Physiological Anatomy of Respiratory Tract

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PROGRAMME OUTCOMES

- PO1- Demonstrate comprehensive knowledge and application of the Trisutra concept to explore root causes, identify clinical manifestations of disease to treat ailments and maintain healthy status.
- PO2- Demonstrate knowledge and skills in Ayurveda, acquired through integration of multidisciplinary perspectives and keen observation of clinical and practical experiences.

COURSE OUTCOMES

- CO1- Explain all basic principles & concepts of Kriya Sharir along with essentials of contemporary human physiology and biochemistry related to all organ systems.

- **Teaching learning methods-** lecture with power point presentation
  Domain- Cognitive/comprehension
  Must to know / desirable to know / Nice to know- Must to know
  Millers pyramid- Knows how(applied knowledge)
  Bloom taxonomy- Understand

Introduction

- Respiration is the process by which oxygen is taken in and carbon dioxide is given out.
- The first breath takes place only after birth. **Fetal lungs are non-functional.**
- So, during intrauterine life the exchange of gases between fetal blood and mother's blood occurs through placenta.
- After the first breath, the respiratory process continues throughout the life. Permanent stoppage of respiration occurs only at death.
- ***Normal Respiratory Rate at Different Age***

Newborn : 30 to 60/minute

Early childhood : 20 to 40/minute

Late childhood : 15 to 25/minute

Adult : 12 to 16/minute.

- **TYPES OF RESPIRATION**

  Two types:

  1. **External respiration that involves exchange of** respiratory gases, i.e. oxygen and carbon dioxide between lungs and blood.

  2. **Internal respiration, which involves exchange of** gases between blood and tissues.

- **PHASES OF RESPIRATION**

  Two phases:

  1. **Inspiration during which air enters the lungs from** atmosphere.

  2. **Expiration during which air leaves the lungs.** During normal breathing, inspiration is an active process and expiration is a passive process.

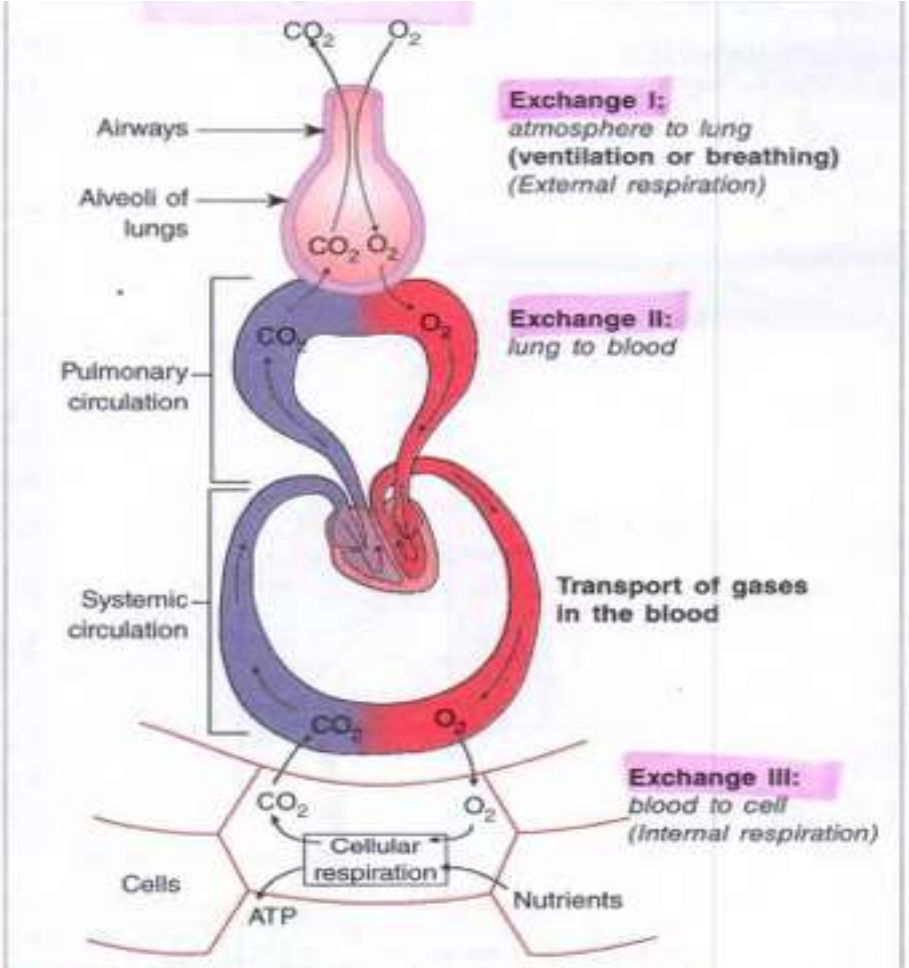


Fig. 45.1 Overview of external and cellular respiration

FUNCTIONAL ANATOMY OF RESPIRATORY TRACT

Respiratory tract is the anatomical structure through which air moves in and out. It includes nose, pharynx, larynx, trachea, bronchi and lungs

- **PLEURA**

Each lung is enclosed by a bilayered serous membrane called pleura or **pleural sac.** Pleura has two layers

1. **Parietal layer-** Adherent to parieties i.e inner side of the chest wall and the thoracic side of the diaphragm
2. **Visceral pleura-** Adherent to the underlying viscus i.e (lungs) itself.

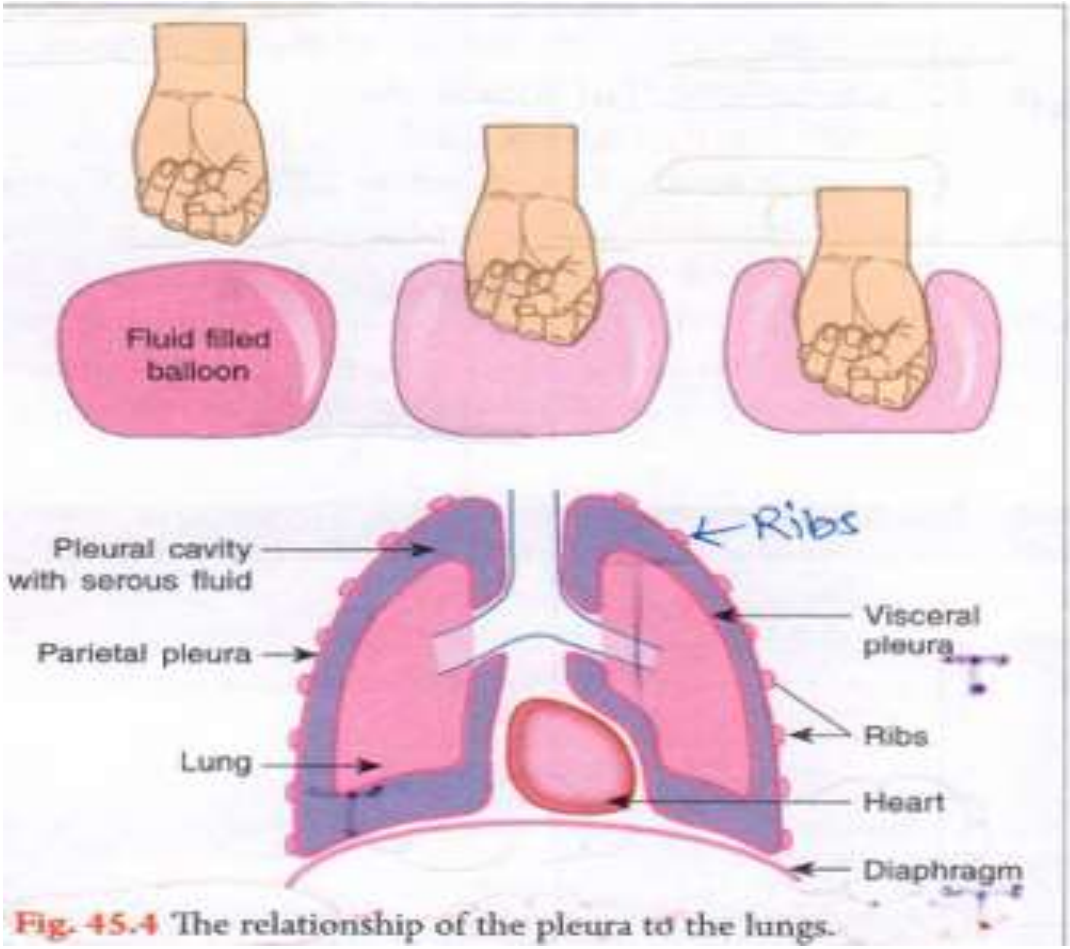


Fig. 45.4 The relationship of the pleura to the lungs.

- ***Intrapleural Space or Pleural Cavity***

  Intrapleural space or pleural cavity is the narrow space in between the two layers of pleura.

- ***Intrapleural Fluid***

1. Intrapleural space contains a thin film of serous fluid(approx.2ml) called intrapleural fluid, which is secreted by the visceral layer of the pleura.
2. It functions as the lubricant to prevent friction between two layers of pleura
3. It is involved in creating the negative pressure called intrapleural pressure within intrapleural space.

- **TRACHEOBRONCHIAL TREE**

  Trachea and bronchi are together called tracheobronchial tree. It forms a part of air passage.

- *Components of tracheobronchial tree*

1. **Trachea bifurcates into two main or primary bronchi** called right and left bronchi
2. Each primary bronchus enters the lungs and divides into **secondary bronchi**
3. Secondary bronchi divide into **tertiary bronchi. In** right lung, there are 10 tertiary bronchi and in left lung, there are eight tertiary bronchi
4. Tertiary bronchi divide several times with reduction in length and diameter into many generations of **bronchioles**
5. When the diameter of bronchiole becomes 1 mm or less, it is called **terminal bronchiole**
6. Terminal bronchiole continues or divides into **respiratory bronchioles, which have a diameter of** 0.5 mm.

- Weibel's lung model

1. According to E R Weibel, a swiss anatomist, between the trachea and alveolar sac each generation air passage divides 23 times.
2. He numbered each generation of tracheobronchial tree thus trachea is designated as generation 0 and two major divisions of the trachea constitute the first gen. and so on.
3. The atria(alveolar sac) is the 23rd and the last generation.
4. The 16th gen. bronchioles where no gas exchange take place are called terminal bronchioles. So air passage from nose and mouth to terminal bronchioles is called dead space or conducting zone.
5. On and from 17th gen. few alveoli can be found on the bronchioles. Although major gas exchange occurs in the alveoli (23rd gen.) but some exchange begins to occur from 17th gen. called the respiratory bronchioles thus along with alveolar duct and alveolar zone they constitute respiratory zone.

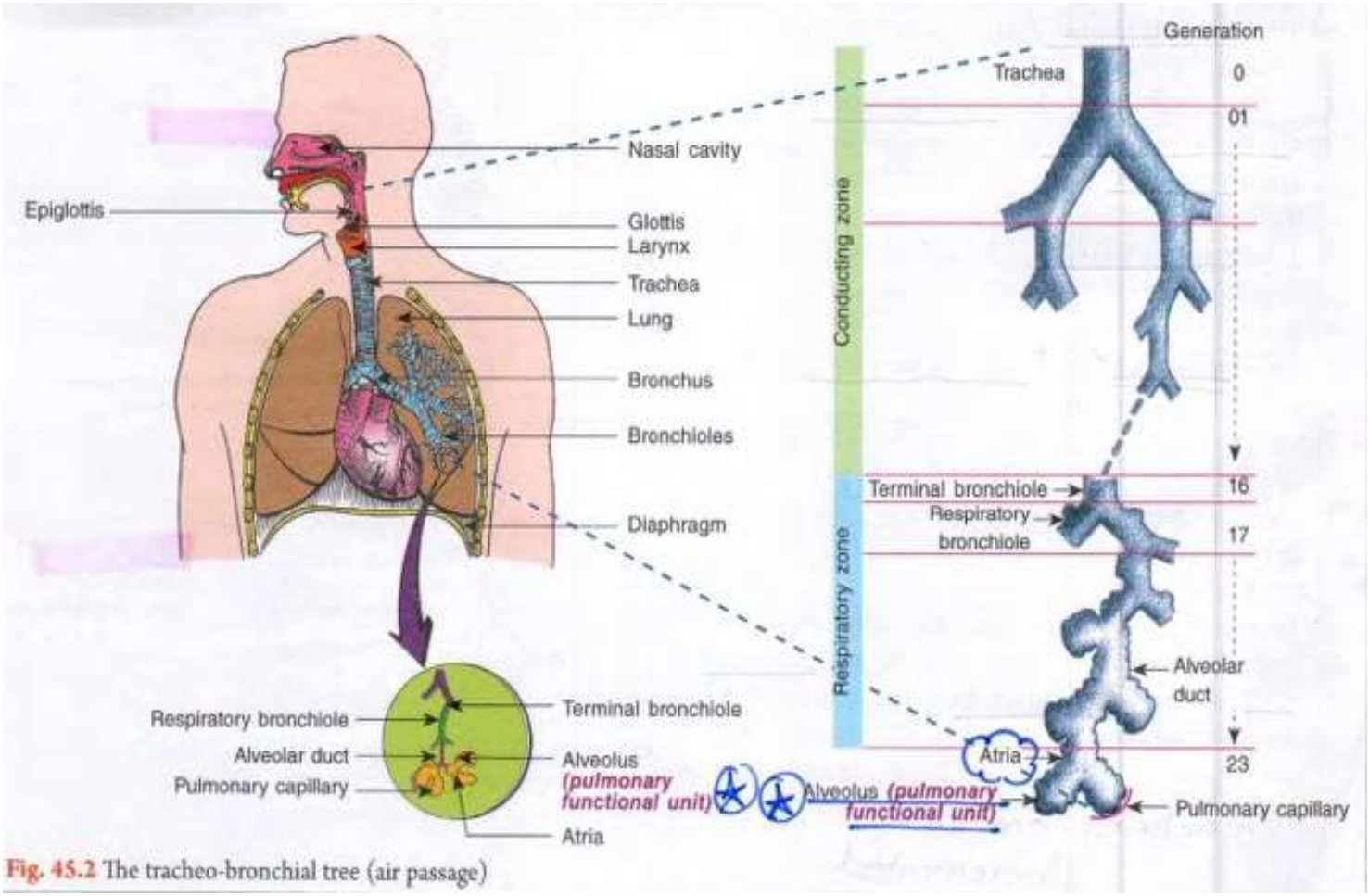


Fig. 45.2 The tracheo-bronchial tree (air passage)

- ***Upper and Lower Respiratory Tracts***

  Generally, respiratory tract is divided into two parts:

  1. Upper respiratory tract that includes all the structures from nose up to vocal cords; vocal cords are the folds of mucous membrane within larynx that vibrates to produce the voice
  2. Lower respiratory tract, which includes trachea, bronchi and lungs.

- **RESPIRATORY UNIT**

  Parenchyma of lungs is formed by respiratory unit that forms the **terminal portion of respiratory tract.** Respiratory unit is defined as the structural and functional unit of lung. Exchange of gases occurs only in this part of the respiratory tract.

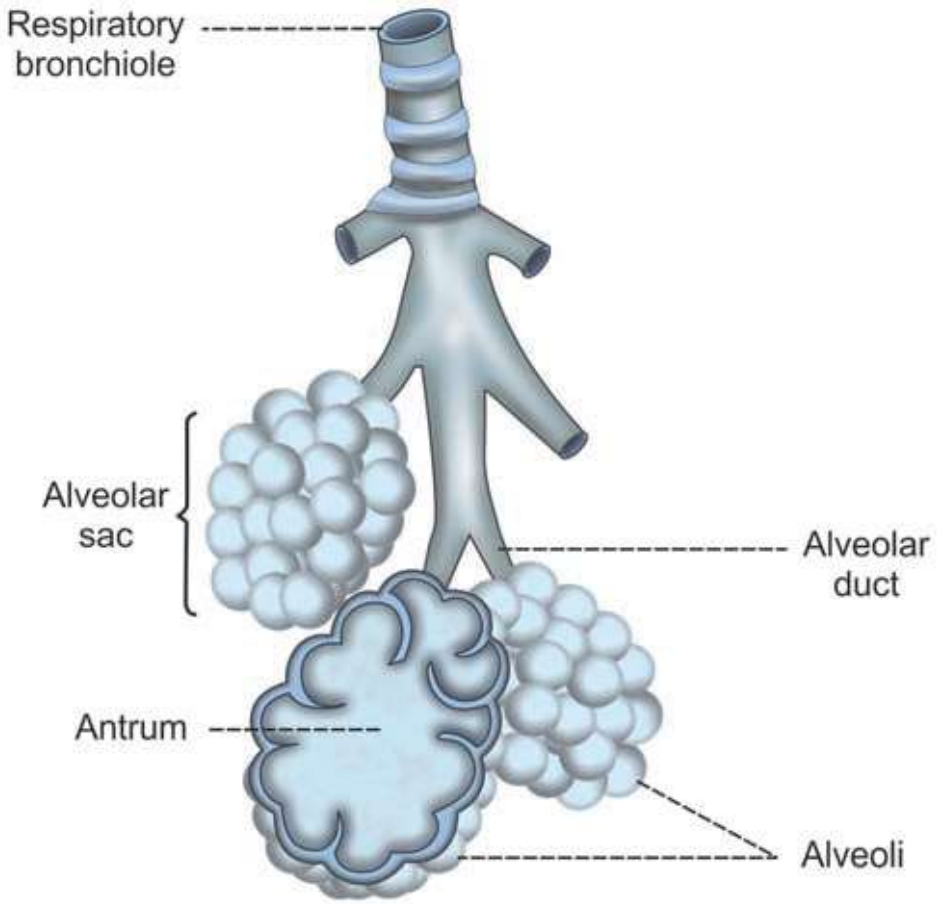
- **STRUCTURE OF RESPIRATORY UNIT**

  It starts from the respiratory bronchioles. Each respiratory bronchiole divides into **alveolar ducts. Each alveolar duct enters an enlarged** structure called the **alveolar sac. Space inside the** alveolar sac is called **antrum. Alveolar sac consists of a** cluster of **alveoli. Few alveoli are present in the wall of** alveolar duct also.

  Thus, respiratory unit includes:

  1. Respiratory bronchioles
  2. Alveolar ducts
  3. Alveolar sacs
  4. Antrum
  5. Alveoli.

  Each **alveolus is like a pouch with the diameter of** about 0.2 to 0.5 mm. It is lined by epithelial cells.


Respiratory bronchiole
Alveolar sac
Alveolar duct
Antrum
Alveoli

- ***Alveolar Cells or Pneumocytes***

  Alveolar epithelium consists of alveolar cells or pneumocytes,

  which are of two types namely type I alveolar cells and type II alveolar cells.

  1.Type I alveolar cells

  Type I alveolar cells are the squamous epithelial cells forming about 95% of the total number of cells. These cells form the site of gaseous exchange between the alveolus and blood.

  2.Type II alveolar cells

  Type II alveolar cells are cuboidal in nature and form about 5% of alveolar cells. These cells are also called **granular pneumocytes. Type II alveolar cells secrete alveolar fluid and surfactant.**

  Alveoli communicate with each other through small pores, called **Pores of Kohn**

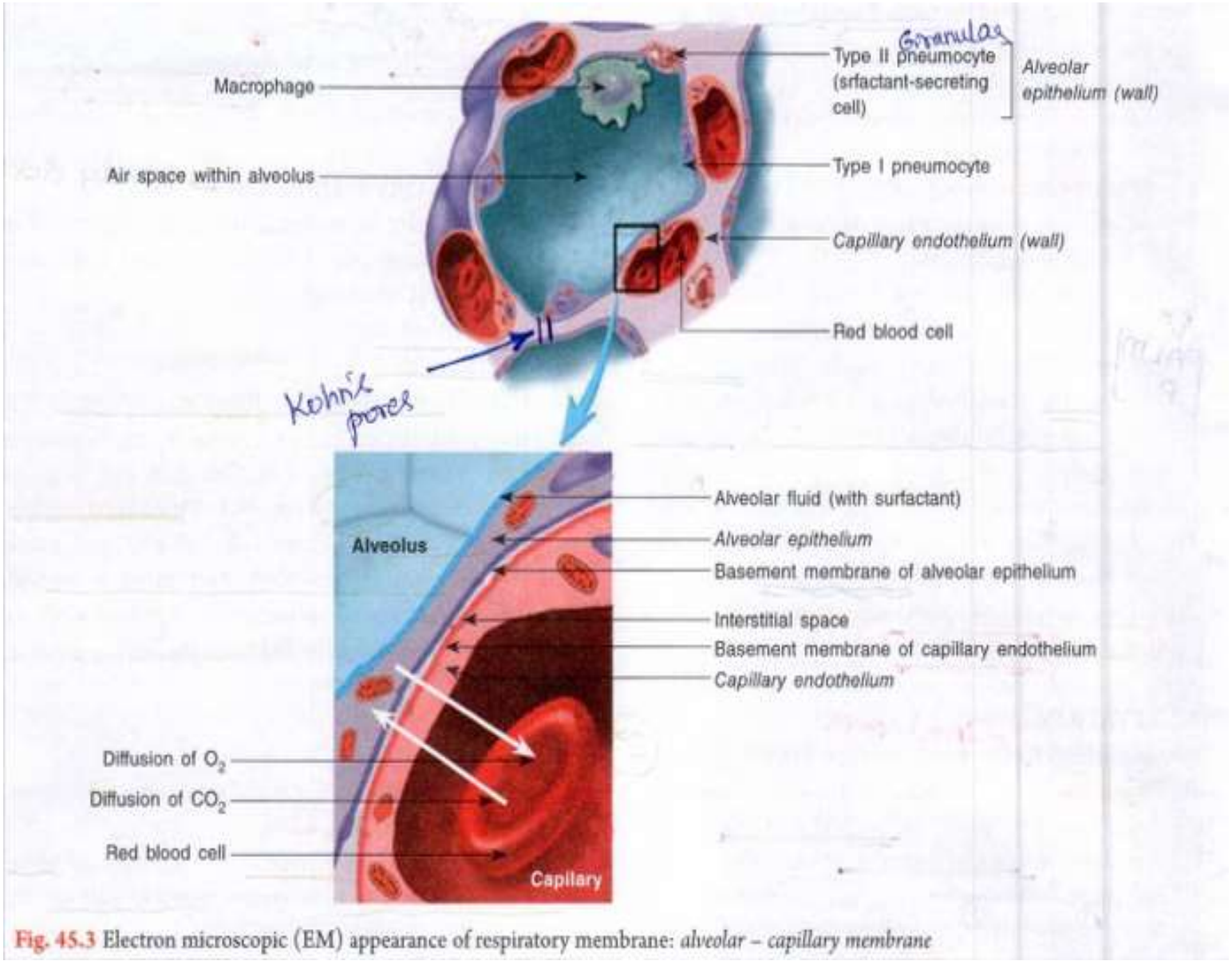
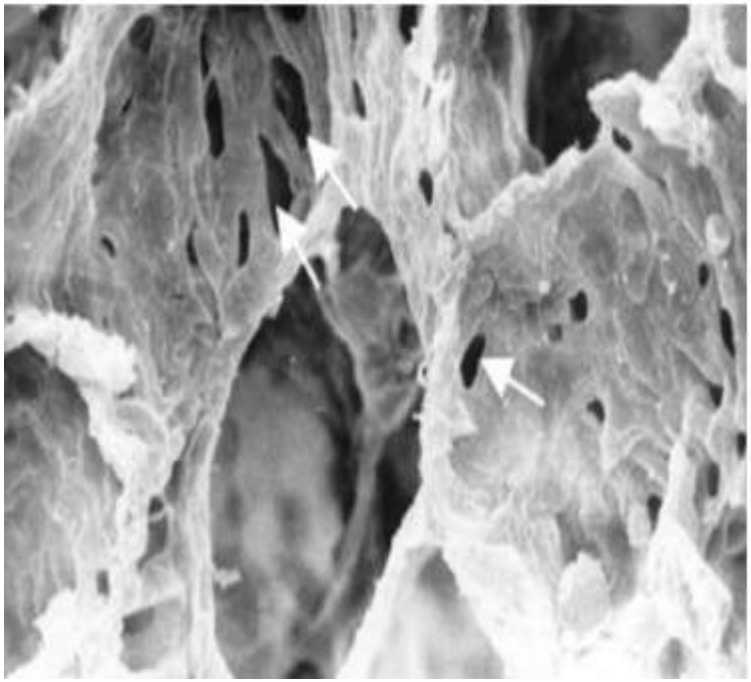
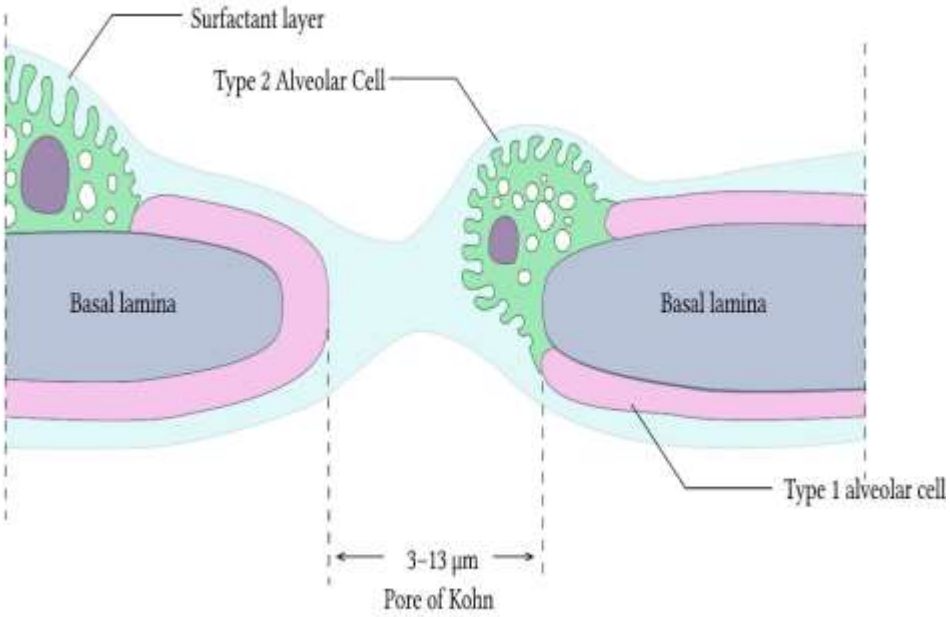


Fig. 45.3 Electron microscopic (EM) appearance of respiratory membrane: *alveolar – capillary membrane*




Surfactant layer
Type 2 Alveolar Cell
Basal lamina
Basal lamina
Type 1 alveolar cell
3–13 μm
Pore of Kohn

- **RESPIRATORY MEMBRANE**

  Respiratory membrane is the membranous structure through which the exchange of gases occurs. Respiratory membrane separates air in the alveoli from the blood in capillary. It is formed by the alveolar membrane and capillary membrane. Respiratory membrane has a surface area of 70 m^2 and thickness of 0.5 micron.

- **NON-RESPIRATORY FUNCTIONS OF RESPIRATORY TRACT**

  1. OLFACTION

  Olfactory receptors present in the mucous membrane of nostril are responsible for **olfactory sensation.**

  2. VOCALIZATION

  Along with other structures, larynx forms the **speech apparatus. However, larynx alone plays major role in** the process of vocalization. Therefore, it is called **sound box.**

- **3. PREVENT DUST PARTICLES FROM REACHING ALVEOLI**

➢ Particles >10µm diameter strained out by hairs in the nostrils or settle down on mucus membrane in the nose and pharynx

➢ Particles 2-10µm diameter fall on the walls of the bronchi as airflow slows in the smaller passages, there they initiate reflex bronchoconstriction and coughing, and moved away from the lungs by the ciliary escalator action.

➢ Particles<2µm diameter generally reach the alveoli, where ingested by the macrophages

4. DEFENSE MECHANISM

Lungs play important role in the immunological defense system of the body. Defense functions of the lungs are performed by their own defenses and by the presence of various types of cells in mucous membrane lining the alveoli of lungs. These cells are leukocytes, macrophages, mast cells, natural killer cells and dendritic cells.

i. *Lung's Own Defenses*

Epithelial cells lining the air passage secrete some innate immune factors called **defensins and cathelicidins.** These substances are the antimicrobial peptides, which play an important role in lung's natural defenses.

ii. ***Defense through Leukocytes***

Leukocytes, particularly the neutrophils and lymphocytes, present in the alveoli of lungs provide defense mechanism against bacteria and virus. **Neutrophils kill** the bacteria by phagocytosis. **Lymphocytes develop** immunity against bacteria.

iii. ***Defense through Macrophages***

Macrophages engulf the dust particles and the pathogens, which enter the alveoli and thereby act as **scavengers in lungs. Macrophages are also involved in** the development of immunity by functioning as **antigen presenting cells.**

iv. *Defense through Mast Cell*

Mast cell is a large cell resembling the basophil. Mast cell produces the **hypersensitivity reactions like allergy** and anaphylaxis. It secretes heparin, histamine, serotonin and hydrolytic enzymes.

v. *Defense through Natural Killer Cell*

- Natural killer (NK) cell is a large granular cell, considered as the third type of lymphocyte.
- Usually NK cell is present in lungs and other lymphoid organs. Its granules contain hydrolytic enzymes, which destroy the microorganisms.
- NK cell is said to be the first line of defense in specific immunity particularly **against viruses.** It destroys the viruses and viral infected or damaged cells, which may form the tumors.
- It also destroys the malignant cells and prevents development of cancerous tumors. NK cells secrete interferons and the tumor necrosis factors.

vi. *Defense through Dendritic Cells*

Dendritic cells in the lungs play important role in immunity. Along with macrophages, these cells function as antigen presenting cells.

- **5. MAINTENANCE OF WATER BALANCE**

Respiratory tract plays a role in water loss mechanism. During expiration, water evaporates through the expired air and some amount of body water is lost by this process.

- **6. REGULATION OF BODY TEMPERATURE**

During expiration, along with water, heat is also lost from the body. Thus, respiratory tract plays a role in heat loss mechanism.

- **7. ANTICOAGULANT FUNCTION**

Mast cells in lungs secrete heparin. Heparin is an anticoagulant and it prevents the intravascular clotting.

8. REGULATION OF ACID-BASE BALANCE

- Lungs play a role in maintenance of acid base balance of the body by regulating the carbon dioxide content in blood.
- Carbon dioxide is produced during various metabolic reactions in the tissues of the body. When it enters the blood, carbon dioxide combines with water to form carbonic acid. Since carbonic acid is unstable, it splits into hydrogen and bicarbonate ions.
- $CO_2 + H_2O \rightarrow \mathbf{H_2CO_3} \rightarrow \mathbf{H^+ + HCO_3^-}$

  Entire reaction is reversed in lungs when carbon dioxide is removed from blood into the alveoli of lungs.

  $H^+ + HCO_3^- \rightarrow \mathbf{H_2CO_3} \rightarrow \mathbf{CO_2 + H_2O}$

  As carbon dioxide is a volatile gas, it is practically blown out by ventilation.

9. SECRETION OF ANGIOTENSINCONVERTING ENZYME

- Endothelial cells of the pulmonary capillaries secrete the angiotensin converting enzyme **(ACE).**
- It converts the angiotensin I into active angiotensin II, which plays an important role in the regulation of ECF volume and blood pressure.

10. SYNTHESIS OF HORMONAL SUBSTANCES

Lung tissues are also known to synthesize the hormonal substances, prostaglandins, acetylcholine and serotonin, which have many physiological actions in the body including regulation of blood pressure.

Assessment

1.Give physiological basis of:

(i) How the lungs slide easily on the chest wall

(ii) Administration of certain drugs by inhalation

(iii) Why no exchange of gases is possible at the level of conducting zone .

2.Write short notes on:

(i) Terminal and respiratory bronchiole

(ii) Alveolar lining epithelium

(iii) Innervation of trachea-bronchial tree

(iv) Partial pressure of gases in inspired and expired air

(v) Non-respiratory functions of lungs

3. What will happen and why, if

(i) excalator action of cilia is is deficient

(ii) if foreign particles enters the pulmonary functional unit

4. How lung protect itself from invading foreign substances.

5. Depict diagrammatically.

(i) Weibel lung model (ii) External and internal respiration (iii) Electron microscopic structure of respiratory membrane

- MCQs

1. Both the lungs contain about ..... million alveoli: (a) 50 (b) 100 (c) 300 (d) 500

2. Alveolar lining epithelium:

(a) Is exceedingly thin, simple squamous type

(b) Contains cilia that beat towards the exterior

(c) Contains type I granular pneumocytes

(d) Contains numerous mucous and serous glands

3. Sympathetic stimulation of the bronchus causes:

(a) Bronchial constriction (b) No effect

(c) Increased secretion from glands (d)Bronchial dilatation

4. Gaseous exchange across respiratory membrane is completed in: (a) Less than 1 sec (b) 1 sec (c) 2 sec (d) 3 sec

5. Particles falling on walls of the bronchi are prevented going to alveoli by: (a) Bronchoconstriction (b) Coughing (c) Ciliary escalator action

d) The maximum particle size that reaches the alveoli is ..... diameter:

(a) 15 µm (b) 10 µm (c) 5µm (d) 2µm

THANKS