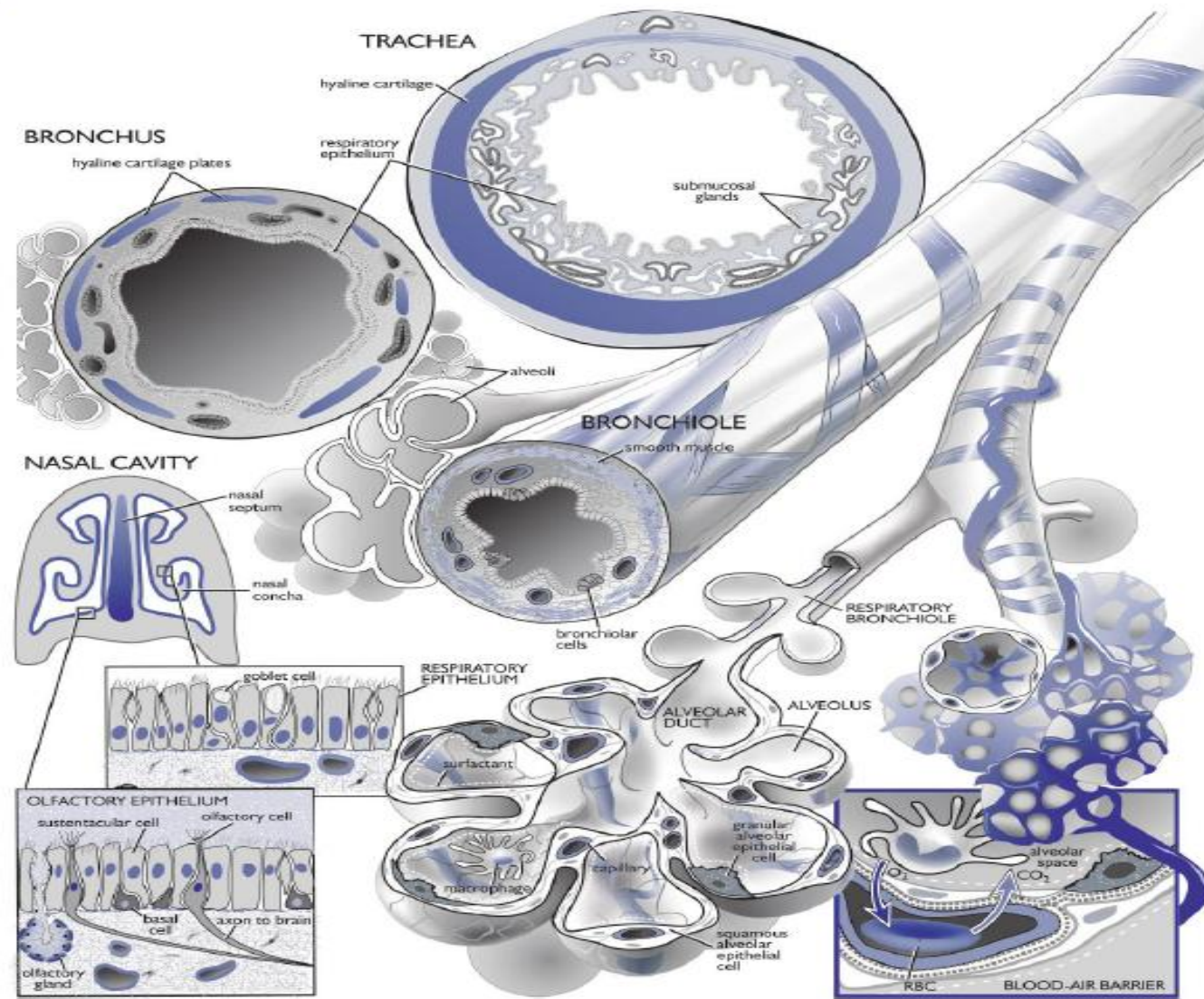




Histology of Respiratory System

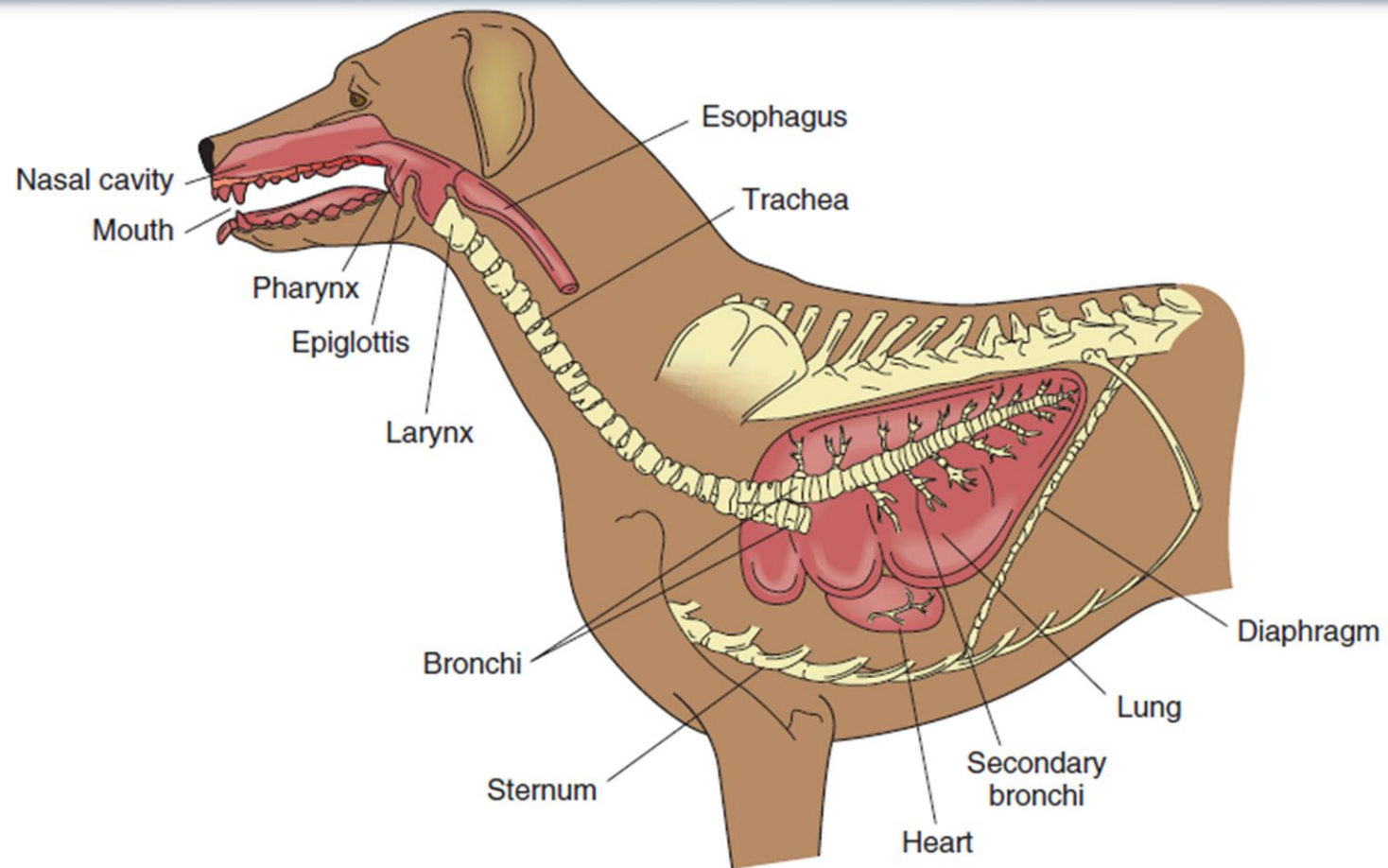
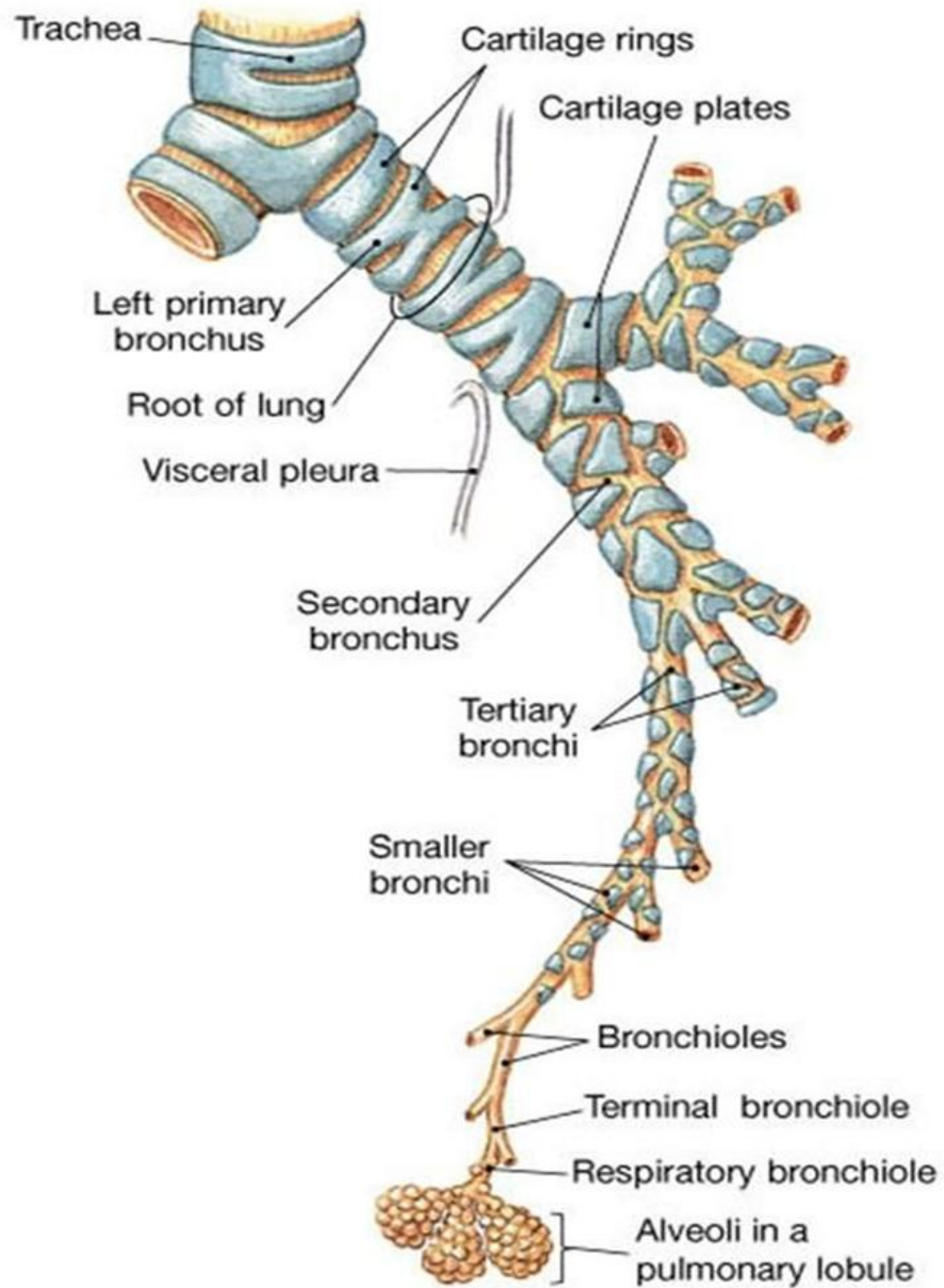
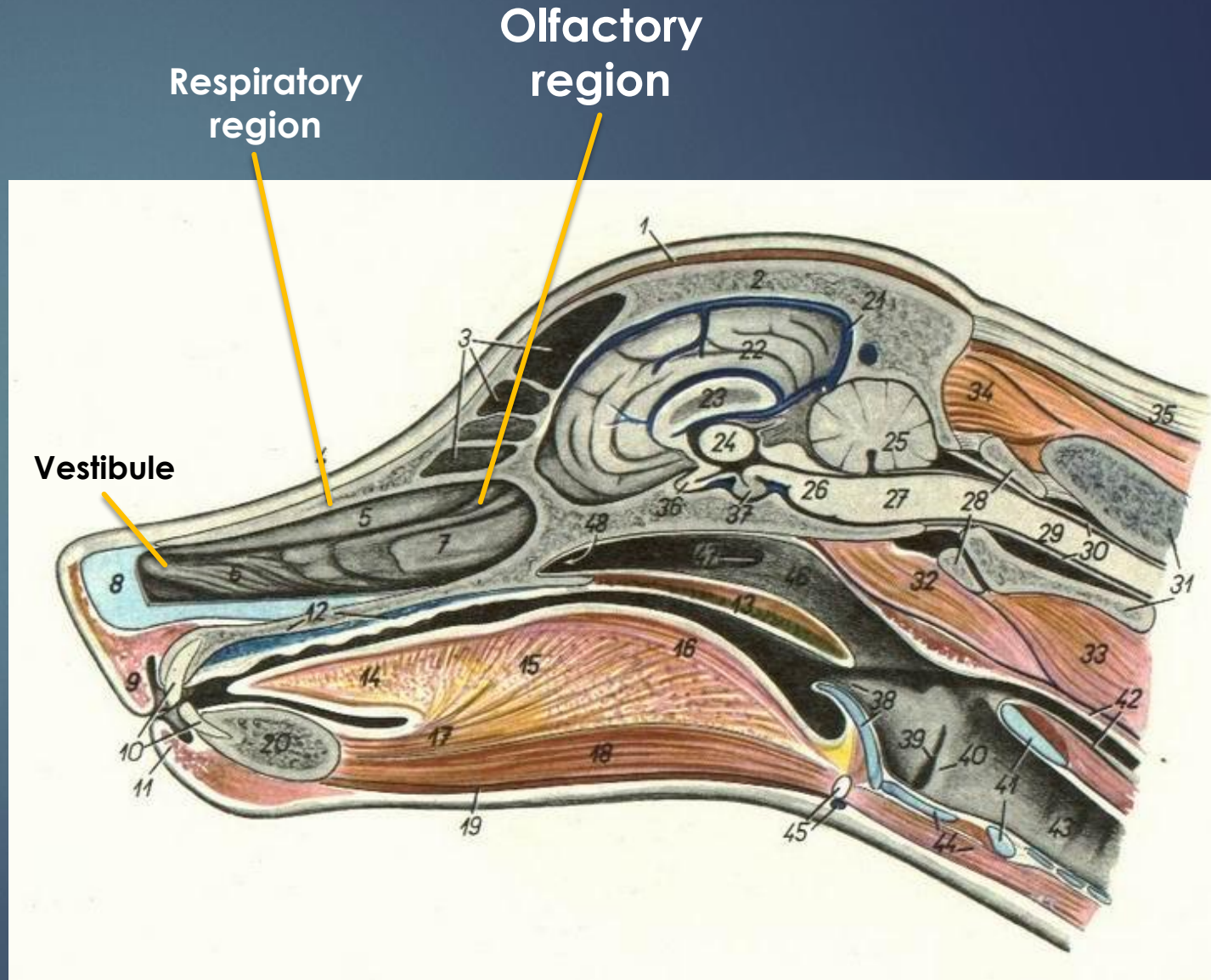


Figure 9-1 Structures of the respiratory system.



Nasal cavity

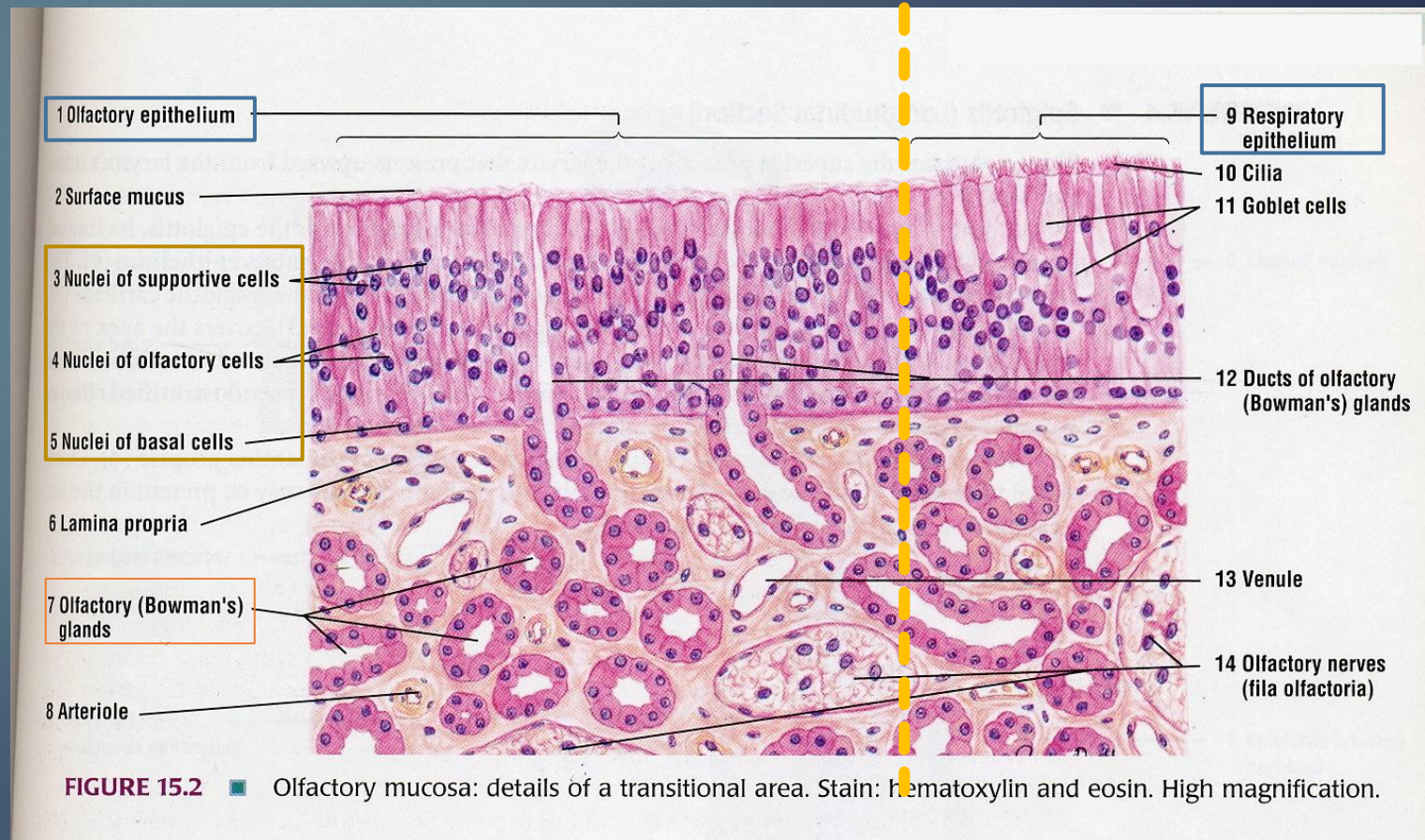
Lining epithelium of the nasal cavity is ciliated pseudostratified columnar epithelium with goblet cells, also known as respiratory epithelium. Secretions from mixed serous and mucous glands humidify the incoming air, while submucosal vascular tissue provides thermoregulation. The conchae are covered by respiratory epithelium.

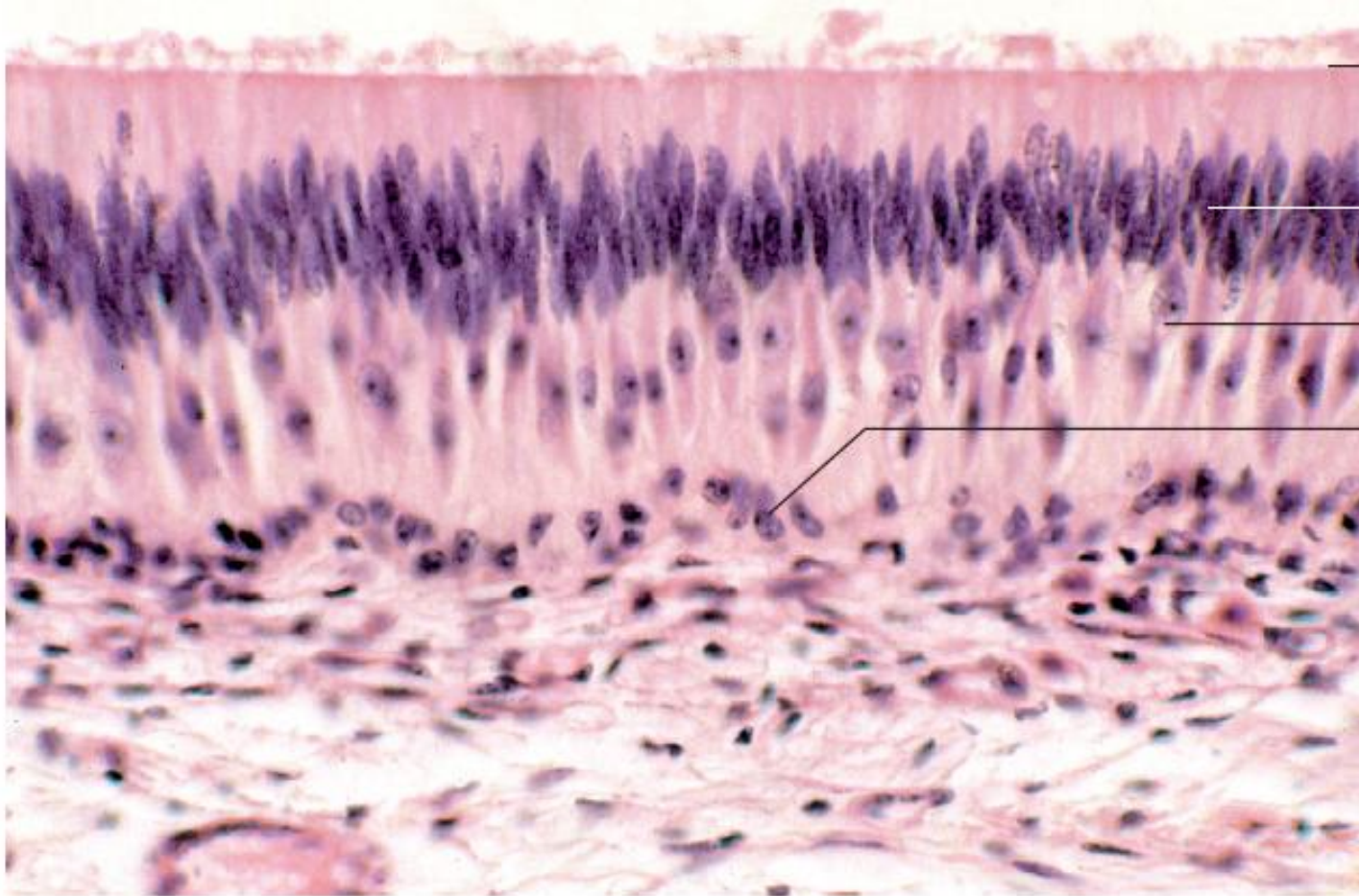


Olfactory mucosa

Olfactory epithelium is comprised of sustentacular, basal and olfactory cells. The uppermost layer of epithelial nuclei belong to supportive sustentacular cells which are columnar shaped and have surface microvilli. The nuclei of epithelial stem cells, the basal cells, form the deepest nuclear layer.

The balance of the nuclei belong to olfactory cells which are bipolar neurons with non-motile cilia. Soluble components of odors are taken up by the olfactory cell. Chemical reaction then generates electrical impulses which are sent to the brain via axons of the olfactory nerve. Olfaction is assisted by serous secretions from olfactory glands (Bowman's glands) beneath the olfactory epithelium.





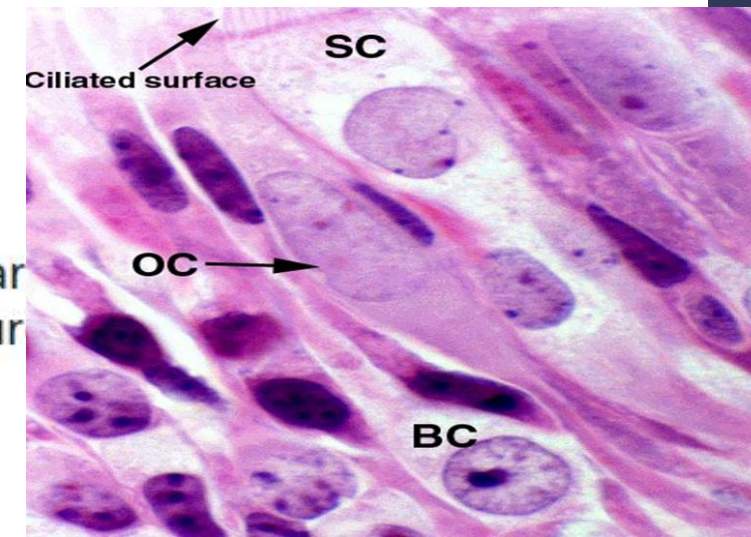
Cilia of neurosensory cells with mucus

Nuclei of sustentacular cells Or Supporting cells

Nuclei of neurosensory cells (bipolar neurons)
Or Olfactory cells

Nuclei of basal cells

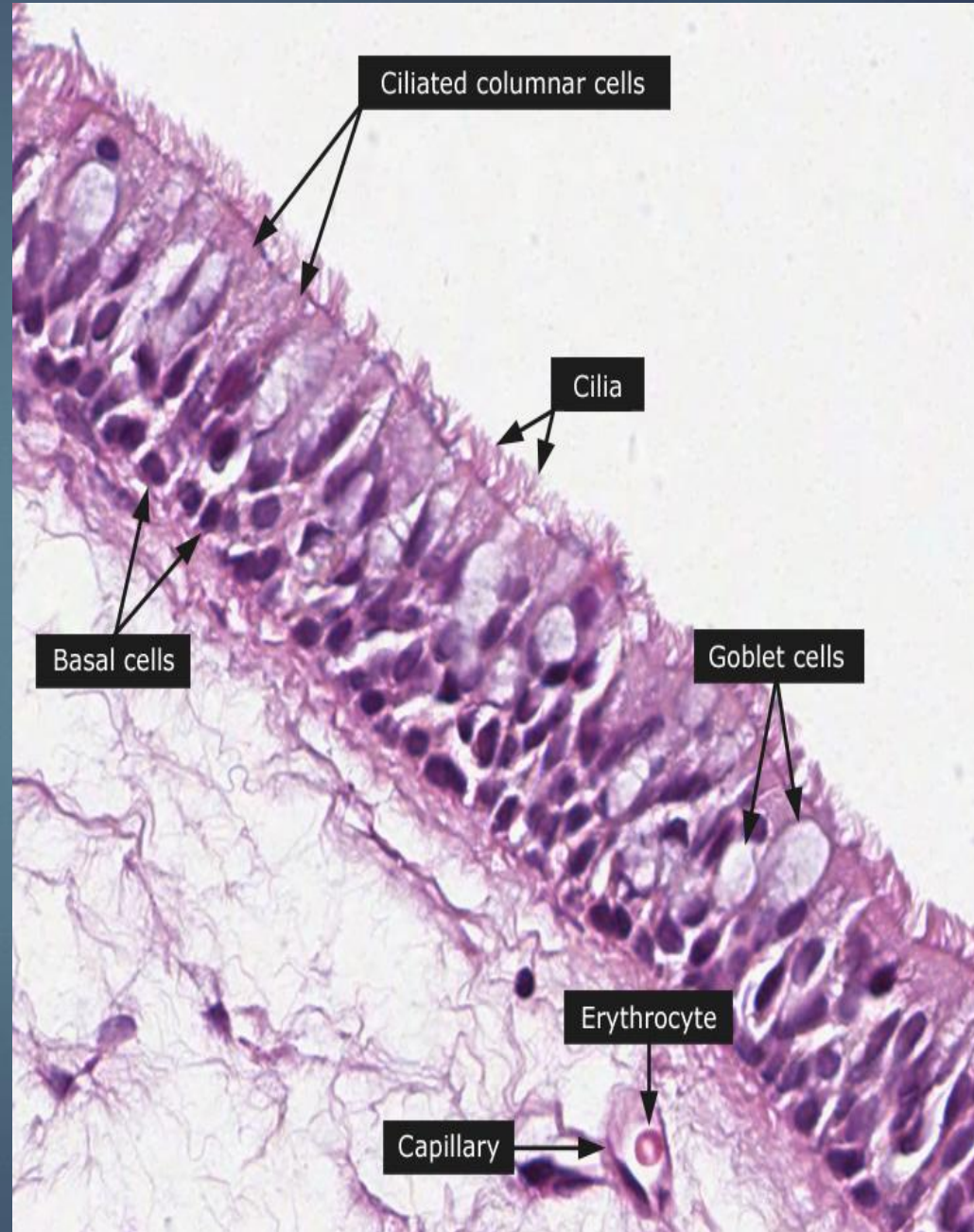
11.4 Olfactory mucosa (dog). The epithelium contains sustentacular cells, bipolar cells considered to serve as reserve cells for replacement of other cell types, including neurosensory cells (x275).



Nasopharynx

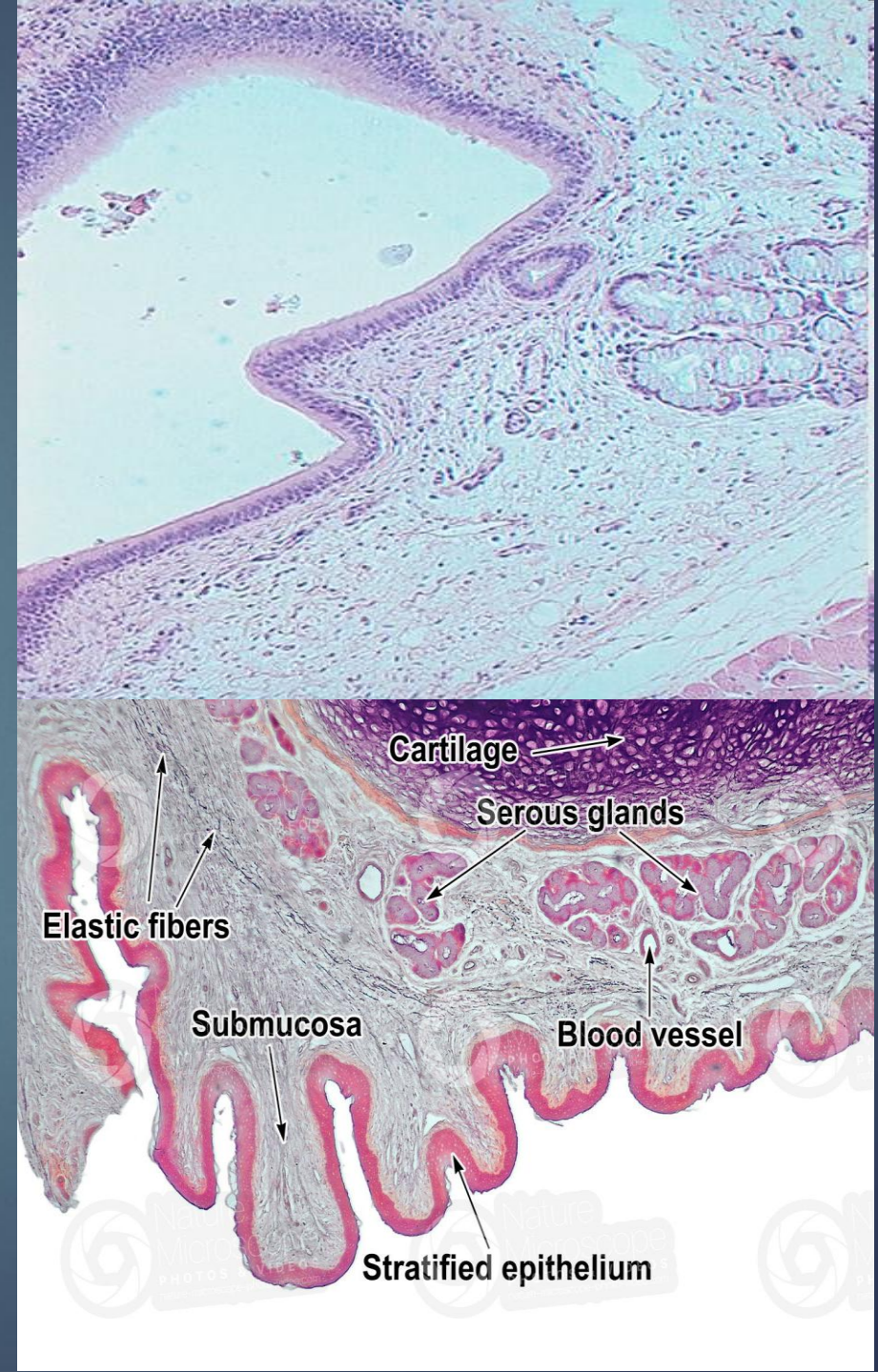
The nasopharynx connects the nasal cavity to the pharynx.

Respiratory epithelium lines the cavity and both diffuse and aggregated lymphatic tissues are present beneath the epithelium. The pharyngeal tonsil is located in the roof of the nasopharynx.



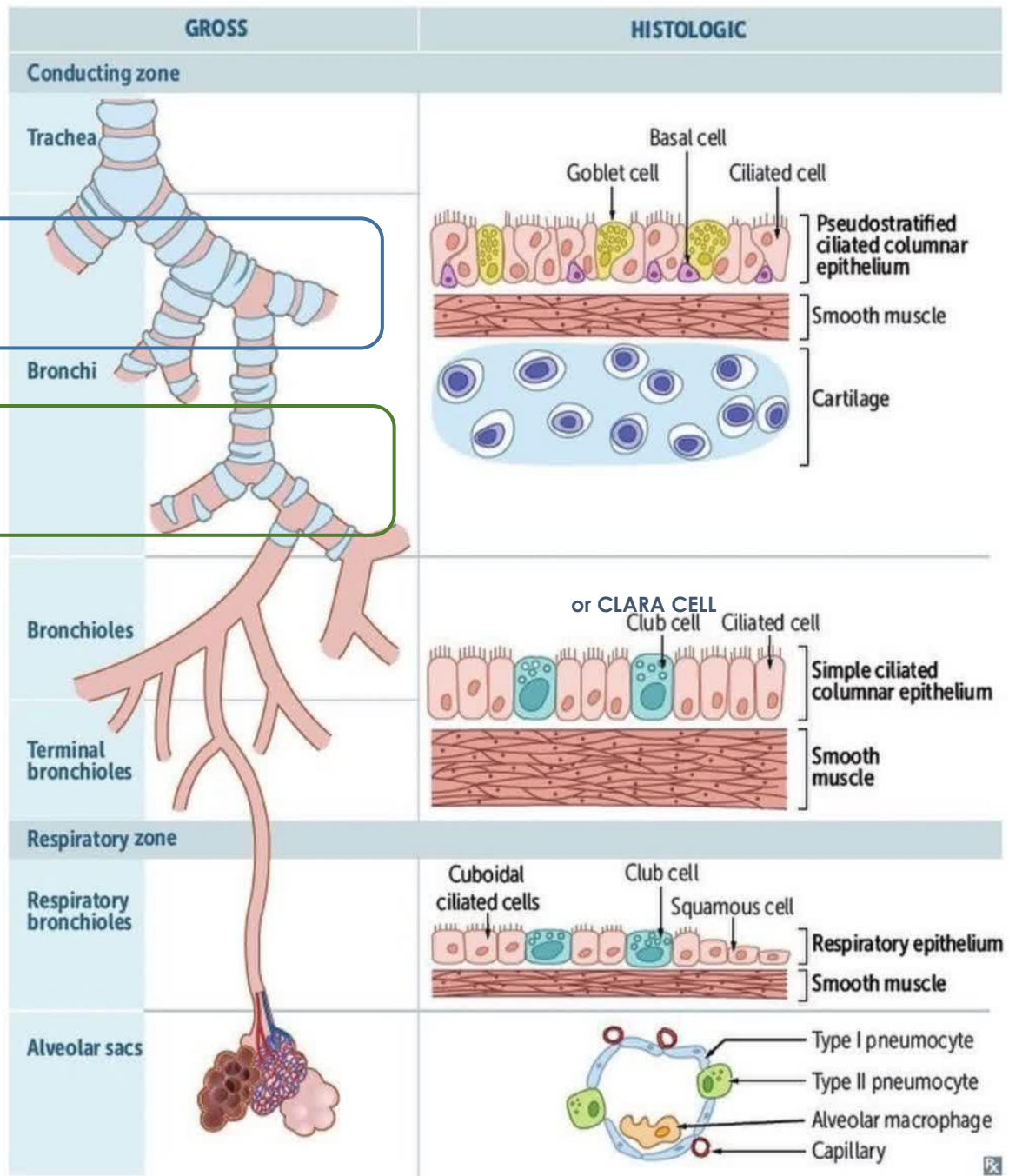
Larynx

The larynx connects the pharynx to the trachea. Stratified squamous epithelium lines the larynx and transitions to respiratory epithelium before reaching the trachea. Elastic cartilage forms the epiglottis cartilage. The remaining laryngeal cartilages are comprised of hyaline cartilage. Lymphatic tissue is present between the epithelium and the cartilage.



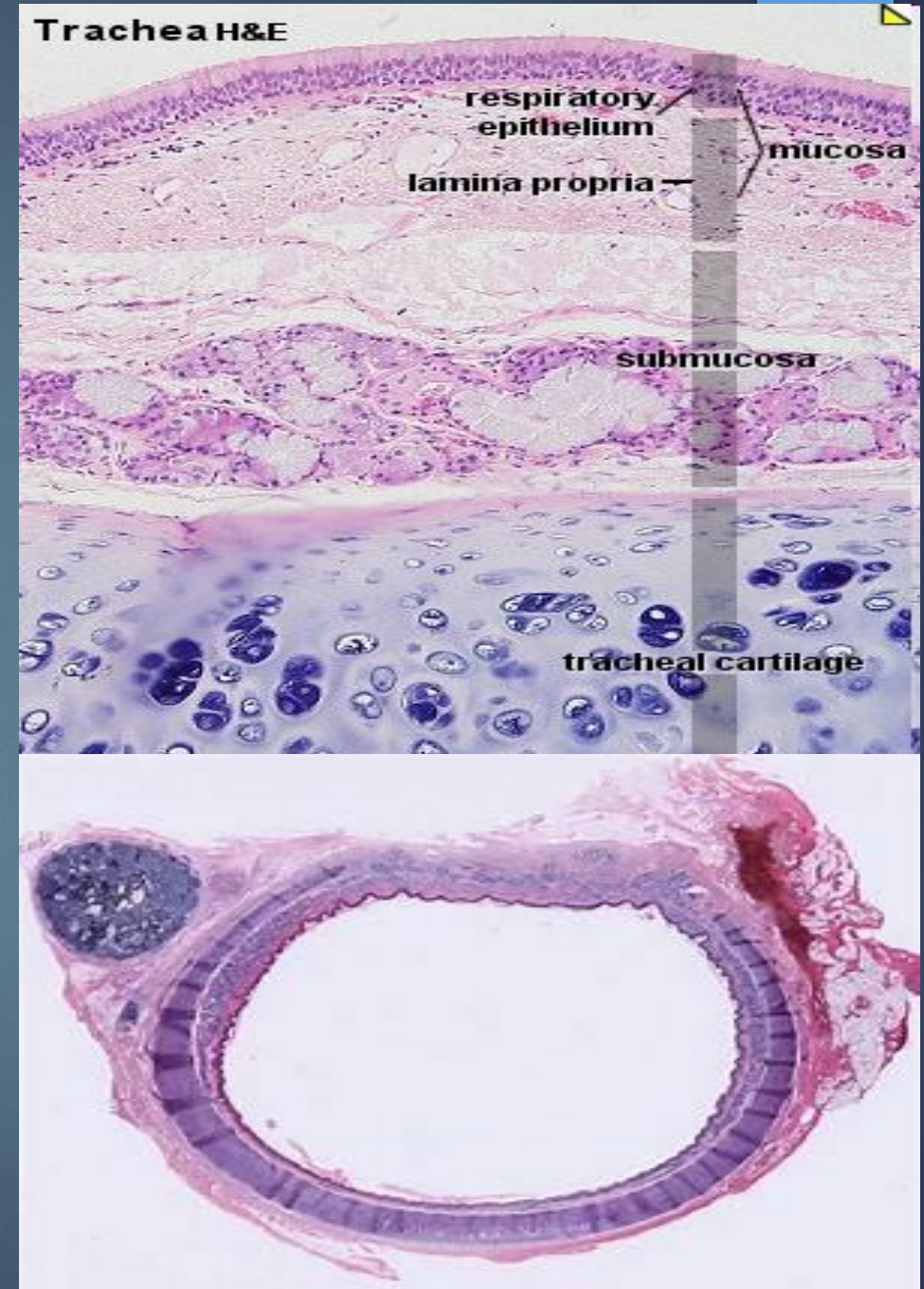
Primary
bronchus

Secondary
bronchus



Trachea

The trachea is lined by respiratory epithelium. Seromucous submucosal glands produce tracheal secretions which are swept toward the larynx by the epithelial cilia. C-shaped hyaline cartilage rings in the propria-submucosa provide shape and support for the tracheal wall. Smooth muscle connects the ends of the tracheal ring. The trachea is surrounded by a tunica adventitia.



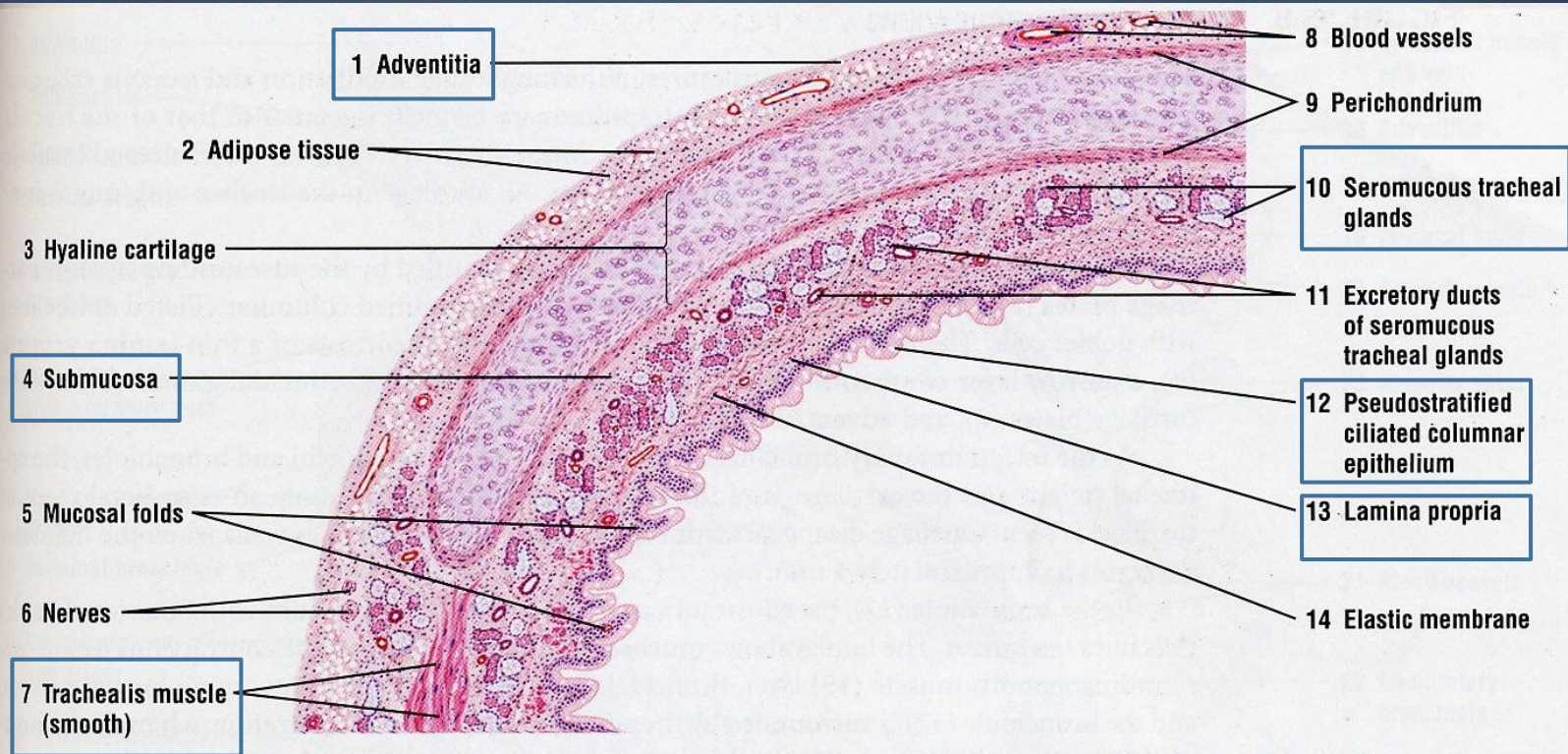
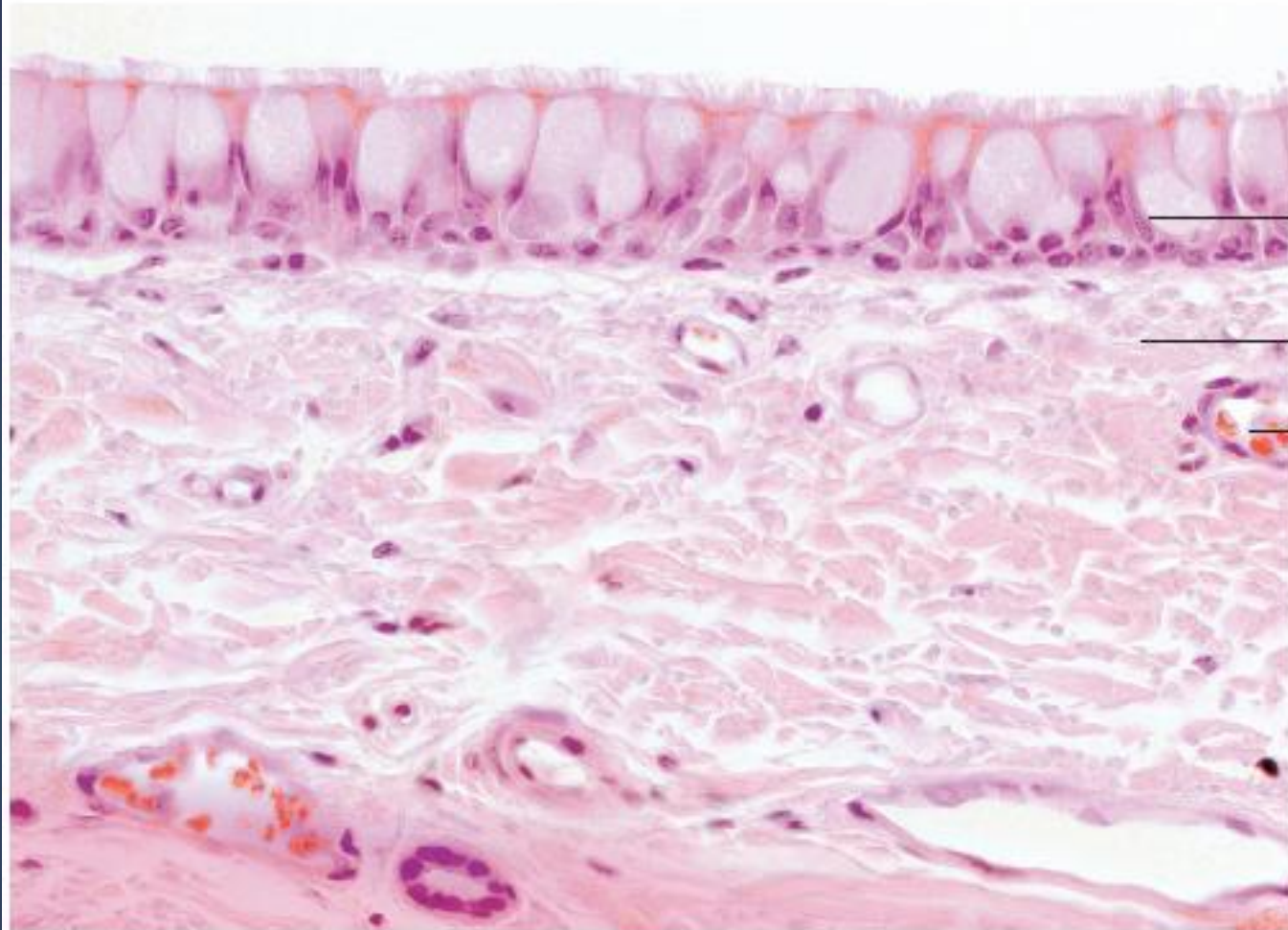


FIGURE 15.6 ■ Trachea (transverse section). Stain: hematoxylin and eosin. Low magnification.



FIGURE 15.7 ■ Tracheal wall (sectional view). Stain: hematoxylin and eosin. Medium magnification.



Respiratory epithelium with goblet cells

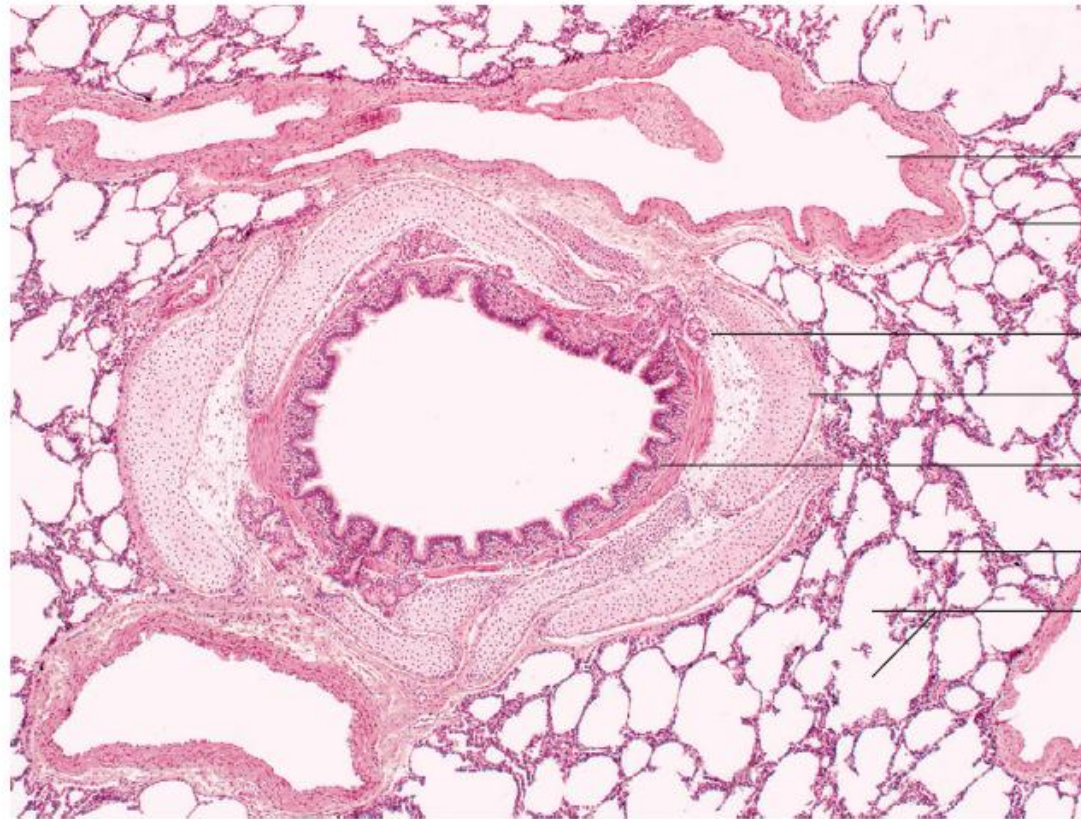
Lamina propria

Mixed glands

11.13 Trachea (dog). The wall is lined by respiratory epithelium with goblet cells, resting on a layer of loose connective tissue containing glands. These layers are surrounded by the cartilage of the tracheal rings. Haematoxylin and eosin (x240).

Bronchus

Each bronchus is lined with respiratory epithelium. Hyaline cartilage in the propria submucosa is arranged in multiple plates.



Vein

Alveoli

Bronchus with mixed glands

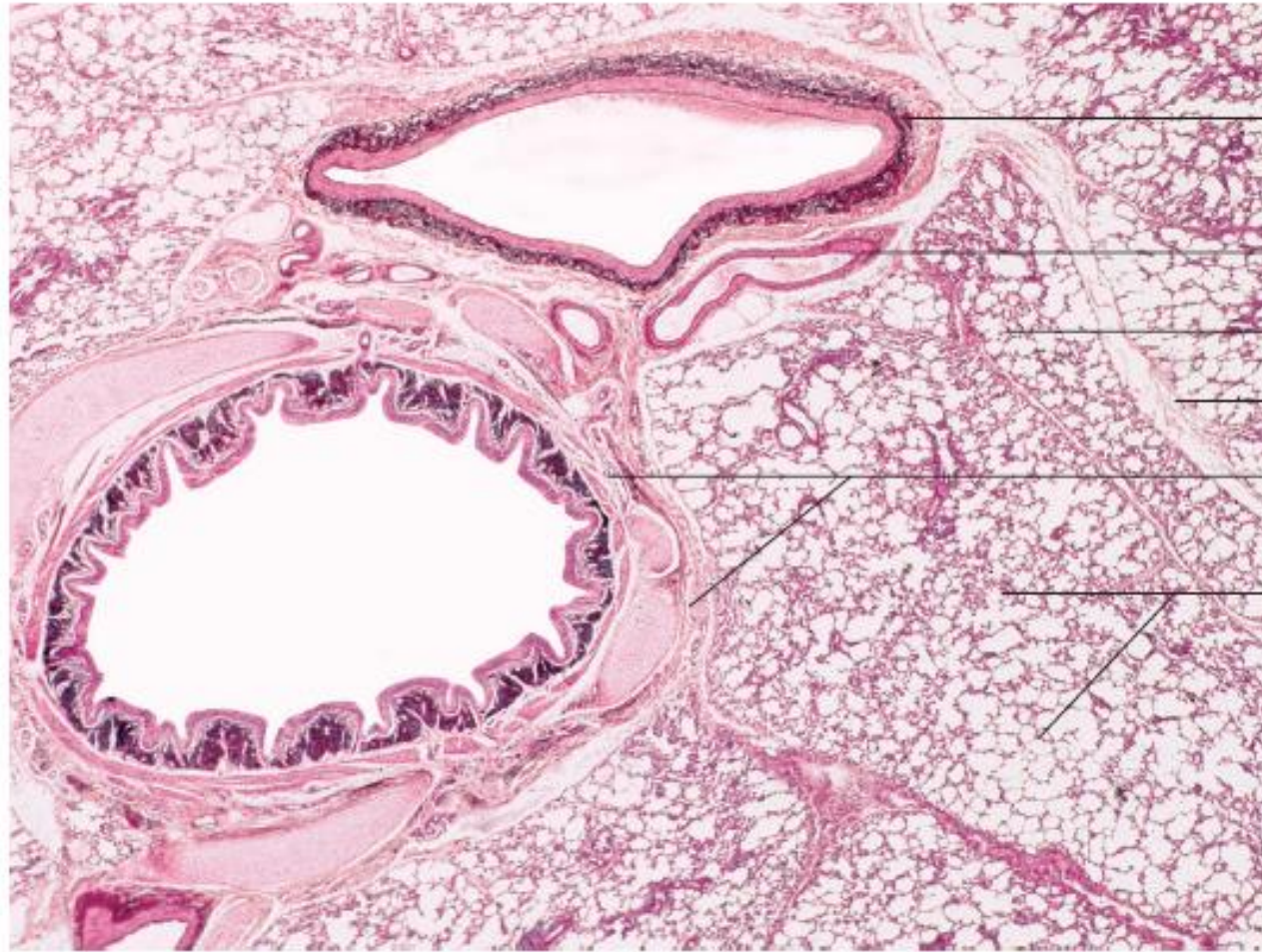
Fragmented rings of hyaline cartilage

Bronchial epithelium

Inter-alveolar septum

Alveoli

11.17 Lung (ox). Bronchi are characterised by the presence of mixed glands and hyaline cartilage rings or fragments. Haematoxylin and eosin stain (x30).



Vein

Artery

Alveoli

Connective tissue

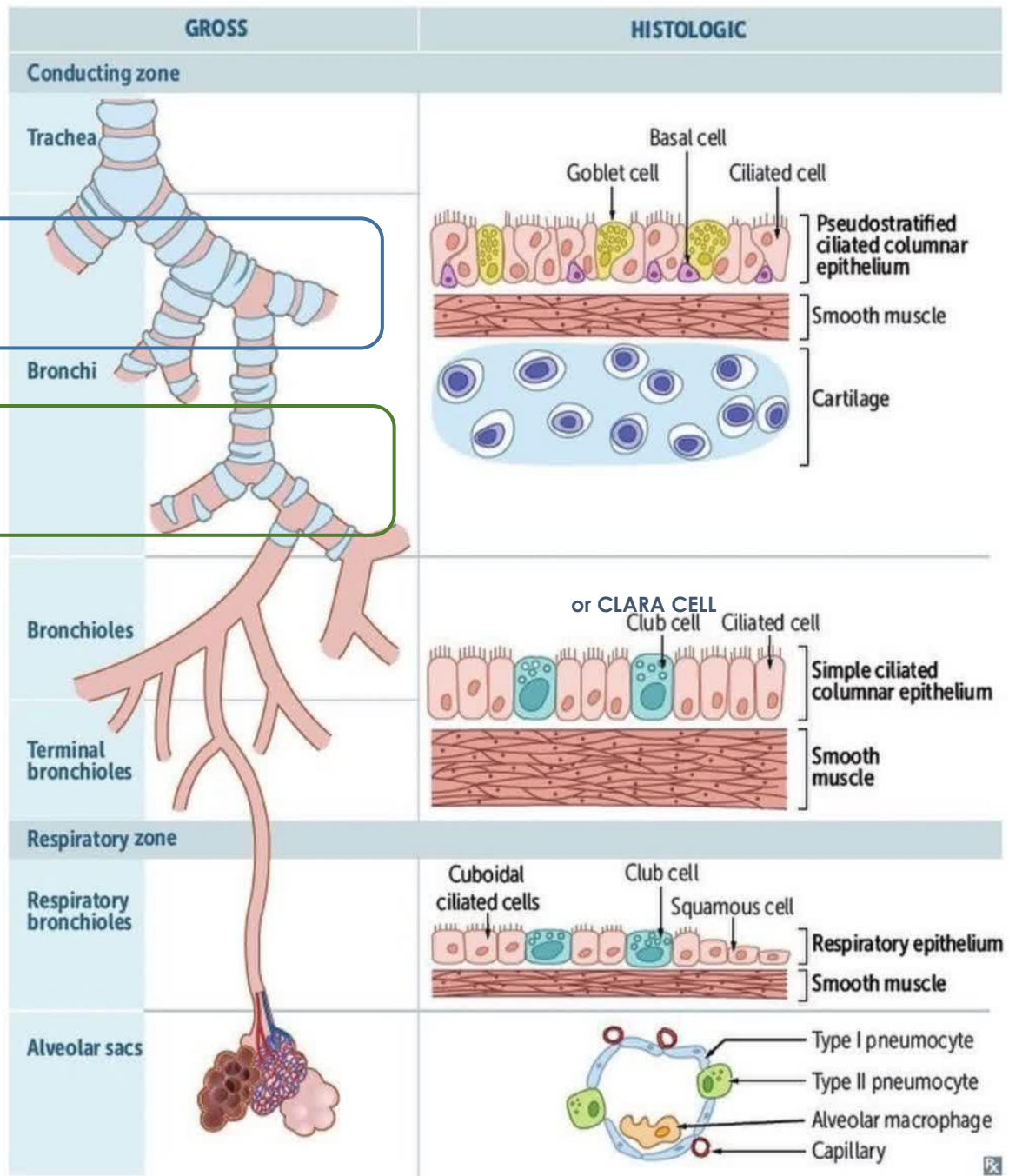
Bronchus with fragments of hyaline cartilage

Alveoli

11.18 Lung (calf). The staining technique used in this section highlights the elastic fibres, which are particularly prominent in the larger bronchial branches. Resorcin–fuchsin–nuclear-fast red (Weigert's elastic) stain (x30).

Primary
bronchus

Secondary
bronchus



Bronchiole

Bronchioles lining epithelium decreases in height to simple cuboidal epithelium. In this region, the epithelium is comprised of bronchiolar cells (Clara cells), ciliated lining cells, and neuroendocrine cells. The cartilage is replaced by prominent smooth muscle.



Loose interstitial connective tissue

Smooth muscle

Lamina propria with isolated smooth muscle cells

Epithelium

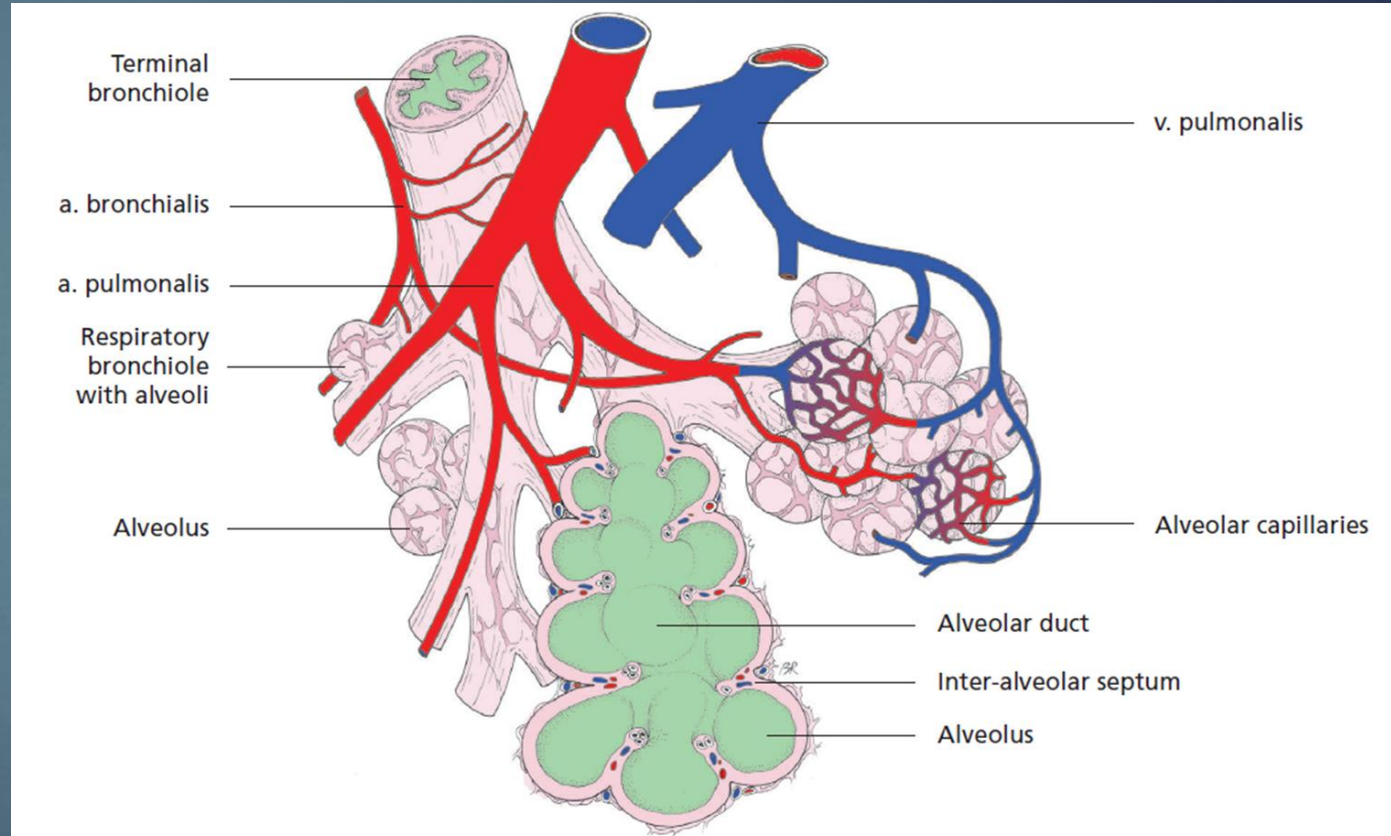
11.21 Bronchiole (lung, ox). The respiratory mucosa is deeply folded, due to the constrictive effect of elastic fibre bundles and smooth muscle. In contrast to bronchi, glands and cartilage are lacking. Haematoxylin and eosin stain (x275).

Respiratory Bronchiole

Bronchioles continue as **respiratory bronchioles**. Gas exchange occurs in the alveoli which protrude from the walls of the respiratory bronchiole.

The **alveolar duct** connects the respiratory bronchiole with the **alveolar sac**, a cluster of alveoli. Smooth muscle is diminished to small patches in the wall of the duct.

The **alveolus** is a thin-walled structure where gas exchange occurs in the lung. Squamous **alveolar epithelial cells** are the primary lining cell. Scattered **granular alveolar epithelial cells** produce surfactant which maintains surface tension in the alveolus. In the lumen, **alveolar macrophages** remove particulate material from the epithelial surface.



11.15 Peripheral bronchial tree with alveoli and vascular supply (schematic).

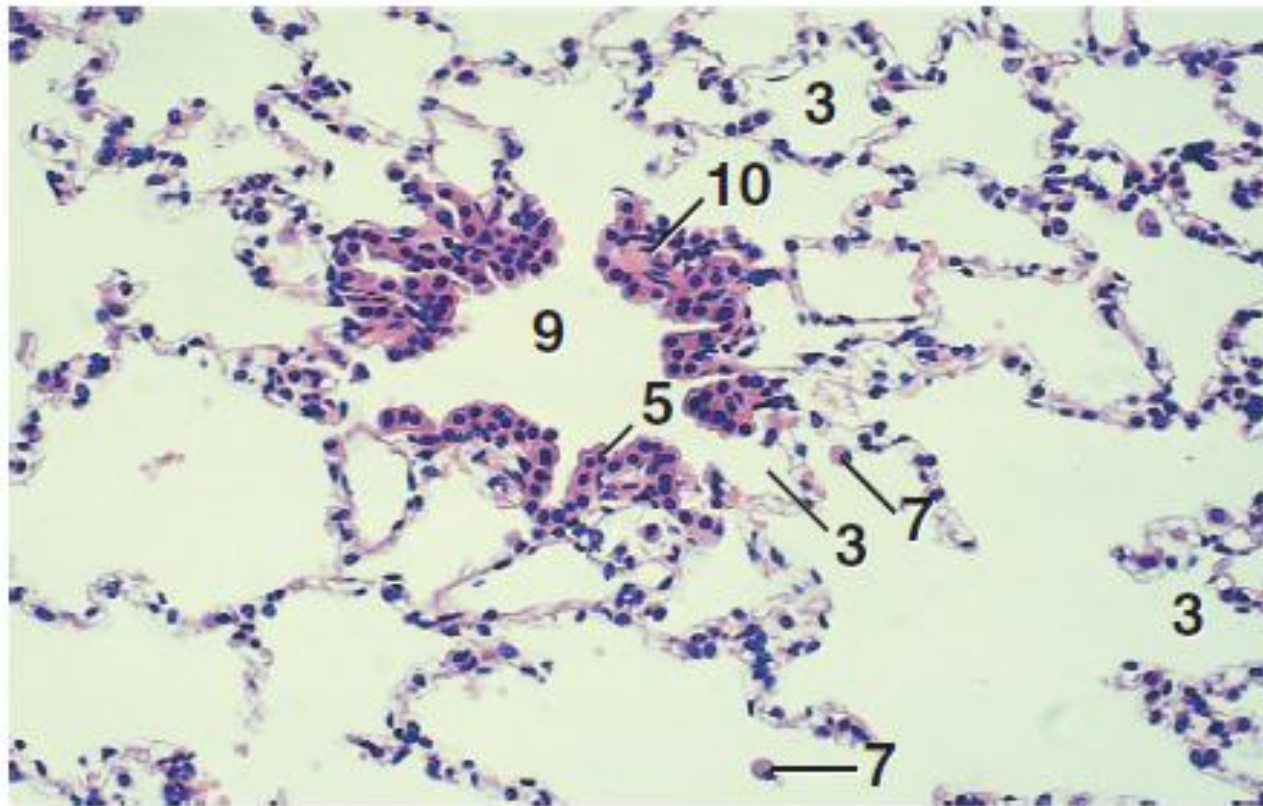


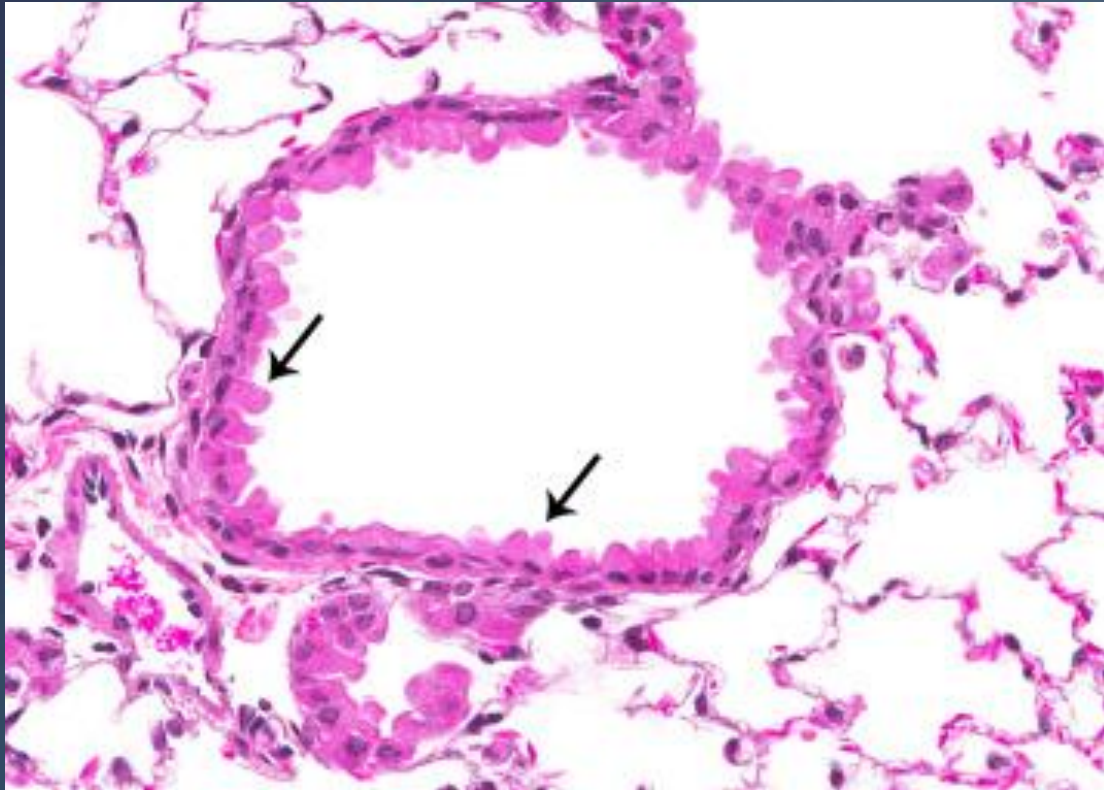
Figure 15.27

×125

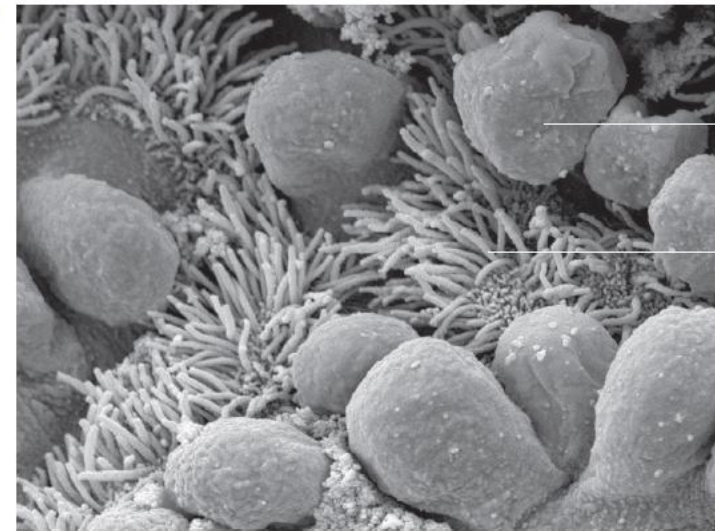
KEY

- | | |
|------------------------|---------------------------|
| 1. Alveolar duct | 6. Elastic fibers |
| 2. Alveolar sac | 7. Macrophage |
| 3. Alveolus | 8. Muscularis |
| 4. Bronchiole | 9. Respiratory bronchiole |
| 5. Cuboidal epithelium | 10. Smooth muscle |

Figure 15.27. Respiratory Bronchiole, x.s., Cat. Respiratory bronchioles are lined by a cuboidal epithelium and have alveoli in their walls.



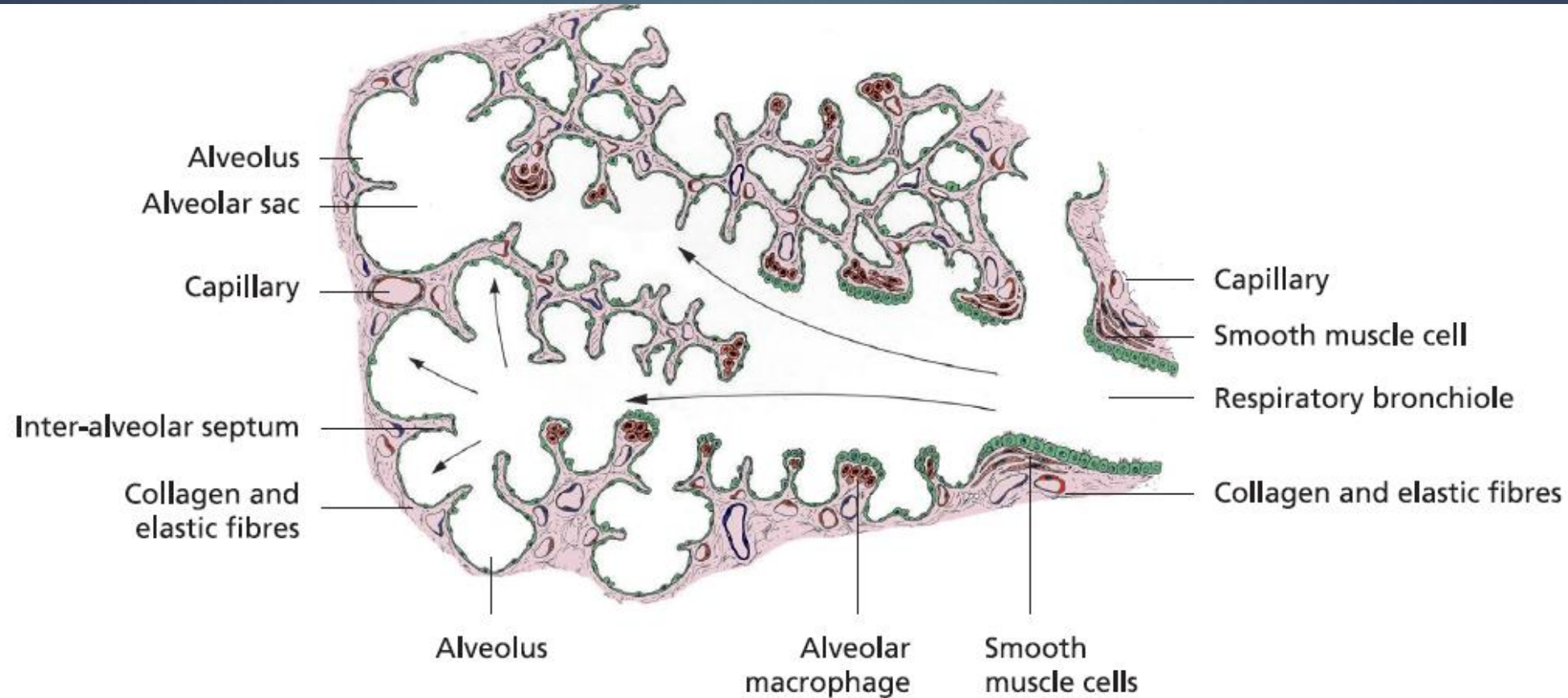
11.25 Scanning electron micrograph of the wall of a bronchiole (x2000). (Courtesy of S. Reese, Munich).



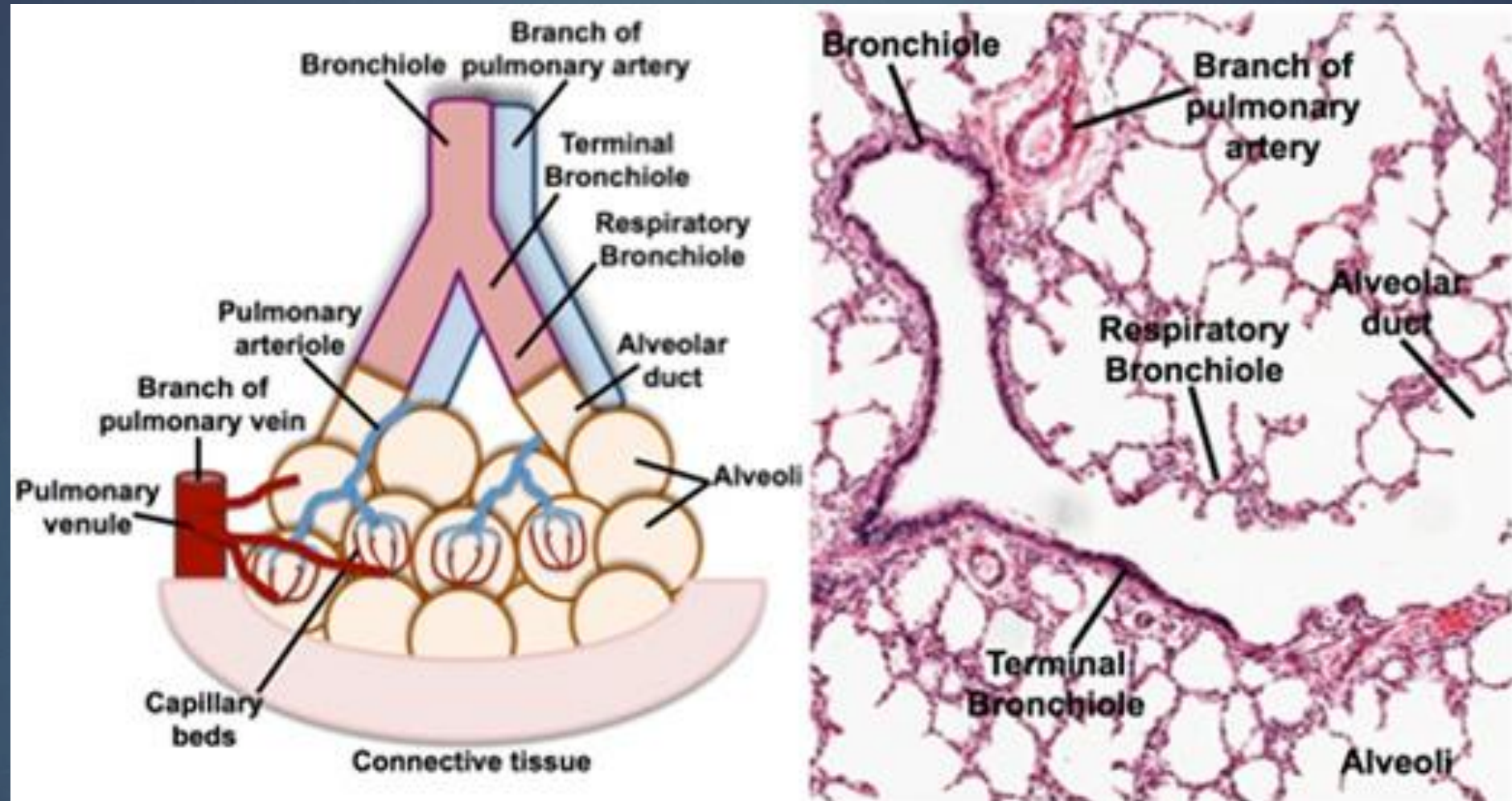
Clara cell

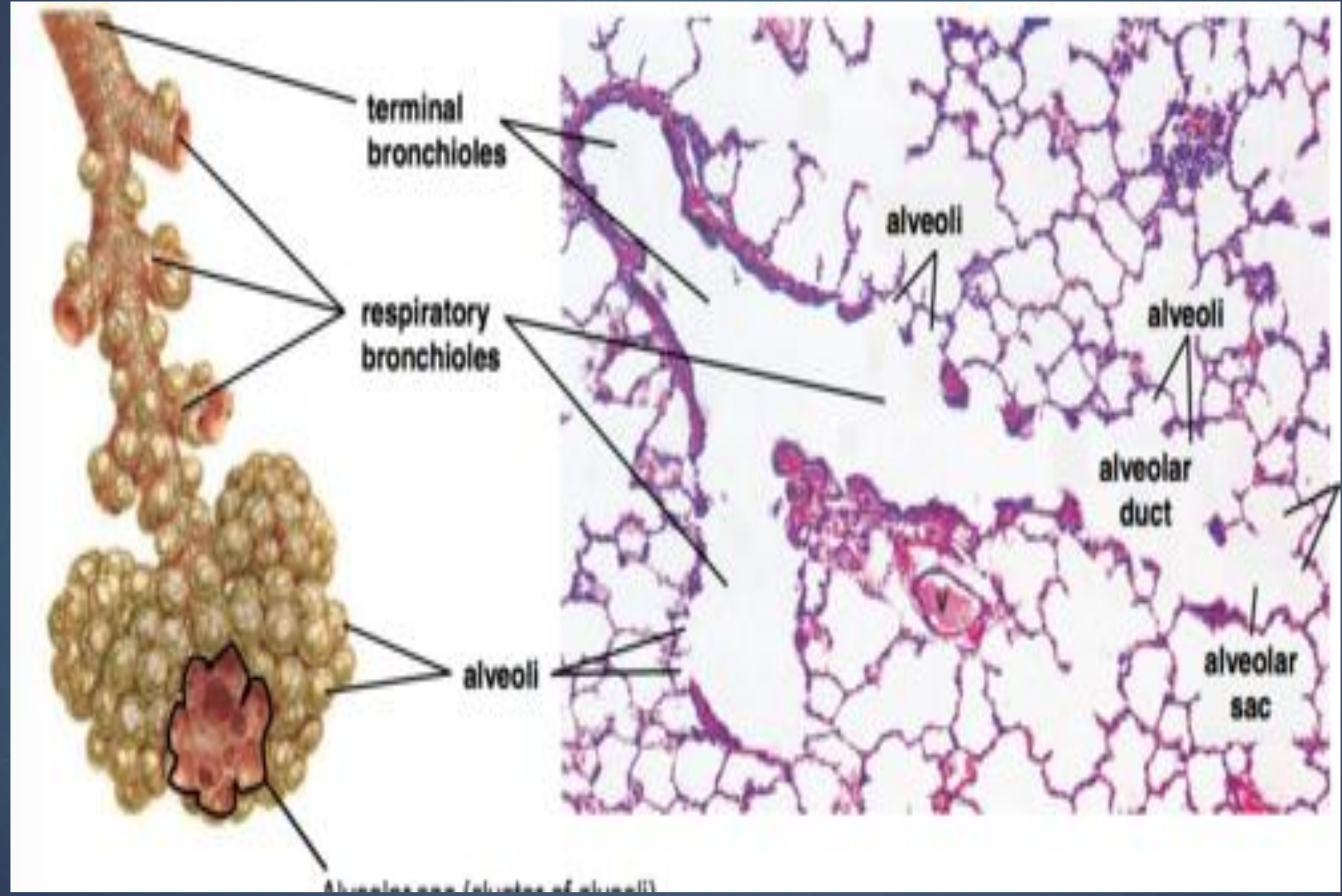
Cilia

The **alveolar duct** connects the respiratory bronchiole with the **alveolar sac**, a cluster of alveoli. Smooth muscle is diminished to small patches in the wall of the duct.

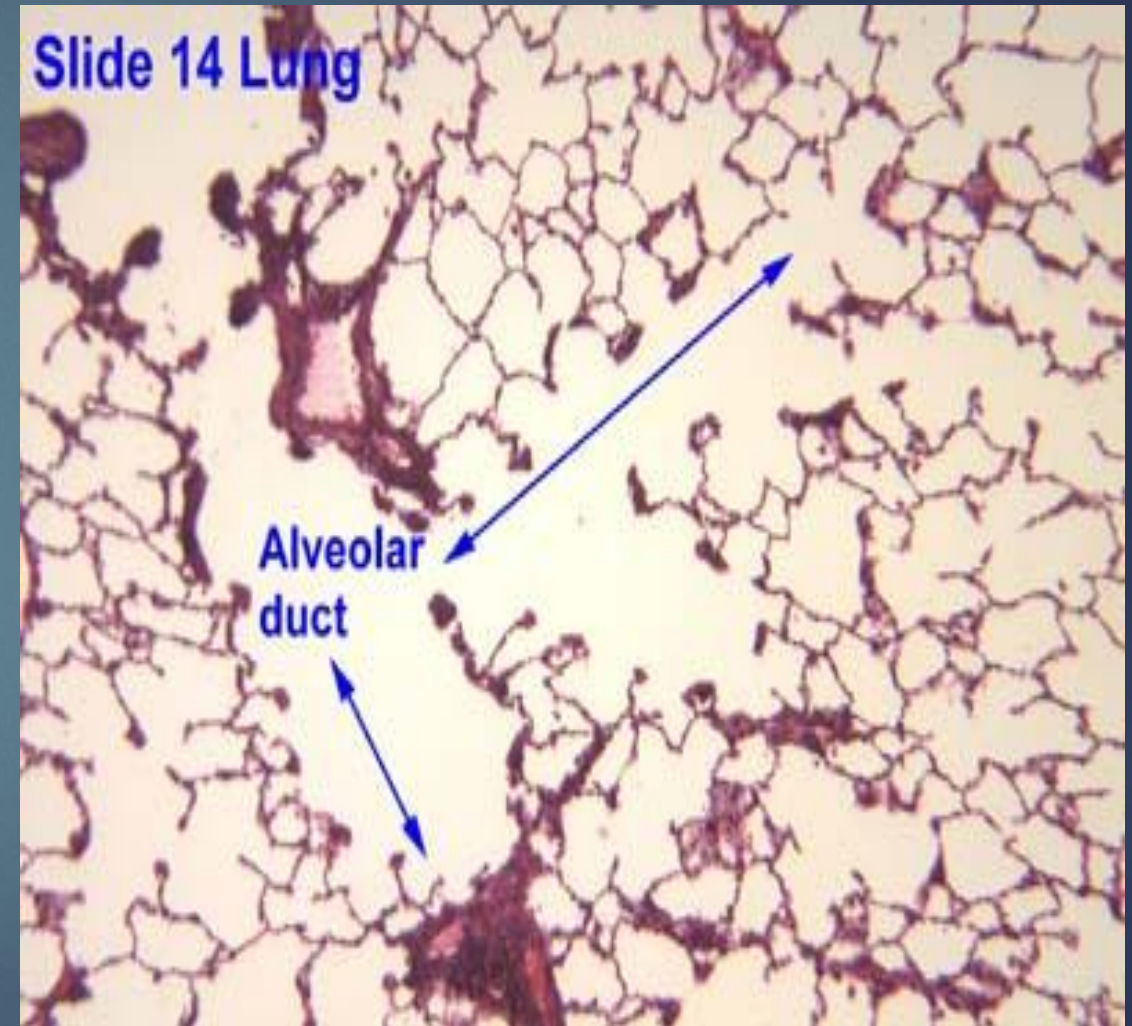
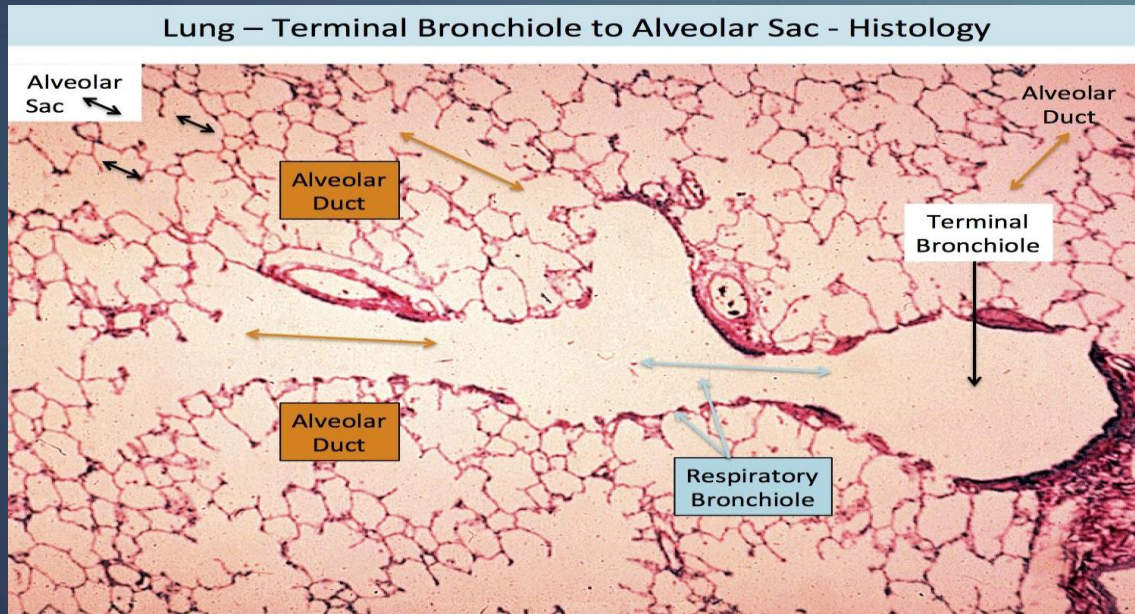


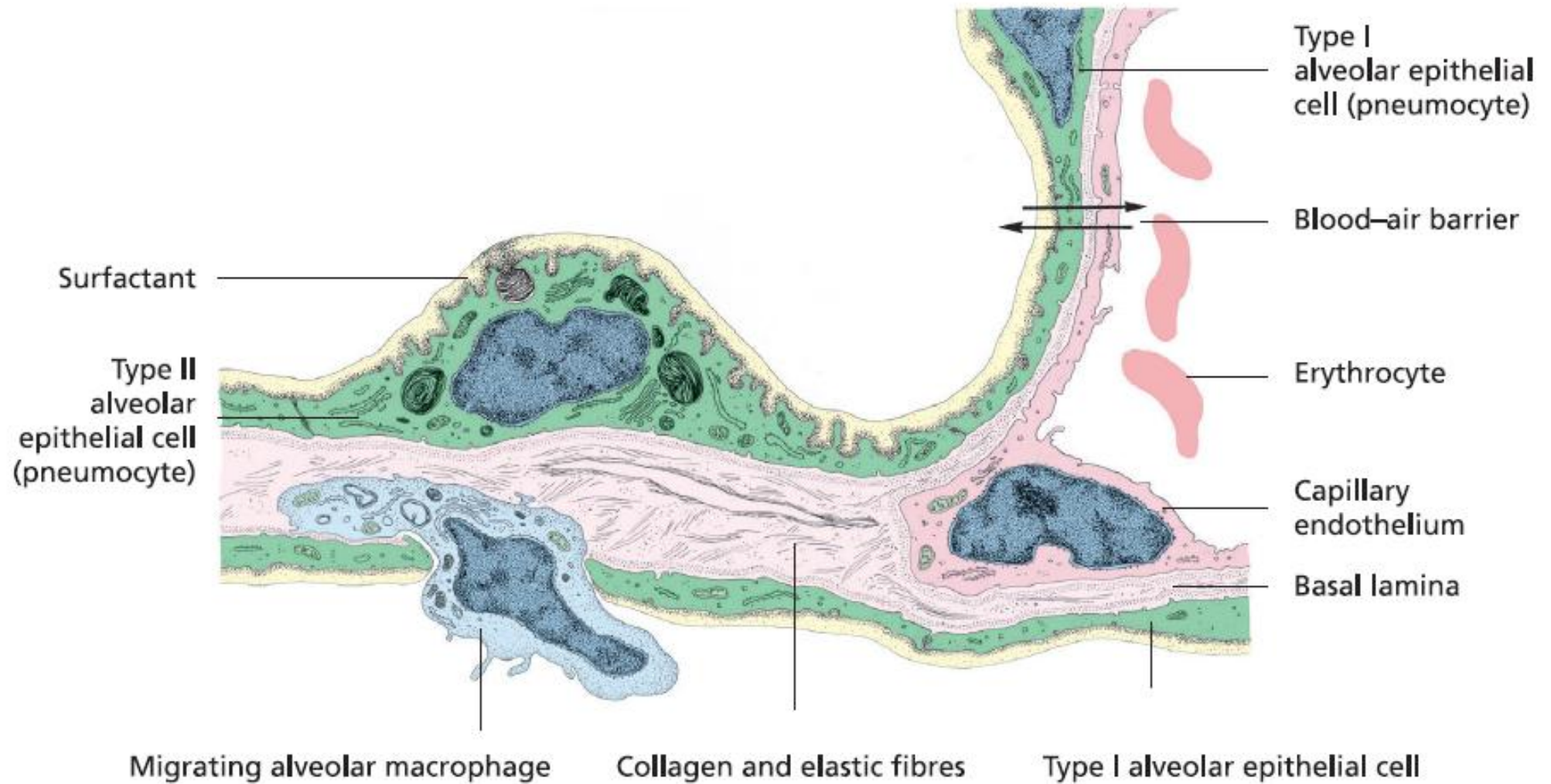
11.24 Terminal branching of a respiratory bronchiole to form alveolar ducts (tips of long arrows), alveolar sacs and numerous alveoli.





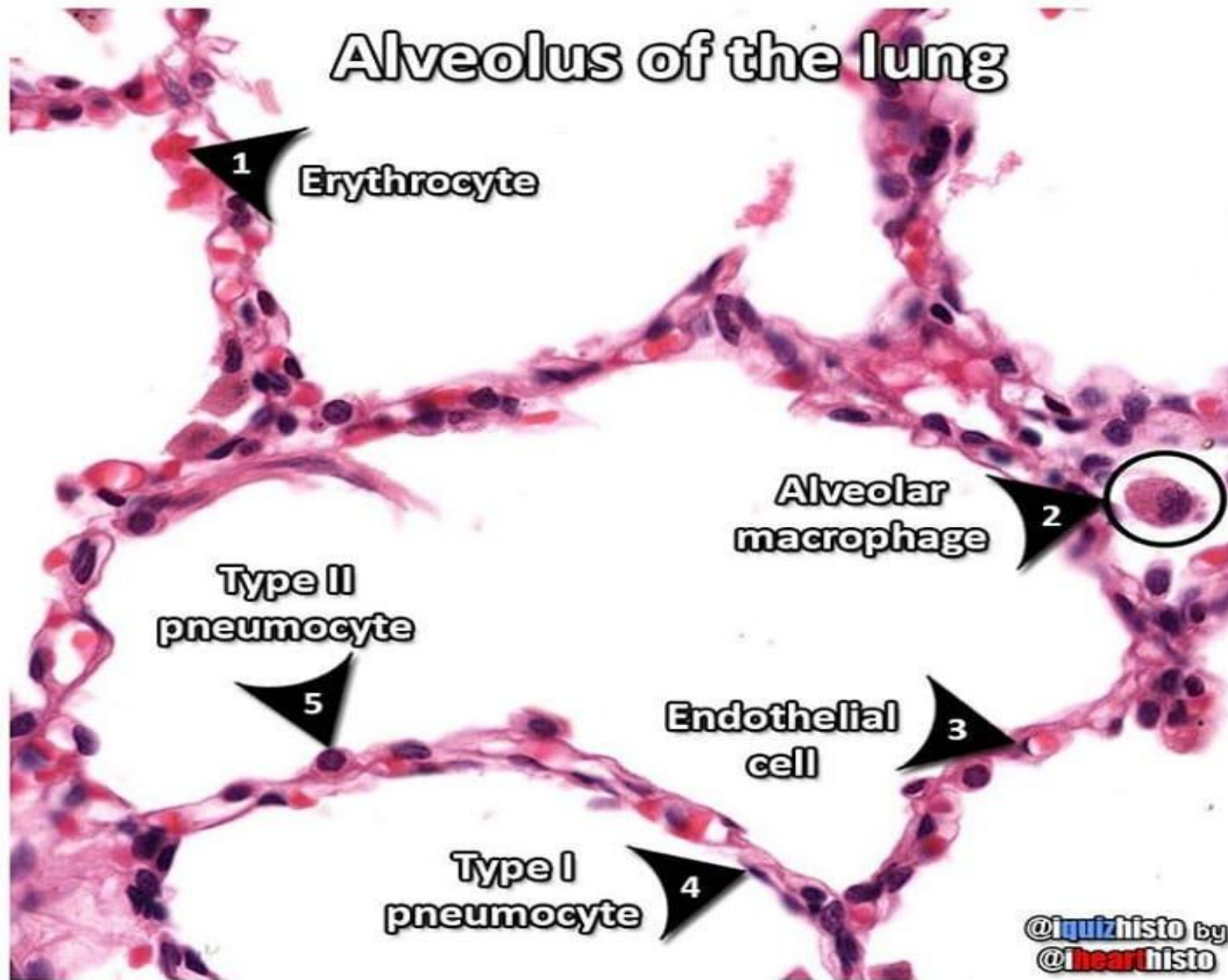
The **alveolus** is a thin-walled structure where gas exchange occurs in the lung. Squamous **alveolar epithelial cells** are the primary lining cell. Scattered **granular alveolar epithelial cells** produce surfactant which maintains surface tension in the alveolus. In the lumen, **alveolar macrophages** remove particulate material from the epithelial surface.





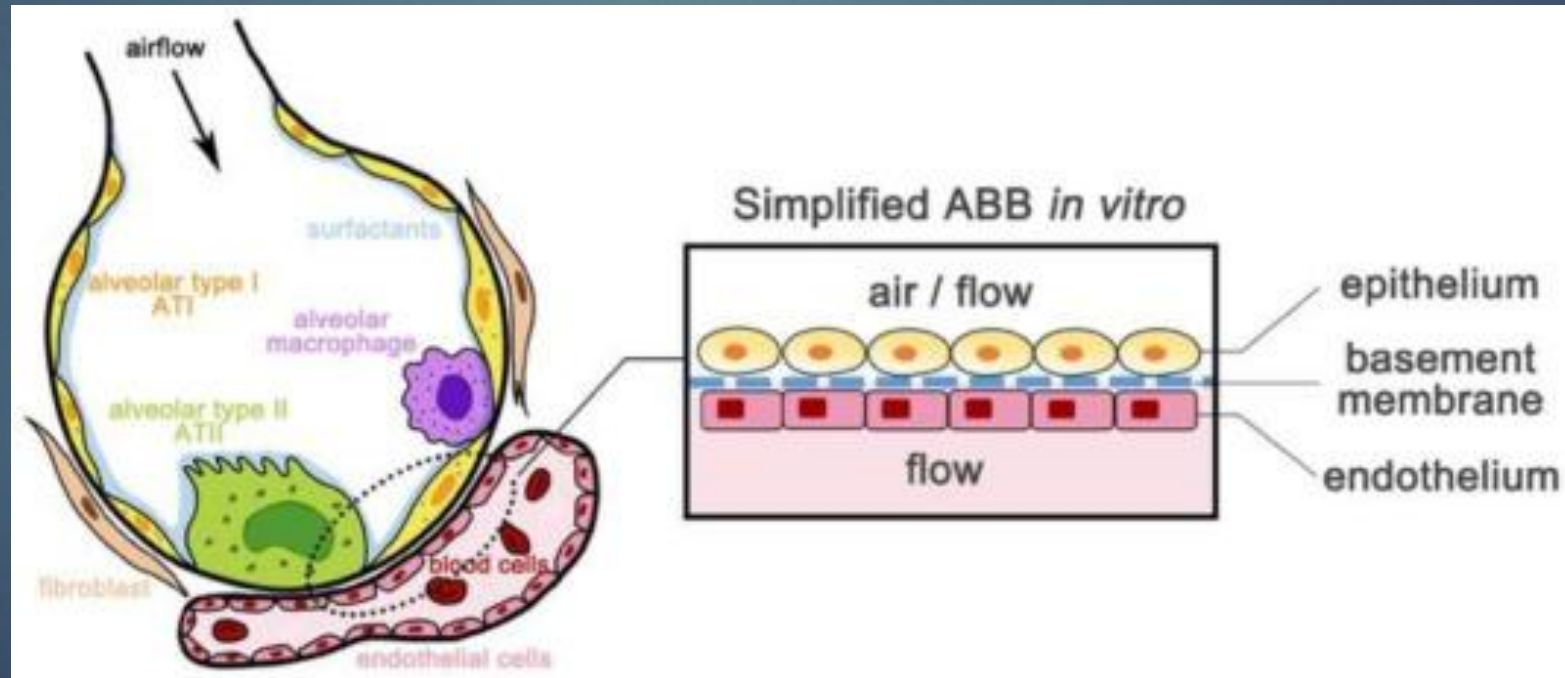
11.27 Blood-air barrier with Type I and II alveolar epithelial cells and capillary wall (schematic).

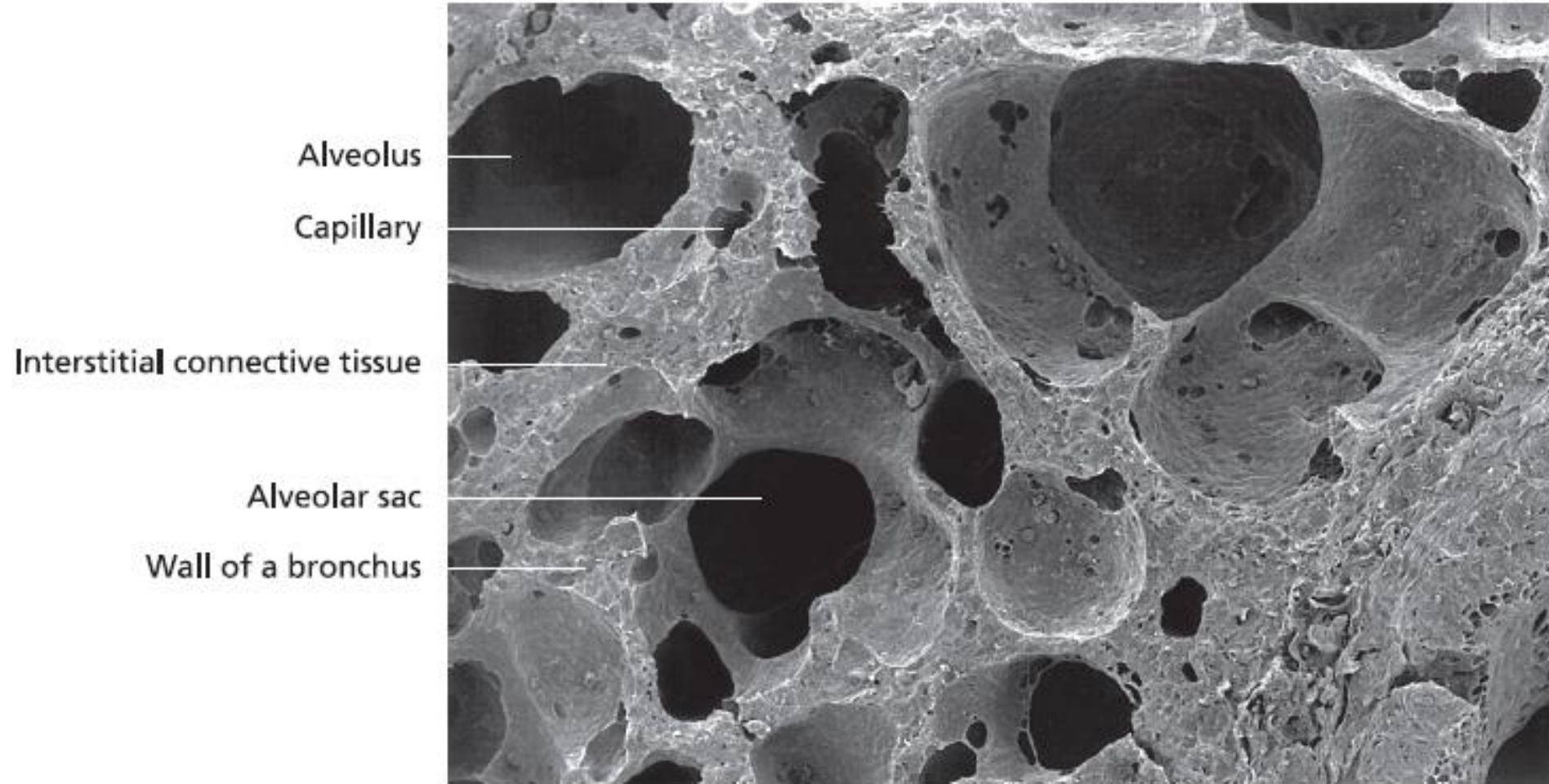
Alveolus of the lung



Blood-Air barrier

The pulmonary artery forms an extensive capillary bed within the lung. Gas exchange occurs across the **blood-air barrier**, consisting of the squamous alveolar epithelial cell, basement membrane of the epithelium, the septal space containing connective tissue and cells, the basement membrane of the pulmonary capillary and the capillary endothelial cell.





11.26 Scanning electron micrograph of the interior of pulmonary alveoli (lung, pig) (x1000).

Table 11.1 Histological features of the conducting airways of domestic mammals.

Segment	Epithelium	Glands	Connective and supportive tissue	Special features
Nasal cavity: nasal vestibule	Keratinised, pigmented, stratified squamous epithelium	Sweat glands and sebaceous glands	Hyaline cartilage, dense connective tissue	Vibrissae
respiratory region	Respiratory mucosa with cilia, microvilli, secretory (mainly goblet) cells	Serous, mucous or mixed tubulo-acinar glands	Tightly adherent to underlying cartilage or periosteum	Cavernous stratum with capacitance veins
olfactory region	Olfactory mucosa with sensory cilia	Tubulo-acinar, predominantly serous glands	Similar to respiratory region	Bipolar neurons (neurosensory cells) with club-like dendritic bulbs, basal cells and sustentacular cells
Nasopharynx	Respiratory mucosa with cilia, microvilli and secretory cells	Branched mucous, serous and mixed glands	Underlaid by skeletal muscle and dense connective tissue	Lymphatic tissue in the form of tonsils (varies with species)
Larynx	Stratified squamous epithelium and respiratory epithelium with secretory cells	Predominantly mucous glands	Hyaline and elastic cartilage, dense connective tissue	Diffuse lymphoid tissue and lymphoid follicles
Trachea	Respiratory mucosa with cilia, microvilli and secretory cells (mainly goblet cells)	Tubulo-acinar mucous and seromucous glands	Hyaline cartilage, dense connective tissue and smooth muscle spanning the free edges of the cartilaginous rings (m. trachealis)	Number and shape of tracheal rings varies with species

Segment	Epithellum	Glands	Connective tissue and muscle	Special features
Bronchi	Respiratory epithellum with cilia, microvilli, goblet cells, neuro-endocrine cells	Tubulo-acinar seromucous glands	Hyaline cartilage plates and fragments, with helically and circularly oriented smooth muscle bundles underlain by dense interstitial connective tissue	Cartilage supported by elastic fibre network
Bronchioles	Transforms from pseudostratified into simple columnar or cuboidal partly ciliated epithellum, Clara cells, neuro-endocrine cells	Absent	No cartilage, helically and circularly oriented smooth muscle fibres, loose interstitial connective tissue	Connective tissue supported by elastic fibre network
Terminal bronchioles	Simple cuboidal epithellum, Clara cells, neuro-endocrine cells	Absent	Smooth muscle cells and connective tissue, elastic fibre network	Particularly well developed in ruminants, pigs and horses
Respiratory bronchioles	Simple cuboidal epithellum, Clara cells, Types I and II alveolar epithelial cells	Absent	Smooth muscle cells and connective tissue, reinforced by elastic fibre network	Number of alveoli increases with each generation (I-III), abundant in carnivores, occasionally seen in the horse, rare in the pig and in ruminants
Alveolar ducts	Simple squamous epithellum (alveolar epithellum), Types I and II alveolar epithelial cells, macrophages	Absent	Elastic fibre network, muscle cells in inter-alveolar septa (acts as sphincter)	Up to 10 alveolar ducts are formed from the branching of each respiratory bronchiole, branching of alveolar ducts gives rise to alveolar sacs
Alveoli	Simple squamous epithellum (alveolar epithellum), Types I and II alveolar epithelial cells, macrophages	Absent	Loose connective tissue with prominent elastic fibre network	Blood-air barrier