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Chapter.02

Structure and Histology of the Respiratory System

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Introduction

The respiratory system function is exchanging carbon dioxide for oxygen, which is then distributed to all of the tissues of the body. To accomplish this function, air must be brought to that portion of the respiratory system where exchange of gases can occur.

The respiratory system, therefore, has two portions:

• **conducting portion**

• **respiratory portion**.

The principal functions of respiratory system are:

- Air conduction, air filtration and gas exchange,
- The larynx is used to produce speech,
- The olfactory mucosa in the nasal cavities carries stimuli for the sense of smell,
- Regulation of immune responses to inhaled antigens,
- Hormone production and secretion.

2.1. Conducting portion of the respiratory system

The **extrapulmonary** region of the conducting portion consists of the nasal cavities, pharynx, larynx, trachea, and bronchi. The **intrapulmonary** region entails the intrapulmonary bronchi, bronchioles, and terminal bronchioles

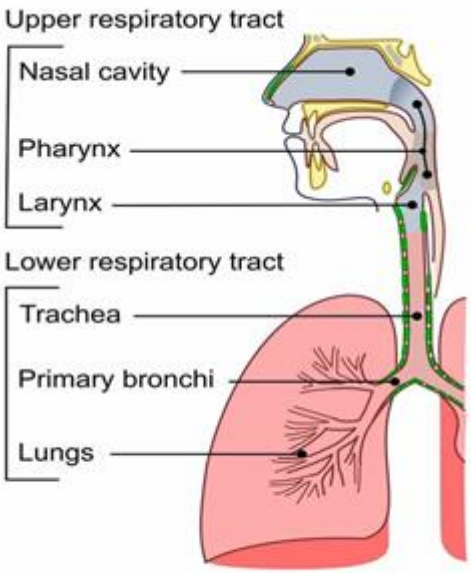

Figure.18. Respiratory system organisation

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2.1.1. The nasal cavities

The nasal cavities are paired chambers separated by a bony and cartilaginous septum. Each cavity communicates anteriorly with the external environment through the (nostrils). The chambers are divided into three regions: vestibule, respiratory segment and olfactory segment.

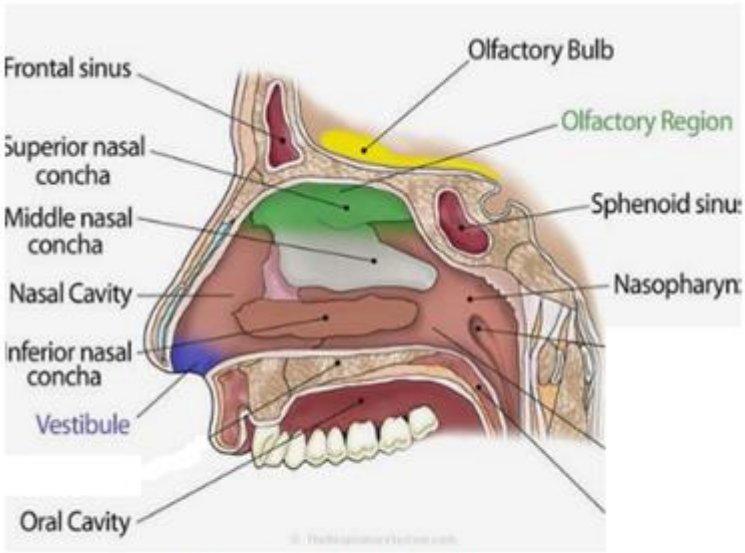

Figure.19. Nasal cavity

A. The vestibule

The vestibule is lined with stratified squamous epithelium, and contains a variable number of stiff hairs, vibrissae. Sebaceous glands are also present in the vestibule. Posteriorly the stratified squamous epithelium become thinner and undergoes to the pseudostratified epithelium that characterizes the respiratory segment.

B. The respiratory portion

The respiratory portion is lined by a **pseudostratified ciliated epithelium** with **goblet cells** supported by the lamina propria, which consists of **connective tissue** with **seromucous glands**. The lamina propria has a rich superficial **venous plexus**. Incoming air is warmed by blood in the venous plexus and moistened by secretions of the seromucous glands and goblet cells.

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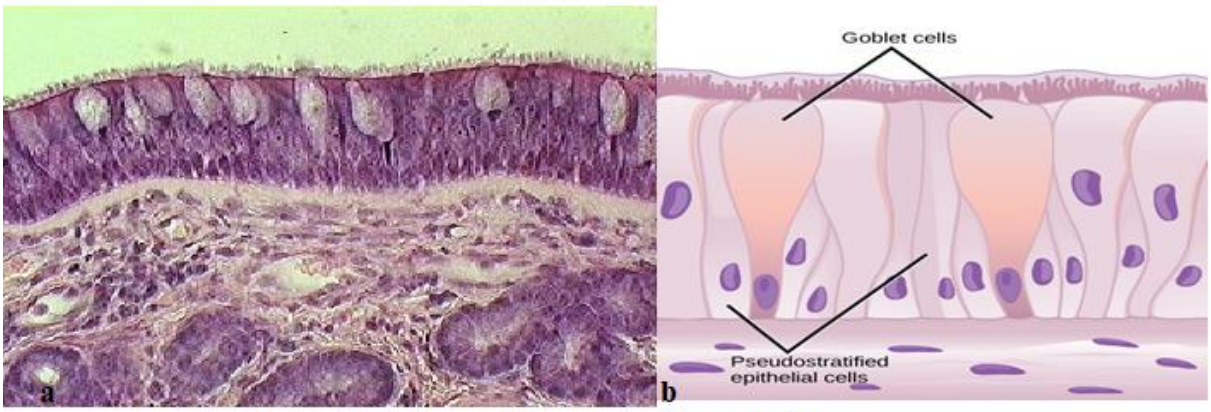

Figure.20. Histology of the respiratory portion

The nasal respiratory epithelium consists of six morphologically distinct cell types: ciliated columnar, non ciliated columnar, mucous (goblet), brush, cuboidal, and basal cells. These cell types are unevenly distributed along the mucosal surface and rest on a basal lamina of reticular and collagen fibrils.

Figure.21. Cell types of the respiratory epithelium

C. The olfactory epithelium

The olfactory epithelium consists of three cell types: olfactory cells (bipolar neurons), basal cells (stem cells that differentiate into olfactory cells) and supporting or sustentacular cells. The underlying lamina propria contains the venous plexus, the olfactory glands of Bowman and nerve bundles.

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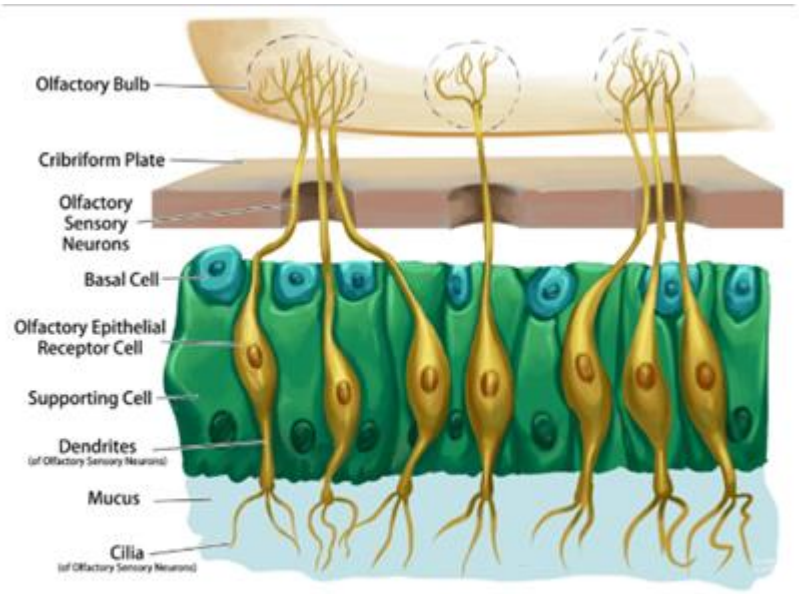

Figure.22. cell types of olfactory portion

In certain areas, the mucosa of the nasal cavity is modified to function in **olfaction** and is referred to as the **olfactory mucosa**. The glands in the lamina propria of this region, known as **Bowman's glands**, produce a thin mucous secretion that dissolves odoriferous substances, and the **olfactory cells** of the pseudostratified columnar olfactory epithelium perceive these sensory stimuli. Olfactory cells are

• **bipolar neurons** whose receptor ends are modified, nonmotile **cilia** that arise from a swelling, the **olfactory vesicle**, and extend into the overlying mucus

• In addition to the olfactory cells, two other cell types compose the olfactory epithelium, namely, sustentacular cells (supporting cells) and basal cells.

-**Sustentacular cells** do not possess any sensory function, but they manufacture a yellowish-brown pigment that is responsible for the coloration of the olfactory mucosa; additionally, they insulate and

support the olfactory cells.

-**Basal cells** are small, dark cells that lie on the basement membrane and probably are regenerative in function forming sustentacular, olfactory, as well as more basal cells.

2.1.2. The larynx

The conducting portion of the respiratory system is supported by a skeleton composed of bone and/or cartilage that assists in the maintenance of a patent lumen, whose diameters are controlled by smooth muscle cells located in their walls.

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• The **larynx**, a region of the conducting portion, is designed for phonation and to prevent food, liquids, and other foreign objects from gaining access to its lumen.

2.1.3. The pharynx

The pharynx connects the nasal and oral cavities to the larynx and esophagus. The posterior portion of the nasal cavities is the nasopharynx. The nasopharynx is lined by a pseudostratified columnar epithelium and changes into nonkeratinizing squamous epithelium at the oropharynx. The mucosa-associated lymphoid tissue is present beneath the nasopharyngeal epithelium, forming Waldayer´s ring. The concentrations of lymphatic nodules form the nasopharyngeal tonsils (adenoids).

2.1.4. The trachea

The lumen of the trachea is held open by a series of C-shaped hyaline cartilage (of 16 to 20). The trachea has three layers, the mucosa, submucosa, and adventitia. The tracheal lumen is lined by a pseudostratified ciliated columnar epithelium, known as respiratory epithelium.

A. Mucosa

Mucosa is composed of various cell types, namely, goblet cells, ciliated cells, basal cells, brush cells, serous cells, and hormone-producing diffuse neuroendocrine system (DNES) cells.

-**Goblet cells,** unicellular glands that produce **mucinogen**, a mucous substance that is released onto the wet epithelial surface where it becomes hydrated to form **mucin**.

-**Ciliated cells** whose cilia sweep the mucus toward the larynx.

-**Basal cells** are regenerative cells that function in replacing the epithelial lining of the trachea.

-**Brush cells** may have neurosensory functions or they may be defunct goblet cells that released their mucinogen.

-**Serous cells** are tall, columnar cells.

-**DNES cells** form polypeptide hormones that they store in small granules localized in their basal cytoplams.

-The trachea subdivides into the two primary bronchi that lead to the right and the left lungs.

B. Lamina propria is a loose connective tissue containing many elastic fibers. It is separated from the dense connective tissue of the submucosa by a condensation of elastic fibers.

C. Adventitia

Adventitia consists of loose connective tissue. It contains fat cells, nerves, blood vessels.

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2.1.5. Bronchi and bronchioles

The intrapulmonary region is composed of **intrapulmonary bronchi** (secondary bronchi), whose walls are supported by irregular plates of hyaline cartilage.

Each intrapulmonary bronchus gives rise to several **bronchioles**, tubes of decreasing diameter that do not possess a cartilaginous supporting skeleton.

The epithelial lining of the larger bronchioles is ciliated with a few goblet cells, but those of smaller bronchioles are simple columnar, with goblet cells being replaced by **Clara cells**. Moreover, the thickness

of their walls also decreases, as does the luminal diameter.

The last region of the conduction portion is composed of **terminal bronchioles.** Terminal bronchioles are lined by a ciliated cuboidal epithelium with Clara cells. Clara cells represent 80% of the epithelial cell population of the terminal bronchiole. Non ciliated Clara cells appear in the epithelial layer with a single layer of ciliated cuboidal cells. The apical region of Clara cells contains secretory granules, mitochondria and numerous vesicles. Clara cells secrete a component of the surfactant material covering the alveoli

The mucosa of the respiratory bronchioles is similar to that of terminal bronchioles,. The low cuboidal epithelium is replaced by squamous alveolar epithelial cells.

A terminal bronchiole and the associated region of pulmonary tissue that it supplies constitute a pulmonary lobule. A pulmonary lobule includes the respiratory bronchioles, alveolar ducts, alveolar sacs, and alveoli. The pulmonary acinus is the portion of the lung supplied by a respiratory bronchiole.

Respiratory bronchioles lead to **alveolar ducts**, each of which ends in an expanded region known as an **alveolar sac**, with each sac being composed of a number of alveoli. The epithelium of alveolar sacs and alveoli is composed of two types of cells:

-highly attenuated **type I pneumocytes**, which form much of the lining of the alveolus and alveolar sac, and

-**type II pneumocytes**, are cells that manufacture **surfactant**, a phospholipid that reduces surface tension of the alveolar surface

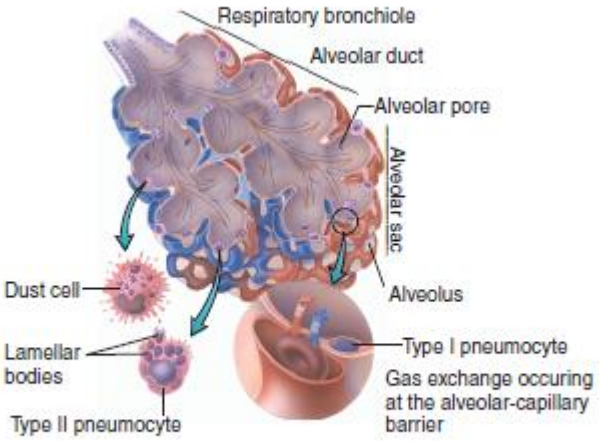

Figure.23. Respiratory portion of respiratory system.

2.1.6. Alveolar Ducts

Alveolar ducts possess no walls of their own. They are long, straight tubes lined by simple squamous epithelium and display numerous outpocketings of alveoli. Alveolar ducts end in alveolar sacs.

2.1.7. Alveolar Sacs

Alveolar sacs are composed of groups of alveoli clustered around a common air space.

2.1.8. Alveolus

An alveolus is a small air space partially surrounded by highly attenuated epithelium. Two types of cells are present in the lining: type I pneumocytes (lining cells) and type II pneumocytes (produce surfactant). The opening of the alveolus is controlled by elastic fibers. Alveoli are separated from each other by richly vascularized walls known as interalveolar septa, some of which present alveolar pores (communicating spaces between alveoli). Dust cells (macrophages), fi broblasts, and other connective tissue elements may be noted in interalveolar septa. The blood-air barrier is am a part of the interalveolar septum, the thinnest of which is composed of surfactant, continuous endothelial cells, type I pneumocyte, and their intervening fused basal laminae.

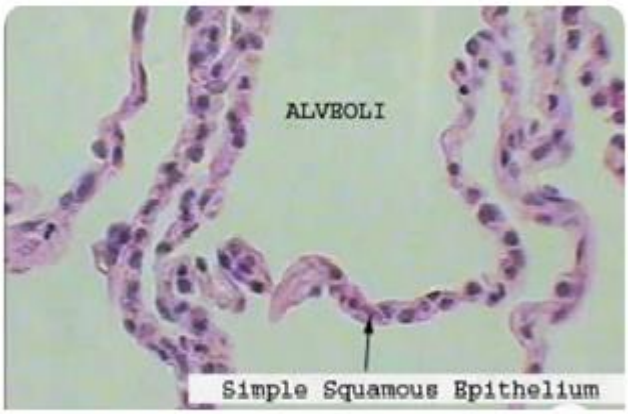

Figure.24. Histological structure of alveoli

3.2.1 Cell types:

The alveolar epithelium consists of **two cell types**:

A. ***Type I alveolar cells*** *(squamous alveolar cells),*

These cells are very thin, often only 25 nm in thickness. The main role of these cells is to provide a barrier of minimal thickness that is permeable to gases.

B.Type II alveolar cells .

These cells ***secrete pulmonary surfactant***. They are located *at the angles*. Type II alveolar cells are polygonal-shaped

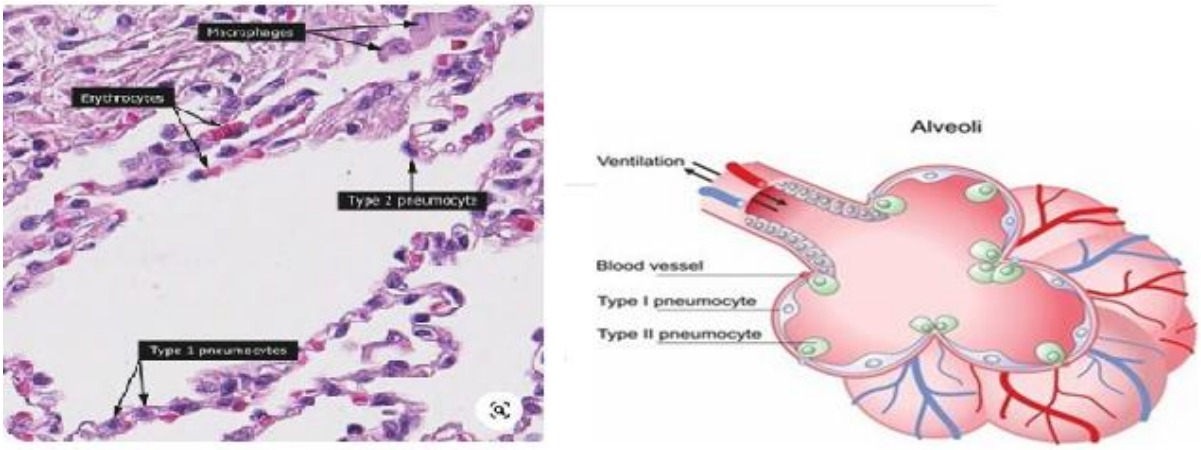

Figure.25. Cell types of the alveoli

The cytoplasm contains secretory granules containing pulmonary surfactant. The pulmonary surfactant is a thin layer of fluid that covers the alveolar surface. The surfactant, a lipid-protein complex that prevents alveolar collapsing.

3.2.2. interalveolar septum or wall

The structure of the alveolar walls is specialized for diffusion between the external and internal environments. Each wall lies between 2 neighboring alveoli and is therefore termed an.

An alveolar septum consists of 2 squamous epithelial layers between which lie **capillaries**, **elastic** and **collagen fibers, macrophages, fibroblasts,** and **mast cells.** The capillaries and connective tissue matrix constitute the **interstitium**.