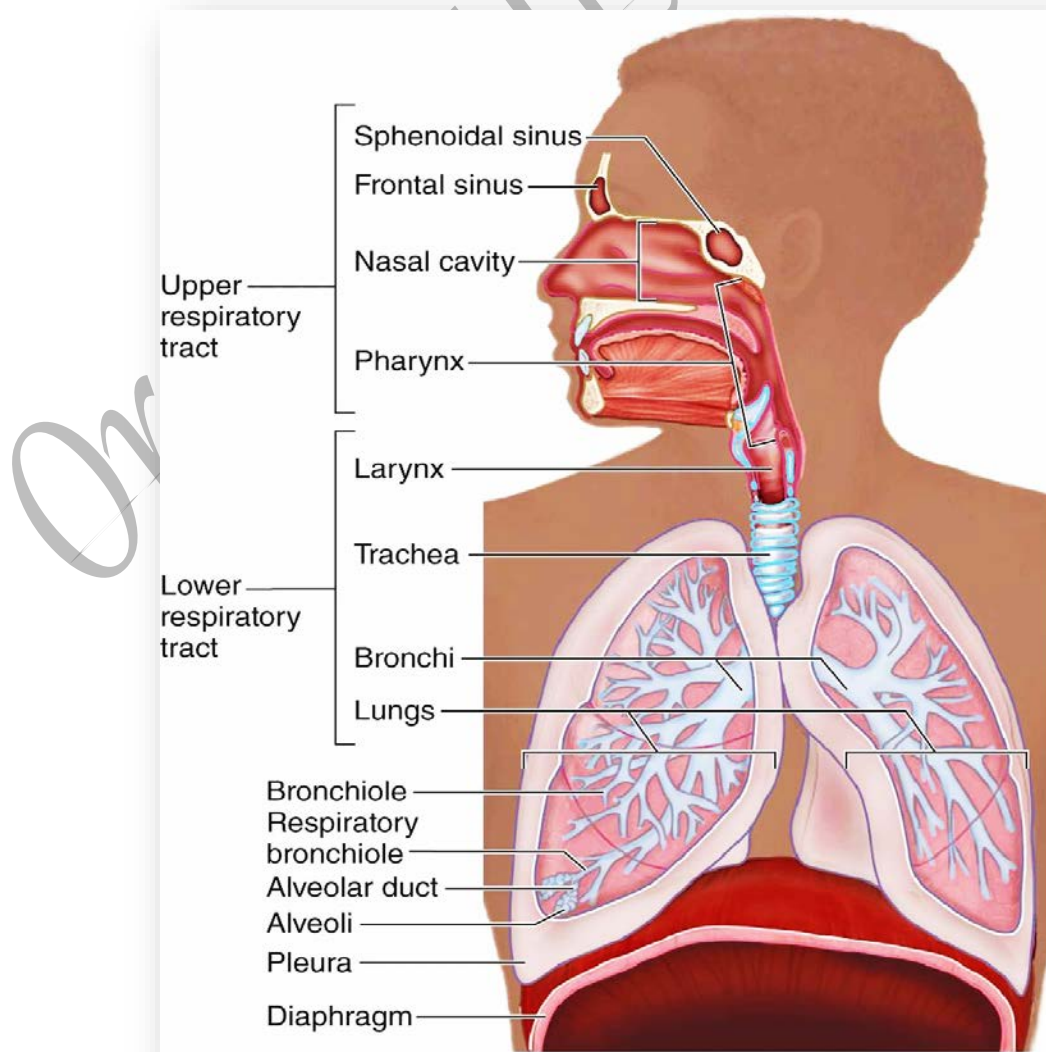


Respiratory system

The respiratory system provides for exchange of **O₂** and **CO₂** to and from the blood. Respiratory organs include the lungs and a branching system of bronchial tubes that link the sites of gas exchange with the external environment. 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. The system is divided **anatomically** into structures of the **upper and lower** respiratory tracts. **Functionally**, the system has **two** components:

- A) The conducting portion**, which consists of the nasal cavities, nasopharynx, larynx, trachea, bronchi, bronchioles, and terminal bronchioles.
- B) The respiratory portion**, where the system's main function of gas exchange occurs, consisting of respiratory bronchioles, alveolar ducts, and alveoli.



Respiratory Epithelium

Most of the nasal cavities and the respiratory system's conducting portion is lined with mucosa having **ciliated pseudostratified columnar epithelium** and commonly known as respiratory epithelium. This epithelium has **five** major cell types, all of which contact an unusually thick basement membrane:

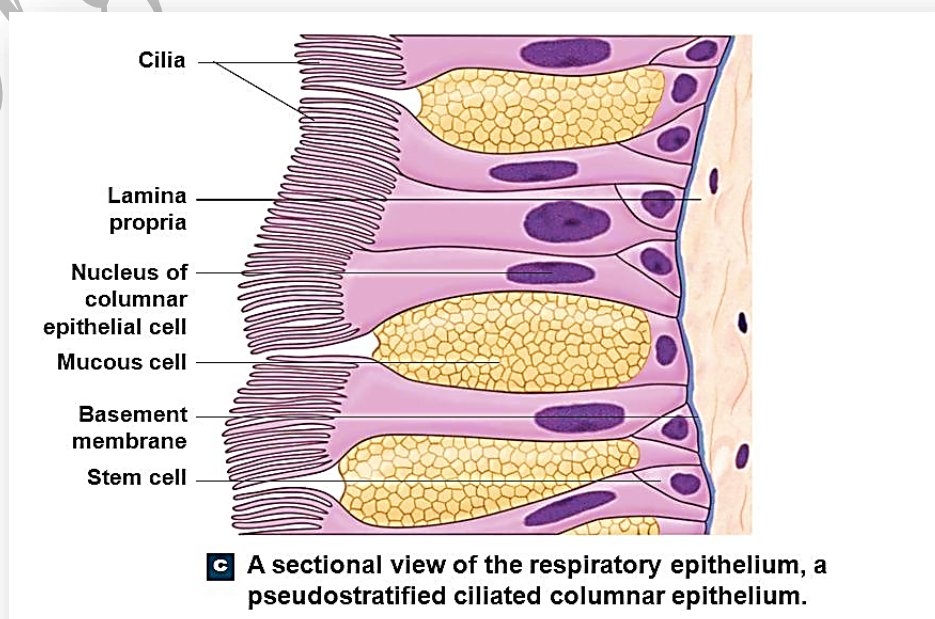
1-Ciliated columnar cells are the most abundant, each with 250-300 cilia on its apical surface.

2-Goblet cells are also numerous and predominate in some areas, with basal nuclei and apical domains filled with granules of mucin glycoproteins.

3-Brush cells are a much less numerous, columnar cell type, in which a small apical surface bears sparse, blunt microvilli. Brush cells are **chemosensory receptors** resembling gustatory cells, with similar signal transduction components and synaptic contact with afferent nerve endings on their basal surfaces.

4-Small granule cells (or Kulchitsky cells) are difficult to distinguish in routine preparations, but possess numerous dense core granules 100 to 300 nm in diameter. Like enteroendocrine cells of the gut, they are part of the **diffuse neuroendocrine system (DNES)**. Like brush cells, they represent only about 3% of the cells in respiratory epithelium.

5-Basal cells are mitotically active stem and progenitor cells that give rise to the other epithelial cell types.



A)The conducting portion

1-Nasal cavity:

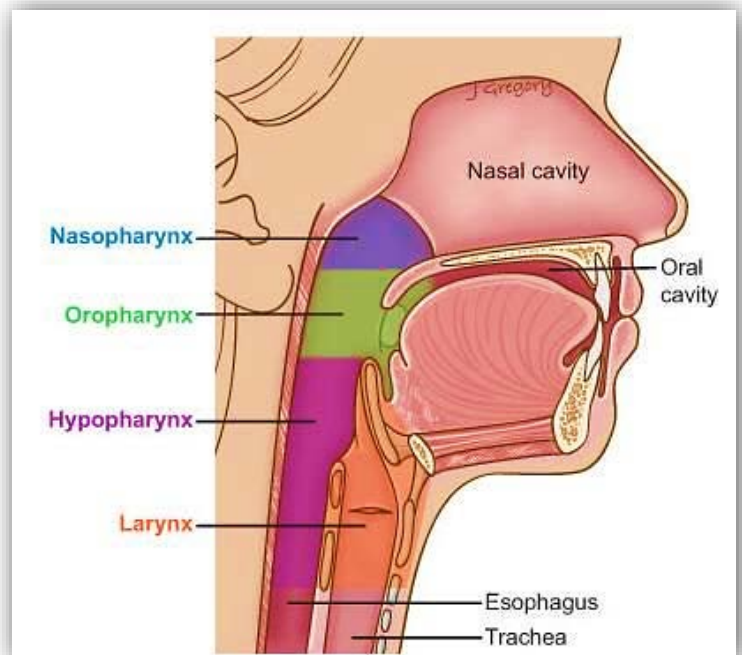
The nasal cavity is subdivided by the median nasal septum into right and left nasal cavities, each leading to the paranasal sinuses, thus providing a large surface area for filtering, moistening, and warming the inspired air.

2-Nasopharynx:

- ✚ The nasopharynx, the posterior continuation of the nasal cavities, becomes continuous with the oropharynx at the level of the soft palate.
- ✚ It is lined by respiratory epithelium, whereas the oropharynx and laryngopharynx are lined by **stratified squamous nonkeratinized epithelium**.
- ✚ The lamina propria of the nasopharynx, located beneath the respiratory epithelium, contains **mucous** and **serous glands** as well as an abundance of lymphoid tissue known as **Waldeyer ring**, including the pharyngeal tonsil. When the pharyngeal tonsil is inflamed, it is called an **adenoid**.
- ✚ Opening into the right and left lateral walls of the nasopharynx are the auditory tubes (**Eustachian tubes**), each arising from its respective middle ear cavity.

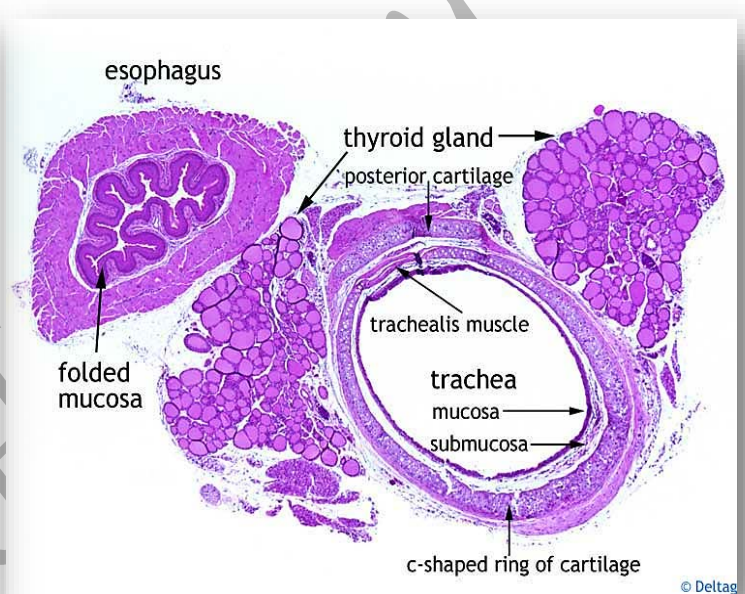
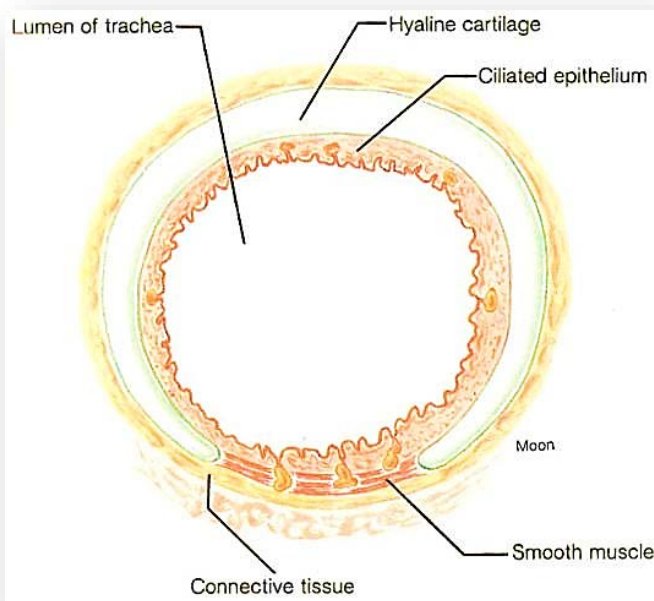
3- Larynx:

The larynx connects the **pharynx** with the **trachea**. It functions to produce sounds and close the air passage during swallowing. The wall of the larynx is supported by **hyaline cartilages** (thyroid, cricoid, and lower part of arytenoids) and **elastic cartilages** (epiglottis, corniculate, and tips of arytenoids). The laryngeal wall also possesses skeletal muscle, connective tissue, and glands. The **epiglottis**, a flattened structure projecting from the upper rim of the larynx, serves to prevent swallowed food or fluid from entering that passage.



4- Trachea:

The trachea, largest conducting section of the respiratory system, bifurcates into the right and left primary bronchi, each of which enters the hilum of the lung on its side. The walls of these structures are supported by C-shaped **hyaline cartilages** whose open ends face posteriorly. Smooth muscle (trachealis muscle in the trachea) extends between the open ends of these cartilages. **Dense fibroelastic** connective tissue is located between adjacent C-rings, permitting elongation of the trachea during inhalation.



5- Bronchi

The trachea divides into **two primary bronchi** that enter each lung at the hilum, along with arteries, veins, and lymphatic vessels. After entering the lungs, the primary bronchi course downward and outward, giving rise to **three** secondary (lobar) bronchi in the **right lung** and **two** in the **left lung**, each of which supplies a pulmonary lobe. These lobar bronchi again divide, forming tertiary (segmental) bronchi.

The mucosa of the larger bronchi is structurally similar to the tracheal mucosa except for the organization of cartilage and smooth muscle. 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. Small mucous and serous glands are abundant, with ducts

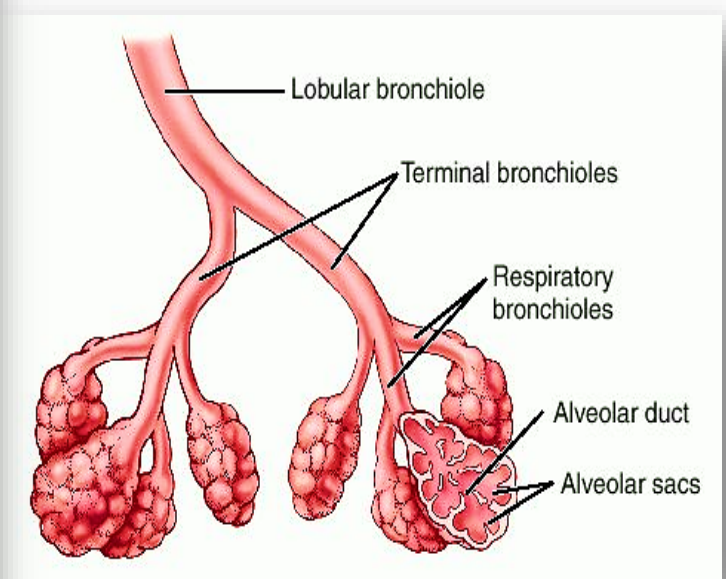
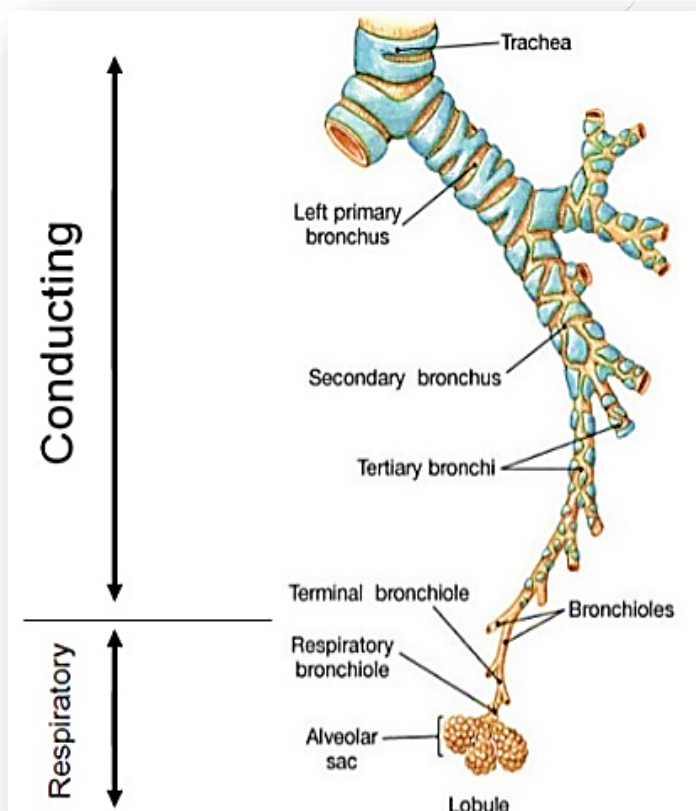
opening into the bronchial lumen. The lamina propria also contains crisscrossing bundles of spirally arranged smooth muscle and elastic fibers, which become more prominent in the smaller bronchial branches.

6- Bronchioles

Bronchioles are typically designated as the intralobular airways with diameters of 1 mm or less, formed after about the 10th generation of branching; they lack both **mucosal glands and cartilage**, although dense connective tissue is associated with the smooth muscle. In the larger bronchioles, the epithelium is still ciliated pseudostratified columnar, but this decreases in height and complexity to become **ciliated simple columnar** or **simple cuboidal epithelium** in the smallest terminal bronchioles, which are the last parts of the air conducting system.

7-Terminal bronchioles

Bronchioles divide to form several terminal bronchioles after entering the pulmonary lobules. Terminal bronchioles are the most distal part of the conducting portion of the respiratory system. They are lined by a **simple cuboidal epithelium** that contains mostly **club cells (Clara cells)**, some **ciliated cells**, and **no goblet cells**.



B) The respiratory portion

This portion of the respiratory system includes the **respiratory bronchioles**, **alveolar ducts**, **alveolar sacs**, and **alveoli**, all in the lung. The exchange of gases takes place in this portion of the respiratory system.

1- Respiratory bronchioles

Each terminal bronchiole subdivides into **two or more** respiratory bronchioles that include saclike alveoli. The respiratory bronchiolar mucosa is structurally identical to that of the terminal bronchioles, except for a few openings to the alveoli where gas exchange occurs. The mucosa lining consists of **Clara cells** and **ciliated cuboidal cells**, with **simple squamous cells** at the alveolar openings and extending into the alveolus.

2- Alveolar ducts

Distal ends of respiratory bronchioles branch into tubes called alveolar ducts that are completely lined by the openings of alveoli. Both the alveolar ducts and the alveoli themselves are lined with extremely attenuated squamous cells. In the thin lamina propria, a strand of smooth muscle cells surrounds each alveolar opening and a matrix of elastic and collagen fibers supports both the duct and its alveoli.

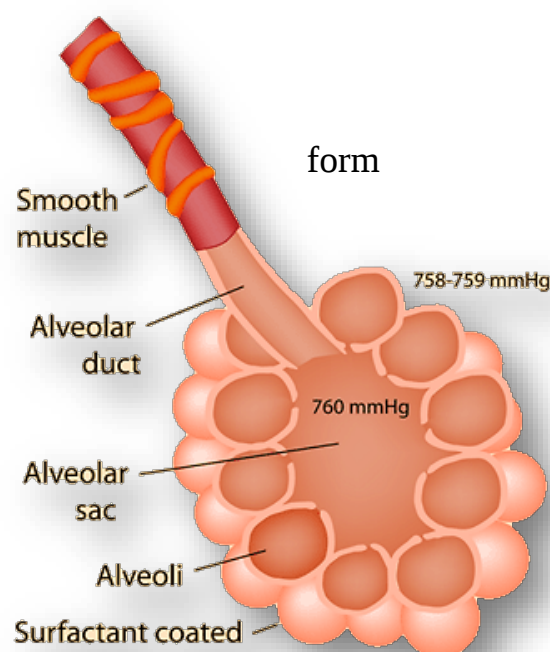
3- Alveolar sacs

Larger clusters of alveoli called alveolar sacs the ends of alveolar ducts distally and occur occasionally along their length.

4- Alveoli

Alveoli are saclike evaginations about 200 μm in diameter in the walls of respiratory bronchioles, in alveolar ducts, and in alveolar sacs. They have thin walls, across which **O₂** and **CO₂** diffuse between the air and the blood. Along with the airways, alveoli are responsible for the spongy structure of the lungs.

Between neighboring alveoli lie thin interalveolar septa consisting of scattered fibroblasts and sparse extracellular matrix (ECM), notably elastic and reticular fibers, of connective tissue. The arrangement of



elastic fibers enables alveoli to expand with inspiration and contract passively with expiration; reticular fibers prevent both collapse and excessive distention of alveoli. The interalveolar septa are vascularized with the richest capillary networks in the body.

Lung

Lung lobules vary greatly in size and shape, but each has an apex directed toward the pulmonary hilum and a wider base directed outward. Each lobule contains a single primary bronchiole, which enters at the apex and branches to form **five** to **seven** terminal bronchioles. The terminal bronchioles in turn divide, ultimately giving rise to alveoli at the base of the lobule.

Pleural membranes

The lung's outer surface and the internal wall of the thoracic cavity are covered by a serous membrane called the **pleura**. The membrane attached to lung tissue is called the **visceral pleura** and the membrane lining the thoracic walls is the **parietal pleura**. The two layers are continuous at the hilum and are both composed of simple squamous mesothelial cells on a thin connective tissue layer containing collagen and elastic fibers. The elastic fibers of the visceral pleura are continuous with those of the pulmonary parenchyma.

