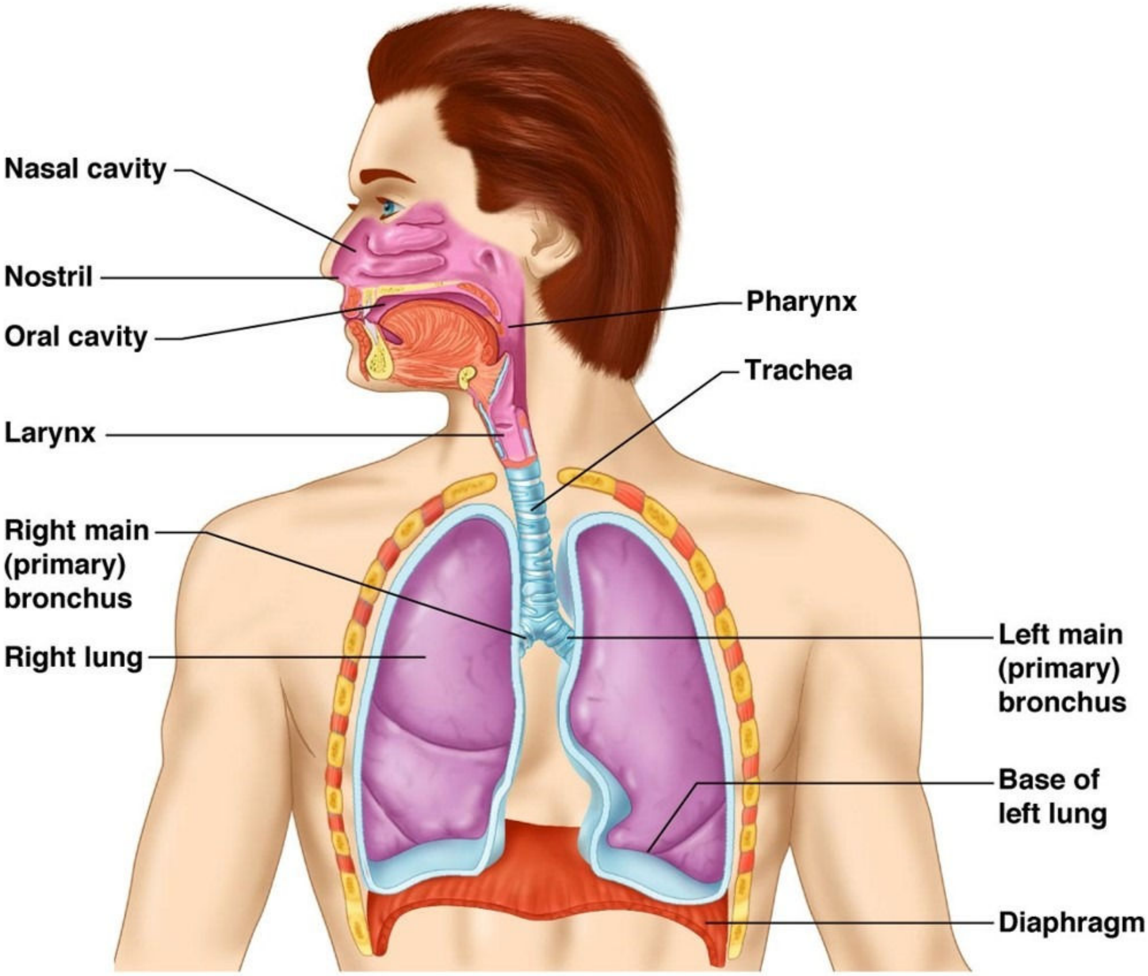
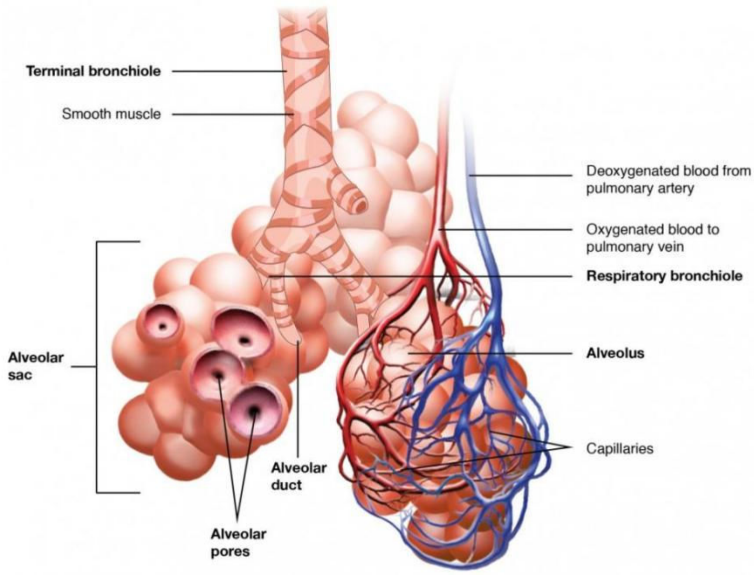
ABDUR REHMAN
BIOLOGY

9 Human gas exchange

9.1 Human gas exchange.

Identify, on diagrams and images, the larynx, trachea, lungs, bronchi, bronchioles, alveoli and associated capillaries.





Describe the features of gas exchange surfaces in humans, limited to: large surface area, thin surface, good blood and air supply.
State the characteristics of, and describe the role of, the exchange surface of the alveoli in gas exchange.

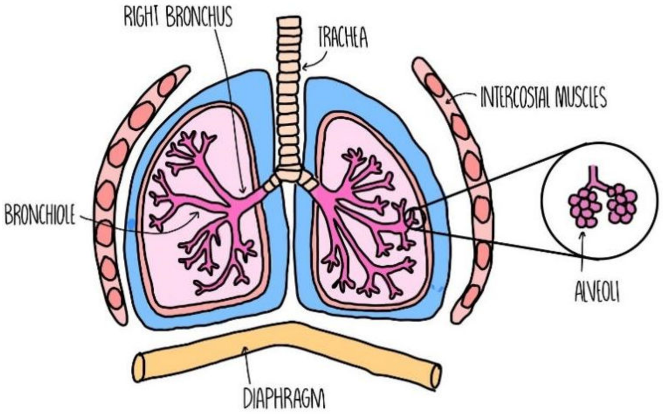
All living organisms require a gaseous exchange system for exchange of oxygen and carbon dioxide with the environment. In humans and other mammals oxygen is gained from the air by means of the lungs.

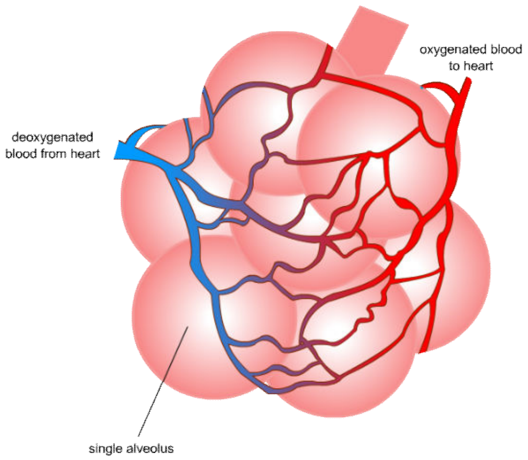
The exchange of Oxygen and carbon dioxide across a respiratory surface depends on and the diffusion of two gases, diffusion occurs more rapidly if:

- There is a lot surface area exposed to the gases.
- There is good blood supply.
- The distance across which diffusion takes place is small.
- There is a big difference in the concentrations of the gas at 2 points achieved by ventilation.

Large Surface Area

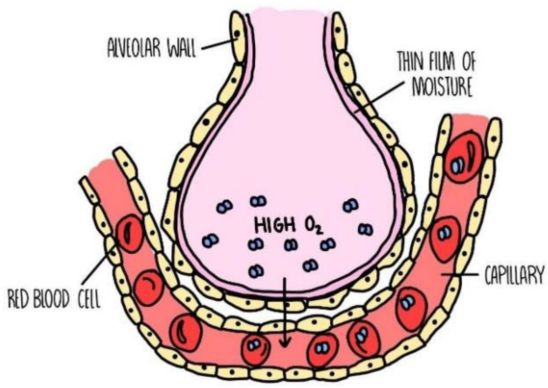
The presence of millions of alveoli in the lungs provides a large surface area. This increased surface area allows for more contact between respiratory surfaces and the surrounding air, enhancing the overall efficiency of gas exchange.





Thin Epithelium

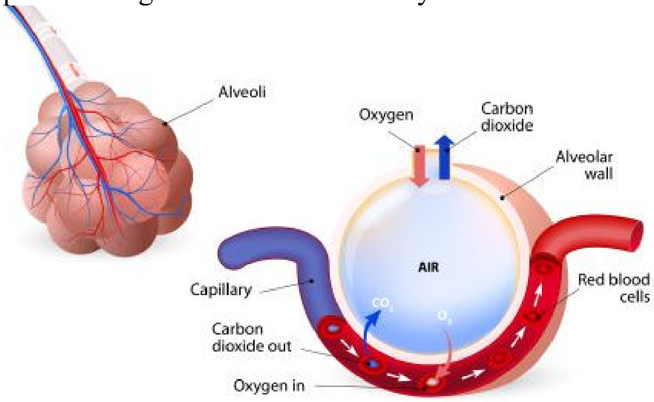
The surfaces involved in gas exchange are extremely thin. Alveoli is a single cell layer and there is only a two-cell layer separating the air in the alveoli from the blood in the capillaries. This thin barrier reduces the distance gases need to diffuse, facilitating a rapid exchange of oxygen and carbon dioxide.



Good Blood Supply.

Adequate blood supply is crucial for gas exchange surfaces. The thin walls of alveoli are surrounded by an extensive network of capillaries, ensuring that blood is in close proximity to the respiratory surfaces for efficient exchange. The blood in these capillaries removes oxygen all the time, keeping the oxygen concentration low. In this way, a steep diffusion gradient is maintained.

Carbon dioxide from the blood is delivered continuously into the alveoli which removes it from the body maintaining a steep diffusion gradient in the same way.

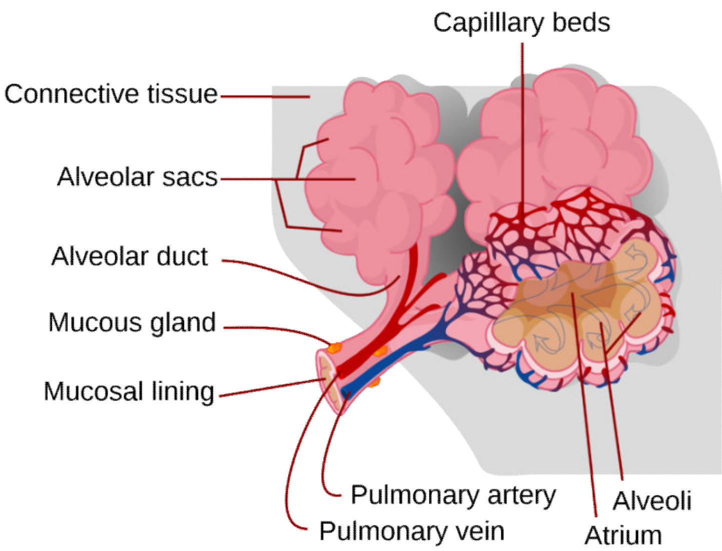


Characteristics of Alveoli.

- Alveoli collectively offer an extensive surface area, optimizing the interaction between air and blood for effective gas exchange.
- The alveolar walls are exceptionally thin, consisting of a single layer of epithelial cells. This thin structure facilitates swift gas diffusion, minimizing the distance for oxygen and carbon dioxide exchange.

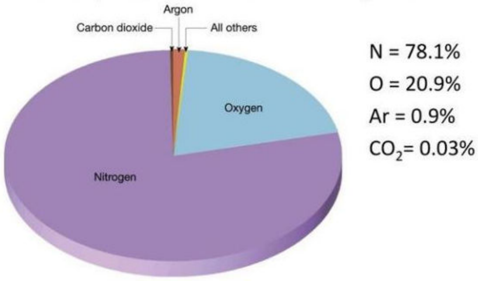
Role of Alveoli in Gas Exchange.

- Inhaled air, rich in oxygen, enters the alveoli. Oxygen efficiently crosses the thin alveolar membrane, entering the bloodstream and binding to hemoglobin for transport to tissues.
- Carbon dioxide, a byproduct of cellular respiration, moves from the blood into the alveoli. It is then expelled from the body during exhalation.
- The thin alveolar walls ensure rapid gas exchange. Both oxygen and carbon dioxide diffuse across the membrane swiftly, driven by concentration gradients.
- Alveoli produce surfactant, reducing surface tension. This prevents alveolar collapse during exhalation, sustaining structural integrity for continuous gas exchange.



<u>**State the percentages of the gases in atmospheric air.**</u>
<u>**Investigate and explain the differences between inspired and expired air.**</u>

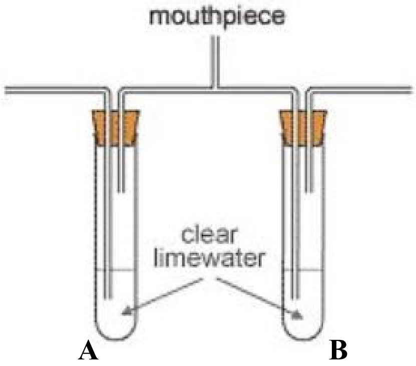
Composition of the atmospheric is explained through the following figure.



To investigate the differences in composition between inspired and expired air, we use limewater because it changes color when the gas is bubbled through, from colorless to milky.
There is more CO2 present in expired air than inspired air. It makes limewater change color more quickly (than inspired air).

- Prepare two large boiling tubes A and B with each containing a small amount of clear lime water. Put the mouth piece in your mouth and breath in and out gently through it for about 15 seconds.
- Notice which tube is bubbling when you breathe out and which one bubbles when you breathe.
- If there is no difference in the appearance of the lime water in the two tubes after 15 seconds continue breathing through them for another 15 seconds.

Results
The limewater in tube being goes milky the limewater in tube a stay clear.
Interpretation.
Carbon dioxide turns limewater milky. Expired air passes through tube inspired air passes through tube A so expired air must contain more carbon dioxide than inspired air.

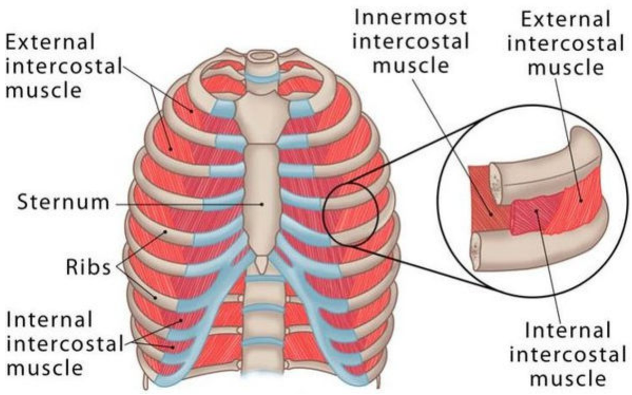


GAS	INSPIRED AIR	EXPIRED AIR
OXYGEN	21%	16%
CARBON DIOXIDE	0.04%	4%
NITROGEN	78%	78%

<u>**Identify, on diagrams and images, the ribs, internal and external intercostal muscles and the diaphragm.**</u>

<u>**Explain the role of the ribs, the internal and external intercostal muscles and the diaphragm in producing volume and pressure changes in the thorax, causing the movement of air into and out of the lungs (breathing).**</u>

The ribs form a protective cage around the thoracic cavity. During breathing, the ribs play a crucial role in expanding and contracting the thoracic space. The diaphragm is a sheet of muscle tissue that separates the thorax from the abdomen. When relaxed, it is domed slightly upwards. The external and internal intercostal muscles are attached to the ribs. The role of all the structures is explained a through the process of inspiration and expiration.

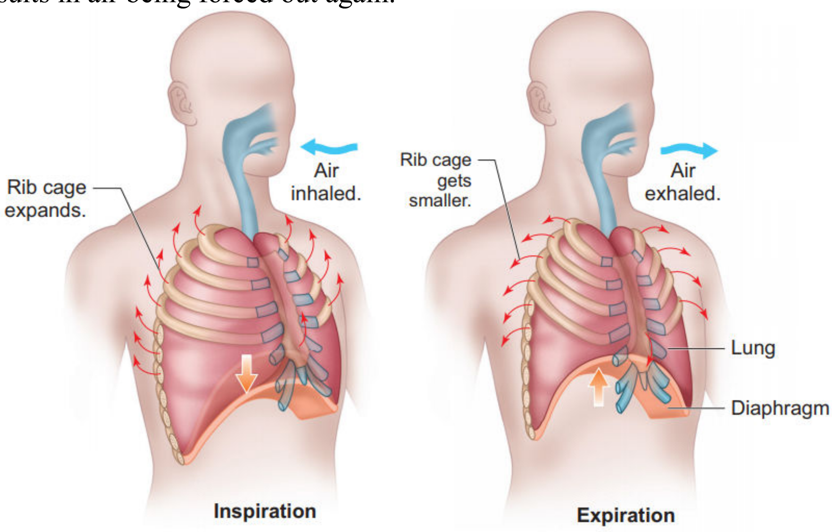


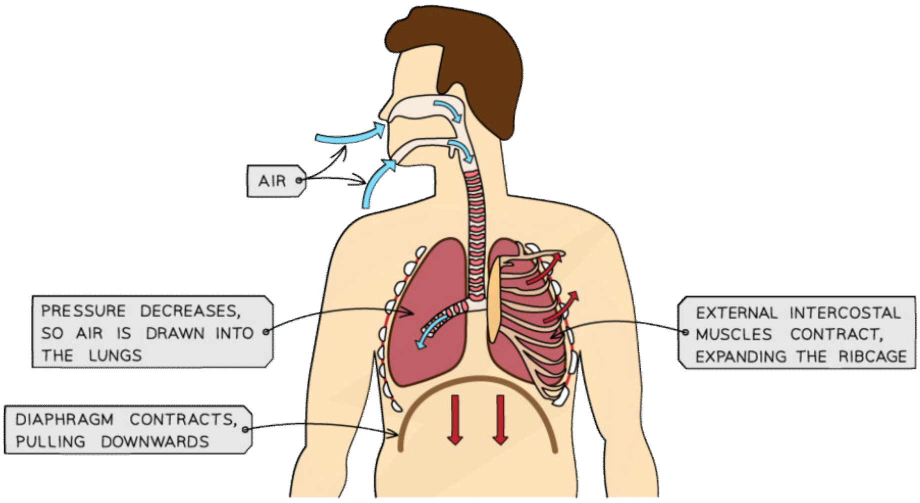
Inspiration.

- Inspiration (inhalation) is the process of taking air into the lungs. It is the active phase of ventilation because it is the result of muscle contraction.
- The diaphragm muscles contract and pull the diaphragm down.
- The internal intercostal muscles relax while the external intercostal muscles contract and pull the ribcage upwards and outwards.
- These two movements make the volume in the thorax bigger so forcing the lungs to expand.
- The reduction in air pressure in the lungs results in air being pulled in through the nose and trachea. This movement of air into the lungs is also known as ventilation.

Expiration.

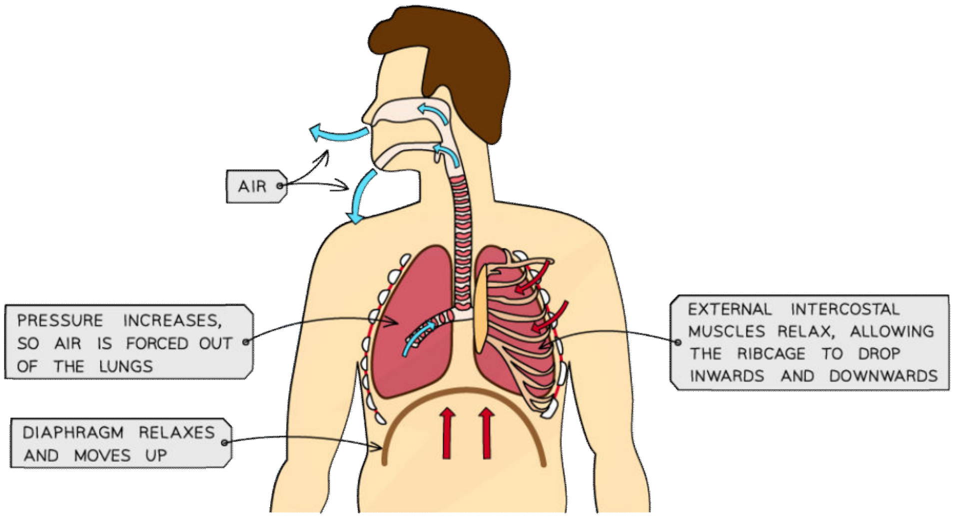
- Expiration (exhalation) is the process of letting air out of the lungs during the breathing cycle.
- The diaphragm muscles relax, allowing the diaphragm to return to its domed shape.
- The external intercostal muscles relax while the internal intercostal muscles contract pulling the ribs downwards to cause a forced expiration.
- The lungs are elastic and shrink back to their relaxed volume, increasing the air pressure inside them.
- This results in air being forced out again.





BREATHING IN

- EXTERNAL INTERCOSTAL MUSCLES CONTRACT
- RIBCAGE MOVES UP AND OUT
- DIAPHRAGM CONTRACTS AND FLATTENS
- VOLUME OF THORAX INCREASES
- PRESSURE INSIDE THORAX DECREASES
- AIR IS DRAWN IN



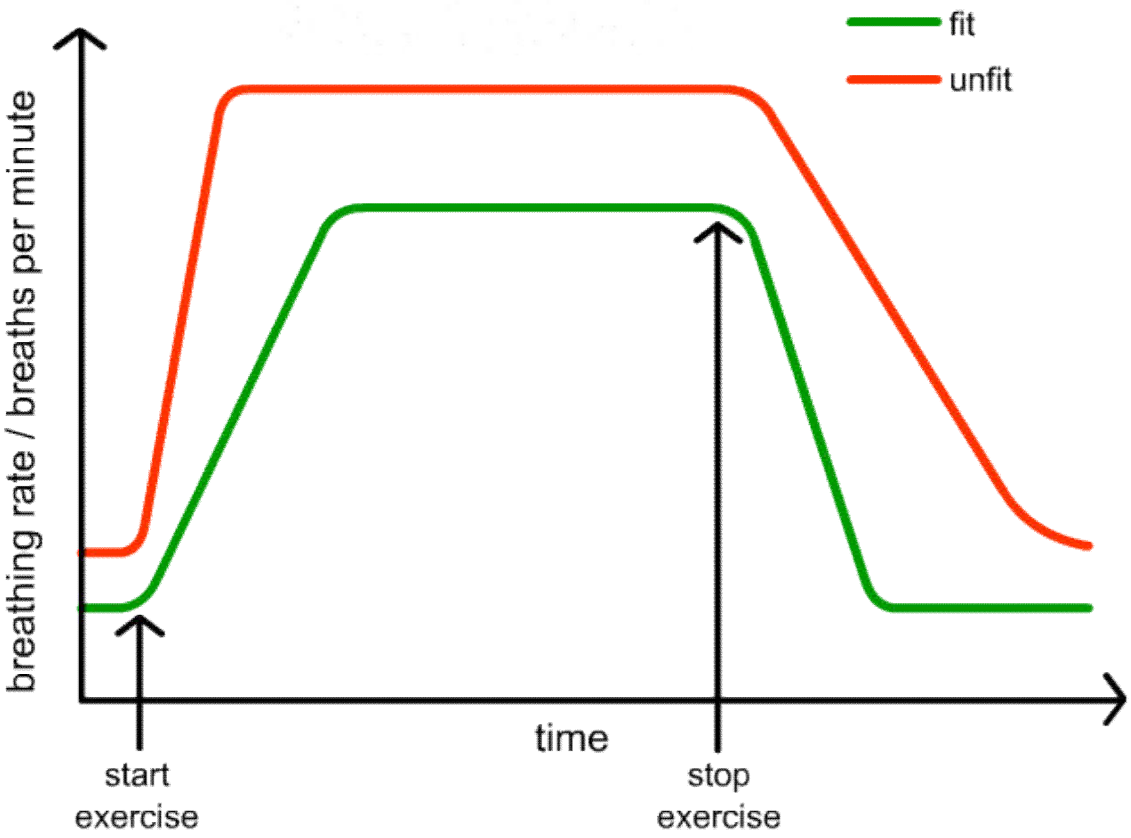
BREATHING OUT

- EXTERNAL INTERCOSTAL MUSCLES RELAX
- RIBCAGE MOVES DOWN AND IN
- DIAPHRAGM RELAXES AND BECOMES DOME-SHAPED
- VOLUME OF THORAX DECREASES
- PRESSURE INSIDE THORAX INCREASES
- AIR IS FORCED OUT

Investigate and explain the effect of physical activity on rate and depth of breathing.

When you're doing physical activities like running or exercising, your body needs more oxygen for your muscles. To meet this demand, you breathe faster, taking more breaths in a minute. At the same time, each breath becomes deeper, allowing your lungs to get more oxygen, which is then sent to your muscles through the blood.
A simple experiment can be carried out investigating the effect of physical activity on rate and depth of breathing.

- Calculate the breathing rate at rest three times and take an average.
- Physical exercise should be done by the same person.
- Recalculate the breathing rate immediately.
- Calculate the change in breathing rate.
- Repeat with different individuals and type of exercise.



Think of it as your body's way of getting more "fuel" (oxygen) during exercise – you speed up and deepen your breathing to keep up with the increased demand. Regular exercise can actually make your lungs and breathing muscles stronger, so you can take in even more oxygen when you're active. After you're done exercising, breathing gradually goes back to normal as your body recovers.
In short, during physical activity, your breathing adjusts to deliver the extra oxygen that your muscles need, and this is a healthy response to exercise.

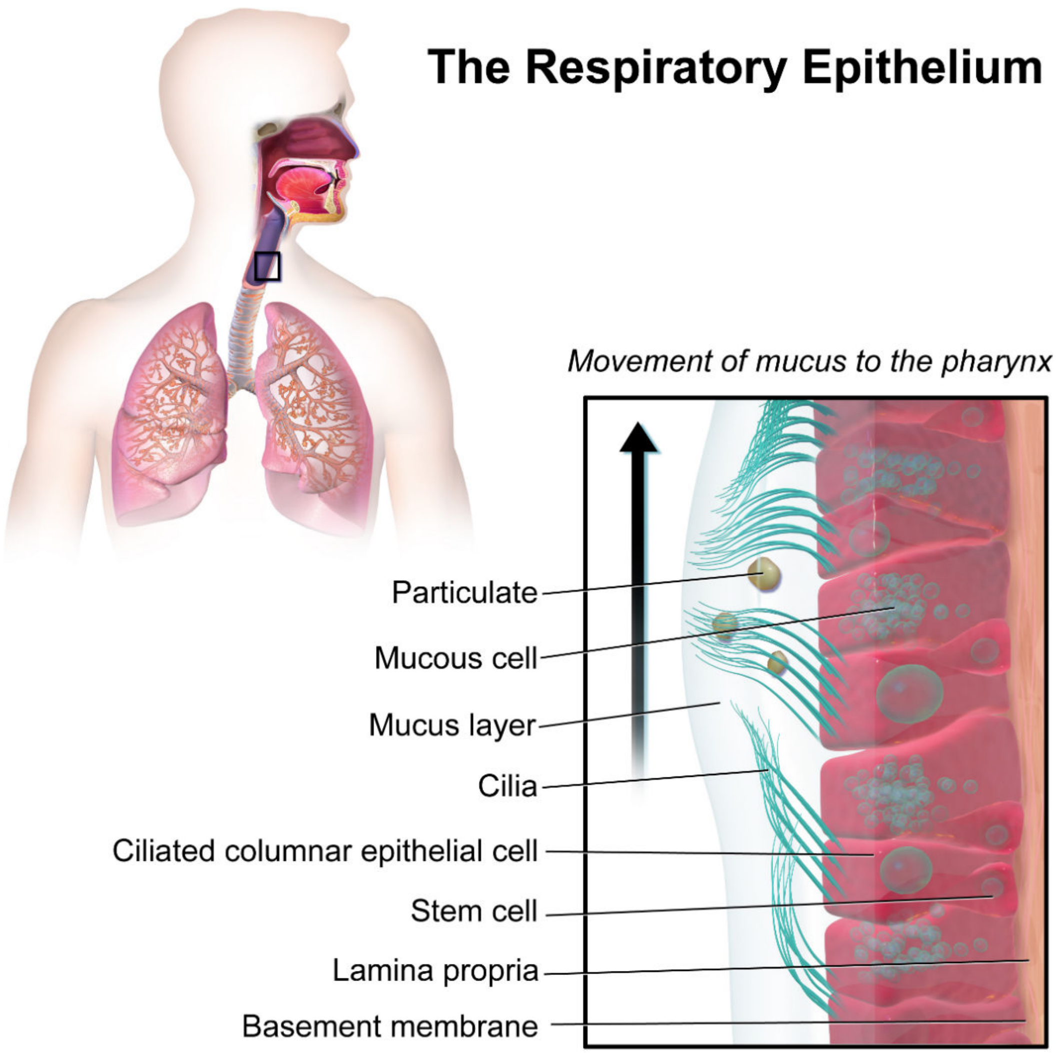
Explain the role of goblet cells, ciliated cells and mucus in protecting the gas exchange system from pathogens and particles.

Pathogens
Pathogens are disease causing organisms. Pathogens and dust particles are present in the air we breathe in and are potentially dangerous if not actively removed. There are two types of cells that are specialized to do this:

- Goblet Cells.
- Ciliated Cells.

Goblet cells.
These are found in the epithelial lining of the trachea, bronchi and some bronchioles of the respiratory tract. Their role is to secrete mucus. This sticky liquid attracts pathogens and small particles, preventing them from entering the alveoli where they could cause infection or physical damage.

Ciliated cells.
These are also present in the epithelial lining of the respiratory tract. They continuously move in a flickering motion to move the mucus upwards and away from the lungs. When the mucus reaches the top of the trachea it passes down the throat during normal swallowing.



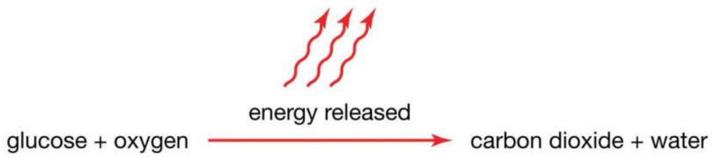
Respiration

10.1 Respiration.

Describe respiration as the chemical reactions in all living cells that release energy from glucose.

State the uses of energy in living organisms including muscle contraction, protein synthesis, cell division, active transport, growth, the passage of electrical impulses along neurones and the maintenance of a constant body temperature.

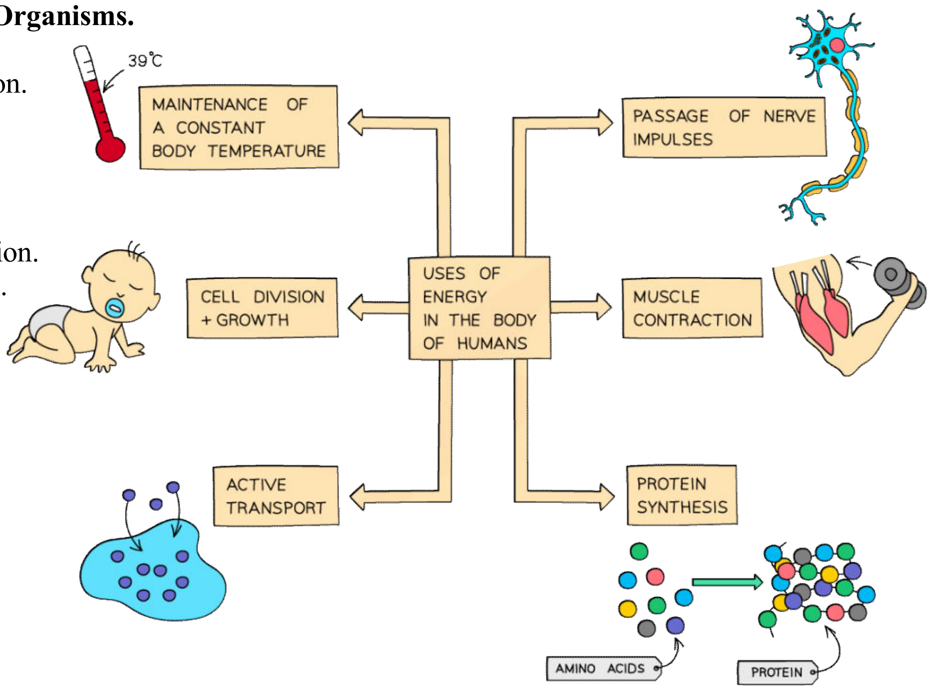
Cellular respiration is the process by which organisms combine oxygen with food molecules, diverting the chemical energy life-sustaining activities and discarding carbon dioxide and water as waste products, . Respiration is a chemical process that takes place in cells and involves the action of enzymes. It is a series of chemical reactions occurring in all living cells, where energy is released from glucose, a simple sugar. This process serves as the primary mechanism for cells to obtain the energy needed for various cellular activities.



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

Uses of energy in living Organisms.

- Muscle Contraction.
- Protein Synthesis.
- Active Transport.
- Cell Division.
- Growth.
- Nervous Conduction.
- Thermoregulation.
- Osmoregulation.



Investigate and describe the effect of temperature on respiration in yeast.

The effect of temperature on a yeast respiration.

- Make some bread dough using flour, water and activated yeast.
- Rub the inside of a boiling tube or measuring cylinder with oil.
- Use a glass rod or the end of an old pencil to push a piece of dough into the bottom of the boiling tube so that tube is about a quarter full of dough.
- Mark the height of the top of the dough on the boiling tube or measuring cylinder using a permanent marker.
- Place the boiling tube into a beaker of water set to a pre-selected temperature.
- Leave it for 20 minutes.
- Record the new height of the dough.
- Repeat the method at different temperatures and compare the rate at which the bread dough rises.

Results.

The door rises faster as the temperature is increased to 35 or 40°C. Further high temperatures slow down the rate and low temperatures may result in no change in the height of the dough.

Interpretation.

Yeast respires anaerobically producing carbon dioxide which causes the dough to rise. The process is controlled by enzymes which work faster as the temperature is increased to optimum around 35 to 40°C.

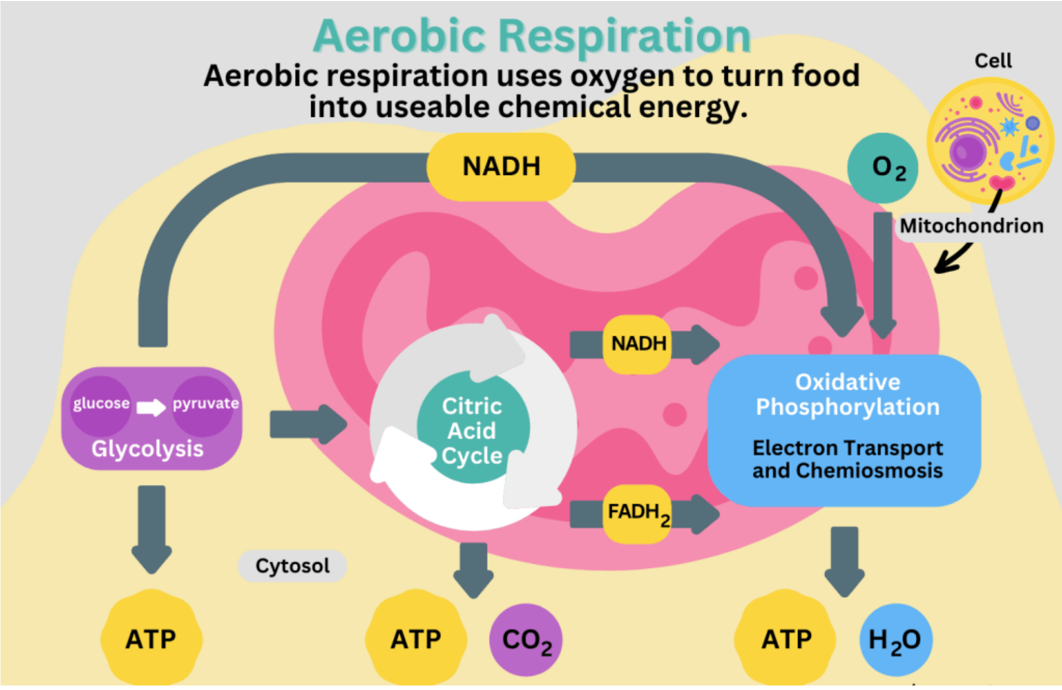
10.2 Aerobic respiration.

Describe aerobic respiration as the release of a relatively large amount of energy by the breakdown of glucose in the presence of oxygen.

Aerobic Respiration.

Aerobic respiration is the release of a relatively large amount of energy by the breakdown of glucose in the presence of oxygen.

All food molecules contain carbon, hydrogen and oxygen atoms. During aerobic respiration oxygen combine with the food molecules. The process of oxidation converts the carbon to carbon dioxide and the hydrogen to water and, at the same time release energy, which the cell can used to drive other reactions.



<u>State the word equation and balanced chemical equation for aerobic respiration.</u>
<u>State the word equation for anaerobic respiration in humans.</u>
<u>State the word equation for anaerobic respiration in yeast.</u>

Aerobic Respiration
Word Equation

Glucose + Oxygen ⟶ Carbon Dioxide + Water + Energy Released

Balanced Chemical Equation.

$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + 2830$ KJ

Anaerobic Respiration in humans

$C_6H_{12}O_6$	⟶	$2C_3H_6O_3$	+	118KJ
Glucose		Lactic Acid		Energy

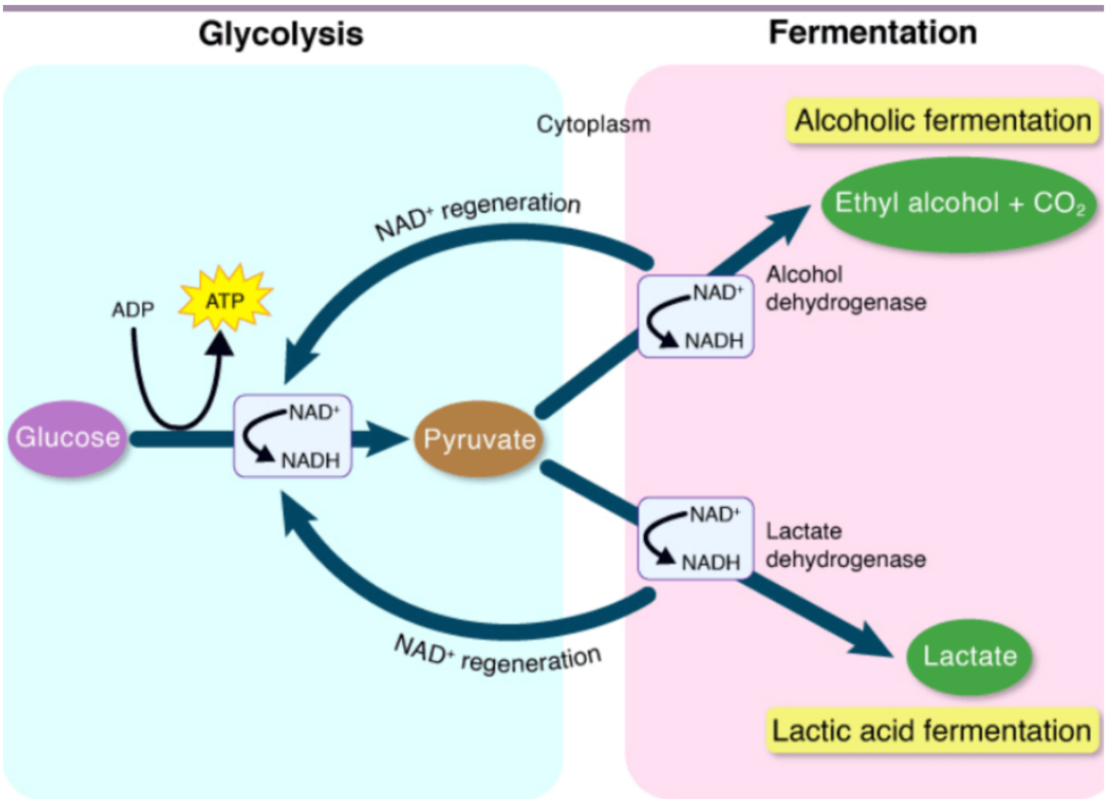
Anaerobic Respiration in Yeast

$C_6H_{12}O_6$	⟶	$2C_2H_5OH$	+	$2CO_2$	+	210KJ
Glucose	⟶	Ethanol	+	Carbon Dioxide	Energy	

10.3 Anaerobic respiration.

Describe anaerobic respiration as the release of a relatively small amount of energy by the breakdown of glucose without using oxygen.

Anaerobic respiration is the release of a relatively small amount of energy by the breakdown of glucose without using oxygen.
Anaerobic respiration is a process where a modest amount of energy is released from the breakdown of glucose without the use of oxygen. This occurs through the common initial step of glycolysis in the cytoplasm, followed by fermentation pathways. In animals, this may lead to the production of lactic acid, while in yeast and some bacteria, it results in ethanol and carbon dioxide. Although less efficient than aerobic respiration, anaerobic respiration serves as a temporary energy source when oxygen is limited or absent.
The process of making ethanol and bread making rely on anaerobic respiration by yeast. The yeast uses the energy for its growth and living processes but much less energy is released by anaerobic respiration then in aerobic respiration.



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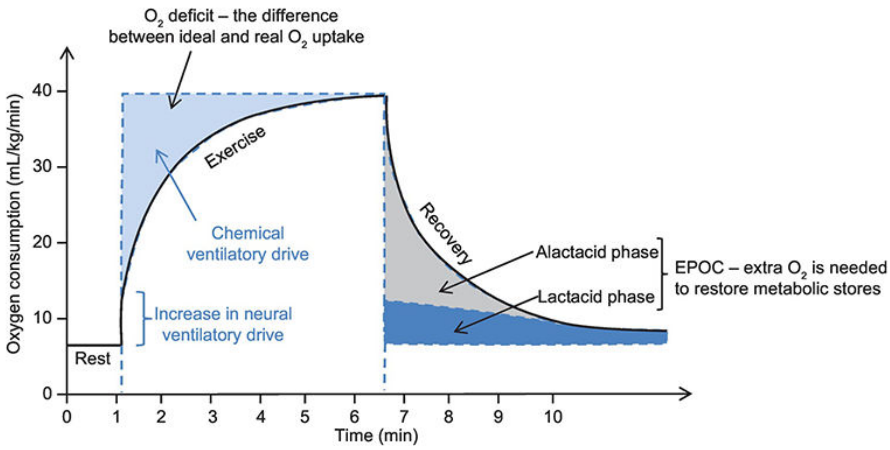
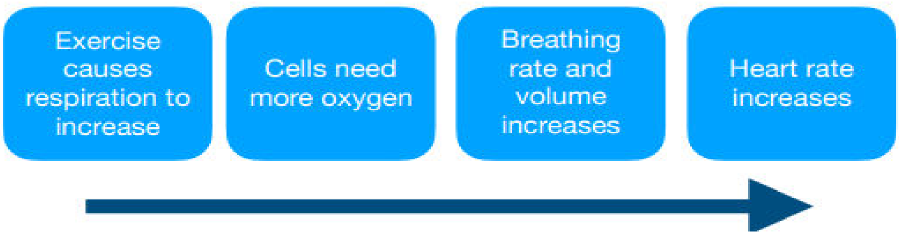
Explain why lactic acid builds up in muscles and blood during vigorous exercise causing Excess Post-exercise Oxygen Consumption (EPOC) or an 'oxygen debt'.
Outline how the oxygen debt is removed after exercise, limited to:
(a) continuation of fast heart rate to transport lactic acid in blood from muscles to the liver (b) continuation of deeper and faster breathing to supply oxygen for the breakdown of lactic acid in the liver.

Anaerobic respiration happens in muscles during vigorous exercise because oxygen cannot be delivered fast enough for the muscles to respire aerobically. Anaerobic respiration is much less efficient than aerobic respiration.
During intense exercise, when oxygen supply falls short, muscles resort to anaerobic respiration, producing lactic acid. The blood needs to move more quickly during and after exercise to maintain this lactic acid removal process, so the heart rate is rapid. This buildup causes muscle fatigue and results in a temporary oxygen debt. After exercise, the body requires extra oxygen to clear lactic acid, contributing to Excess Post-exercise Oxygen Consumption (EPOC). This phenomenon is part of the recovery process, aiding in the restoration of normal cellular function and reducing muscle soreness. EPOC is actually the amount of oxygen needed to return the body to its normal rusting level of metabolic function. It is important because build-up of lactic acid in the muscles results in muscular fatigue leading to cramp.



Removing Oxygen Debt After Exercise
(a) Continuation of Fast Heart Rate:
- After exercise, the heart continues to beat faster than normal.
- Fast heart rate helps pump blood quickly, carrying lactic acid from muscles to the liver.
- Lactic acid is a byproduct of anaerobic respiration in muscles and needs to be transported for further processing.

(b) Continuation of Deeper and Faster Breathing:
- Post-exercise, breathing remains deeper and faster.
- Increased breathing ensures a higher intake of oxygen from the air.
- Oxygen is crucial for the liver to break down lactic acid through aerobic respiration, converting it into less harmful substances.



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