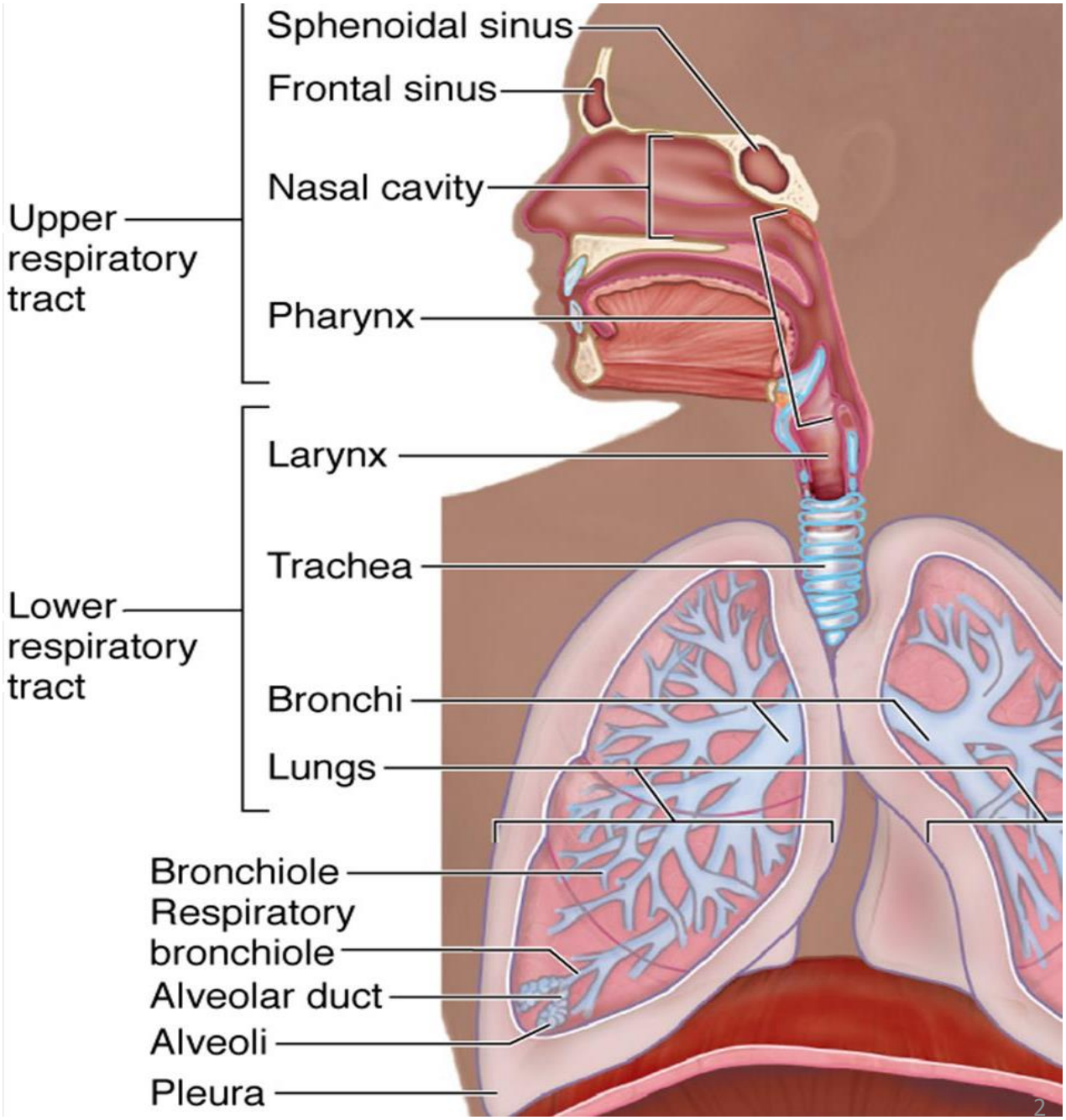
جامعة تكريت - كلية الطب

Human Histology
Lec: The Respiratory System

Dr. Hussain Ibrahim

Tikrit University - College of Medicine


Sphenoidal sinus
Frontal sinus
Nasal cavity
Upper respiratory tract
Pharynx
Larynx
Trachea
Lower respiratory tract
Bronchi
Lungs
Bronchiole
Respiratory bronchiole
Alveolar duct
Alveoli
Pleura

Components of the Respiratory System

The respiratory system consists of lungs and numerous air passages, or tubes, of various sizes that lead to and from each lung .

In addition, the system consists of a **conducting portion** and a **respiratory portion**.

The **conducting portion** of the respiratory system consists of passageways outside (extrapulmonary) and inside (intrapulmonary) the lungs that conduct air for gaseous exchange to and from the lungs. In contrast, the **respiratory portion** consists of passageways within the lungs that not only conduct the air, but also allow for respiration, or gaseous exchange.

The extrapulmonary passages, which include the **trachea‹ bronchi,** and **larger bronchioles‹** are lined by a distinct **pseudostratified ciliated columnar epithelium** containing numerous **goblet cells.** As the passageways enter the lungs, the bronchi undergo extensive branching and their diameters become progressively smaller. There is also a gradual decrease in the height of the lining epithelium, amount of cilia, and number of goblet cells in these tubules. The bronchioles represent the terminal portion of the conducting passageways. These give rise to the respiratory bronchioles, which represent the transition zone between conducting and respiratory portions. The respiratory portion consists of **respiratory bronchioles, alveolar ducts, alveolar sacs,** and **alveoli**. Gaseous exchange in the lungs takes place in the **alveoli**, the terminal air spaces of the respiratory system. In the alveoli, goblet cells are absent and the lining epithelium is thin **simple squamous.**

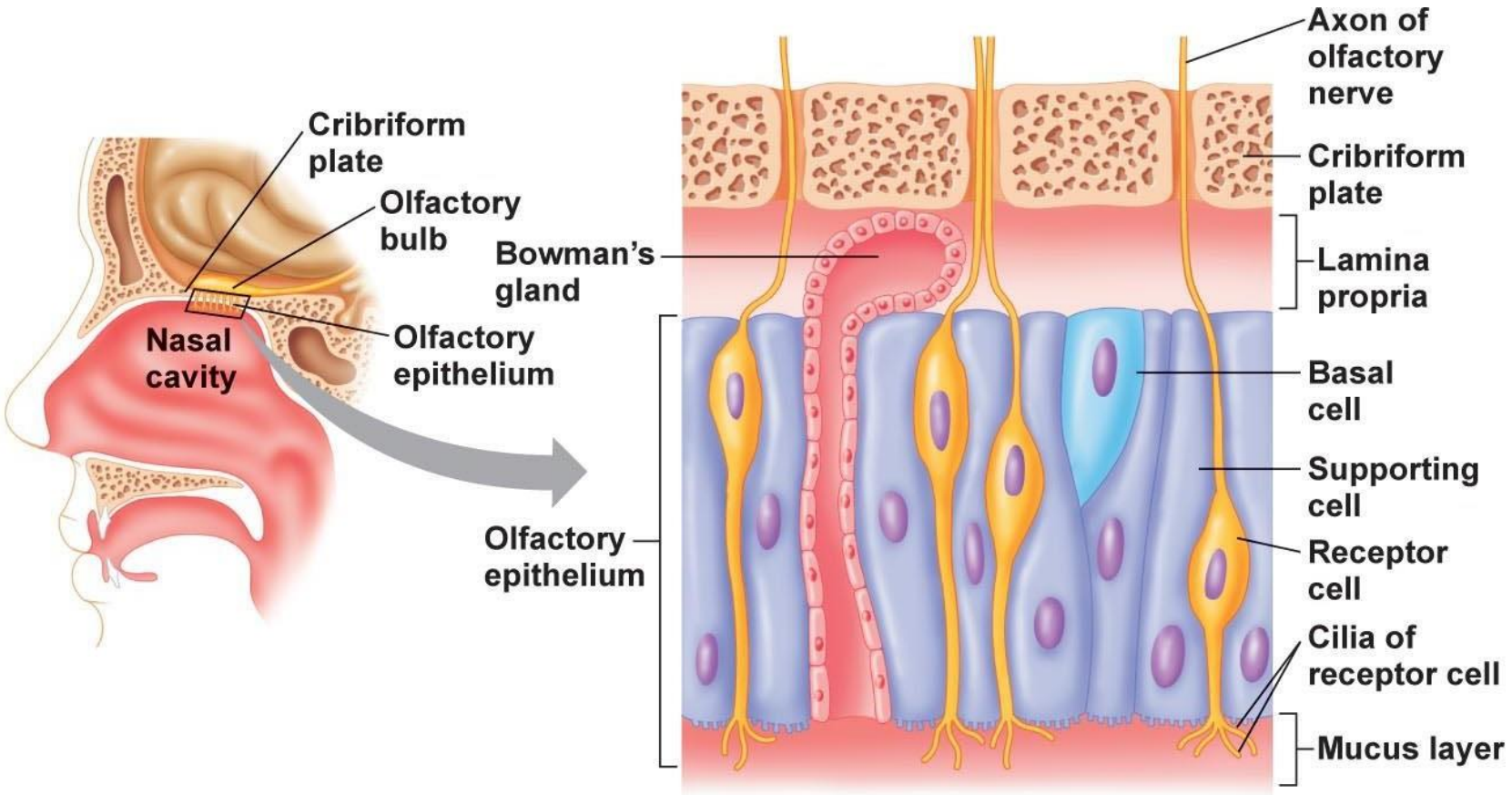
Olfactory Epithelium

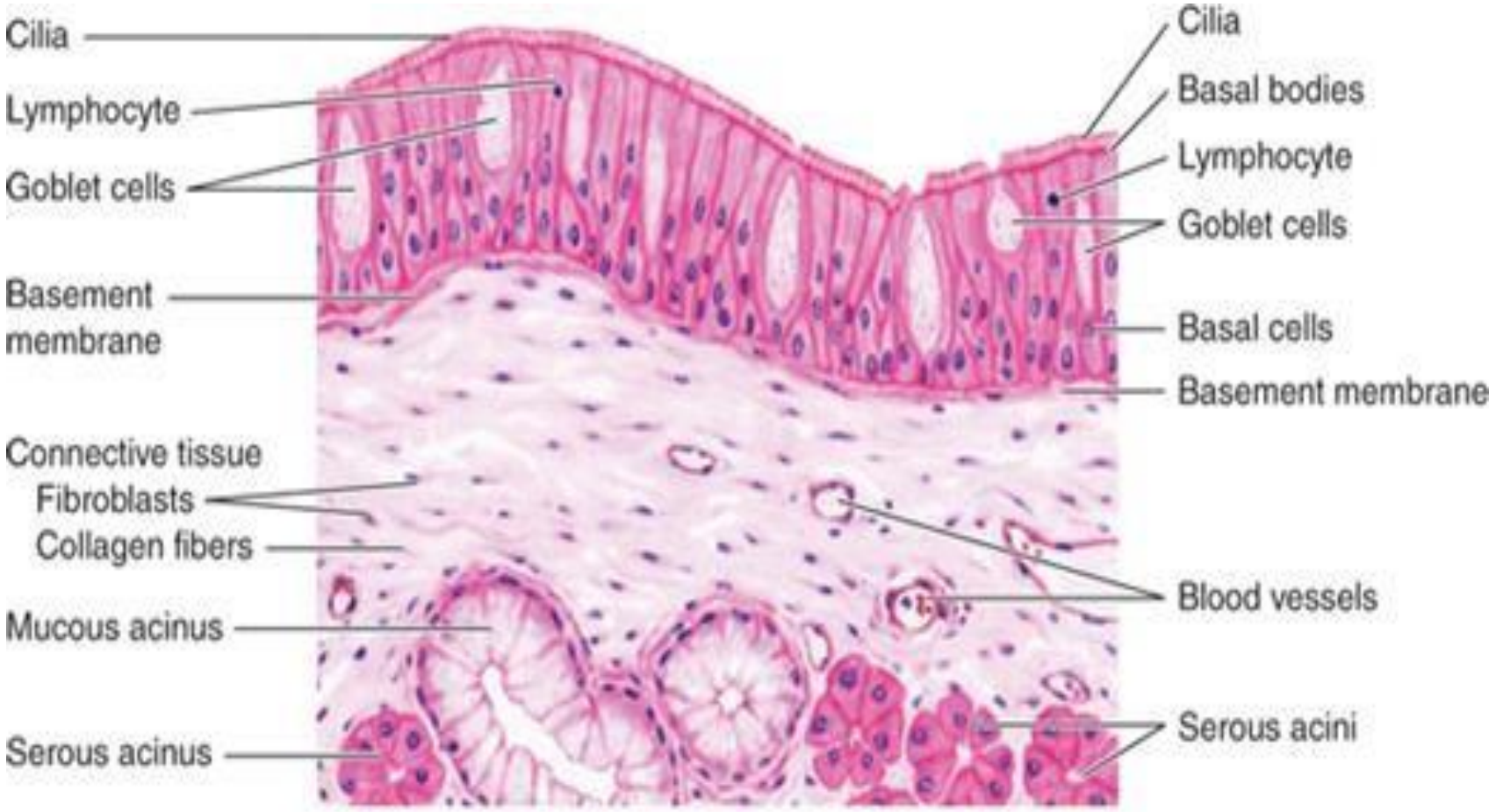
Air that enters the lungs first passes by the roof or superior region of the nasal cavity. Located in the roof of the nose is a highly specialized epithelium, called the olfactory epithelium، which detects and transmits odors. This epithelium consists of three cell types: **supportive (sustentacular), basal,** and **olfactory (sensory).** Located below the epithelium in the connective tissue are the serous olfactory glands.

Olfactory cells are the sensory bipolar neurons that are distributed between the more apical supportive cells and the basal cells of the olfactory epithelium. The olfactory cells span the thickness of the epithelium and end at the surface of the olfactory epithelium as small, round bulbs, called the olfactory vesicles. Radiating from each olfactory vesicle are long, non motile olfactory cilia that lie parallel to the epithelial surface; these non motile cilia function as **odor receptors**. In contrast to respiratory epithelium, the olfactory epithelium has no goblet cells or motile cilia.

In the connective tissue directly below the olfactory epithelium are **olfactory nerves** and **olfactory glands**.

Olfactory (Bowman's)glands produce a serous fluid that bathes the olfactory cilia and serves as a solvent to dissolve the odor molecules for detection by the olfactory cells.





Olfactory epithelium

- Pseudostratified ciliated columnar epithelium

Conducting Portion of Respiratory System

The conducting portion of the respiratory system consists of the **nasal cavities, pharynx, larynx, trachea, extra pulmonary bronchi, and a series of intrapulmonary bronchi** and **bronchioles** with decreasing diameters that end as terminal bronchioles. Hyaline cartilage provides structural support and ensures that the larger air passageways are always patent (open). Incomplete C shaped hyaline cartilage rings encircle the trachea. Elastic and smooth muscle fibers, called the **trachealis muscle.** bridge the space between the ends of the hyaline cartilage.

Nasal Cavity

- Respiratory epithelium everywhere except at the top (which has specialized olfactory epithelium.(
- Serous and mucous glands and numerous blood vessels in lamina propria.
- Nasal septum: midline structure consisting of bone and hyaline cartilage.
- Nasal fossa: chambers on each side of septum.

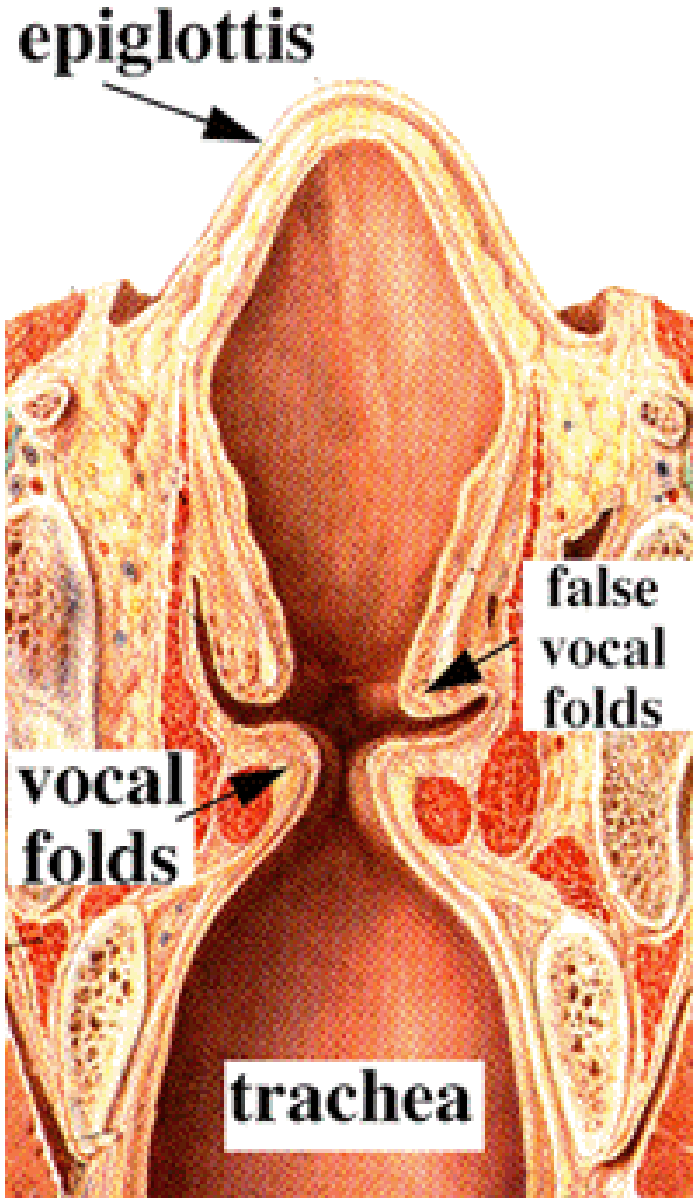
Epiglottis covers laryngeal opening during swallowing.

Core of elastic cartilage.

Superior surface: **nonkeratinized stratified squamous epithelium.**

Inferior surface: **respiratory epithelium**

Vocal folds are covered by **nonkeratinized stratified squamous epithelium**



Laryngeal cartilages support the wall of the larynx and serve as attachments for vocalis muscles.

False vocal folds are covered by **respiratory epithelium**

Larynx and epiglottis

Nasal Cavity Histology

The nasal cavity is lined by a respiratory mucosa like the rest of the respiratory system.

Respiratory mucosa is different from oral mucosa lining the oral cavity but similar to that lining the trachea and bronchi. It consists of ciliated pseudostratified columnar epithelium.

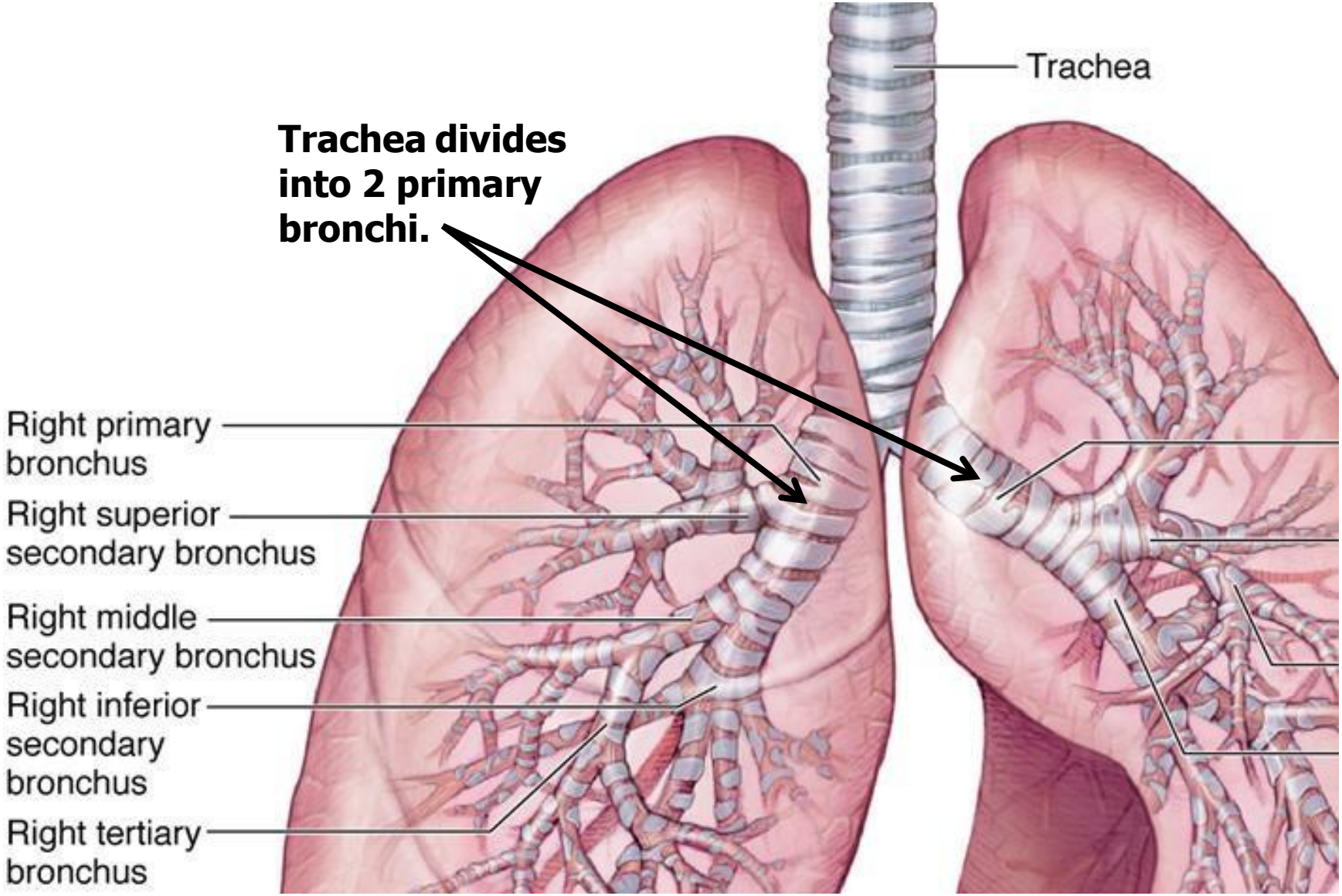
Within the epithelium, and surrounded by mucous and serous glands, are goblet cells, which rest on the basement membrane. Fluids or mucus from the goblet cells and glands keep this mucosa moist, provide humidity, and trap any foreign materials from the inspired air. The moist mucus forms a superficial coating on the respiratory mucosa.

Nasal Cavity Histology

This coating is moved by ciliary action posteriorly to the nasopharynx, where it is either expectorated or swallowed. In this manner, foreign materials are trapped and removed. Because the lamina propria of the mucosa is extremely vascular, it also warms the incoming breathed air.

Trachea

- Extends from larynx and divides into two primary bronchi.
- Contains 16-20 C-shaped hyaline cartilage rings with the dorsal opening bridged by smooth muscle (**trachealis muscle**.(
- Lined by **respiratory epithelium**.
- Seromucous glands in lamina propria and submucosa.


Trachea
Trachea divides into 2 primary bronchi.
Right primary bronchus
Right superior secondary bronchus
Right middle secondary bronchus
Right inferior secondary bronchus
Right tertiary bronchus

Trachea

Bronchi

- Trachea divides into two primary bronchi, which divide into secondary bronchi.
- Secondary bronchi divide into tertiary bronchi, which supply bronchopulmonary segments.
- Tertiary bronchi divide into smaller bronchi, which divide into bronchioles.

Morphologic Changes as Bronchi Branch

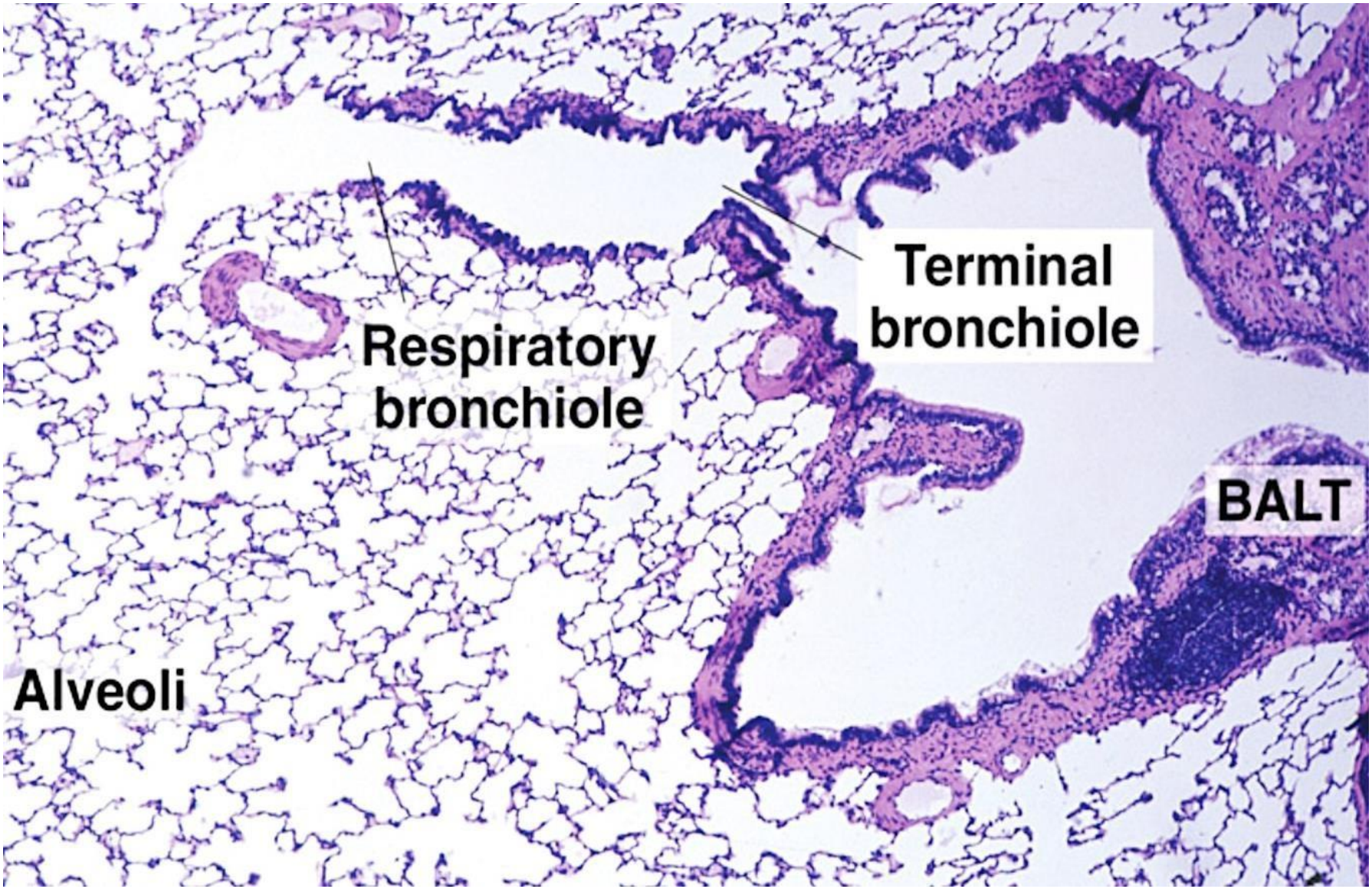
- Bronchi undergo 9-12 branchings.
- As branching progresses:
  - Connective tissue decreases in thickness
  - Relative amount of smooth muscle and elastic tissue increases
  - Cartilage disappears (gone by bronchioles(

Bronchioles

- NO glands or cartilage.
- Larger bronchioles have **respiratory epithelium.** Smaller bronchioles have low columnar epithelium.
- In asthma, the smooth muscle in the bronchioles constricts, causing difficulty breathing.

Terminal Bronchioles

- **Simple cuboidal epithelium with cilia**.
- Also: **Clara cells** (non-ciliated epithelial cells with secretory granules.(
- No goblet cells.
- As you go down the respiratory tract, goblet cells are lost before cilia.



Respiratory bronchiole

Respiratory Portion of the Respiratory System

The respiratory portion of the respiratory system is the distal continuation of the conducting portion and starts with the air passageways where respiration or gaseous exchange occurs.

Terminal bronchioles give rise to respiratory bronchioles, which exhibit thin-walled out pocketing's called **alveoli** and where respiration can take place. The respiratory bronchioles represent the transitional zone between air conduction and gaseous exchange or respiration.

Respiration can only occur in alveoli because the barrier between inspired air in the alveoli and venous blood in capillaries is extremely thin. Other intrapulmonary structures in which respiration occurs are the alveolar ducts and alveolar sacs.

In addition to the cells in the passageways, there are other cell types in the lung. The alveoli contain two cell types. The most abundant cells are the **squamous alveolar cells or type I pneumocytes.** These are extremely squamous cells that line all alveolar surfaces. Interspersed among the squamous alveolar cells either singly or in small groups are **the type II pneumocytes.** **Lung macrophages**, derived from circulating blood **monocytes**, are also found both in the connective tissue of alveolar walls or inter-alveolar septa (alveolar macrophages) and in the alveoli (**dust cells**). Also present in the inter-alveolar septa are extensive capillary networks, pulmonary arteries, pulmonary veins, lymphatic ducts, and nerves.

Alveoli

- Sac-like structures with super-thin walls so O_2 and CO_2 can diffuse between air and blood.
- Separated by interalveolar septae, which contain capillaries.
- Cells lining interalveolar septae:
  - Type I cells (thin, flat squamous cells(
  - Type II cells (pneumocytes): produce surfactant
  - Alveolar macrophages (dust cells(

Type I Cells

- Cover 95% of alveolar surface
- **Simple squamous cells** with thin cytoplasm
- Blood-air barrier includes (from air to blood:(
  - Type I cells
  - Fused basal laminae of type I cells and capillary endothelial cells
  - Capillary endothelial cells

Type II Cells (Pneumocytes(

- Cover 5% of alveolar surface.
- Large cuboidal cells with round nuclei.
- Typical secretory cell structure. Lamellar bodies in cytoplasm make and store surfactant.
- Surfactant decreases surface tension in alveoli and prevents collapse of alveoli during expiration.

Alveolar Macrophages (Dust Cells(

- Found on surface of alveoli, within alveoli and in interstitial connective tissue.
- Remove debris and particles that escape mucus and cilia in conducting portion of respiratory tract

Typical respiratory epithelium consists of 5 cell types (as seen in the electron microscope):

A. Ciliated Columnar Cells: Constitute the most abundant type. Each cell has about 300 cilia on its apical surface; beneath the cilia, in addition to basal bodies, are numerous small mitochondria which supply ATP for ciliary beating.

B. Mucous Goblet Cells: The next most abundant cells in the respiratory epithelium. The apical portion of these cells contains the mucous droplets composed of glycoproteins.

C. Brush Cells: The remaining columnar cells because of the numerous microvilli on their apical surface. Brush cells have afferent nerve endings on their basal surfaces and are considered to be chemosensory receptors.

D. Basal (Short) Cells: Are small rounded cells that lie on the basal lamina but do not extend to the luminal surface of the epithelium. These cells are believed to be generative stem cells that undergo mitosis and subsequently differentiate into the other cell types.

E. 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).

(Important Note)

Smell (Olfaction) The olfactory chemoreceptors are located in the olfactory epithelium, a specialized area of the mucous membrane covering the superior conchae at the roof of the nasal cavity. In adult humans, it is about $10cm^2$ in area and up to 100μm in thickness. This thick, pseudostratified columnar epithelium has three major cells