Histology Department

(1st week/Lecture 3)

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Histology of the Respiratory tract

Conducting portion

Learning objectives

After this lecture, students should be able to:

- Know the different classifications of the respiratory tract:

  - Upper & lower airways.

  - Conducting and respiratory portions.
- Correlate functions of the conducting & respiratory portions with histological structure.
- Discriminate the type of the lining epithelium of the nasal cavity, paranasal sinuses, nasopharynx, larynx and trachea.
- List the cells of the respiratory epithelium and correlate the histological structure and function of these cells with clinical data.
- Classify the bronchial tree.
- Compare between the histological structure of the trachea, bronchi, bronchioles, and discriminate the type of their lining epithelium.

The upper airways comprise those parts of the respiratory tract above the trachea. However, it must be remembered that the same term is also used to refer to all airways which conduct inspired gases from the atmosphere to the terminal bronchioles, where gas exchange starts.

Conducting & respiratory portions of the Respiratory tract

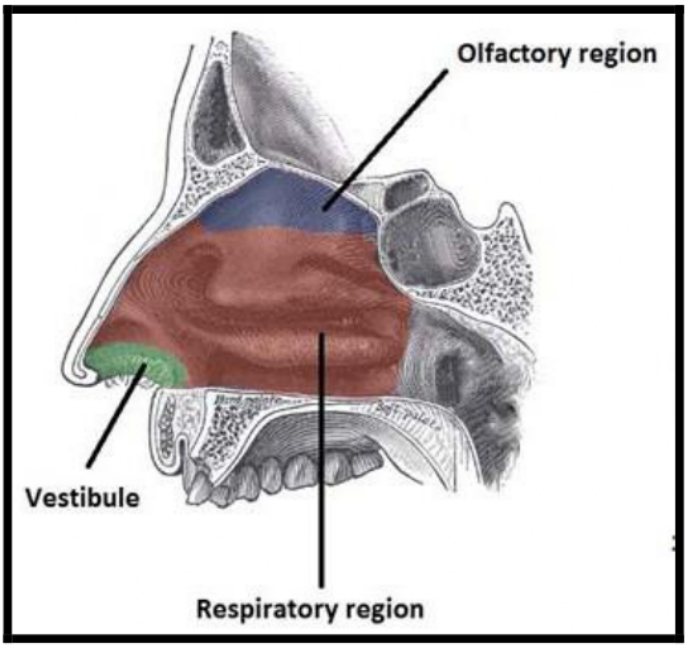
- **The conducting portion:** {does not participate in gas exchange} consists of **nasal cavity**, **paranasal sinuses**, **nasopharynx**, **larynx**, **trachea**, **bronchi** and **bronchioles** that further divide into **terminal bronchioles**.
- **The respiratory portion:** (Lung parenchyma), participates in gas exchange consists of **respiratory bronchioles**, **alveolar ducts**, **alveolar sacs** and **alveoli**.

	Conducting portion	**Respiratory portion**
Functions	Warm, humidify and filter air. {The activity of the **cilia** and the mucous secretion of **goblet cells** make up the **"mucociliary escalator"**, which is important in removing the inhaled particles}.	Gas exchange. {The lungs are the only place in our body where blood capillaries come into direct contact with the outside air, as a result of the fusion of the **type I** alveolar cells with the pulmonary capillary endothelium}.

Nasal cavity

- The nose moistens, warms inhaled air & preventing particulate matter from entering the airways. It is playing an important role in the **sense of smell**.
- The left and right nasal cavities each have two components: the external dilated **vestibule** (see the practical book) and the internal **nasal cavity**. Air enters the nose through the anterior nares (nostrils), passing the anterior nasal hairs (vibrissae); these trap and prevent inhalation of larger foreign particles. The epithelial lining changes shortly after entering the nose from **keratinized** to **respiratory epithelium**.

- **Olfactory epithelium**, possess receptors that bind specific odorants, is found in the upper regions of the nasal airway above the superior conchae and is specialized for the detection of smell (see the practical book).



Remember that:
- **The vestibule is lined with skin.**
- **The superior area of the nasal cavity is lined with olfactory epithelium.**
- **The rest of the nasal cavity is lined with respiratory epithelium.**

Paranasal sinuses

- Hollow, air-filled bony cavities that surround the nose.
- There are four pairs: the maxillary, frontal, ethmoidal and sphenoidal sinuses.
- Lined with **respiratory epithelium** and produce mucus that drains into the nasal cavity by the activity of the ciliated epithelial cells.

Nasopharynx

- The nasopharynx is the area behind the nose and above the soft palate. It is lined with **respiratory epithelium**.
- It is protected from the regurgitation of food during swallowing by the **soft palate** rising upwards and closing it off from the rest of the pharynx.
- The **pharyngeal tonsil** (a collection of lymphoid tissue commonly known as the adenoids) is found in the posterior wall and roof of the nasopharynx.
- The **eustachian tube**, a conduit with the **middle ear**, enters at the level of the floor of the nose on the lateral walls. This explains the common concurrence of throat and middle ear infections.

Larynx

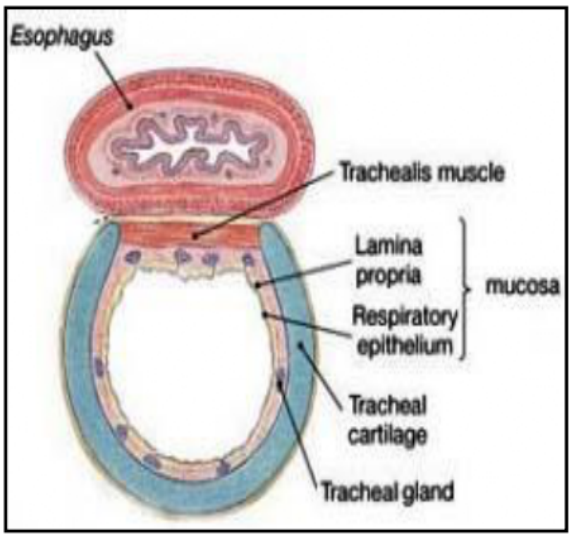
- Is a musculocartilaginous structure between the pharynx and the trachea, acts as an airway sphincter during swallowing and contains the **vocal cords** which are responsible for sound (vocalization).
- Its wall is reinforced by **cartilages** (thyroid, cricoids, epiglottis, and paired corniculate and cuneiform arytenoids) with ligaments and muscles that regulate the size of the laryngeal inlet.
- The **epiglottis** is an **elastic flap of cartilage**, which lies behind the tongue and forms the entrance to the larynx. It serves to prevent swallowed food or fluid from entering that passage.
- The mucosa of the anterior surface of epiglottis & vocal cords is **non-keratinized stratified squamous epithelium** while the rest of the larynx is lined with **respiratory epithelium**.

(Structure of the larynx, see the practical book)

Remember that:

- **The thyroid, cricoid and lower parts of arytenoids are hyaline cartilages.**
- **The epiglottis, corniculate, cuneiform and vocal processes of arytenoids are elastic cartilages.**

Trachea



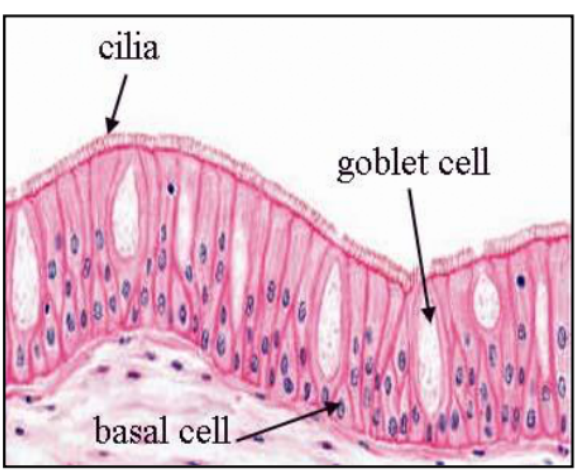
- The trachea is a tube lies between the larynx and main bronchi of the lungs. It has a series of **20 C-shaped hyaline cartilage rings** that keep the tracheal lumen open with a band of smooth muscle (trachealis muscle) **over the cartilage-deficient area posteriorly** (i.e. against the esophagus).

- The trachea is lined with **respiratory epithelium**, which acts as an **escalator**, wafting particulate matter in the mucus upwards, away from the lower airways. The **elastic fibers** in the lamina propria prevent excessive distention of the lumen. The submucosa contains numerous **seromucous** (mixed) glands.
  (structure of the trachea, see the practical book)

Respiratory epithelium

- It is characteristically **pseudostratified columnar ciliated with goblet cells**.

- **This epithelium has five major cell types:**



1- Ciliated columnar cells.
2- Goblet cells.
3- Basal cells.
4- Brush cells.
5- Pulmonary neuroendocrine cells.

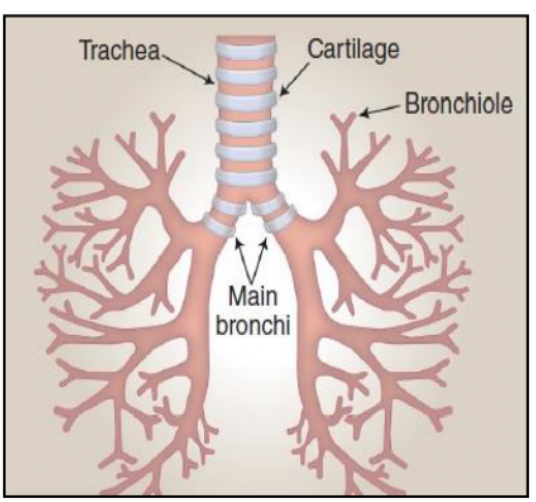
(structure of the cells, see the practical book)

Ciliated columnar cells	Goblet cells	Basal cells	Brush cells	Pulmonary neurendocrine cells (PNECs) or Kulchitsky (K) or small granule cells
The **beating motion of the cilia** and the **mucous secretion of the goblet** cells make up the "**mucociliary escalator**" which is important in removing the inhaled particles. This is an important defense against the entry of foreign particles to the lung.		They are **stem cells** for new ciliated, goblet and brush cells.	They are **chemoreceptors** rich in afferent fibers.	They are **argentaffin-like cells**, resemble the enteroendocrine cells of GIT. They have **neuro-endocrine** function, secrete peptides and endocrine factors that may play role in sensing low tissue oxygen and inducing lung growth and repair. PNEC hyperplasia led to small cell lung cancer, is thought to be induced by nicotine.

☻ The respiratory epithelium of people chronically exposed to irritants undergoes **"metaplasia".**

Bronchial tree

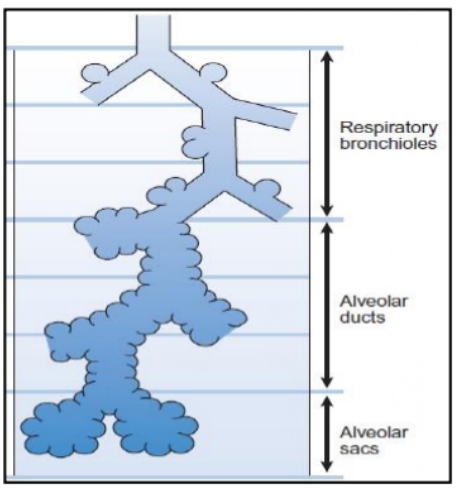
- The trachea ends by dividing into right and left **main (primary) bronchi** that enter each lung at the **hilum** which demarcates extrapulmonary and intrapulmonary bronchi.



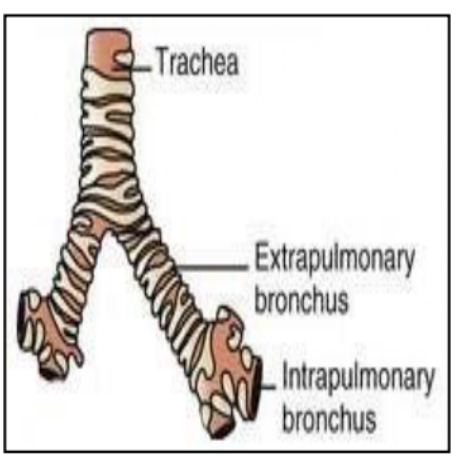
- Inside the lungs, bronchi divide into **lobar (secondary) bronchi** each of which supplies a

pulmonary **lobe** (the right lung possesses three lobes & the left lung possesses two lobes).

- The lobar bronchi continue to divide forming **segmental (tertiary) bronchi** that form **bronchioles** which each supply a single **lobule**. Each bronchiole divides into **5–7 terminal bronchioles** which then form **2–5 respiratory bronchioles**.
- Distally, respiratory bronchioles form **2–11 alveolar ducts**, from which most alveoli lead via **alveolar sacs**.



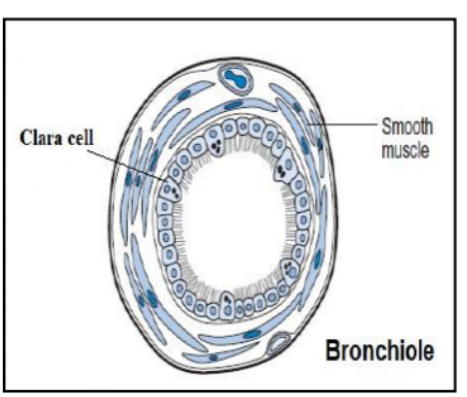
➢ In the **primary bronchi** (extrapulmonary bronchi) most **cartilage rings completely encircle the lumen**, but as the **bronchial diameter decreases** (intrapulmonary bronchi), cartilage rings are gradually replaced with smaller isolated plates of hyaline cartilage. Cartilage maintains airway patency. **Bronchioles do not have cartilage or glands.**



➢ **Smooth muscle bands** become more prominent around the bronchiolar airways.

– What is the relevance of this fact to bronchial asthma?

☻Bronchial asthma (bronchospasm) is a condition characterized by sudden constrictions of the smooth muscle in bronchioles.



➢ The respiratory epithelium changes from pseudostratified ciliated columnar with goblet cells (**in the bronchi**) to ciliated simple columnar with occasional goblet cells (**in large bronchioles**) to ciliated simple cuboidal as **bronchioles become progressively smaller**. **Clara cells** lack cilia, are located in the **terminal bronchioles**. Microscopically, Clara cells can be identified by secretory granules in the apical cytoplasm. Clara cells secrete protein to protect the

airway lining from damage, degrade toxins and act as bronchiolar stem cells for the airway epithelial layer.

(Structure of the bronchi, bronchioles see the practical book)

References:

- **USMLE Step 1 Lecture Notes 2021. Anatomy. KAPLAN MEDICAL. Part II Chapter 2. Pages: 45-49.**
- **Oxford Handbook of Medical Sciences 2nd edition (2011), p: 362-374.**
- **Lippincott Illustrated Reviews: Integrated Systems (2015), p: 218-222.**

ASSESS YOUR KNOWLEDGE

Choose the correct answer:

1- **Air moving rapidly across the vocal cords and causing them to vibrate and produce sound is contacting what type of epithelium?**
   a. Pseudostratified ciliated.
   b. Stratified squamous keratinized.
   c. Stratified squamous nonkeratinized.
   d. Simple squamous.
   e. Simple cuboidal.

2- **Which of the following features distinguishes a bronchus within a lung from the primary bronchi?**
   a. Glands in the submucosa.
   b. Pseudostratified ciliated columnar epithelium.
   c. Smooth muscle in the wall.
   d. Irregular plates of cartilage.
   e. Goblet cells in the epithelium.

3- **T.S. of the trachea reveals:**
   a. Multiple plates of cartilage.
   b. No cartilage.
   c. C-shaped elastic cartilage rings.
   d. Compact bone.
   e. C-shaped hyaline cartilage rings.

4- **The smooth muscle fibers of the trachea are present:**
   a. In the submucosa.
   b. Between the cartilage ends.
   c. In the mucosa.
   d. Over the cartilage-deficient area anteriorly.
   e. Around the lumen.

5- **The epithelium of trachea is:**
   a. Stratified squamous non-keratinized epithelium.
   b. Stratified columnar ciliated epithelium with goblet cells.
   c. Pseudostratified columnar ciliated epithelium with goblet cells.
   d. Simple columnar ciliated epithelium with goblet cells.
   e. Simple cuboidal ciliated with Clara cells.