**THE RESPIRATORY SYSTEM:**

1-The respiratory system includes the **lungs** and a branching system of tubes that link the sites of gas exchange with the external environment. 2-Air is moved through the lungs by a ventilating mechanism, consisting of the thoracic cage, intercostal muscles, diaphragm, and elastic components of the lung tissue. .

**RESPIRATORY EPITHELIUM.**

Most of the conducting portion is lined with ciliated pseudostratified columnar epithelium known as **respiratory epithelium** . This epithelium has at least **five cell types,** all of which touch the thick basement membrane:

**1-Ciliated columnar cells:** are the most abundant, each with about 300 cilia on its apical surface .

**2-Goblet cells :** are also abundant in some areas of the respiratory epithelium , filled in their apical portions with granules of mucin glycoproteins.

**3-Brush cells: *i)***Brush cells are a much more sparsely scattered and less easily found, columnar cell type, which has a small apical surface bearing a tuft of many short,blunt microvilli and are considered to be chemosensory receptors.

**4-Small granule cells:** are also difficult to distinguish in routine preparations, but possess numerous dense core granules . Like brush cells, they represent about 3% of the total cells and are part of the diffuse neuroendocrine system .

**5-Basal cells**: small rounded cells on the basement membrane and not extending to the luminal surface, are stem cells that give rise to the other cell types.

**TRACHEA:**

1-The **trachea** is 12-14 cm long and lined with a typical respiratory mucosa. In the lamina propria numerous seromucous glands produce watery mucus and in the submucosa 16–20 C-shaped rings of hyaline cartilage keep the tracheal lumen open . 2-The open ends of the cartilage rings are on the posterior surface, against the esophagus, and are bridged by a bundle of smooth muscle (**trachealis muscle**) and a sheet of fibroelastic tissue attached to the perichondrium.

The entire organ is surrounded by adventitia.

**Function of trachea:** 1-The trachealis relaxes during swallowing to facilitate the passage of food by allowing the esophagus to bulge into the lumen of the trachea, with the elastic layerpreventing excessive distention of the lumen. 2- In the cough reflex the muscle contracts to narrow the tracheal lumen and provide for increased velocity of the expelled air and better loosening of material in the air passage.

**Bronchi:**

***1)***The mucosa of the larger bronchi is structurally similar to the tracheal mucosa except for the organization of cartilage and smooth muscle. ***2)*** In the primary bronchi most cartilage rings completely encircle the lumen, but as the bronchial diameter decreases, cartilage rings are gradually replaced with isolated plates of hyaline cartilage. ***3)*** Abundant mucous and serous glands are also present, with ducts opening into the bronchial lumen. ***4)*** In the bronchial lamina propria is a layer of crisscrossing bundles of spirally arranged smooth muscle , which become more prominent in the smaller bronchial branches. ***5)*** Contraction of this muscle layer is responsible for the folded appearance of the bronchial mucosa observed in histologic section.

***6)***The lamina propria also contains elastic fibers and abundant mucous and serous glands whose ducts open into the bronchial lumen. ***7)***Numerous lymphocytes are found both within the lamina propria and among the epithelial cells. Lymphatic nodules are present and are particularly numerous at the branching points of the bronchial tree. ***8)***Elastic fibers, smooth muscle, become relatively more abundant as bronchi become smaller and cartilage and other connective tissue are reduced.

**Bronchioles:**

1-Bronchioles are the intralobular airways with diameters of 5 mm or less, formed after about the tenth generation of branching, and have neither cartilage nor glands in their mucosa . 2-In the larger bronchioles, the epithelium is still ciliated pseudostratified columnar, but this decreases in height and complexity to become

ciliated simple columnar or cuboidal epithelium in the smaller terminal bronchioles. 3-The bronchiolar lamina propria is composed largely of smooth muscle and elastic fibers. 4-The musculature of both the bronchi and the bronchioles is under the control of the vagus nerve and the sympathetic nervous system, in addition to the influence of neuroendocrine peptides. Stimulation of the vagus nerve decreases the diameter of these structures; sympathetic stimulation produces the opposite effect.

**Cells of bronchoiles:** Goblet cells disappear during this transition, but the epithelium of terminal bronchioles instead contains other numerous columnar cells: ***i)*the exocrine bronchiolar cells**, commonly called **Clara cells**. These mitotically active cells secrete surfactant components and have various important defensive roles. ***ii)*** **Scattered neuroendocrine cells** are also present, producing serotonin and other peptides that help control the tone of the local smooth muscle. ***iii)*** **Groups of similar cells**, called **neuroepithelial bodies**, occur in some bronchioles and at higher levels in the bronchial tree. These are innervated by autonomic and sensory fibers and some of the cells appear to function as chemosensory receptors in monitoring air O2 levels. Epithelial stem cells are also present in these groups of cells.

**Lung**

**Respiratory Bronchioles:**

1-Each terminal bronchiole subdivides into two or more respiratory bronchioles that serve as regions of transition between the conducting and respiratory portions of the respiratory system . 2- The respiratory bronchiolar mucosa is structurally identical to that of the terminal bronchioles, except that their walls are interrupted by the openings to saclike alveoli where gas exchange occurs. 3-Portions of the respiratory bronchioles are lined with ciliated cuboidal epithelial cells and Clara cells, but at the rim of the alveolar openings the bronchiolar epithelium becomes continuous with the squamous alveolar lining cells (type I alveolar cells). 4-Proceeding distally along these bronchioles, the alveoli increase in number, and the distance between them is reduced. Between alveoli the bronchiolar epithelium consists of ciliated cuboidal epithelium, although cilia may be absent in more distal portions. 5-Smooth muscle and elastic connective tissue lie beneath the epithelium of respiratory bronchioles.

**Alveolar Ducts:**

1-Proceeding distally along the respiratory bronchioles, the number of alveolar openings in the bronchiolar wall slowly increases. Respiratory bronchioles branch into tubes called **alveolar ducts** that are completely lined by the openings of alveoli. 2- Both the alveolar ducts and the alveoli are lined with extremely attenuated squamous alveolar cells. 3- In the lamina propria surrounding the rim of the alveoli is a thin network of smooth muscle cells, which disappears at the distal ends of alveolar ducts. 4- A rich matrix of elastic and collagen fibers provides the only support of the duct and its alveoli. 5-Alveolar ducts open into atria of two or more **alveolar sacs** . Elastic and reticular fibers form a network encircling the openings of atria, alveolar sacs,and alveoli. 6-The elastic fibers enable the alveoli to expand with inspiration and to contract passively with expiration. The reticular fibers serve as a support that prevents overdistention and damage to the delicate capillaries and thin alveolar septa. Both fibers contribute to the connective tissue housing the network of capillaries around each alveolus.

**Alveoli:**

Alveoli are saclike evaginations of the respiratory bronchioles, alveolar ducts, and alveolar sacs. Alveoli are responsible for the spongy structure of the lungs .

**Structure of alveoli: *a)*** alveoli resemble small pockets that are open on one side, similar to the honeycombs of a beehive. Within these cuplike structures, O2 and CO2 are exchanged between the air and the blood. ***b)*** The structure of alveolar walls is specialized to enhance diffusion between the external and internal environments. Generally, each wall lies between two neighboring alveoli and is therefore called an **interalveolar septum**. ***c)***These septa contain the cells and connective tissue, notably the elastic and collagen fibers, which is vascularized with the richest capillary network in the body .  ***d)***Pores occur in the interalveolar septum and connect neighboring alveoli opening to different bronchioles. These pores equalize air pressure in the alveoli and promote collateral circulation of air when a bronchiole is obstructed.

***e)***Air in the alveoli is separated from capillary blood by **three components** referred to collectively as the **respiratory membrane** or **blood-air barrier:**

**Blood-air barrier:  *i)***Surface lining and cytoplasm of the alveolar cells, ***ii)***Fused basal laminae of the closely apposed alveolar cells and capillary endothelial cells, and ***iii)***Cytoplasm of the endothelial cells.

**Alveolar cells:**

***A)*Type I alveolar cells:** (also called type I pneumocytes or squamous alveolar cells) are extremely attenuated cells that line the alveolar surfaces. ***i)***These cells are so thin the electron microscope was needed to prove that all alveoli are covered with an epithelial lining. ***ii)***The cytoplasm in the thin portion contains pinocytotic vesicles, which may play a role in the turnover of surfactant and the removal of small particulate contaminants from the outer surface. ***iii)*** In addition to desmosomes, all type I epithelial cells have occluding junctions that prevent the leakage of tissue fluid into the alveolar air space . ***iv)***The main role of these cells is to provide a barrier of minimal thickness that is readily permeable to gases.

***B)*Type II alveolar cells** (type II pneumocytes): are interspersed among the type I alveolar cells with which they have occluding and desmosomal junctions . ***i)***Type II cells are rounded cells that often occur in groups of two or three along the alveolar surface at points where the alveolar walls unite. ***ii)***These cells rest onthe basement membrane and are part of the epithelium, with the same origin as the type I cells that line the alveolar walls. ***iii)***They divide by mitosis to replace their own population and also the type I population. ***v)*** In histologic sections, they exhibit a characteristic vesicular or foamy cytoplasm.These vesicles are caused by the presence of **lamellar bodies** .

**C)Alveolar macrophages**: also called **dust cells** are found in alveoli and in the interalveolar septum. ***i)***Tens of millions of monocytes migrate daily from the microvasculature into the lung tissue, where they phagocytose erythrocytes lost from damaged capillaries and air-borne particulate matter that has entered alveoli. ***ii)*** Some debris within these cells was most likely passed from the alveolar lumen into the interstitium following the pinocytotic activity of type I alveolarcells. ***iii)***Active macrophages in lung are often slightly darker due to their content of dust and carbon from air and complexed iron (hemosiderin) from erythrocytes.