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B.Sc. (Hons), M.Sc.

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UNIT 05

Animal Form and Function

Gas Exchange in Animals

SAMPATH LANKADHEERA
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6. and inhibits the action of cilia in the respiratory tract
7. causing accumulation of mucus in bronchioles
8. and blocking them, leading to bronchial inflammation/bronchitis.
9. As a result, breathing may become difficult.
10. hydrogen cyanide in cigarette smoke stops the cilia from working properly.
11. dust and other particulate matter get collected in the lung,
12. resulting in an increase in phagocytic cells in the lung tissue.
13. the alveolar tissue is destroyed, thus reducing the effective area available for gas exchange.
14. Carbon monoxide (CO) is absorbed into the blood and bind to hemoglobin
15. oxygen transport through blood is decreased.
16. Tobacco smoke contains a large number of cancer-causing substances (carcinogens).
17. Long term exposure to such chemicals may results a cancer.
18. the cancer may spread to other parts of the lungs and or to other organs.
19. Silicosis may caused by long-term exposure to dust containing silica compounds.
20. When silica particles are inhaled they accumulate in the alveoli.
21. These particles are ingested by macrophages.
22. Progressive fibrosis is stimulated which obliterates the blood vessels/respiratory bronchioles.
23. leads to pulmonary hypertension and heart failure.
24. Asbestosis occurs when asbestos fibers are inhaled with dust.
25. particles penetrate the level of respiratory bronchioles and alveoli.
26. Macrophages accumulate in the alveoli and the shorter asbestos fibers are ingested.
27. The macrophages that have engulfed fibers move out of the alveoli
28. and accumulate around respiratory bronchioles and blood vessels,
29. stimulating the formation fibrous tissue.
30. These cause progressive destruction of lung tissue and pulmonary hypertension
31. Tuberculosis is an infectious disease caused by the bacterium Mycobacterium tuberculosis.
32. The bacterium spreads when an infected person coughs
33. and the bacterium enters the body of an uninfected person through inhaled air.
34. The most common form is Pulmonary TB which affects the lungs.
35. Other organs may also be affected.
36. Symptoms of this disease are loss of appetite, loss of weight, excessive sweating, fever, a racking cough and spitting up blood.
37. Asthma is characterized by wheezing and chest tightness causing breathing difficulty.
38. This is caused by the sudden contractions of smooth muscles in the walls of the bronchioles
39. During this time breathing causes whistling or wheezing sound.
40. It is an over reaction of an immune response to stimuli like pollen/dust/mites/spores/particular food/cold air/exercise/smoking gases.
41. Anti-inflammatory drugs help control.

Gas exchange in animals

Need of respiratory structures in animals and evolution of complexity of respiratory structures in different animal groups

Respiratory gas exchange (uptake of oxygen into the body and release of carbon dioxide into the external environment) occurs by …….... In simple animals e.g. cnidarians and flat worms ……. ……... in the body is ……... enough to the ……. ……... so that gas exchange can occur directly between all cells and the environment. Diffusion through body surface is adequate as these animals have a simple body form and …….. …….. requirement.

In ……... animals, body ……... and ……. ……. is high and the bulk of the cells in the body ……... immediate access to the external environment. Hence, …….. ……. through the body ……. is not adequate to full fill their energy requirements. As a result, ……... surfaces referred to as ……... ……. have evolved where gaseous exchange occurs.

With the increase of the body size and complexity the ……..…… ……..... to ……. ratio (A/V) of animals decreases. However, a large surface area is required for efficient gas exchange and thus diverse respiratory …….. with large surface area with ……..... and ……. has evolved for efficient gas exchange. Examples for such respiratory structure are ……..., ……..., and ……... External projections of the body such as ……... were evolved in aquatic animals for efficient …….. of dissolved oxygen from water. On the other hand, surface ……... like trachea and lungs were evolved in …….. animals for efficient extraction of oxygen from the atmosphere.

Characteristics of respiratory surfaces

An effective respiratory surface must have the following properties.

……..
……..
……..
……..
……..
……..

Respiratory structures in animals

- Body surface : ……...
- Gills
  - External Gills : ……...

7. between the alveolar air in the lungs and blood during external respiration
8. and blood and tissues during internal respiration.
9. During inhalation, fresh air mixes with the stale air in the lungs.
10. This mixture in the lungs has a higher partial pressure of oxygen (PO_2)
11. and a lower partial pressure of carbon dioxide (PCO_2)
12. than the blood in the alveolar capillaries.
13. There is thus a concentration gradient favoring the diffusion of these two gases
14. in opposite directions.
15. Net diffusion of O_2 takes place from the air in the alveoli to the blood
16. and net diffusion of CO_2 takes place from the blood into the alveoli.
17. When O_2 molecules diffuses into blood capillaries they bind to heamoglobin in the red blood cells.
18. Four molecules of O_2 bind reversibly with one molecule of haemoglobin
19. and form oxyhaemoglobin.
20. When blood leaves the alveolar capillaries the oxygen
21. and carbon dioxide partial pressures are in equilibrium with those of alveoli air.
22. Once this blood returns to the heart through pulmonary veins, it is pumped through the systemic circuit.
23. Blood reaching the tissues in the systemic capillaries have a higher PO_2
24. and a lower PCO_2 than in the tissues.
25. These partial pressure gradients result in the net diffusion of O_2 from the blood stream into the tissue
26. and CO_2 diffusion from the cells into the blood stream across the extracellular fluid/interstitial fluid.
27. This is called unloading of O_2 and loading of CO_2 .
28. Then the blood returns to heart and pumped to lungs again.

4. Describe the homeostatic control of breathing in man.

1. Typically breathing is regulated by involuntary mechanisms.
2. These involuntary mechanisms help coordinate gas exchange with blood circulation and metabolic demands
3. Medulla oblongata is the main breathing regulating center found at the base brain.
4. There are a pair of breathing control centers found in medulla oblongata and they are responsible for regulating the breathing rhythm.
5. A negative-feedback mechanism is involved in regulating this process.
6. Sensors which detect stretching of the lung tissues are found in the lungs.
7. During inhalation, these sensors send nerve impulses to the neurons that act as control circuits in the medulla oblongata
8. and further inhalation is inhibited
9. and this prevents the lungs from over expanding.
10. To regulate breathing, the medulla oblongata depends on pH changes in tissue fluids.
11. The pH of tissue fluid is an indicator of blood carbon dioxide concentration.
12. For example, when metabolic activities increase,
13. the concentration of CO_2 in the blood increases.
14. Because CO_2 diffuse into the cerebrospinal fluid,
15. this results in an increase of CO_2 concentration in the cerebrospinal fluid as well.
16. There CO_2 reacts with water and form carbonic acid (H_2CO_3).
17. H_2CO_3 dissociate into HCO^-; and H^+
18. Hence, a high CO_2 concentration results in an increase in H^+ concentration, thereby a lower pH.
19. This pH change is detected by the sensors in the medulla oblongata
20. and in major blood vessels (carotid arteries and aorta).
21. Sensors in the medulla and major blood vessels detect this decrease in pH.
22. In response, the control circuits in medulla increase the depth and rate of breathing until the excess CO_2 is removed in exhaled air
23. and the pH of blood comes to its normal value which is 7.4
24. The O_2 level has little influences on the breathing control centers.
25. But, when O_2 concentration becomes very low,
26. O_2 sensors found in the aorta
27. and the carotid arteries send impulses to the medulla oblongata
28. to increase the breathing rate.
29. The regulation of breathing is also modulated by additional neural circuits
30. in the pons varolii, a part of the brain stem found above the medulla.

5. Briefly explain the causes of major disorders of the human respiratory system and suggest necessary preventive measures to avoid or minimize the impacts of those disorders.

1. Cigarette smokers inhale large number of chemicals come from burning tobacco.
2. Nicotine is temporarily increases the rate of heart beat
3. and constriction of peripheral blood vessels
4. causing a temporary increase in blood pressure.
5. Cigarette smoke stimulates the secretion of mucus by the goblet cells

Essay AID

1. **Describes the gross structure of the human respiratory system relates the structure with the function of each part of the respiratory system.**

1. Human respiratory system consists of nostrils,
2. nasal cavity, pharynx, larynx,
2. a series of branching ducts starting from the trachea,
3. two bronchi one leading to each lung and smaller bronchioles,
4. which finally end in air sacs called alveoli.
5. The bronchioles and the alveoli are contained
6. within the paired, cone-shaped lungs located in the thoracic cavity.
7. The two lungs differ slightly in shape and size.
8. The left lung is slightly smaller than the right
9. and it has 2 lobes
10. while the right lung has 3 lobes.
11. Each lung is surrounded by two membranes.
12. The inner membrane,
13. called the visceral pleura
14. adheres to the outer surface of the lungs
15. while the outer membrane
17. called the parietal pleura
18. adheres to the wall of the thoracic cavity.
19. air enters the respiratory system through the nostrils.
20. In the nasal cavity air is filtered by hairs and is warmed
21. and humidified as it travels through spaces in the nasal cavity.
22. The nasal cavity leads to the pharynx which is a common passage for both air and food.
23. In the larynx are vocal cords
24. which are made up of largely elastic bands of muscles.
25. These vocal cords help produce sound
26. walls of the larynx and trachea are strengthened by cartilage
27. that help airways to keep open.
28. The air passes from the trachea into the two bronchi that lead into each lung.
29. Within the lungs the air passes through smaller and smaller branches called bronchioles.
30. At the tips of tiniest bronchioles are large number of small air sacs clustered together.
31. The air passes into these air sacs called alveoli where gas exchange occurs.
32. This inner lining of the alveoli is coated by a thin film of fluid.
33. The lungs contain millions of alveoli.
34. This allows a large surface area for gas exchange.

2. **Describes the mechanism of ventilation of lungs.**

1. Ventilation is the alternating movement of air into (inhalation)
2. and out of (exhalation) the lungs.
3. Inhalation is an active process.
4. Contraction of rib muscles/intercoastal muscles
5. and the diaphragm leads to the expansion of the thoracic cavity.
6. Thereby, increasing its volume.
7. The visceral and parietal pleurae surrounding the lung stick together
8. due to the surface tension of the fluid between these two membranes.
9. This allows the two membranes to slide smoothly pass each other.
10. as the volume of the thoracic cavity increases, the lung volume increases as well.
11. As a result. the pressure within the lungs decrease relative to the outside air.
12. This creates a pressure gradient between the atmosphere and the lungs.
13. Thus, air flows from a high pressure in the atmosphere
14. to a lower pressure in the lungs. This is inhalation.
15. During exhalations which is usually a passive process,
16. the rib muscles and the diaphragm relax.
17. This cause the volume of the thoracic cavity to reduce.
18. As a result, the pressure inside the lungs increase in relation to the air outside.
19. This pressure forces air to move out of the lungs through the respiratory tubes
20. into the atmosphere. This is exhalation.
21. When a man is at rest contraction of rib muscles
22. and contraction of diaphragm are enough for breathing.
23. additional muscles may be used to aid deep breathing such as muscles of the neck.
24. back and chest.
25. In deep inspiration, these muscles further help to increase the volume of the thoracic cavity by raising the rib cage.

3. **Explain the processes of exchange of gases between blood and air, blood and tissue.**

1. Gas exchange at the alveoli and in the tissues is a continuous process.
2. It requires transport of O_2 from the lungs to the blood
3. and movement of CO_2 from the blood referred to as external respiration
4. and movement of O_2 from blood to the tissues
5. and CO_2 from tissues to the blood referred to as internal respiration.
6. Diffusion of O_2 and CO_2 requires partial pressure gradients

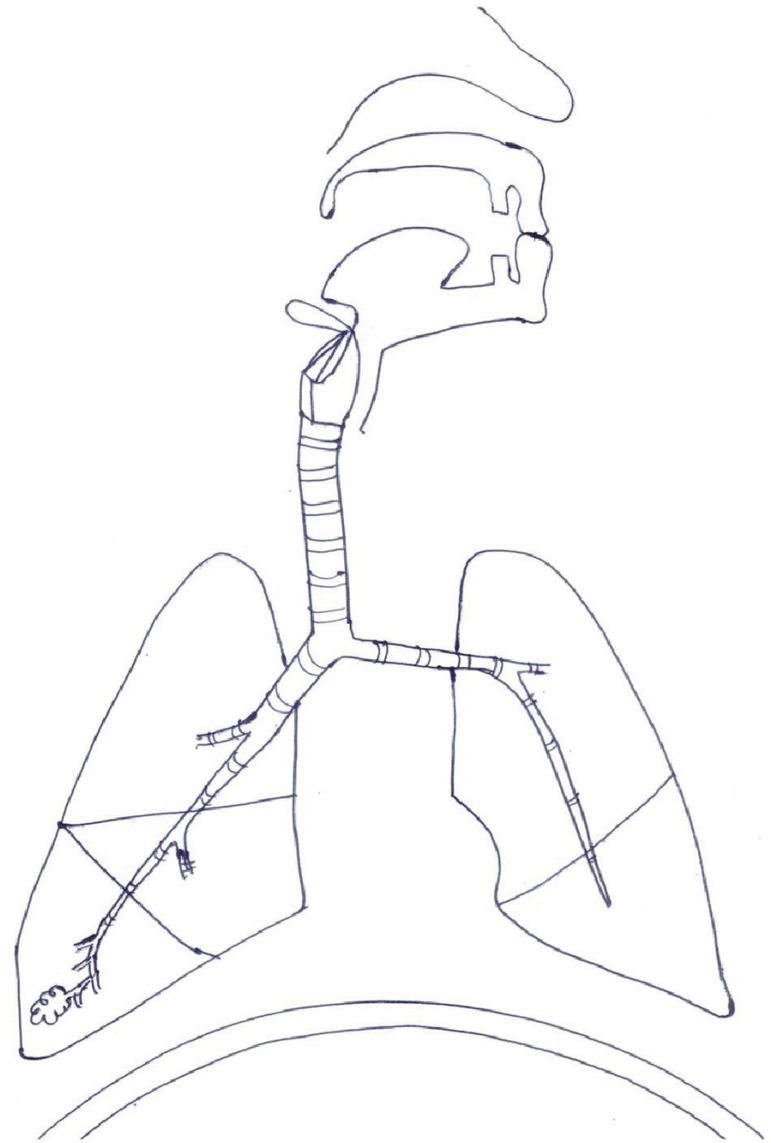
- Internal Gills : .....
- Tracheal systems : .....
- Lungs : .....
- Skin : .....
- Book lungs : .....

Human respiratory system

Gross structure function of the human respiratory system

Human respiratory system consists of the following major parts: ……..., ……., ……., ……., a series of branching ducts starting from the trachea, two ……... one leading to each lung and smaller ……., which finally end in air sacs called ……... The bronchioles and the alveoli are contained within the paired, …… ……. lungs located in the ……... cavity. The two lungs differ slightly in ……. and ……... The left lung is slightly ……... than the right because the ……... of the heart is slightly to the left of the median plane and it has …….. lobes while the right lung has ….. lobes. Each lung is surrounded by …….. membranes. The inner membrane, called the …….. pleura adheres to the outer surface of the lungs while the outer membrane called the ……. pleura adheres to the wall of the thoracic cavity. Between these two membranes there is a ……., fluid filled space.

During breathing, air enters the respiratory system through the ……... In the nasal cavity air is …….. by …….. and is ……. and …….. as it travels through spaces in the nasal cavity. The nasal cavity leads to the pharynx which is a common passage for both ……. and ……... That means air passage and food passage cross each other. During swallowing of food the larynx moves …….. which allows the ……... to close the opening of the …….. called the glottis. This allows food to go …….. the ……. to the stomach. The rest of the time the glottis is open so that air can move from the …….. through the larynx to the trachea. In the larynx are ……... ……. which are made up of largely …….. bands of ……... These vocal cords help ……. …….. when expired air ……. across the stretched or tensed vocal cords, causing them to vibrate. Both the walls of the larynx and trachea are …….. by ……. that help these airways to keep ……... The air passes from the trachea into the two bronchi that lead into each lung. Within the lungs the air passes through ……... and smaller branches of the bronchi called ……...



B. (i) Four oxygen molecules bind reversibly with one molecule of hemoglobin
(ii) Partial pressure gradients (iii) $Hb+4O_2 \leftrightarrow HbO_8$ (iv) They reach equilibrium with those of alveoli air

C. (i) Higher PO_2 and lower PCO_2 than in the tissues
(ii) Unloading of O_2 and loading of CO_2
(iii) Higher partial pressure of oxygen (PO_2) and lower partial pressure of carbon dioxide (PCO_2) than the blood in alveolar capillaries (iv) (a) Hemoglobin (b) Oxyhemoglobin

4. A. (i) In the medulla oblongata at the base brain (ii) 7.4 (iii) $CO2 + H2O \leftrightarrow H2CO3 \leftrightarrow HCO3- + H+$
(iv) Carotid arteries and aorta

B. (i) By involuntary mechanisms that coordinate gas exchange with blood circulation and metabolic demands
(ii) A negative-feedback mechanism involving sensors that detect lung tissue stretching
(iii) O2 sensors in the aorta and carotid arteries send impulses to the medulla oblongata to increase breathing rate
(iv) (a) The pons varolii, a part of the brain stem found above the medulla

C. (i) Blood pH falls due to rising levels of CO2 in tissues
(ii) Nearly 90% of lung cancers

5. A. (i) It temporarily increases heart rate and constriction of peripheral blood vessels, causing temporary increase in blood pressure
(ii) It binds to hemoglobin better than oxygen and combines irreversibly, decreasing oxyhemoglobin production and oxygen transport
(iii) A disease caused by long-term exposure to silica dust. High-risk industries include quarrying granite/slate/sandstone, mining, stone masonry, and glass/pottery work

B. (i) Mycobacterium tuberculosis
(ii) Loss of appetite, loss of weight, excessive sweating, fever, and racking cough with blood in sputum
(iii) It stimulates mucus secretion by goblet cells and inhibits ciliary action, causing mucus accumulation in bronchioles leading to bronchitis
(iv) A disease caused by inhaling asbestos fibers, where macrophages accumulate in alveoli, leading to fibrous tissue formation and progressive lung tissue destruction

C. (i) It stops cilia from working properly, leading to dust accumulation and increased phagocytic activity, resulting in alveolar tissue destruction
(ii) Through inhaled air when an infected person coughs, spreading the bacteria to uninfected persons
(iii) Sudden contractions of smooth muscles in bronchioles causing narrowing; characterized by wheezing, chest tightness, and breathing difficulty

6. A. (i) Volume of air passing into and out of lung with each normal breath; about 500 ml
(ii) VC = TV + IRV + ERV (iii) About 1,200 ml (iv) Around 3100 mL in women and 4800 mL in men

B. (i) Around 6000 mL
(ii) The system of branching conducting tubes (trachea, bronchi and bronchioles) that never contributes to gas exchange; typically about 150 mL
(iii) The volume of air remaining in lungs at end of normal expiration; FRC = RV + ERV
(iv) The total volume of air that can be inspired with maximum effort; IC = TV + IRV
(v) It is important for continuous exchange of gas in the alveoli and to prevent the collapse of alveoli during expiration

Biology II
Part A (Structured Essay)

1. A. (i) For uptake of oxygen into body and release of carbon dioxide/Required because large animals' cells lack direct access to external environment/Needed for efficient gas exchange to meet energy requirements
(ii). Simple animals (cnidarians, flatworms) use body surface/As body size/complexity increased, specialized respiratory surfaces evolved/Different structures (gills, trachea, lungs) evolved with folding and branching for increased surface area/Aquatic animals evolved gills, terrestrial animals evolved trachea and lungs
(iii) Must be permeable and wet for gas dissolution/Must be thin for efficient diffusion/Must have large surface area for sufficient gas exchange/Must have good blood supply to maintain diffusion gradient
(iv) a) Body surface: Cnidarians, Flatworms, Earthworms b) External gills: Marine annelids c) Internal gills: Fish, shrimps, prawns d) Tracheal system: Insects e) Lungs: Mammals, Reptiles, Birds f) Skin: Amphibians g) Book lungs: Spiders, Scorpions

B. (i) Nostrils/Nasal cavity/Pharynx/Larynx/Trachea/Bronchi/Bronchioles/Alveoli
(ii) Bronchioles/Alveoli
(iii) Left lung is slightly smaller than right/Left lung has 2 lobes while right has 3 lobes/Left lung is affected by heart position (apex of heart to left)
(iv) (a) Visceral pleura (inner membrane)/Parietal pleura (outer membrane) (b) pleural fluid

C. (i) Filters air through hairs/Warms the air/Humidifies the air
(ii) They have a simple body form, low energy requirement, and cells close enough to the external environment
(iii) 1) Must be permeable and wet 2) Must be thin 3) Must have large surface area 4) Must have good blood supply (iv) It decreases

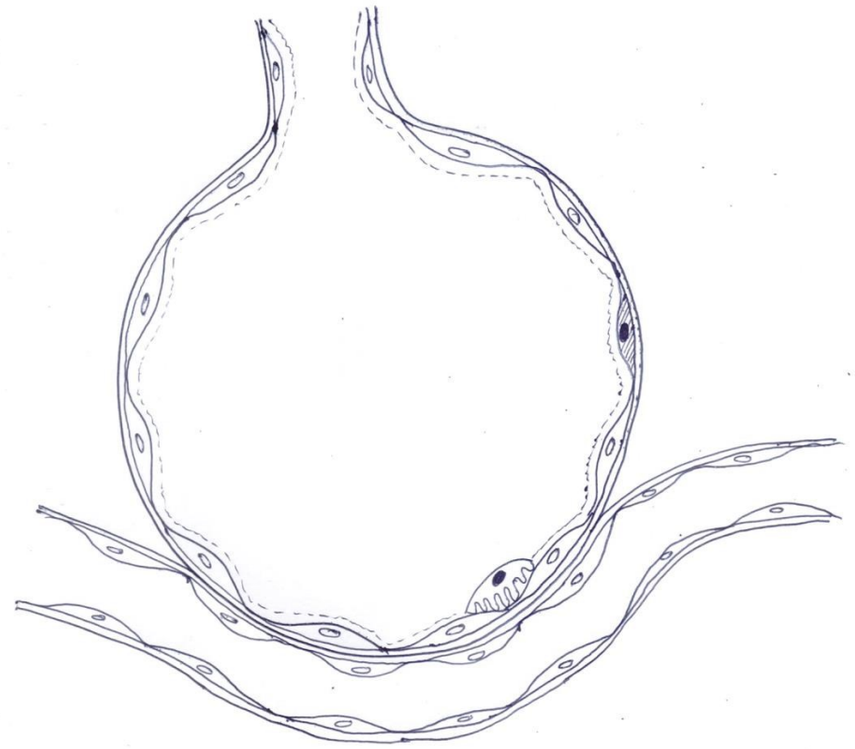
D. (i) (a) Gills, Trachea, and Lungs (b) Marine annelids (c) Fish, shrimps, and prawns (d) Book lungs
(ii) For efficient extraction of dissolved oxygen from water
(iii) For efficient extraction of oxygen from the atmosphere (iv) Amphibians

2.A. (i) Left lung has 2 lobes, right lung has 3 lobes
(ii) Because the apex of the heart is slightly to the left of the median plane
(iii) It's the process where beating cilia moves mucus upwards towards the pharynx; it helps clean the respiratory system (iv) (a) Surfactant (b) White blood cells in the alveoli engulf foreign particles

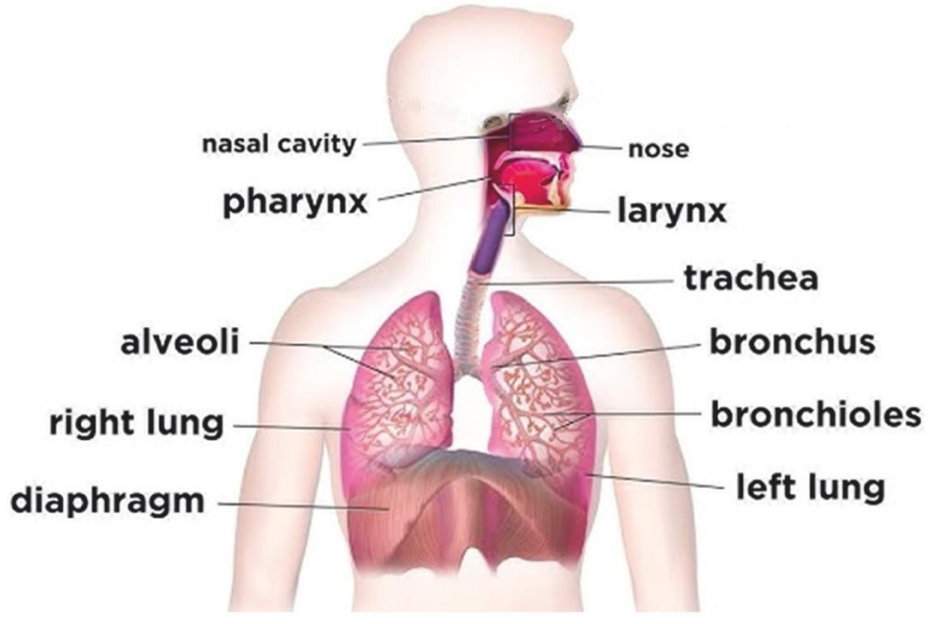
B. (i) The glottis is closed by the epiglottis when the larynx moves upwards
(ii) When expired air rushes across stretched vocal cords, causing them to vibrate
(iii) Air is filtered by hairs, warmed, and humidified
(iv) A single layer of flattened epithelial cells that lack cilia

C. (i) (a) Negative pressure breathing where air is pulled rather than pushed into lungs
(b) Contraction of rib muscles (intercostal muscles) and the diaphragm
(ii) (a) Due to the surface tension of the fluid between these two membranes (b) A passive process
(iii) Muscles of the neck, back and chest
(iv) 1) Alveoli create a large surface area for gas exchange 2) Alveoli and capillary walls are lined by simple squamous epithelia which reduce diffusion distance

3. A. (i) Partial pressure gradients between the alveolar air in the lungs and blood and blood and tissues
(ii) The pressure decreases relative to the outside air
(iii) External respiration (gas exchange between lungs and blood) and internal respiration (gas exchange between blood and tissues) (iv) To dissolve respiratory gases for diffusion



The epithelium found in the major branches of this respiratory tract has …….. and a thin film of ……..... The mucus helps trap the dust and other ……... contaminants in the inhaled air. Then the beating of cilia moves this mucus upwards towards the pharynx where it is ……... into the …….. This process is referred to as the "…….. ……...……". It helps clean the respiratory system. At the tips of …….. bronchioles are large number of small …….. ……... clustered together. The air passes into these air sacs called ……... where gas exchange occurs. The Walls of the alveoli are made up of a …….. layer of flattened epithelial cells that ……... cilia. This inner lining of the alveoli is coated by a thin film of fluid. The lungs contain …….. of alveoli. This allows a large surface area for gas exchange. Each alveolus is also surrounded by a …….. of capillaries. Oxygen in the air that enters the alveoli dissolves in the moist film and rapidly diffuse across the thin epithelium into the capillaries. Meanwhile a net diffusion of carbon dioxide occurs from the capillaries into the alveoli. Since there are no cilia in the alveoli, there are white blood cells in the alveoli to engulf foreign particles. Alveoli are also coated with a ……. that reduces the surface tension thereby preventing the collapse of alveoli due to high surface tension.



B. (i) What bacteria causes tuberculosis?

……..

(ii) List four symptoms of tuberculosis.

……

(iii) How does cigarette smoke affect the respiratory tract's cleaning mechanism?

……

……

(iv) What is asbestosis and how does it develop?

……

……

C. (i) How does hydrogen cyanide in cigarette smoke damage the lungs?

……

……

(ii) How is tuberculosis transmitted?

……

(iii) What causes asthma symptoms and what are its main characteristics?

……

……

6. A. (i) What is tidal volume (TV) and what is its average in a resting adult?

……

(ii) What is the formula for vital capacity (VC)?

……

(iii) What is the typical residual volume (RV) in the lungs?

……...

(iv) How does vital capacity differ between men and women?

……

B. (i) What is the total lung capacity (TLC) normally?

……..

(ii) What is the anatomical dead space and how much air does it typically contain?

……

……

(iii) What is Functional Residual Capacity (FRC) and how is it calculated?

……

(iv) What is Inspiratory Capacity (IC) and how is it calculated?

……

(v) What is the purpose of functional residual capacity?

……

MCQ Answers

1- (3)	2- (3)	3- (A,B,D)	4- (1)	5- (2)	6- (3)	7- (2)
8- (4)	9- (1)	10- (5)	11- (1)	12- (3)	13- (1)	14 - (2)
15- (2)	16- (A,C,D)	17- (1)	18- (1)	19- (4)		

(iii) What chemical equation represents oxygen binding with hemoglobin?

……

(iv) What happens to the oxygen and carbon dioxide partial pressures when blood leaves the alveolar capillaries?

……

C. (i) What are the conditions in systemic capillaries compared to tissues?

……

(ii) What is the process called when O_2 moves from blood to tissues and CO_2 loads into blood?

……

(iii) During inhalation, what is the state of gas mixture in the lungs compared to blood?

……

(iv) (a) What protein in red blood cells is responsible for carrying oxygen?

……

(b) When oxygen molecules bind with hemoglobin, what is the resulting compound called?

……

4. A. (i) Where is the main breathing regulating center located in the brain?

……

(ii) What is the normal blood pH value?

……..

(iii) Write a chemical equation shows the formation of bicarbonate from CO2?

……

(iv) Which blood vessels contain sensors that detect pH changes?

……..

B. (i) How is breathing typically regulated?

……

(ii) What prevents the lungs from over-expanding during inhalation?

……

(iii) What happens when O2 concentration becomes very low?

……

(iv) (a) Which additional brain structure modulates breathing regulation?

……

C. (i) What happens to blood pH when CO2 levels increase in tissues (e.g., during exercise)?

……

(ii) What percentage of lung cancers is attributed to smoking?

……

5. A. (i) What is the primary effect of nicotine on the body?

……

……

(ii) How does carbon monoxide in tobacco smoke affect oxygen transport?

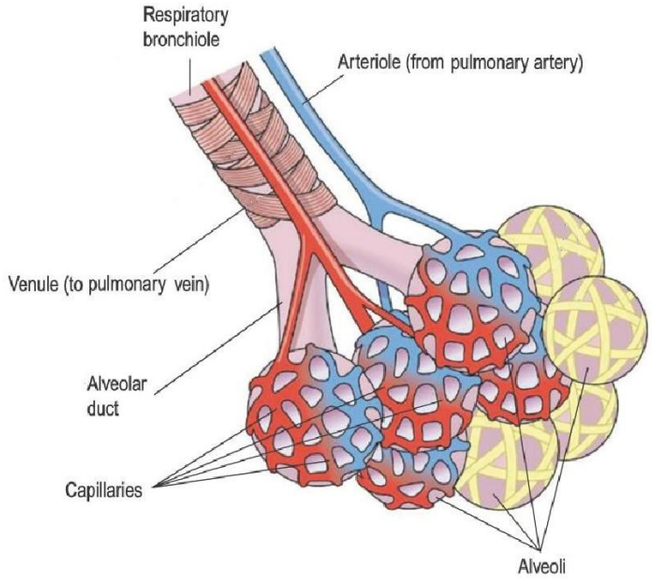
……

……

(iii) What is silicosis and what industries are at high risk?

……

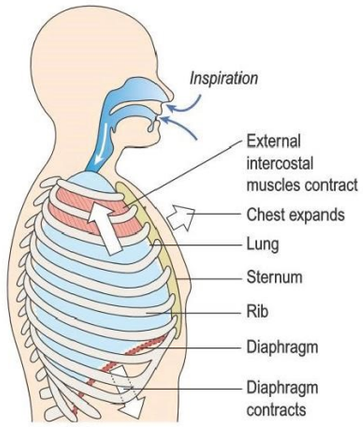
……



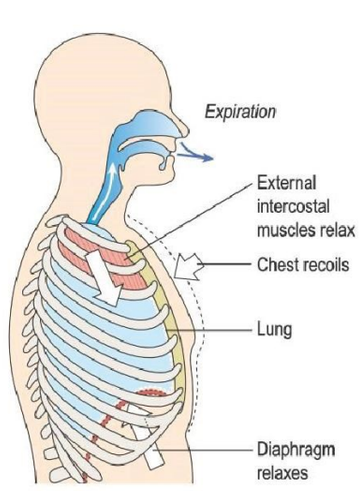
Mechanism of ventilation of the lungs

Ventilation of the lungs is necessary to maintain high …….... and low ……. concentrations in the ……... or the ……... ……... surface.

- Ventilation is accomplished by breathing, which is the alternating movement of air into (inhalation) and out of (exhalation) the lungs.
- Humans employ what is referred to as ……... pressure ……. where air is ……... rather than ……... into lungs.
- Inhalation is an …….. process. Contraction of ……... muscles or ……. muscles and the …….. which is a sheet of skeletal muscle that forms the bottom of the thoracic cavity leads to the expansion of the thoracic cavity. Thereby, increasing its volume.
- The …….... and ……... pleurae surrounding the lung stick together due to the ……. …….. of the fluid between these two membranes. This allows the two membranes to slide …….... pass each other. Hence, as the volume of the thoracic cavity increases. the lung volume increases as well.
- As a result. the pressure within the lungs ……... relative to the outside air. This creates a ……... gradient between the atmosphere and the lungs.
- Thus, air flows from a high pressure in the atmosphere to a lower pressure in the lungs. This is ……..



- During exhalations which is usually a passive process, the rib muscles and the diaphragm relax. This cause the volume of the thoracic cavity to reduce.
- As a result, the pressure inside the lungs increase in relation to the air outside. This pressure forces air to move out of the lungs through the respiratory tubes into the atmosphere. This is exhalation.



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.....

.....

2.A. (i) How many lobes are in the left and right lungs respectively?

.....

(ii) Why is the left lung slightly smaller than the right lung?

.....

(iii) What is the "mucus escalator" and what is its function?

.....

.....

(iv) (a) What prevents the collapse of alveoli?

.....

(b) How are foreign particles dealt with in the alveoli since there are no cilia?

.....

B. (i) What happens to the glottis during swallowing?

.....

(ii) How are sounds produced in the larynx?

.....

(iii) What happens to air in the nasal cavity?

.....

(iv) What makes up the walls of alveoli?

.....

C. (i) (a) What type of breathing do humans employ?

.....

(b) What causes the initial expansion of the thoracic cavity during inhalation?

.....

(ii) (a) Why do the visceral and parietal pleurae stick together?

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(b) Is exhalation typically an active or passive process?

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(iii) What additional muscles are used during deep breathing?

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(iv) Why are the lungs considered an efficient respiratory surface? Give two reasons.

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3. A. (i) What is necessary for diffusion of O_2 and CO_2?

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(ii) What happens to the pressure within the lungs during inhalation?

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(iii) What are the two types of respiration based on exchange?

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(iv) Why is the alveoli surface moist?

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B. (i) How many oxygen molecules bind to one molecule of hemoglobin?

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(ii) What drives the diffusion of gases in both external and internal respiration?

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(iv) States different respiratory structures of animals with suitable examples

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B. (i) State parts of human respiratory system

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(ii) State structures contained in lungs

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(iii) State 3 differences between left and right lungs

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(iv) (a) State 2 membranes surrounding lungs

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(b) State the name of the fluid found in between above mentioned 2 membranes

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C. (i) State functions of nasal cavity

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(ii) Why can simple animals like cnidarians perform gas exchange directly through their body surface?

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(iii) What are the four essential properties of an effective respiratory surface?

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(iv) What happens to the surface area to volume ratio (A/V) as body size increases?

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D. (i) (a) Name three types of respiratory structures that evolved for efficient gas exchange.

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(b) Which animals use external gills for respiration?

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(c) Which animals use internal gills for respiration?

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(d) What type of respiratory system do spiders and scorpions have?

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(ii) Why did aquatic animals evolve gills?

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(iii) Why did terrestrial animals evolve trachea and lungs?

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(iv) Which animals use their skin as a respiratory surface?

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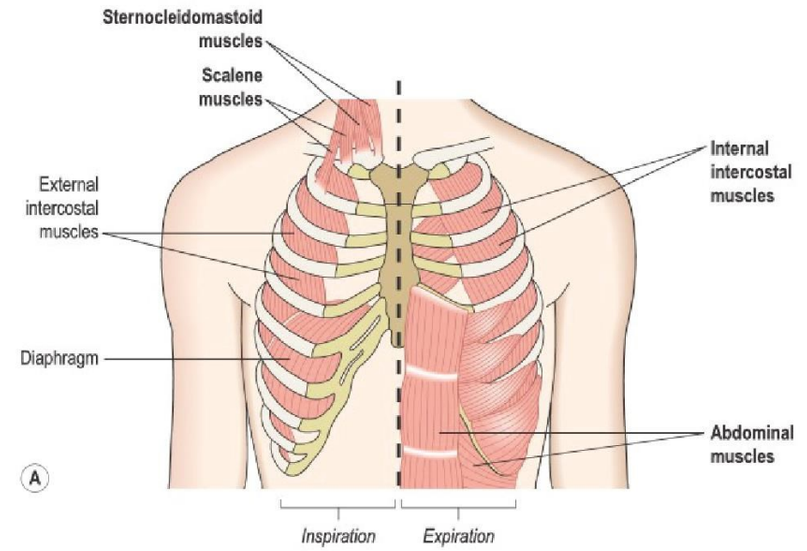

- The lungs serve as an efficient respiratory surface because: Alveoli create a ……. surface area for …….. ……...
- Alveoli and capillary walls are both lined by ……... ……. epithelia which reduce the distance the gasses need to travel by diffusion.
- The alveoli surface is moist to dissolve respiratory gasses for diffusion.
- Alveoli are highly vascularized which enables the maintenance of a steep diffusion gradient of respiratory gasses

Exchange of gasses between air and blond; blood and tissues

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Net diffusion of O_2 takes place from the air in the alveoli to the blood and net diffusion of CO_2 takes place from the blood into the alveoli.

When O_2 molecules diffuses into blood capillaries they bind to heamoglobin in the red blood cells. Four molecules of O_2 bind reversibly with one molecule of haemoglobin and form oxyhaemoglobin.

$$Hb + 4\ O_2 \rightleftharpoons HbO_8$$

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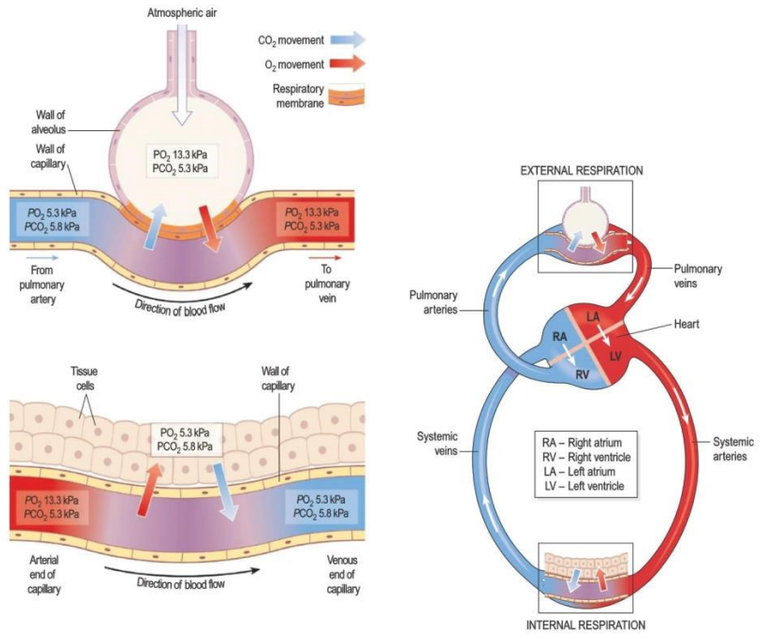

15. Which of the following statements regarding regulation of breathing in man is correct?
(1) It is regulated by the respiratory centres located in medulla oblongata and hypothalamus,
(2) Due to stimulation of medulla oblongata, nerve impulses are sent to external intercostal muscles.
(3) Increase in the pH of arterial blood stimulates chemoreceptors in aorta.
(4) Stimulation of stretch receptors in lungs inhibits expiratory centre.
(5) Stimulation of expiratory centre results in the contraction of diaphragm.

16. Smoking
(A) stimulates the secretion of mucus by goblet cells in the respiratory tract.
(B) causes tuberculosis. (C) decreases the oxygen transport in blood.
(D) inhibits the action of cilia in the respiratory tract. (E) reduces heart beat.

17. Four respiratory volumes of a resting person are as follows.
Inspiratory reserve volume = 2500 ml Tidal volume = 450 ml
Expiratory reserve volume = 1450 ml Residual volume = 1100 ml
Inspiratory capacity, functional residual capacity and vital capacity of this person in correct sequence are
(1) 2950 ml, 2550 ml and 4400 ml. (2) 1900 ml, 1550 ml and 5050 ml.
(3) 2950 ml, 1900 ml and 4400 ml. (4) 2950 ml, 2550 ml and 5050 ml.
(5) 2550 ml, 3950 ml and 5500 ml. (2020 AL/23)

18. In which of the following, is (ii) caused by (i) during the homeostatic control of breathing of man?
A : (i) Carbon dioxide level in tissues increases.
(ii) Blood pH decreases.
B : (i) Medulla oblongata detects decreasing pH of cerebrospinal fluid.
(ii) Depth of ventilation of lungs decreases.
C : (i) Sensors in aorta detects high concentration of carbon dioxide in blood.
(ii) Medulla oblongata receives signals from aorta.
(1) In A only. (2) In A and B only. (3) In A and C only. (4) In B and C only.
(5) In A, B and C. (2021 AL/21)

19. If the tidal volume, residual volume, inspiratory reserve volume and expiratory reserve volume of a person are 500 mL, 1200 mL, 3100 mL and 1100 mL respectively, vital capacity of this person is
(1) 1600 ml. (2) 1700 ml. (3) 3600 ml. (4) 4700 ml. (5) 5200 ml. (2022 AL/22)

Biology II
Part A (Structured Essay)

1. A. (i) States the need of respiratory structures in animals

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(ii). Describes how the complexity of respiratory structures of different animal groups has evolved over the time

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(iii) Describes the characteristics of respiratory surfaces

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7. Which one of the following is an incorrect statement regarding human ventilation?
(1) It is the mechanical process that moves air into and out of the lungs.
(2) During inspiration the diaphragm relaxes.
(3) Under resting conditions expiration is a passive process.
(4) Normal ventilation is rhythmic and involuntary.
(5) Respiratory center in medulla oblongata inhibits inspiration and stimulates expiration.

8. Which of the following statements regarding human lungs is incorrect?
(1) Right lung has three lobes and the left lung has two lobes.
(2) Tidal volume at rest is about 0.5 liters. (3) Lung contain millions of alveoli.
(4) Alveolar wall is made up of a single layer of cuboidal epithelial cells.
(5) FRC is important for continuous exchange of in the alveoli and to prevent the collapse of alveoli during expiration.

9. Which of the following statements regarding human respiratory system is incorrect?
(1) Alveoli coated with thin film of fluid with high surface tension.
(2) Vital capacity of lung is about 3100ml female.
(3) Bronchi are lined with ciliated pseudostratified epithelial cells.
(4) Cartilages are present in the bronchi.
(5) Pharynx is connected both to the nasal cavity and buccal cavity.

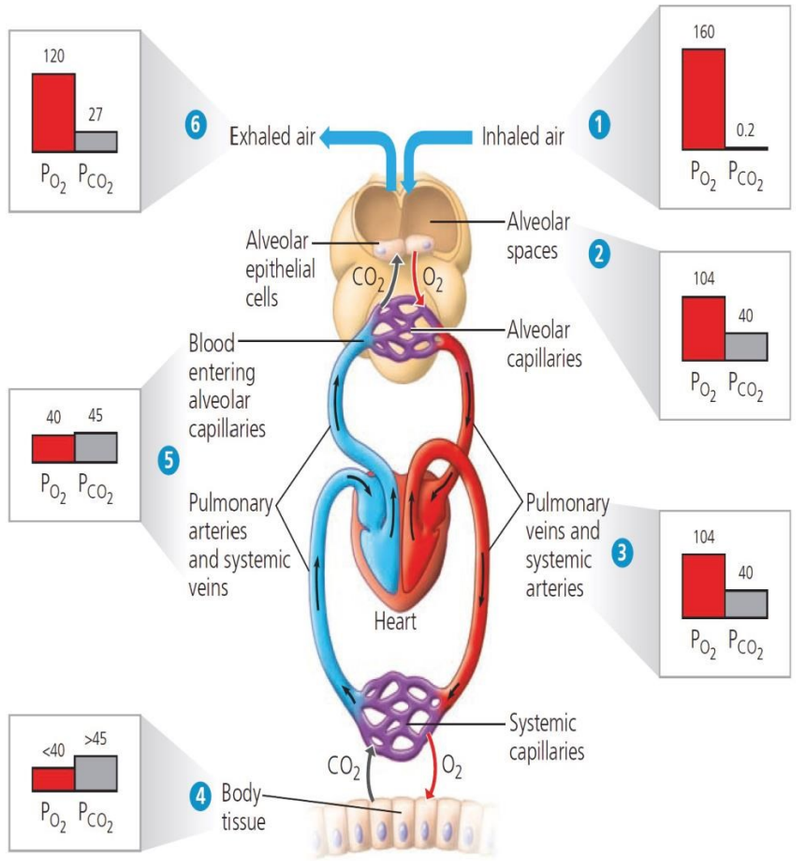
10. Respiratory gases are transported through the respiratory surface s of animals by
(1) Diffusion and osmosis only. (2) Diffusion, osmosis and active transport only.
(3) Diffusion and active transport only.
(4) Diffusion and with the aid of carrier molecules only. (5) Diffusion only.

11. Which of the following statements regarding the respiratory system of man is correct?
(1) Contraction of rib muscles and relaxation of diaphragm results inhalation.
(2) Tracheal cavity is lined with columnar epithelium.
(3) Right lung consists of two lobes.
(4) Exchange of respiratory gases in the lung requires energy.
(5) Larynx is located in the neck

12. Which one of the following statements is incorrect regarding regulation of respiration in man?
(1) Lowered blood pH increases respiratory rate.
(2) Stimulation of stretch receptors in lungs causes inspiration to stop.
(3) Respiratory center is located in the pons Varolli and hypothalamus.
(4) Chemoreceptors involved in regulation are located in carotid arteries.
(5) Negative feed back mechanisms involve in the regulation of respiration.

13. Select the correct statement with regard to human respiration.
(1) Ventilation is necessary to maintain high oxygen and low carbon dioxide concentration in the alveoli.
(2) To regulate breathing medulla oblongata depends on pH of blood.
(3) diaphragm relaxes during inspiration.
(4) bronchioles are lined by ciliated columnar epithelium.
(5) Regulation of breathing is also modulated by additional neural circuits in medulla

14. Which of the following statements regarding cigarette smoke is correct?
(1) Long term exposure to it retards the activity of the germinal layer of the epithelium of the respiratory tract.
(2) It stimulates the goblet cells and ciliated cells in the epithelium of the respiratory tract increasing their activity.
(3) It increases the rate of heart beat and oxygen transportation through blood.
(4) It dilates peripheral blood vessels and increases the blood supply to skin.
(5) it contributes to the release of a large amount of lytic enzymes from lung tissue.



Homeostatic control of Breathing

- Typically breathing is regulated by involuntary mechanisms. These involuntary mechanisms help coordinate gas exchange with blood circulation and metabolic demands

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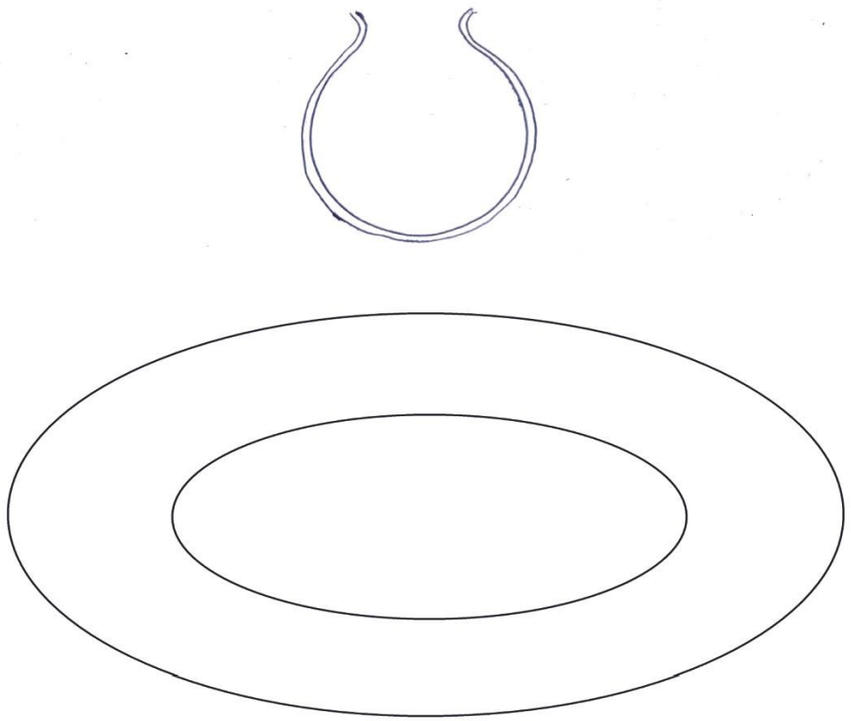


- Count pulse during one minute, at rest.
- Stand up and step-march, to a rhythm set by the teacher for a period of three minutes.
- Determine pulse rate over a period of one minute and breathing rate over a period of three minutes.
- Repeat at five minute intervals and determine time taken by each pupil to return to resting values.
- Tabulate and analyze the results for the entire class as well as for each individual.

MCQs

1. Some respiratory structures found among animals and the phyla to which the animals that possess these structures belong are given below. Which one of the following respiratory structure – phylum combinations is incorrect?

Respiratory	**Animal**
(1) External gills	Marine annelids
(2) Tracheal system	Insects
(3) Book lungs	Molluscs
(4) Lungs	Reptiles
(5) Body surface	Flatworms

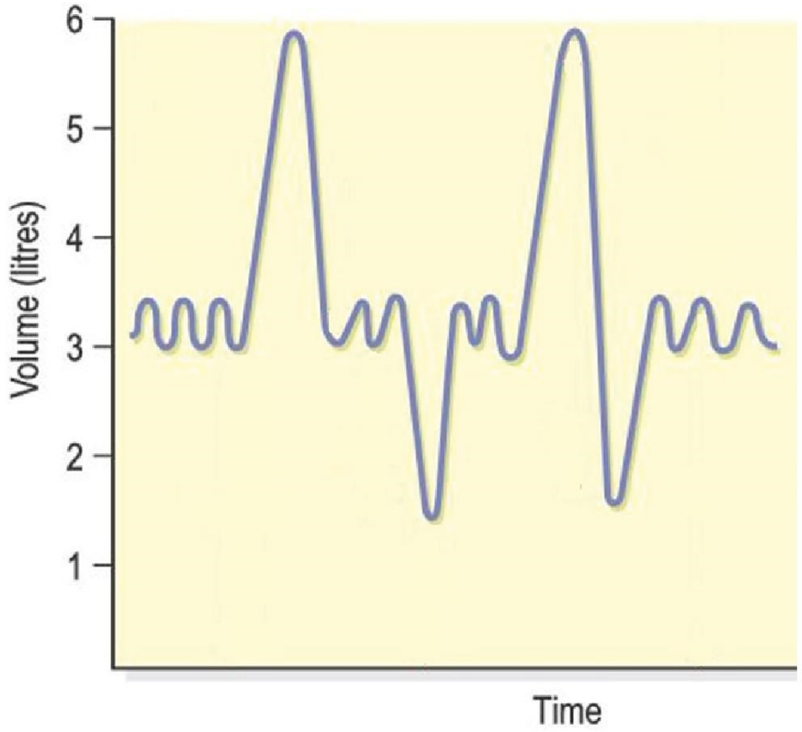
2. Out of the following respiratory organs, which is not in contact with blood.
(1) External gills (2) internal gills (3) tracheal system (4) book lungs (5) lungs.

3. Correct about the exchange of respiratory gases through the body surface
(A) is not an adaptation to terrestrial life.
(B) is efficient when surface : volume ratio is high.
(C) occurs via active transport.
(D) is a major feature that contributed to increase in biodiversity on earth.
(E) is confined to invertebrates.

4. Which one of the following statements regarding respiration of man is incorrect?
(1) The basic rhythm of respiration is controlled by the respiratory centre located in the cerebrum.
(2) A ventilation composed of two phases.
(3) Respiratory gas exchange takes place in the alveoli.
(4) Inhalation is an active process while exhalation is a passive process.
(5) The chemoreceptors sensitive to partial pressure of oxygen in the blood are present in the carotid arteries and aorta.

5. Which of the following organs of the respiratory system of man is incorrectly paired with its functions?
(1) Nose - humidifies and warms incoming air (2) Pharynx - produces mucous
(3) Larynx - produces sound (4) Trachea - mucus escalation
(5) Alveoli - exchange gases

6. Which of the following is the incorrect statement regarding respiration of animals?
(1) Gaseous exchange at the respiratory surfaces always occurs by diffusion.
(2) Book lungs are the respiratory structures of scorpions.
(3) Tracheal system present in insects and spiders.
(4) Tidal volume of a normal healthy adult person at rest is about 500 ml.
(5) In man, Stimulation of stretch receptors in the lungs causes inspiration to stop.



IRV : lnspiratory reserve volume
IC : Inspiratory capacity
FRC : Functional residual capacity
ERV : Expiratory reserve volume
RV : residual volume
VC : Vital capacity
TLC : Total lung capacity

PRACTICAL NO. 18

- Study of human respiratory system using models/diagrams and observation of effects of exercise on respiratory rate and the pulse rate.

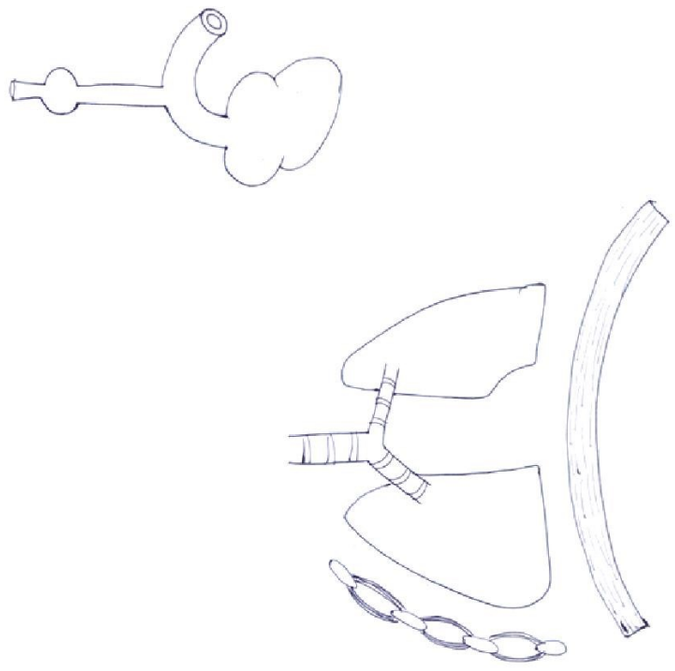
Materials and Equipment's

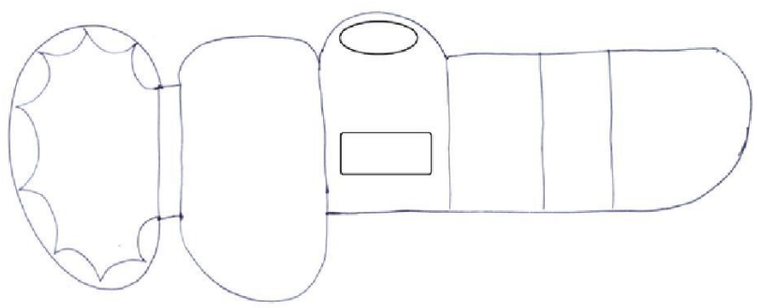
- Models/charts/computer illustrations of the human respiratory system. Stop watch

Instructions

- Study the model or chart and note the relative positions and gross structure of different components of respiratory system.
- Observe the status of the thorax during full inspiration, full expiration and during normal uncontrolled breathing.
- Hold the back of their hand immediately below their nostrils to count the number of expirations during normal breathing over a period of five minutes.

$CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons HCO_3^- + H^+$





- **Residual volume (RV):** The volume of air that remains in the lungs even after forceful expiration. This is on average is about 1,200 ml.

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- **Inspiratory capacity (IC):** The total volume of air that can be inspired with maximum effort
  Thus, IC = TV + IRV
- **Functional residual capacity (FRC):** The volume of air remaining in the lungs at the end of a normal expiration.
  Thus. FRC = RV + ERV
  The functional residual capacity is important for continuous exchange of gas in the alveoli and to prevent the collapse of the alveoli during expiration.
- **Vital capacity (VC):** The maximum volume of air which can be inhaled and exhaled. It is normally around 3100 mL in women and 4800 ml in men.
  VC = TV + IRV + ERV
- **Total lung capacity (TLC):** The maximum volume of air the lungs can hold or the sum of all lung volumes. This is normally around 6000 ml.

In addition, some of the inspired air fills the system of branching conducting tubes (trachea, bronchi and bronchioles) and never contributes to the gas exchange in the alveoli. This volume of air is referred to as the anatomical dead space and it is typically about 150 ml.

Lung cancer

Nearly 90% of lung cancer is due to smoking. When one smokes, the nasal hairs, mucus and cilia in the respiratory tract that otherwise is sufficient to protect the lung from chemical and biological irritants, are overwhelmed and eventually stop functioning. As a result, irritants, free radicals, carcinogens and pathogens accumulate in the lungs. Eventually these cause lung cancer.

Tuberculosis (TB)

Tuberculosis is an infectious disease caused by the bacterium *Mycobacterium tuberculosis*, The bacterium spreads when an infected person coughs and the bacterium enters the body of an uninfected person through inhaled air. The most common form is Pulmonary TB which affects the lungs. Other organs may also be affected. Transmission of pulmonary TB is by inhaling the bacterium into the lungs. This bacterium can survive in the air and in the house dust for long periods. Malnutrition and other infectious can reduce resistance to the disease.

Symptoms of this disease are loss of appetite, loss of weight, excessive sweating, fever, a racking cough and spitting up blood.

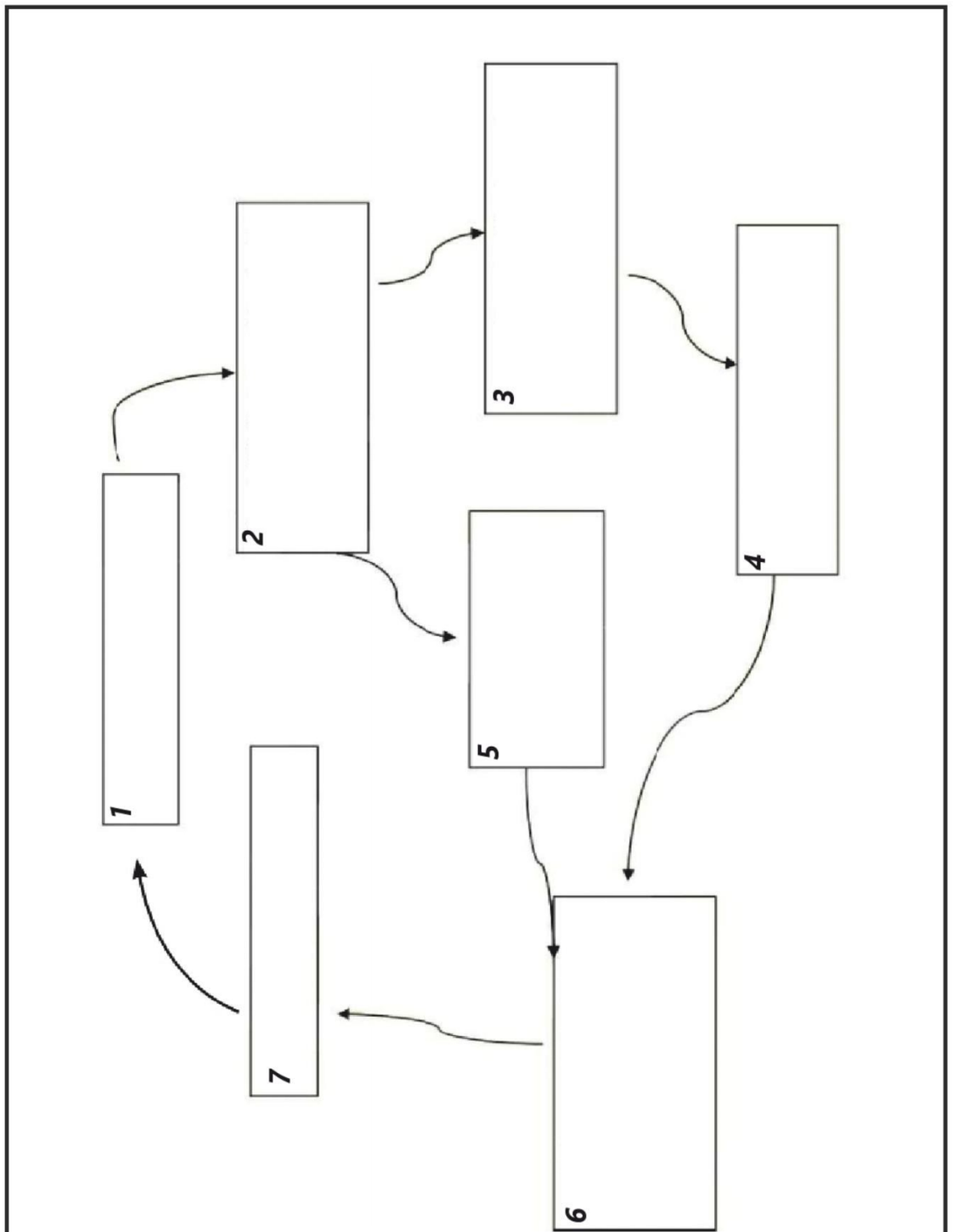
Asthma

Asthma is characterized by wheezing and chest tightness causing breathing difficulty. This is caused by the sudden contractions of smooth muscles in the walls of the bronchioles which causes the bronchioles to narrow or even close. During this time breathing causes whistling or wheezing sound. The cause of asthma is an over reaction of an immune response to stimuli like pollen. dust, mites, spores. particular food, cold air, exercise. smoking gases. Anti-inflammatory drugs help control.

Respiratory cycle and lung volumes and capacities

Inhalation and exhalation during a single breath is referred to as a respiratory cycle. The amount of air that flows in and out of the lungs depends on the conditions of inspiration and expiration. Thus, four respiratory volumes are described.

- **Tidal volume (TV):** This is the volume of air passing into and out of the lung with each breath during normal breathing. On average it is about 500 ml in a resting adult human.
- **Inspiratory reserve volume (IRV):** This is the extra volume of air that can be forcibly inhaled beyond the tidal volume.
- **Expiratory reserve volume (ERV):** The extra volume of air which can be forcibly expelled from the lungs after a normal expiration.



Disorders of the respiratory system

The effect of smoking on the smooth functioning of the respiratory system

- Cigarette smoke harms nearly every organ in the body including the organs of the respiratory system and increase the risk of illness, disability and death. Smokers inhale large number of chemicals which mainly come from burning tobacco. Some of these inhaled compounds are chemically …….. and can trigger damaging changes in the body.
- ……... is among the compounds inhaled in tobacco smoke which is the addictive drug in the smoke. It …….. ……. the rate of ……. ……... and constriction of peripheral blood vessels causing a temporary increase in blood pressure.
- Cigarette smoke stimulates the secretion of ……... by the goblet cells and inhibits the action of cilia in the respiratory tract causing accumulation of mucus in bronchioles and ……. them, leading to …….. ……. or bronchitis. As a result, breathing may become difficult.
- Some chemicals such as ……. ……... in cigarette smoke stops the ……... from working properly. Due to loss of action of cilia, dust and other particulate matter get collected in the lung, resulting in an increase in …… cells in the lung tissue. Due to release of large amounts of ……. enzymes by these cells, the alveolar tissue is destroyed thus reducing the effective area available for gas exchange.
- ……..… …….. (CO) present in tobacco smoke is absorbed into the blood and is able to bind to hemoglobin better than oxygen and combines irreversibly with hemoglobin. Thus it decreases the amount of oxyhaemoglobin produced. Therefore, oxygen transport through blood is decreased.
- Tobacco smoke also contains a large number of cancer-causing substances (carcinogens). Nearly …….. of lung cancers are due to smoking. Long term exposure to such chemicals in cigarette smoke results in the proliferation of cells in the bronchial epithelium, forming a mass of abnormal cells. A cancer may develop among these cells. If these cells break free, the cancer may spread to other parts of the lungs and or to other organs.
- Passive or second hand smoking will also result in the above mentioned ill effects

Silicosis

This may be caused by long-term exposure to dust containing silica compounds. High risk industries are.

- Quarrying granite, slate, sandstone Mining hard coal, gold, tin, copper
- Stone masonry and sand blasting
- Glass and pottery work

When silica particles are inhaled they accumulate in the alveoli. These particles are ingested by macrophages. some of which remain in the alveoli and come out in to the connective tissue around bronchioles and blood vessels close to the pleura. Progressive fibrosis is stimulated which eventually obliterates the blood vessels and respiratory bronchioles. Gradual destruction of lung tissue eventually leads to **pulmonary hypertension** and **heart failure**.

Asbestos related diseases - Asbestosis

Those who are involved in making or using products containing asbestos are at risk. This occurs when asbestos fibers are inhaled with dust. In spite of their large size the particles penetrate the level of respiratory bronchioles and alveoli. Macrophages accumulate in the alveoli and the shorter asbestos fibers are ingested. The larger fibers are surrounded by macrophages, protein materials and iron deposits. The macrophages that have engulfed fibers move out of the alveoli and accumulate around respiratory bronchioles and blood vessels, stimulating the formation fibrous tissue. These cause progressive destruction of lung tissue and **pulmonary hypertension.**