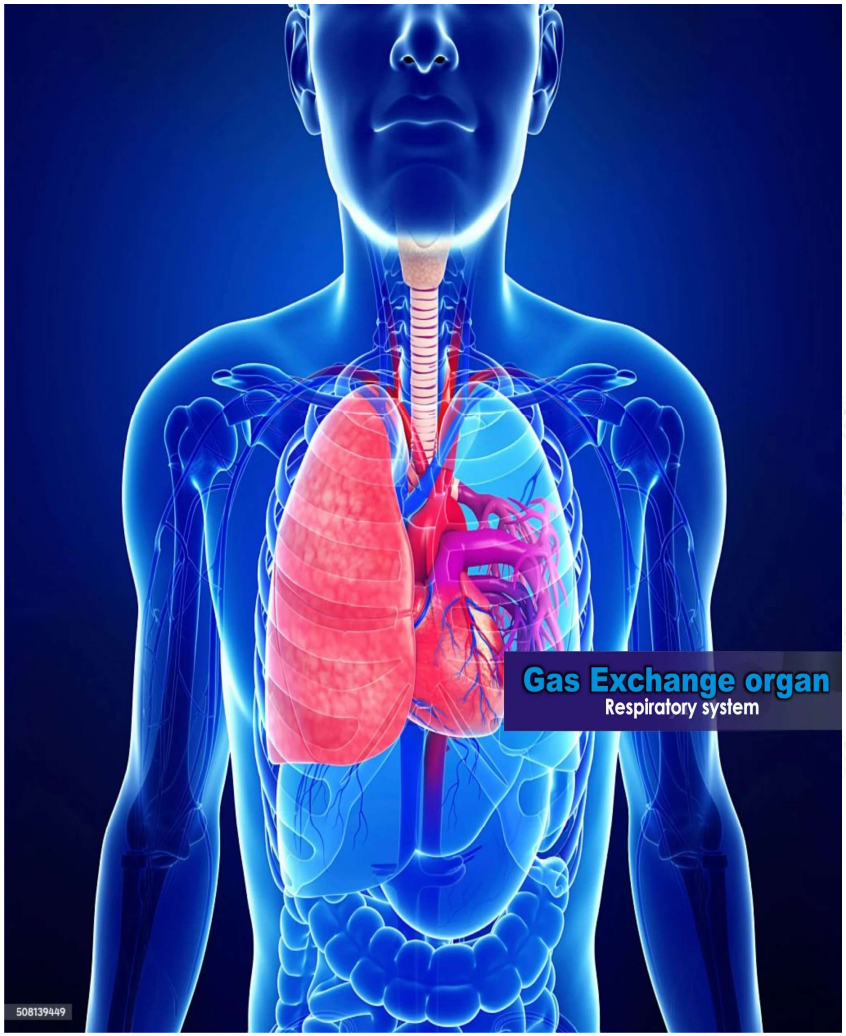
ADAPTATION OF GASEOUS EXCHANGE SURFACES

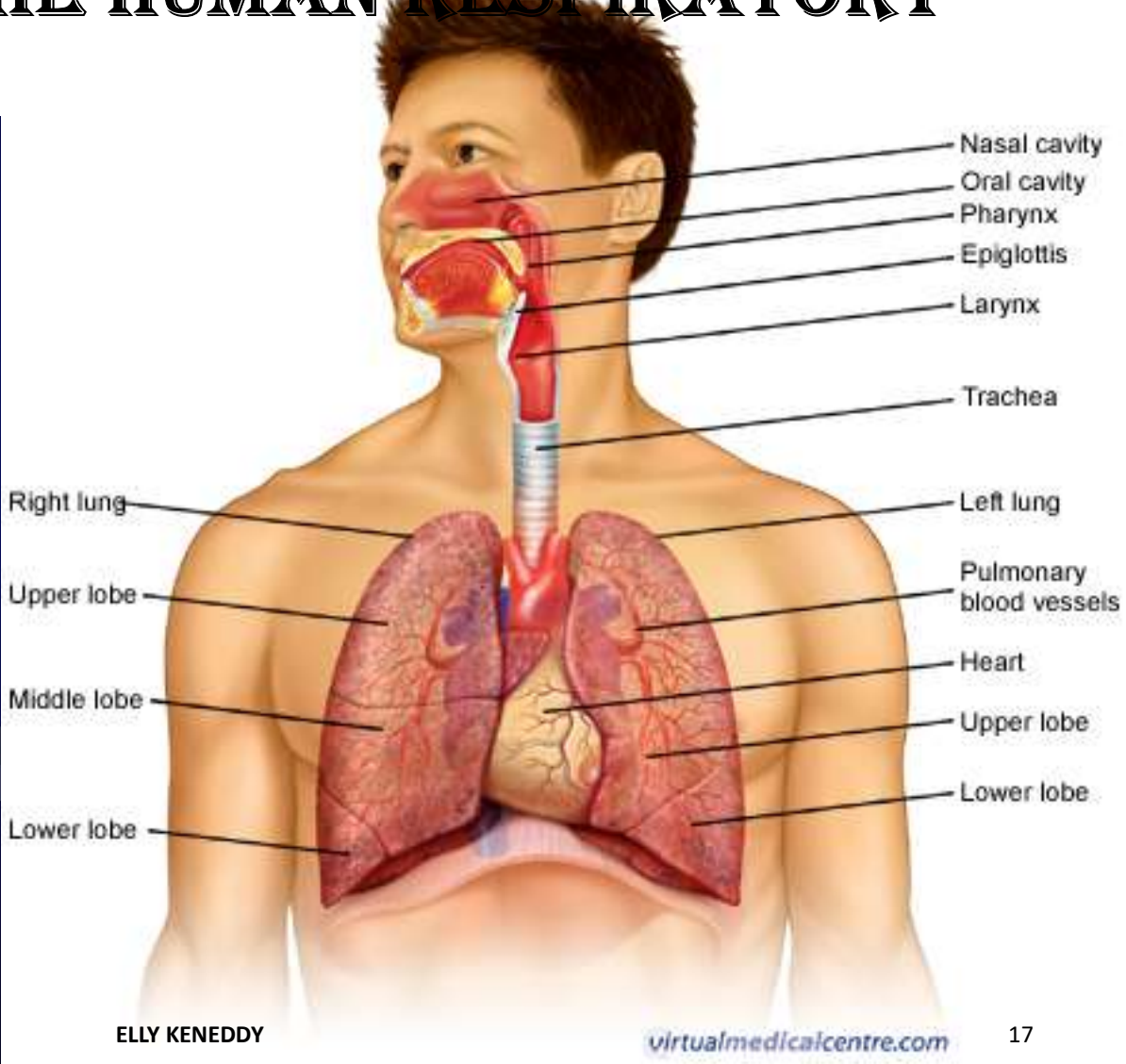
- ***Thin walled*** /epithelium; **to reduce diffusion distance** ensuring rapid gaseous exchange;
- ***Moist surfaces***; to **dissolve gases** increasing diffusion rate;
- ***Dense network of blood capillaries***; for rapid **transport of respiratory gases maintaining a steep diffusion gradient**;
- ***Well ventilated***; **for taking in oxygen and releasing carbon dioxide**;
- Small sized/large surface area to volume ratio; for rapid diffusion of gases.

NAME THE DIFFERENT RESPIRATORY SURFACES OF DIFFERENT ORGANISMS.

- Amoeba
- Insects
- Fish
- Flatworm
- Plants
- Tadpoles
- Adult amphibians
- Mammal

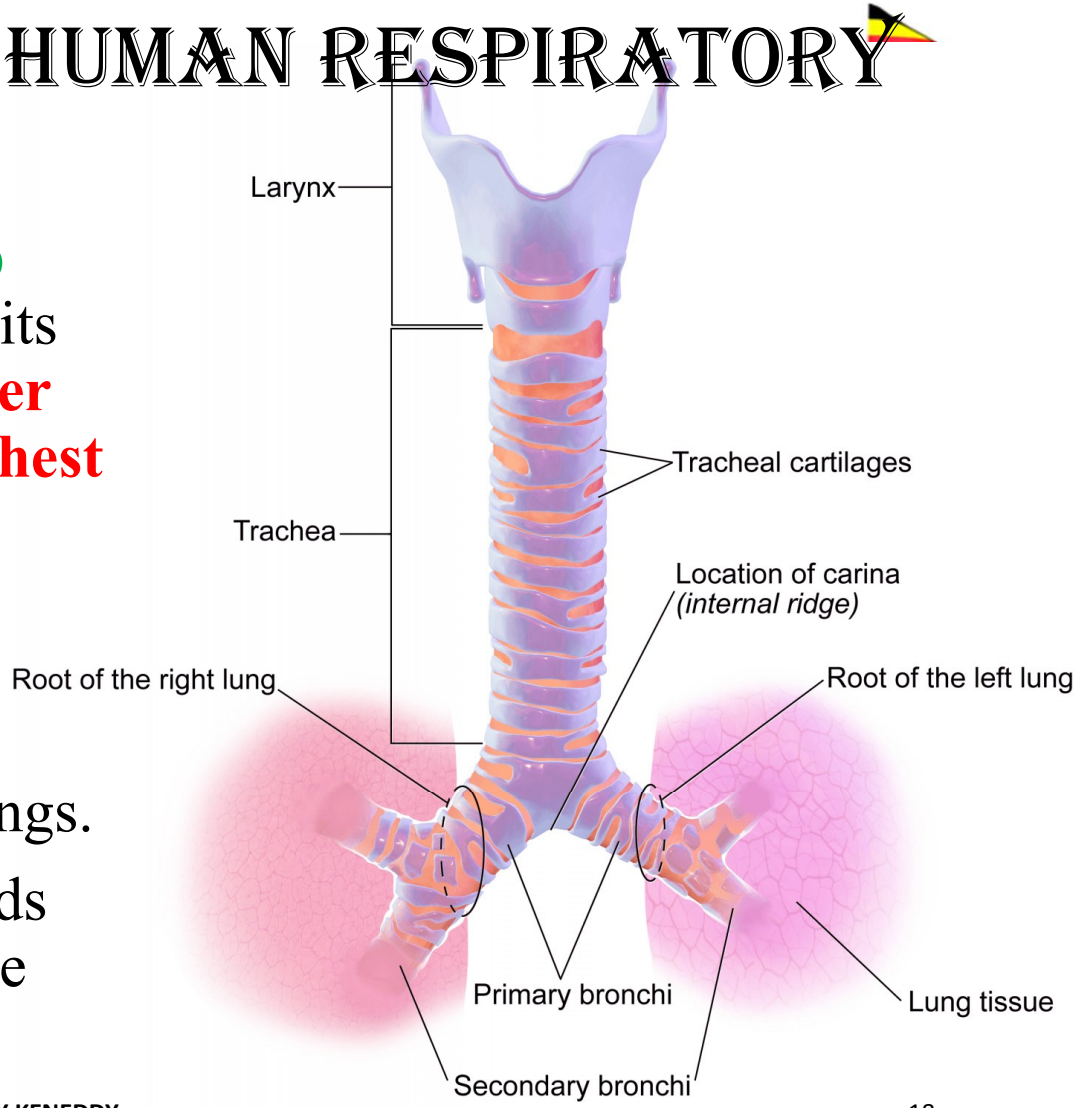
STRUCTURE OF THE HUMAN RESPIRATORY SYSTEM





DESCRIPTION OF THE HUMAN RESPIRATORY SYSTEM.

- **The trachea**: This is a tube **made up incomplete rings of cartilage** along its length which **resist collapse whenever there is decreased pressure in the chest cavity.**
- The inner lining has **cilia** and also produces mucus to trap and filter microorganisms and dust particles, preventing them from entering the lungs.
- The cilia beats moving mucus upwards towards the pharynx at the back of the mouth where they are swallowed.



- **The bronchus**: At the lower end, the trachea divides into two tubes called bronchi, which penetrate further into the lungs and divide repeatedly to form small tubes called **bronchioles**.
- The bronchioles have no rings of cartilage and divide into many small tubes called **alveolar ducts**, which ends up into a tiny sac called alveoli.
- **The alveoli**: An alveolus is a **sac-like structure**. Each alveolus is kept moist and thin walled surrounded by an extensive a network of blood capillaries.
- **The lungs**: These are two elastic spongy-like structures located within the thoracic cavity and protected by the rib cage. Each lung is enclosed by two membranes called the pleural membranes. The space between the membranes is the pleural cavity filled with pleural fluid.

PARTS , DESCRIPTION AND FUNCTIONS (ADAPTATIONS)

Part	Description	function
Nasal cavity	Hollow, with hairs , mucus	Allow uninterrupted entry and exit of air
pharynx	Hollow	Allow movement of air into the trachea
Epiglottis	Muscular	Regulates opening and closure of trachea/
trachea	Hollow , with rings of cartilage	Allow uninterrupted movement of air
Bronchus	Paired , hollow	Allow uninterrupted passage of air
Bronchiole	Hollow, small	Allow uninterrupted passage of air

CONT.....

Alveolus	Moist, thin membrane, with blood vessels	Provide surface area for gaseous exchange
Diaphragm	Muscular, curved	Regulate volume of thoracic cavity and the lungs
Lung	Folded into alveolus, dense blood vessels	Hold air temporarily before and after gaseous exchange
Rib cage	Made up of ribs, intercostal muscle	Regulates the volume of the thoracic cavity and the lungs
Pleural membrane	Surrounds the lungs	Secretes a fluid that lubricates the surface of the lungs

FLOW OF AIR

- Air enters through the nostrils into the nasal cavity where it is warmed to body temperature.
- The nasal cavity is lined with mucus secreting cells and hairs. The mucus and hairs filter and trap dust and micro-organisms from the air.
- The air is then passed to the pharynx from which it goes into the larynx through a small opening called glottis which has a flap known as the epiglottis which closes when a person is swallowing to prevent food from entering the trachea.
- The air then enters the trachea. Choking and coughing are reflex actions which remove any liquid or solid particles which accidentally enter the trachea.
- From here, air travels to the lungs through the bronchus, bronchioles and lastly to the alveolus.

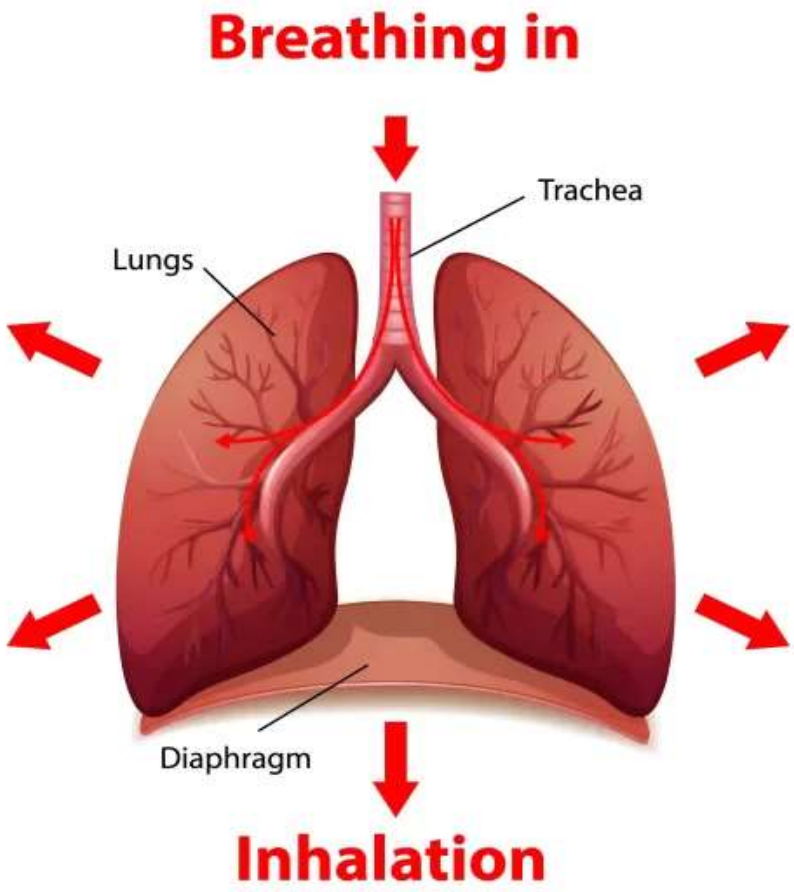
ASSIGNMENT

- How is the human respiratory system suited to its functions?

MECHANISMS OF BREATHING (VENTILATION)

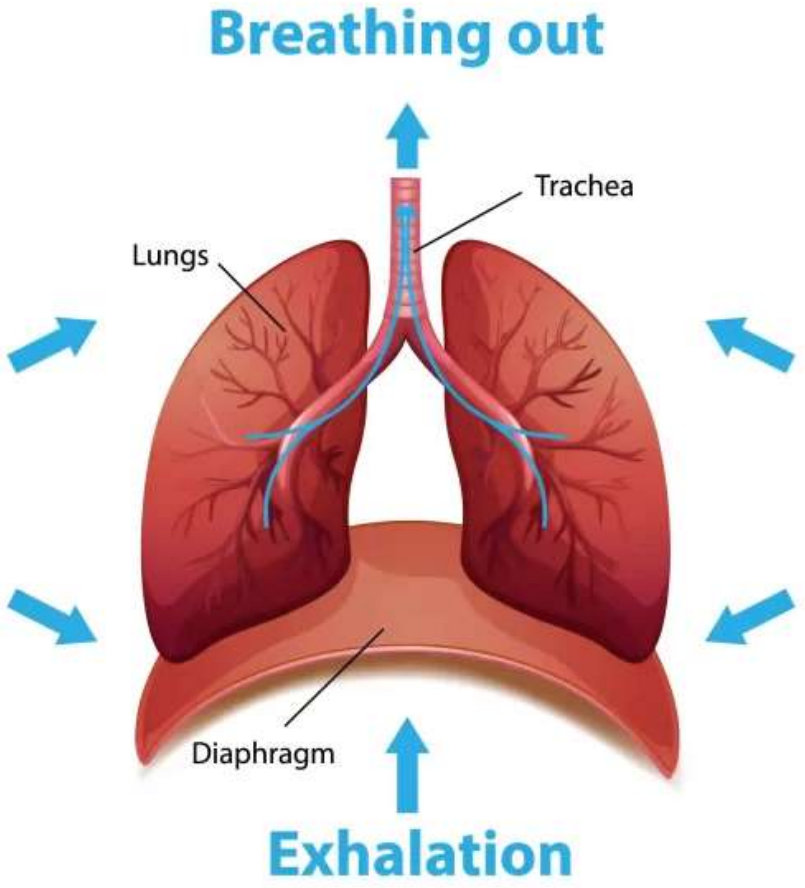
Breathing in

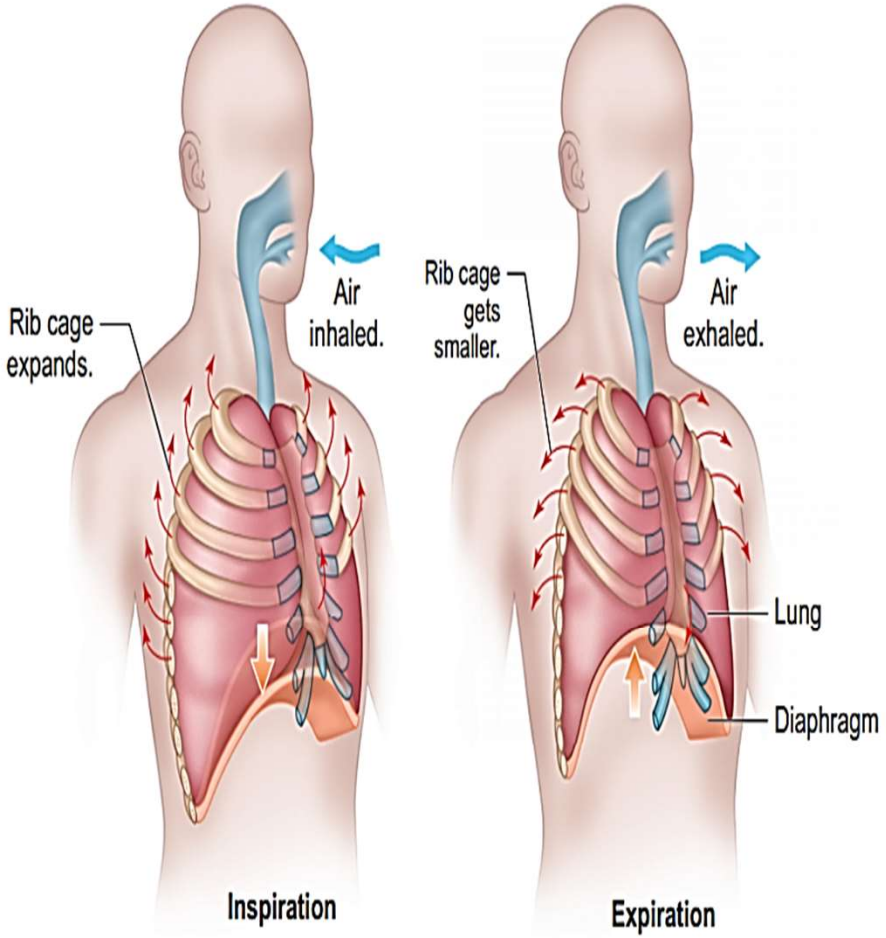
- The external intercostal muscles contract while the internal intercostal muscles relax.
- This makes the rib cage to move outwards and upwards. The diaphragm contracts and flattens.
- This increases the volume of the thoracic cavity and reduces the pressure in it below that of the atmosphere.
- Air moves into the lungs through the nostril, trachea, bronchi, and bronchioles until it reaches the alveoli.

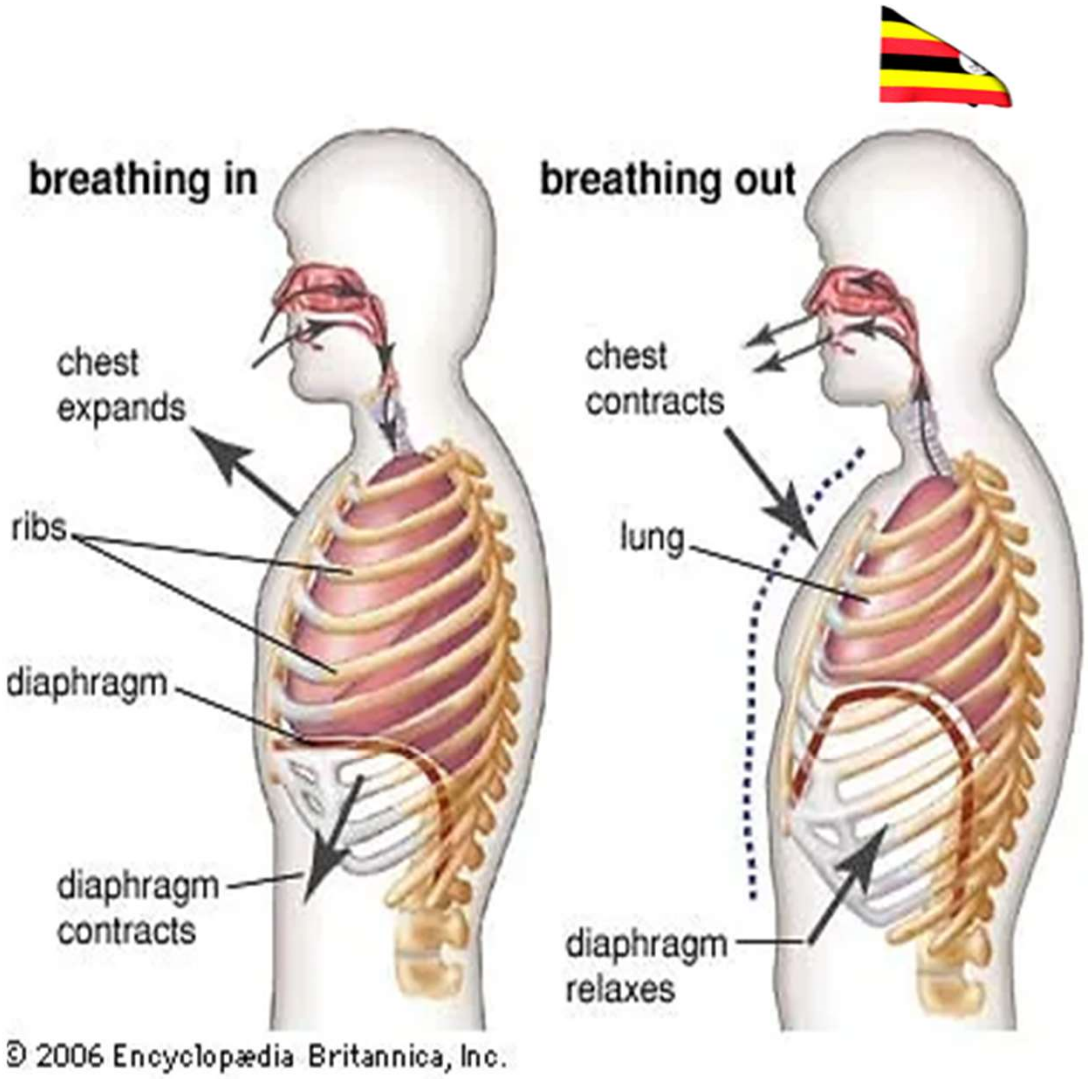


BREATHING OUT

- The internal intercostal muscles contract and the external intercostal muscles relax.
- This makes the rib cage to move downwards and inwards.
- The diaphragm muscles relax and the diaphragm returns to its dome shape.
- The volume of the thoracic cavity reduces and pressure increases beyond atmospheric pressure.
- This forces the lungs to contract and release air out of the lungs through the bronchi, trachea and nostrils.




Rib cage expands.
Air inhaled.
Inspiration
Rib cage gets smaller.
Air exhaled.
Lung
Diaphragm
Expiration


breathing in
chest expands
ribs
diaphragm
diaphragm contracts
breathing out
chest contracts
lung
diaphragm relaxes
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Feature	Breathing in/Inhalation/ inspiration	Breathing out/exhalation/expiration
Internal intercostal muscles	Contracts	relaxes
External intercostal muscles	Relax	contracts
Diaphragm	Contracts and flattens	Relaxes and becomes dome-shaped
Chest cavity	Moves upwards and outwards	Moves downwards and inwards
Thoracic volumes	Increases	Decreases
Thoracic pressure	Decreases below environmental pressure.	Increases above environmental pressure.
Direction of air	Air enters through nostrils, trachea, bronchi, bronchioles, alveoli	Air leaves from alveoli, bronchioles, bronchi, trachea, nostrils to environment.

NOTE

- Expiration or exhalation or breathing out is largely a passive process under resting conditions brought about by the elastic recoil of the lungs , respiratory muscles and rib cage.

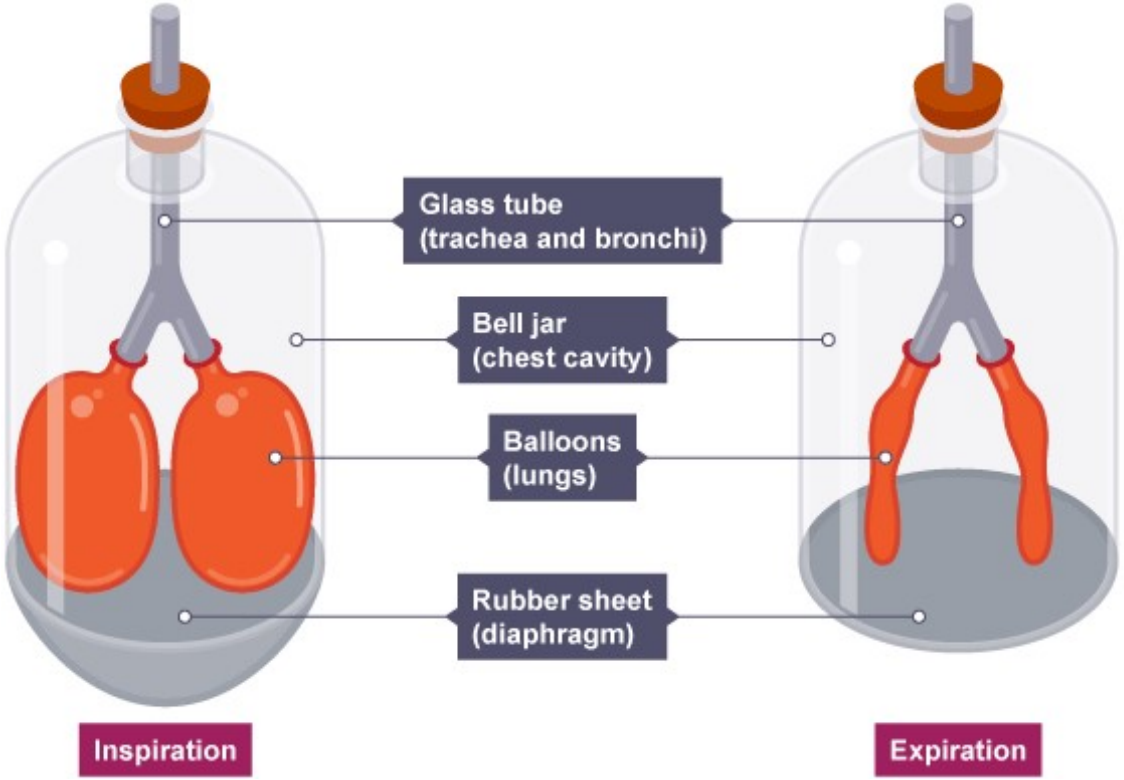
PROJECT WORK

- Design a models that can be used to demonstrate how atmospheric air reaches the gaseous exchange surfaces in humans.

EXPERIMENT TO DEMONSTRATE BREATHING IN MAMMALS

Materials

- *Glass tubing*
- *Bell jar*
- *Cork,*
- *Two balloons*
- *Rubber tubing*
- *Rubber sheet*
- *Y tube*
- *Thread*



PROCEDURE

✓Get a bell jar and fix a cork with glass tubing in its mouth.

✓ Use a rubber tubing to connect a Y tube to the glass tubing inside the bell jar.

✓ Tie balloons on each end of the Y tube to act as lungs.

✓ Tie a rubber sheet using a rubber band at the open end of the bell jar to act as a diaphragm.

✓ Tie the end of a rubber sheet using a piece of thread.

MODEL

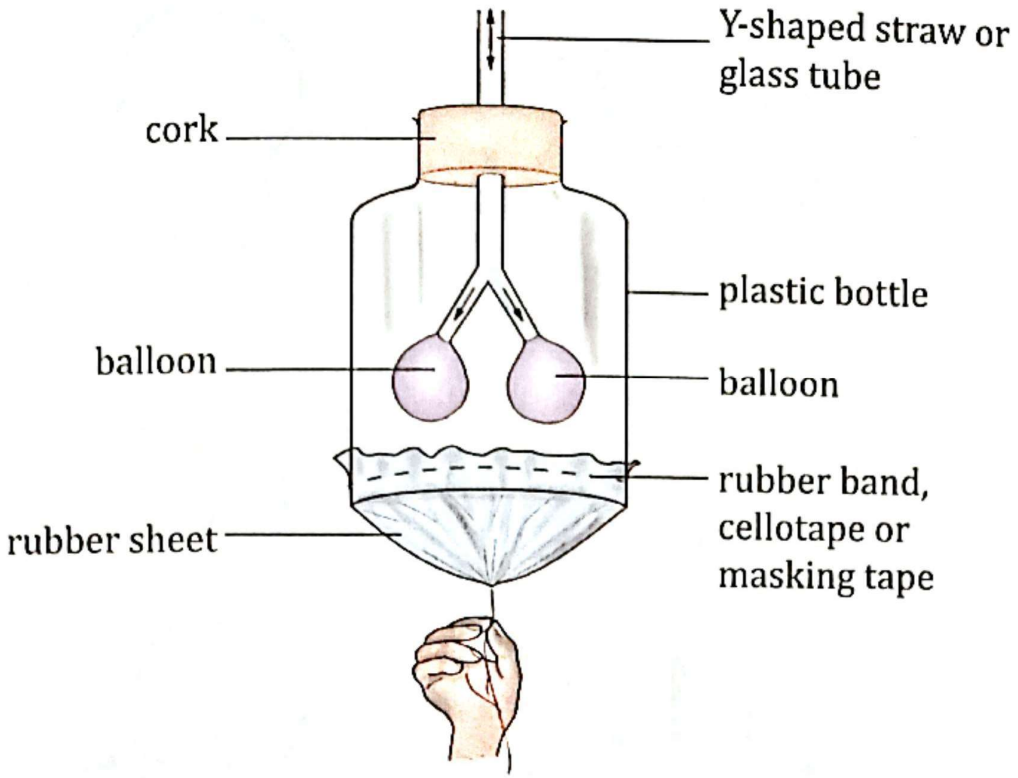


Figure 1.3: Model of a human respiratory system

3. Pull the rubber sheet downwards. What do you observe?
4. Replace the rubber sheet. What do you observe?
5. Discuss your findings.

Discussion questions

(a) How do the following parts relate to the human respiratory system?

(i) balloons inside the bottle or bell jar

(ii) the Y-shaped straws or glass tube

(iii) rubber sheet covering the bottom of the bottle or bell jar

(iv) plastic bottle or bell jar.

(b) From the model, explain the mechanisms of breathing in human beings.

(c) What happens when you pull down the rubber sheet and when you release it? Explain.

(d) Explain why you used two balloons in the model.

(e) Observe the following diagram. Discuss and describe the breathing process. Then come up with a flowchart to show how breathing (inhalation and exhalation) takes place. Choose your own design for the flow chart. Ensure that your flow chart shows that inhalation and exhalation occur in a cycle.

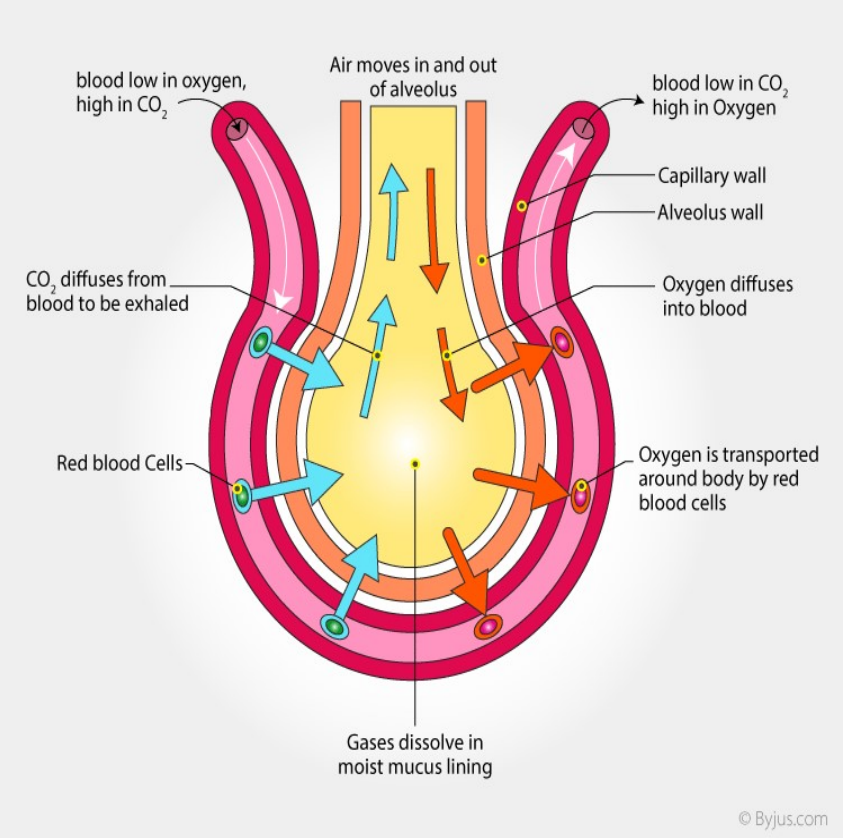
FOLLOW UP NOTES

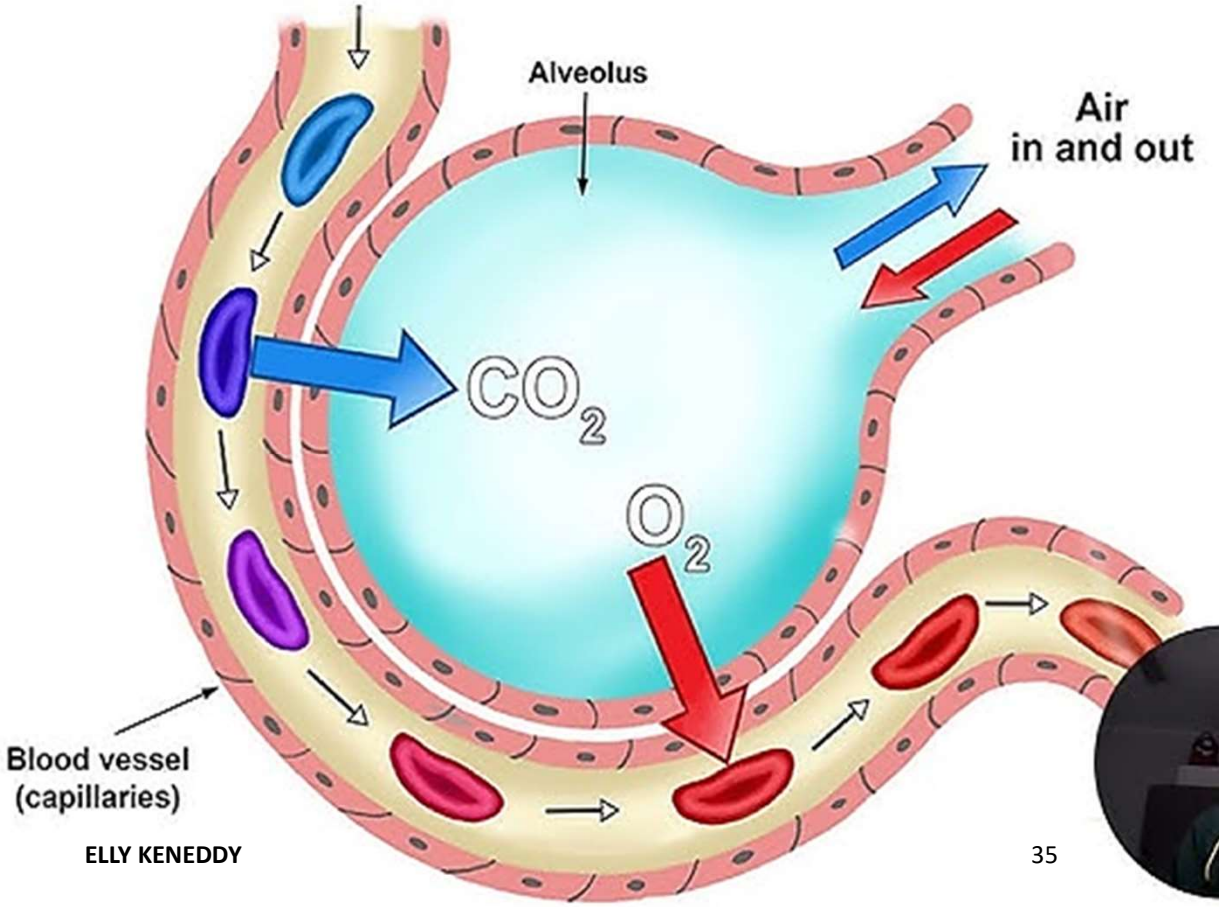
Part in the set up	Corresponding part in humans
Polythene sheet	diaphragm
Wall of mineral water bottle	Rib cage comprising ribs, intercostal muscle and sternum
Ballon	Left and right lungs
Open end of delivery tube	Nasal openings
Space in which balloons are	Thoracic cavity
Region of bottles where cork is fitted	Neck

MECHANISM OF GASEOUS EXCHANGE

- This takes place across walls of alveoli and blood capillaries by diffusion.
- During inspiration, air is taken into the lungs filling the alveoli.
- When there is a high concentration of oxygen in the air spaces of alveoli than in the blood, ***oxygen diffuses across the membranes of the alveoli and capillaries into the blood stream in the capillaries***.
- The ***oxygen combines with haemoglobin to form oxyhaemoglobin***. Some oxygen dissolves in the plasma.
- The **oxygen is transported to the tissues and body organs**. Oxyhaemoglobin ***releases oxygen to the tissues which use it during respiration*** and produce carbon dioxide.
- When tissues have a high concentration of carbon dioxide than the blood in the capillaries, ***the carbon dioxide diffuses from the tissue cells across the membranes of the capillaries into the blood.***

DEMONSTRATION OF GASEOUS EXCHANGE





CONT.....

- Some carbon dioxide dissolves in plasma to form carbonic acid and some of the gas combines with haemoglobin to form carbamino-haemoglobin.
- Some carbon dioxide dissolves in plasma to form carbonic acid and some of the gas combines with haemoglobin to form carbamino-haemoglobin.
- Carbon dioxide diffuses across the membranes of capillaries and alveoli into the alveolar space
- Carbon dioxide is released from the alveolar space through the nostrils as a person is breathing out

NOTE

- **Removal of carbon dioxide**

Concentration of carbon dioxide is higher in blood than that in alveolar air, carbon dioxide moves along a concentration gradient, by diffusion into the alveolar air

- **Entry of oxygen**

Concentration of oxygen is higher in alveolar air than that in blood, oxygen therefore moves from alveolar air along a concentration gradient, by diffusion into blood.

CHANGES IN APPROXIMATE AIR COMPOSITION DURING BREATHING

Gas	Inhaled air (percentage)	Exhaled air(percentage)
Oxygen	21%	16%
Carbon dioxide	0.03%	4%
Nitrogen	79%	79%
Water vapour	Variable (less)	Variable (more)

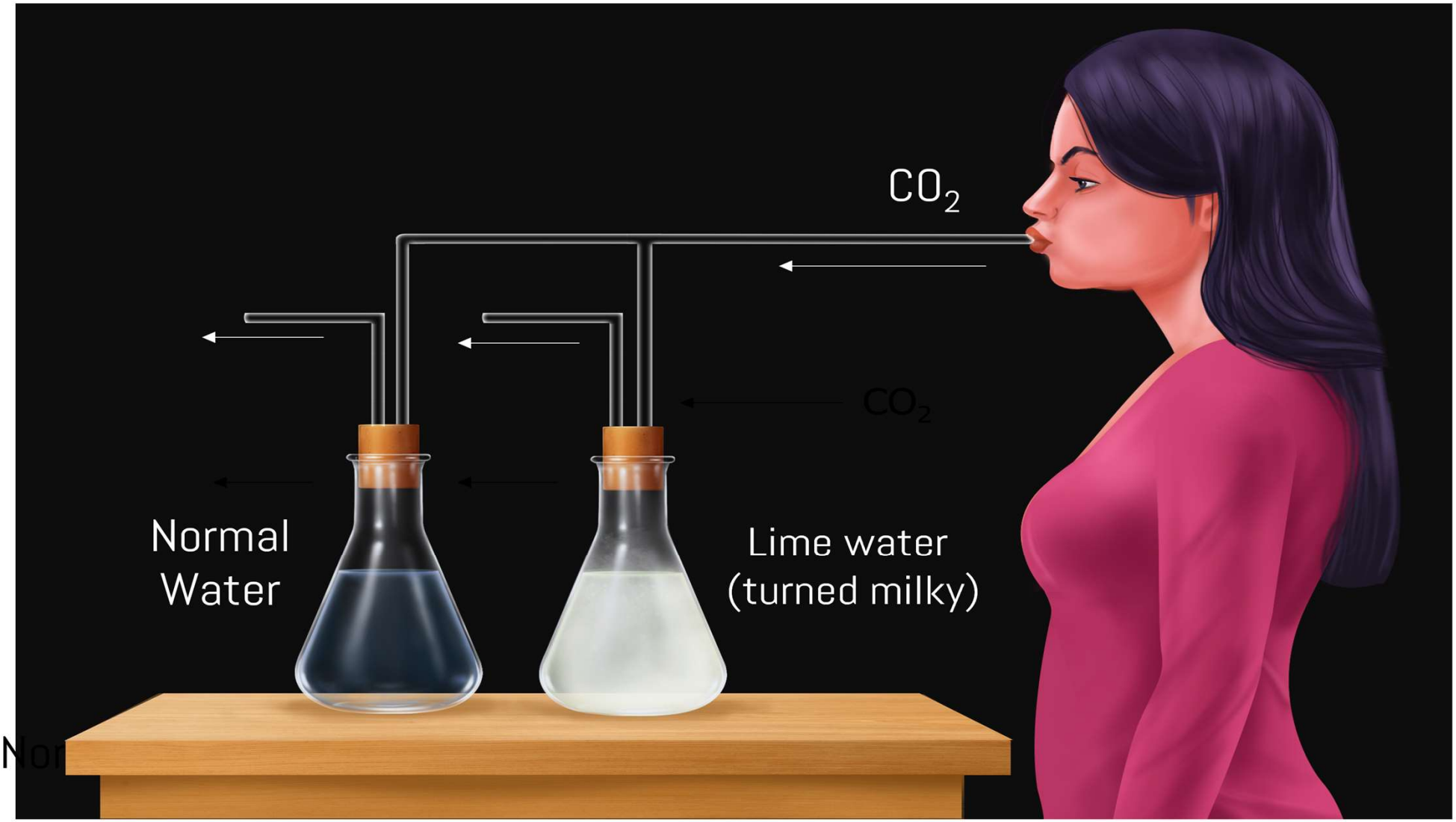
EXPLANATION

- Percentage of oxygen is lower in exhaled air than inhaled air because ***some oxygen is used in aerobic respiration in the body to produce energy***
- Percentage of carbon dioxide is higher in exhaled air than in inhaled air because ***carbon dioxide is not used in the body but rather produced from aerobic respiration increasing its concentration in blood*** thus in exhaled air.
- Percentage concentrations of nitrogen are same in inhaled and exhaled air because nitrogen is neither used or produced in the body.
- Exhaled air is at body temperatures while inhaled air is at environmental temperatures
- Exhaled air is more moist than inhaled air because ***it contains more a water vapour from the aerobic respiration*** in the body.

AN EXPERIMENT TO SHOW THE COMPOSITION OF EXHALED AIR AND INHALED AIR

Materials

- Thistle funnel
- Soda lime
- Cotton wool
- Two conical flasks
- Lime water
- Two rubber tubings
- T-tube and three delivery tubes



Nor

PROCEDURE

- Prepare the apparatus as shown in the figure below:
- Hold tight to close rubber tubing
- A and breathe in through the mouthpiece, release the rubber tubing A and hold to close rubber tubing B and breathe out still through the mouthpiece.
- Repeat the procedure three times while observing the changes on the lime water.
- **Observation**: The lime water in the conical flask where air blown out passes turns milky whereas the lime water in the conical flask where air sucked in passes remains clear.
- **Conclusion**: Exhaled air contains carbon dioxide gas.

CHALLENGE

- Assuming the plants give out all the oxygen animals breathe in, and animals give out the carbon dioxide plants use.
- Explain why destruction of forests is a concern to us. (6 scores)

SMOKING

- It refers to the act of ***inhaling and exhaling the smoke produced by burning tobacco or other substances.***
- It is typically done by lighting a cigarette, cigar, or pipe, and inhaling the smoke into the lungs.
- Smoking is a **common method of consuming nicotine,** whose main health effect is its addictiveness.
- This smoke contains a mixture of chemicals, including nicotine, tar, carbon monoxide, and various carcinogens (cancer-causing substances).

DANGERS OF SMOKING

Introduction.

Harmful substances in the air we inhale include tar in cigarette smoke ,nicotine, sulphurdioxide, nitrogen dioxide and carbon monoxide found in exhaust gases of motor vechicles and other sources of pollution.

These affect the human respiratory system , causing damage to lungs and respiratory diseases.

This reduces the efficiency of gasesous exchange in the alveoli

The different harmful substances have the following effects on human respiratory system.

COMPONENTS OF SMOKE

Component	Effect of component.
Heat	➢ Burns the cilia and dries moisture of the lining of the alveolus
Tar	➢ Causes irritation of linings of the respiratory system resulting into mucus production.
Carbon dioxide	➢ Dissolves the moisture of lining of alveoli forming an acidic solution that corrodes the cells
Carbon monoxide	➢ Combines with hemoglobin forming carboxy-haemoglobin reducing oxygen transport
Nitrogen oxide	➢ Causes lung damage, irritation anf inflamation

NOTE.

- Tar is also carcinogenic.
- Carcinogens are substances that cause cancer. Smoking therefore increases the risk of getting lung cancer.
- Tar is a sticky brown substance left behind during burning of tobacco.
- Tar and other harmful chemicals contained in cigarette smoke damage goblet cells that produce mucus and ciliated cells that move mucus towards the pharynx.
- Damage of ciliated cells leads to build up of mucus in the lungs resulting into smokers cough


Symptoms of Acute
Bronchitis
• Sore throat.
• Fever.
• Cough that brings up clear, yellow,- or green mucus.
• Chest congestion.
• Shortness of breath.
• Wheezing.
• Chills.
• Body aches.
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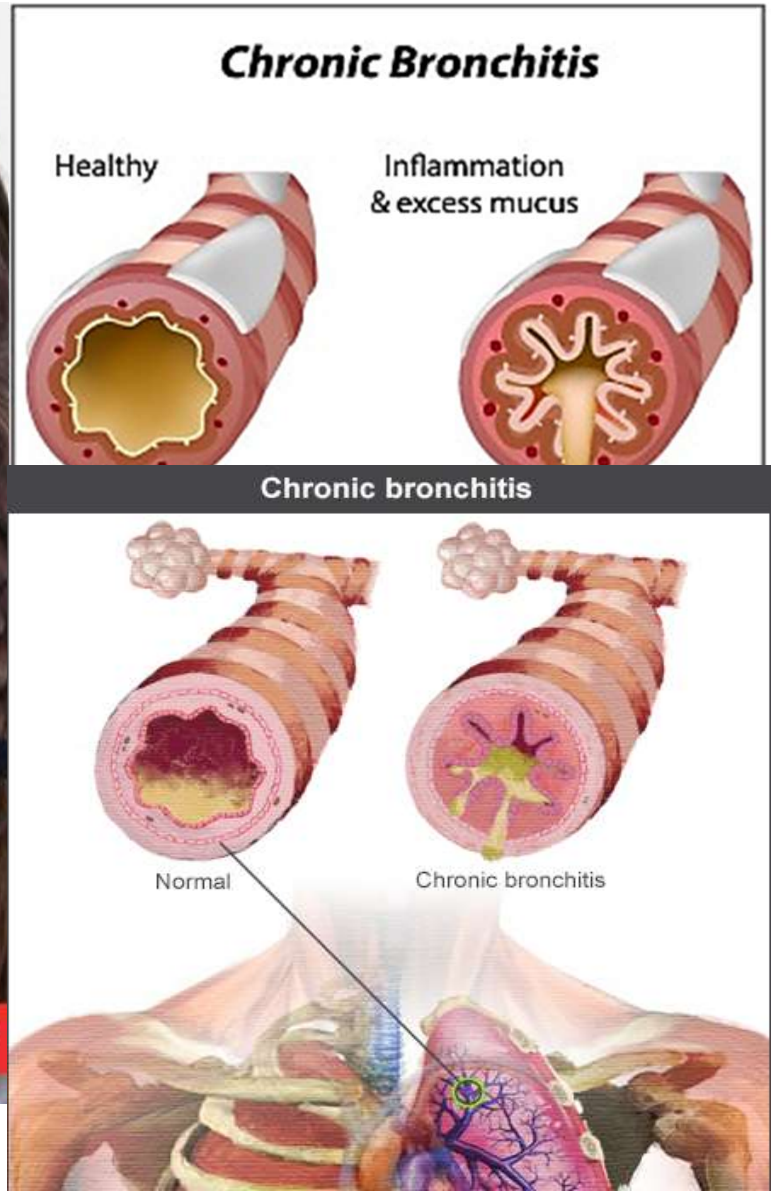
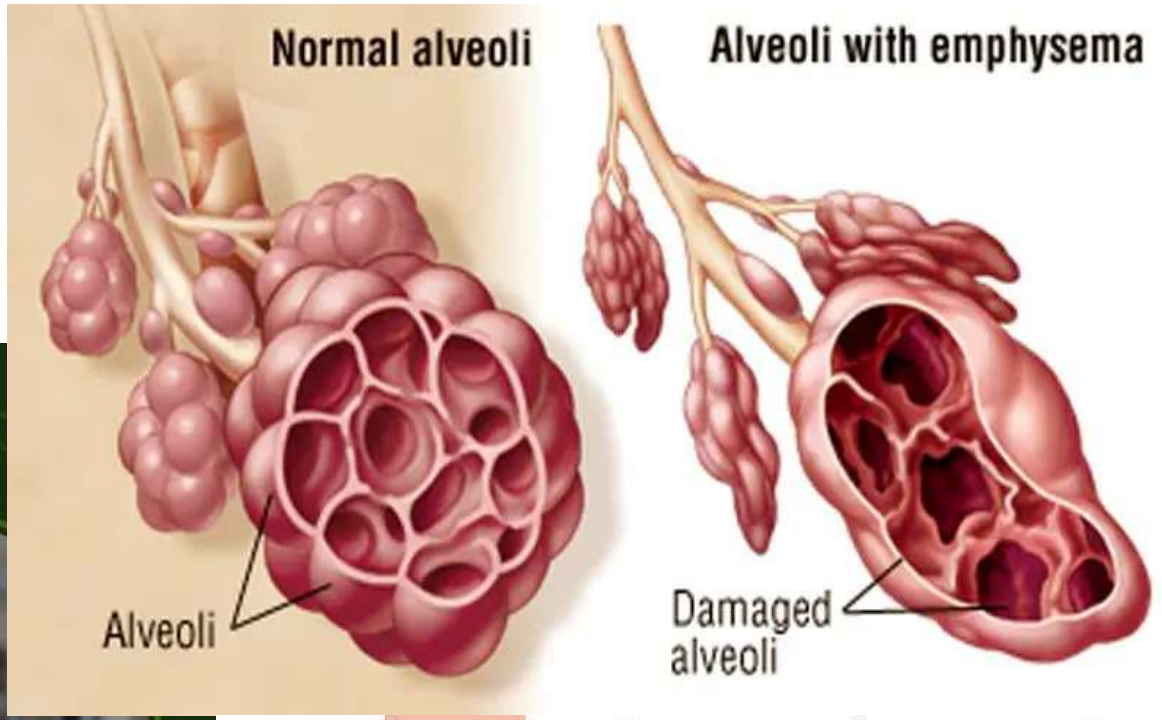
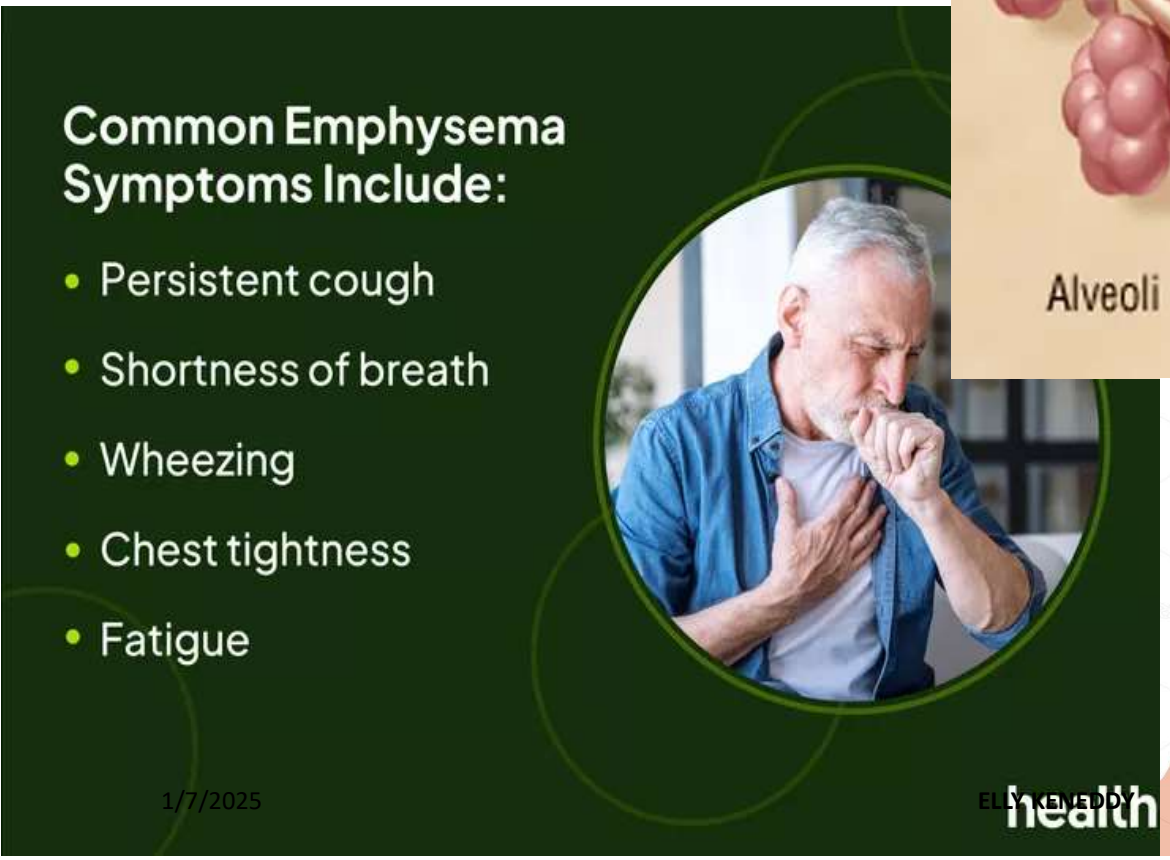

Chronic Bronchitis
Healthy
Inflammation & excess mucus
Chronic bronchitis
Normal
Chronic bronchitis

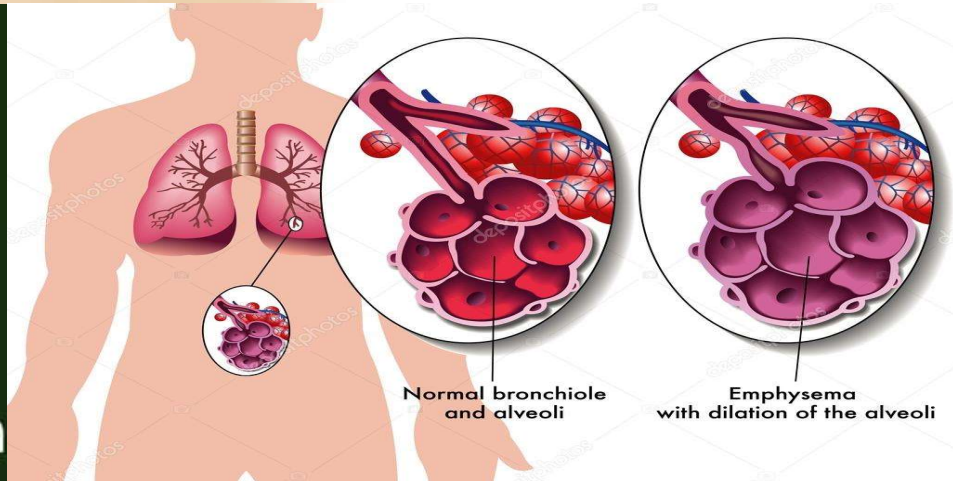
RESPIRATORY DISEASES AND ASSOCIATED CAUSES.

Respiratory diseases	Cause	Signs and symptoms	Treatment
Bronchitis: an inflammation of the bronchial tubes.	Triggered by viruses, bacteria or exposure to irritant particles, such as tobacco tar and smoke, dust and toxic gases.	➢ Persistent hacking cough which may produce clear, yellowish or grey mucus. ➢ Low fever and chills ➢ Feeling of tightness in the chest ➢ Sore throat ➢ Body aches ➢ Shortness of breath ➢ Headache ➢ Runny, blocked nose and sinuses.	There is no cure for bronchitis. Relief measures include. ✓ Resting ✓ Taking enough fluid ✓ Using a humidifier ✓ Oxygen therapy ✓ Antibiotics ✓ Anti inflammatory and steroid drugs to reduce inflammation

EMPHYSEMA

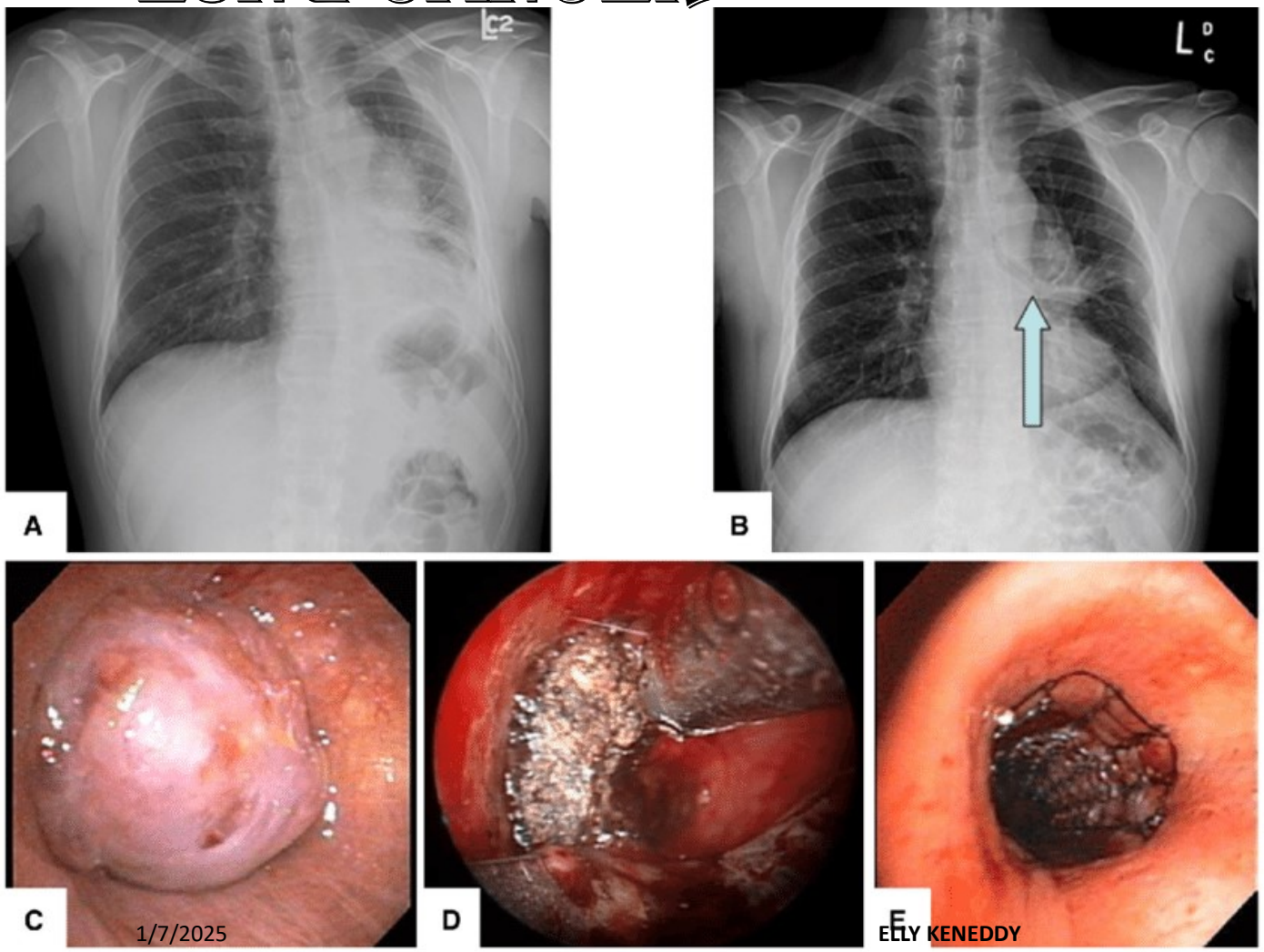

Normal alveoli
Alveoli with emphysema
Alveoli
Damaged alveoli


Common Emphysema Symptoms Include:
• Persistent cough
• Shortness of breath
• Wheezing
• Chest tightness
• Fatigue
health


Normal bronchiole and alveoli
Emphysema with dilation of the alveoli

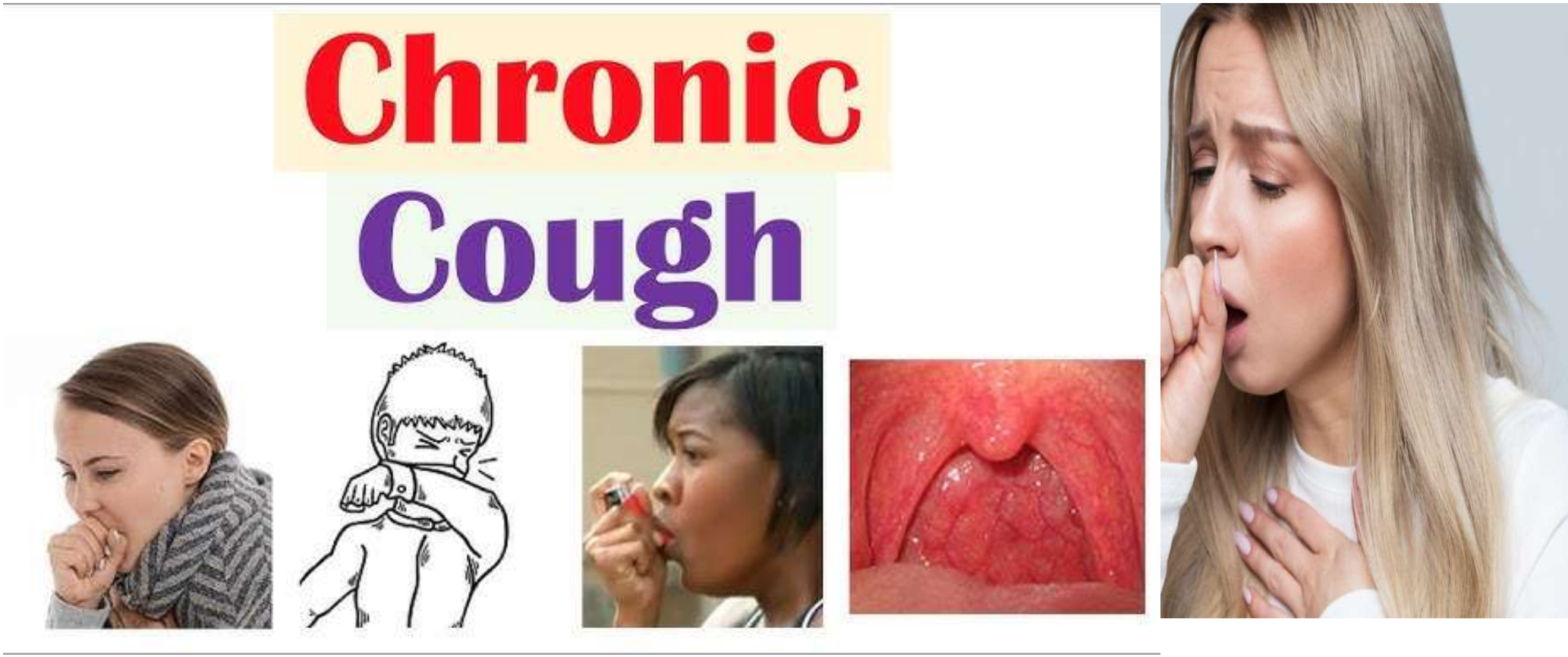
Respiratory disease	Cause	Signs and symptoms	Treatment
Emphysema : damage to the walls of the alveoli, making them unable to support the bronchial tubes which collapse.	• Smoking • Air pollutants • Respiratory infections.	• Shortness of breath even during light exercises climbing steps. • Difficulty in breathing • Long term cough • Fatigue • Long term cough or sputum	• There is no cure for **Emphysema** Treatment to relieve symptoms include: • Bronchodilator medications to relax muscles around airways • Inhaled steroids to reduce inflammation • Antibiotics

LUNG CANCER



Respiratory disease	Cause	Signs and symptoms	Treatment
Lung cancer: a condition where the cells in the lungs divide uncontrollably causing development of tumors	✓ Cigarette smoking and exposure to smoke and other air pollutants	✓ Loss of appetite ✓ Raspy hoarse voice ✓ Frequent chest infections like pneumonia and bronchitis ✓ Persistent cough ✓ Shortness of breath ✓ Weight loss ✓ wheezing	✓ Surgery to remove cancerous tissue(tumors) ✓ Chemotherapy : use of powerful cancer killing drugs to destroy cancer cells ✓ Radiation therapy: use of high energy x-rays to kill cancerous cells. ✓ Targeted therapy: the use of particular medications that specifically target a particular behaviour in cancer cells

CHRONIC COUGH



Respiratory disease	Cause	Signs and symptoms	Treatment
➢ **Chronic cough**: a persistent cough that lasts eight weeks or longer in adults or four weeks in children	➢ Exposure to chemicals and risk factors include: ➢ Tobacco use ➢ Whooping cough caused by bacteria ➢ Tuberculosis ➢ Chronic Obstructive ➢ Pulmonary Disease(COPD) ➢ Chronic bronchitis	➢ Sneezing ➢ Running nose ➢ Fever ➢ Sore throat ➢ Hard and dry cough ➢ Crackling sound during breathing ➢ Wheezing ➢ Regular chest pain ➢ Heart burn and sour taste in the mouth ➢ Shortness of breath	

THROAT CANCER

Cause	Symptom	Prevention.
• Exposure to carcinogens • smoking cigarettes • Exposure to second hand smoke • Exposure to chemicals	• Coughing up blood • Shortness of breath • Chest or throat pain • Swelling in neck or pain • Lump in neck or throat • Change in voice	• Quit smoking • Avoid exposure to second hand smoke • Avoid exposure to chemicals and like asbestos and benzene • Healthy diet with plenty of fruits and vegetables

GENERAL EFFECTS OF AIR POLLUTION ON RESPIRATORY SYSTEM

- Irritation of the air ways
- Shortness of breath
- Coughing
- Chest pain
- Mucus secretion
- Asthmatic attacks
- Wheezing(high pitched sound, coarse whistling when breathing)


ALWAYS AIM FOR EXCELLENCE
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