The Respiratory System

Undergraduate - Graduate
Histology Lecture Series

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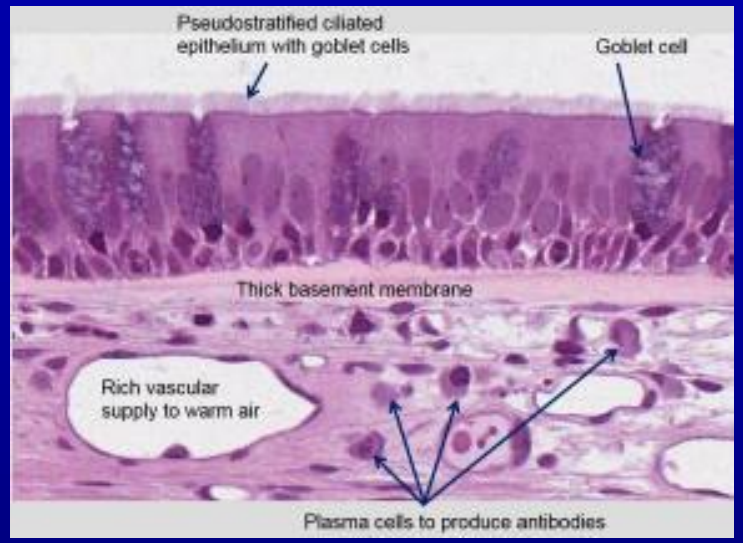
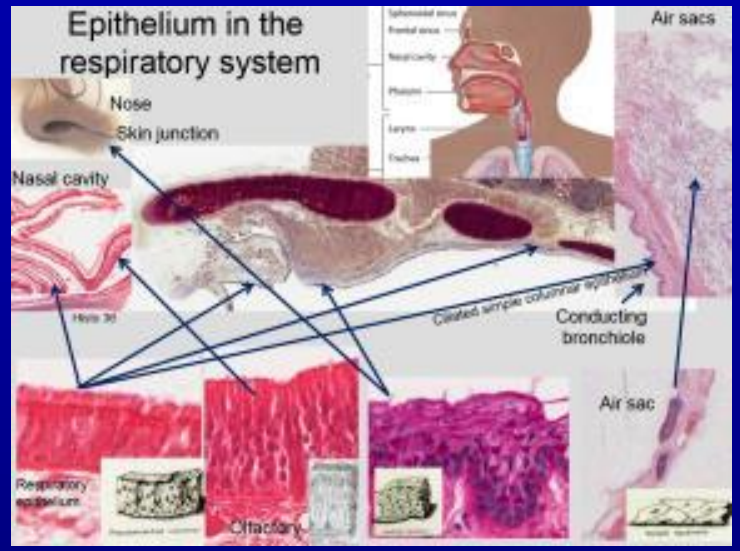
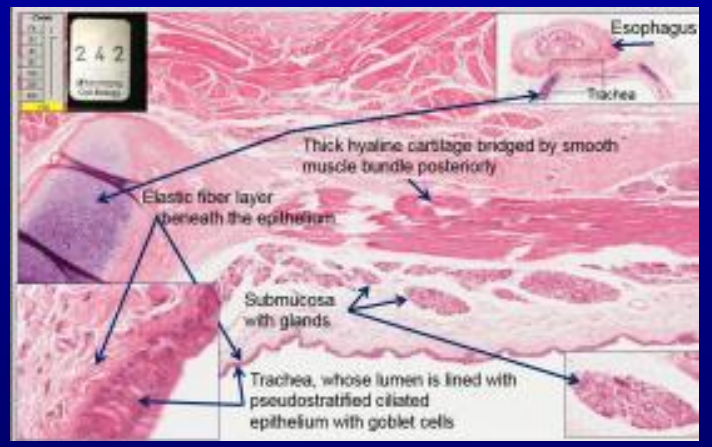
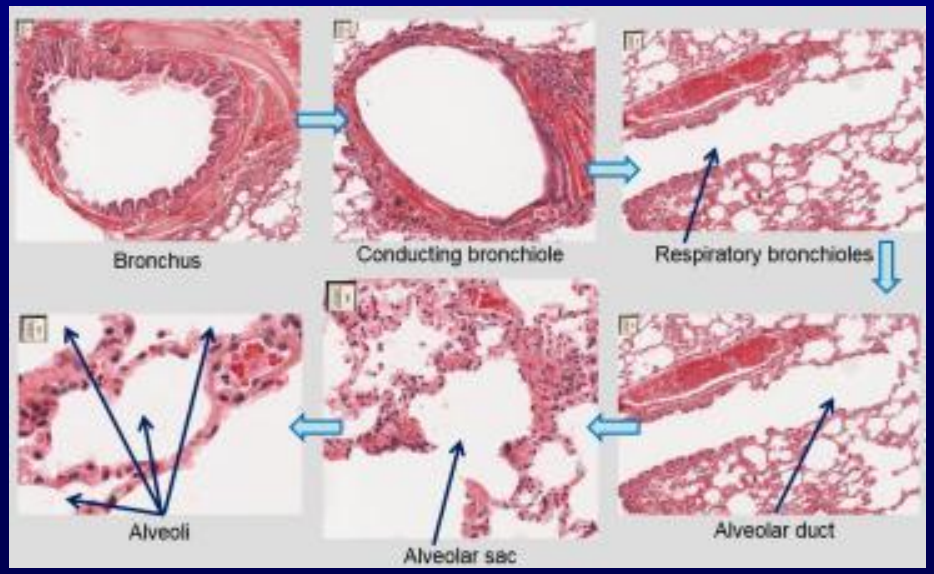
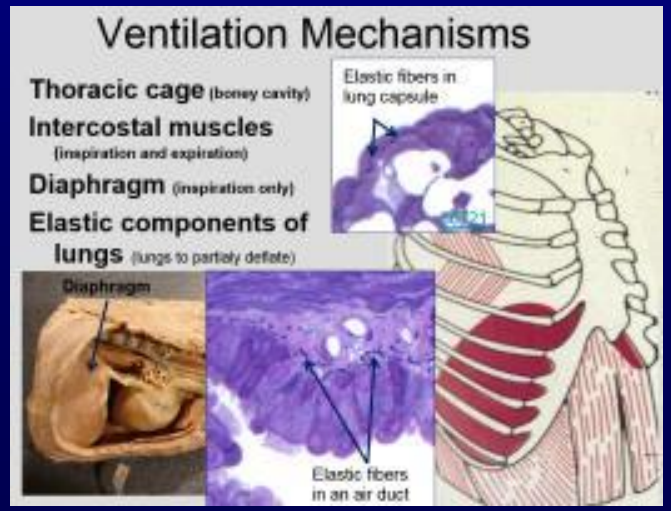
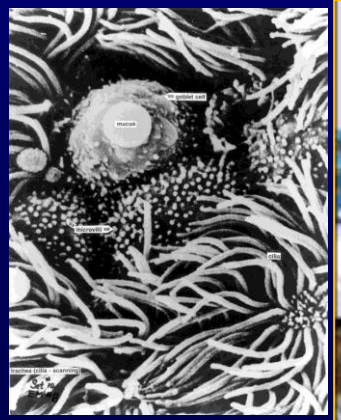






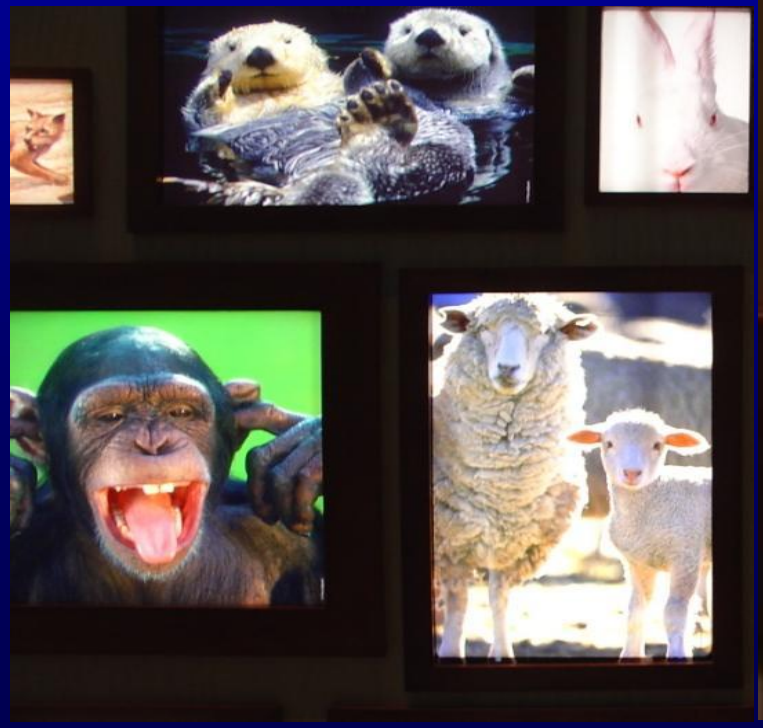




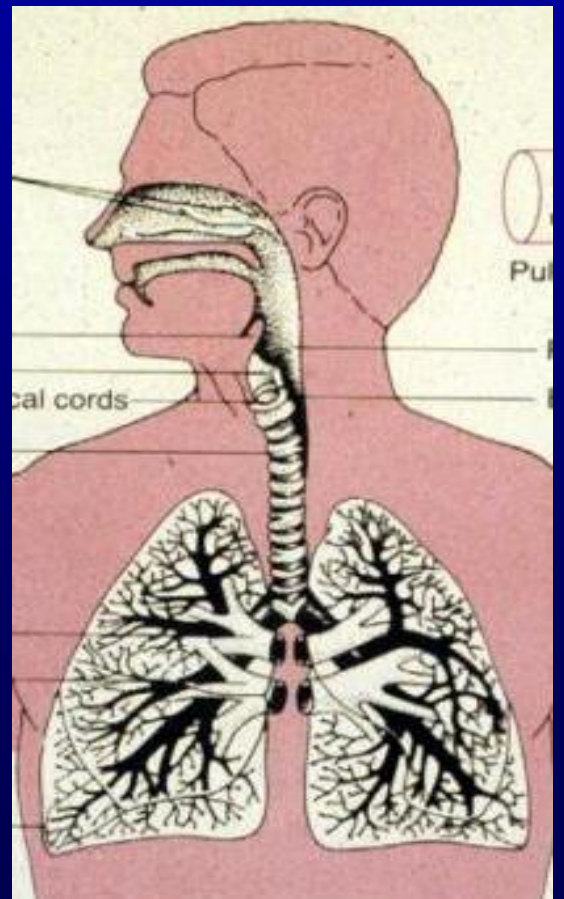


All higher animals require a mechanism to:

1. Obtain O_2 from the environment
2. and get rid of CO_2

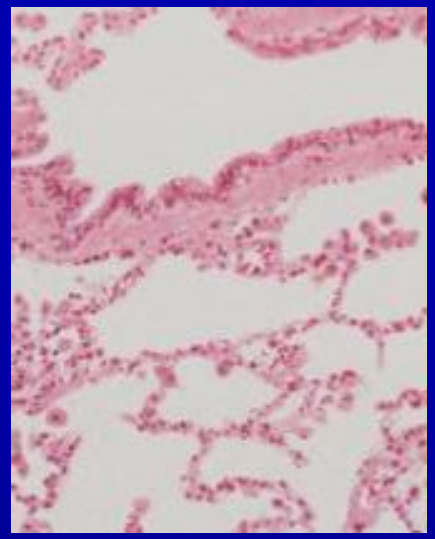


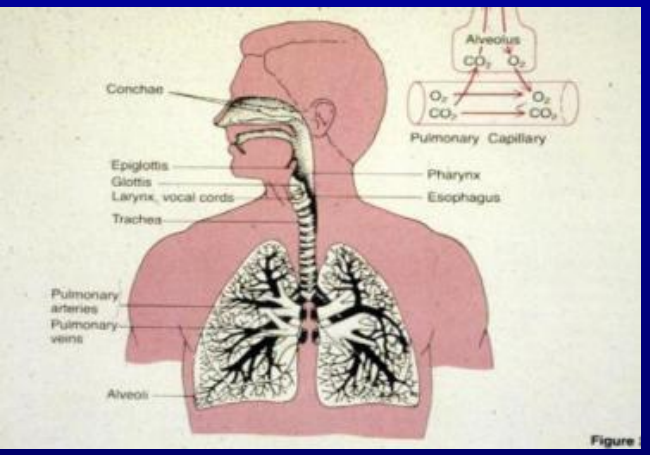
The respiratory system *exchanges* these gases with the external environment

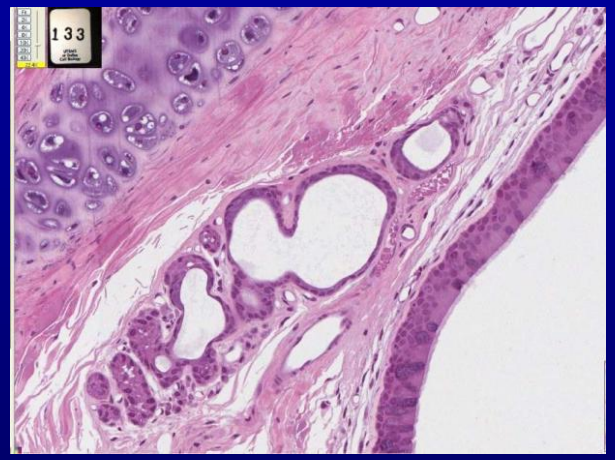


Objectives

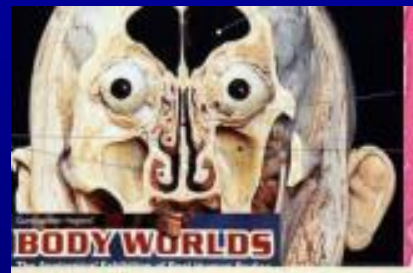
The histologic characteristics of the components of conducting portion and respiratory portion of the respiratory system

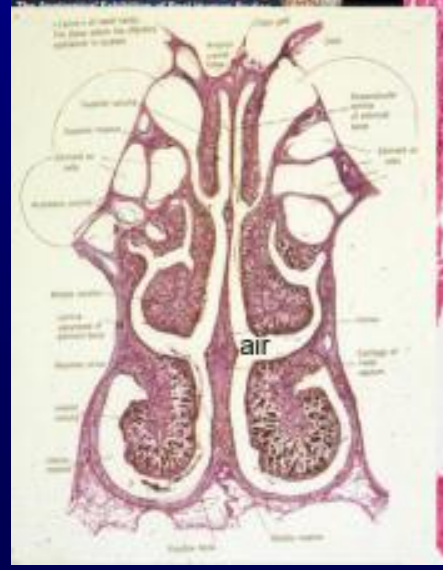


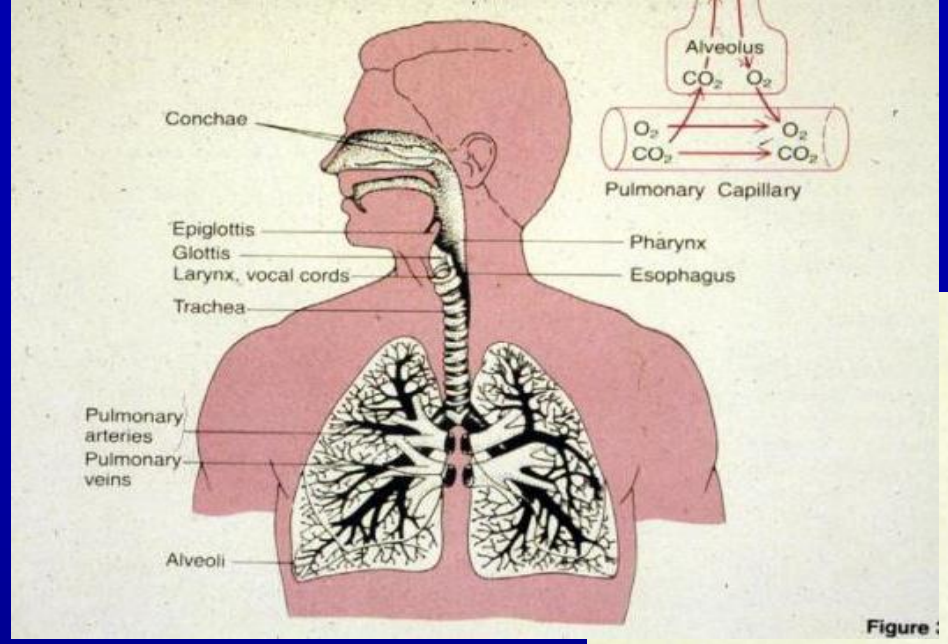




How these characteristics allow each component to contribute to the overall function of the respiratory system.



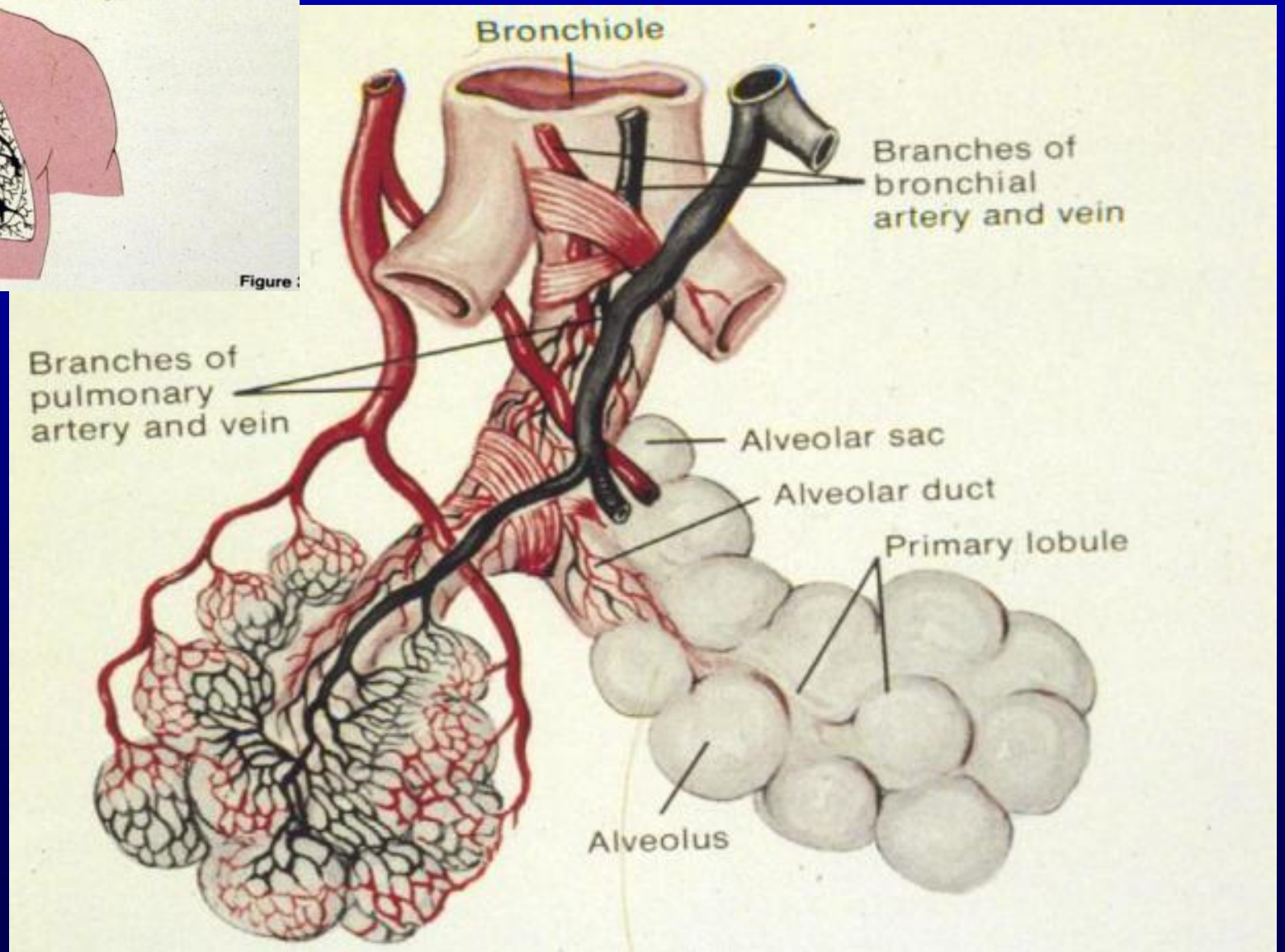




The respiratory system has a direct conduit to the environment and brings air close to the blood.

Function?

Function of the respiratory system is “gas exchange”

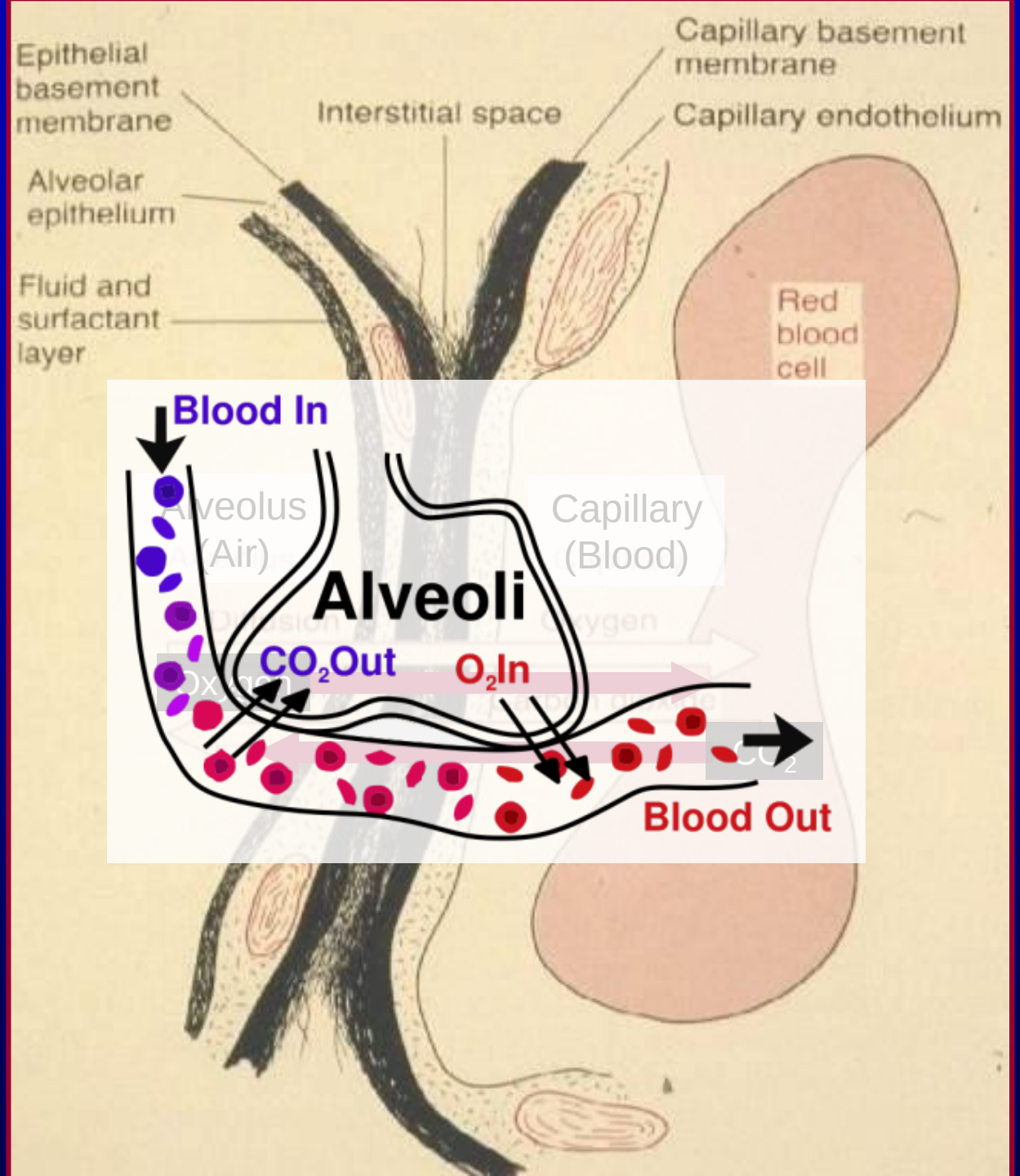


Gas Exchange?

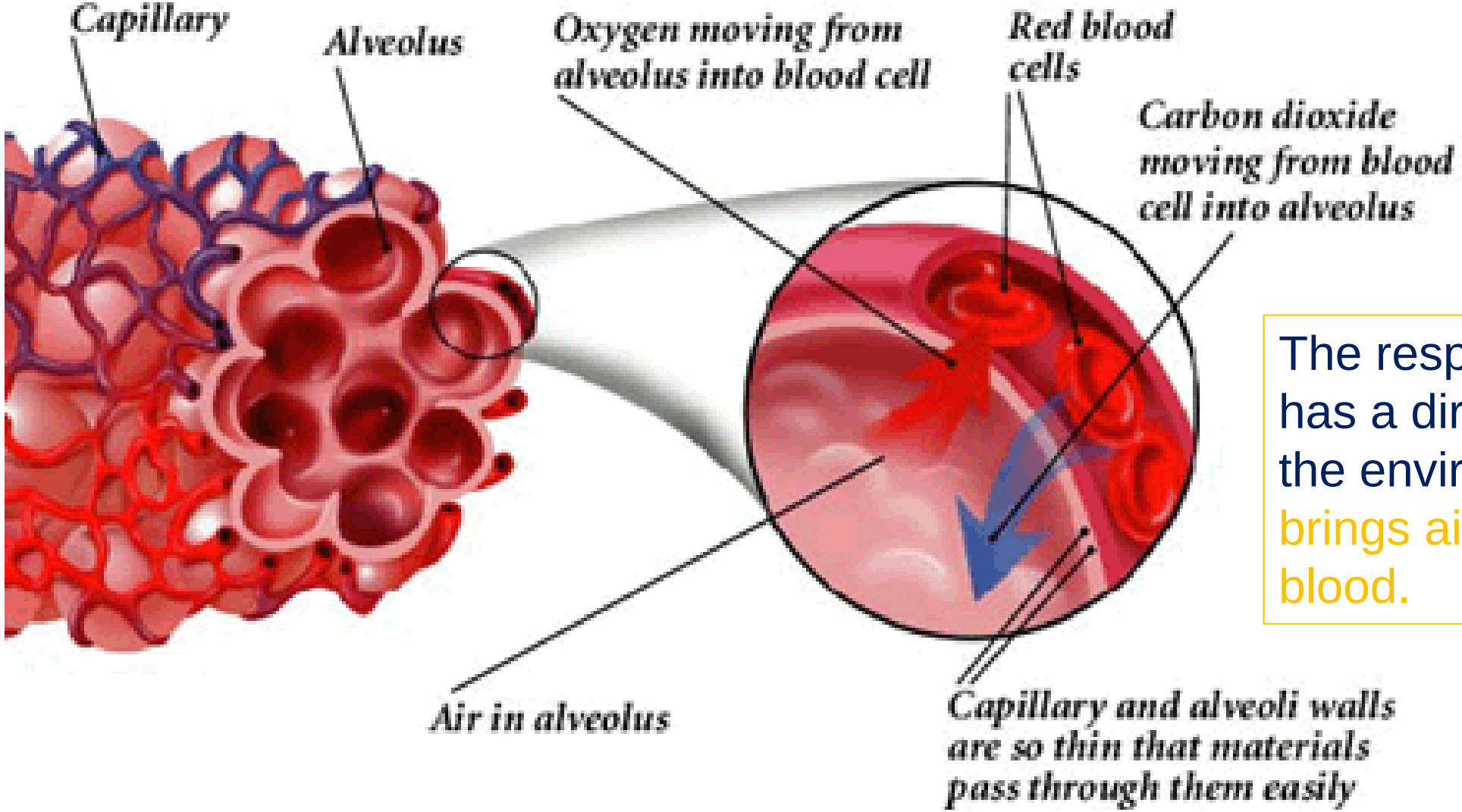
Oxygen diffuses out and **Carbon Dioxide** diffuses into the air space of the alveolus

Diffusion: spontaneous process of equalization of physical states (e.g., heat spreading in a room)

Diffuse: to spread in all directions



Alveoli: Gas Exchange



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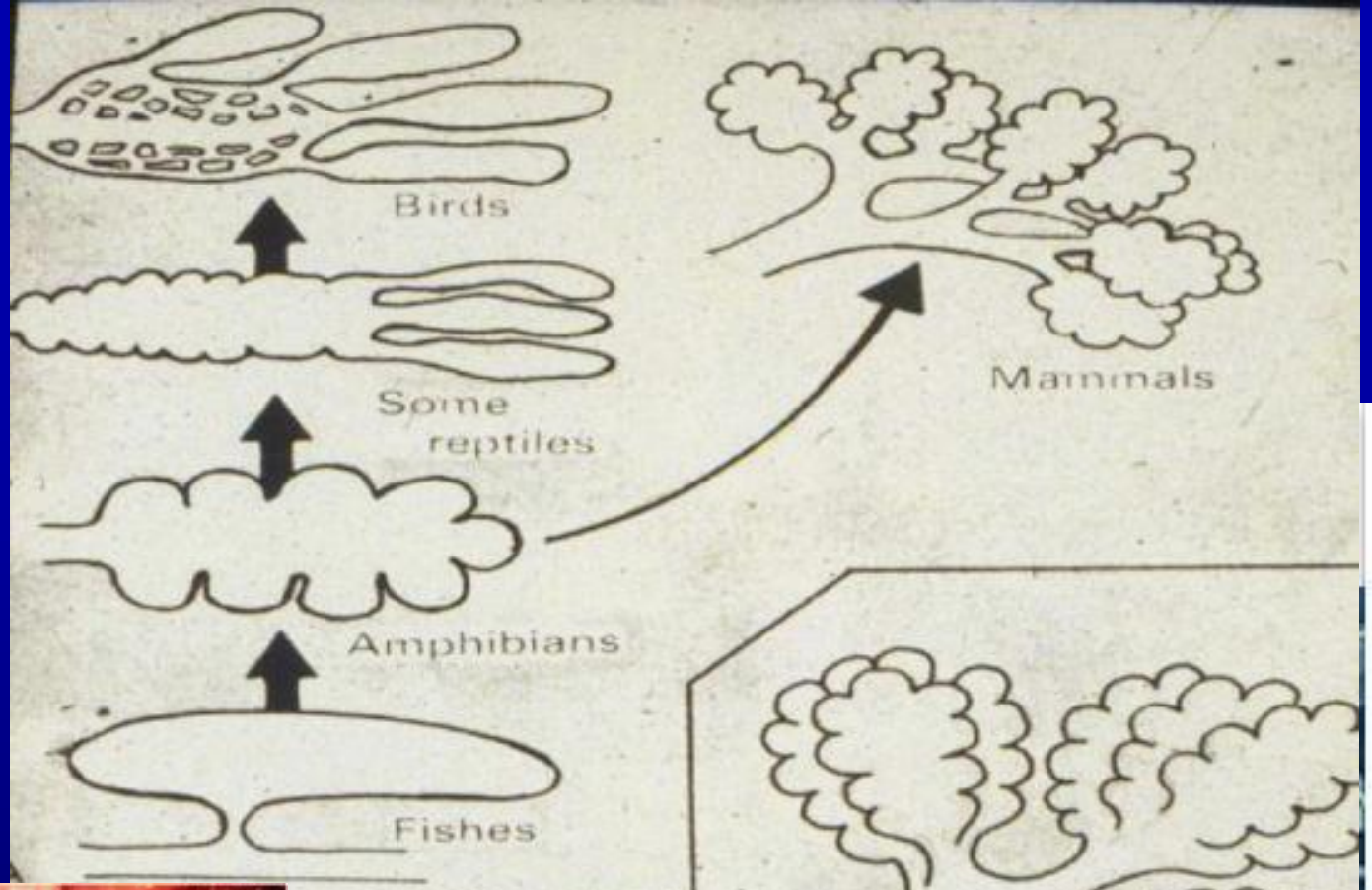


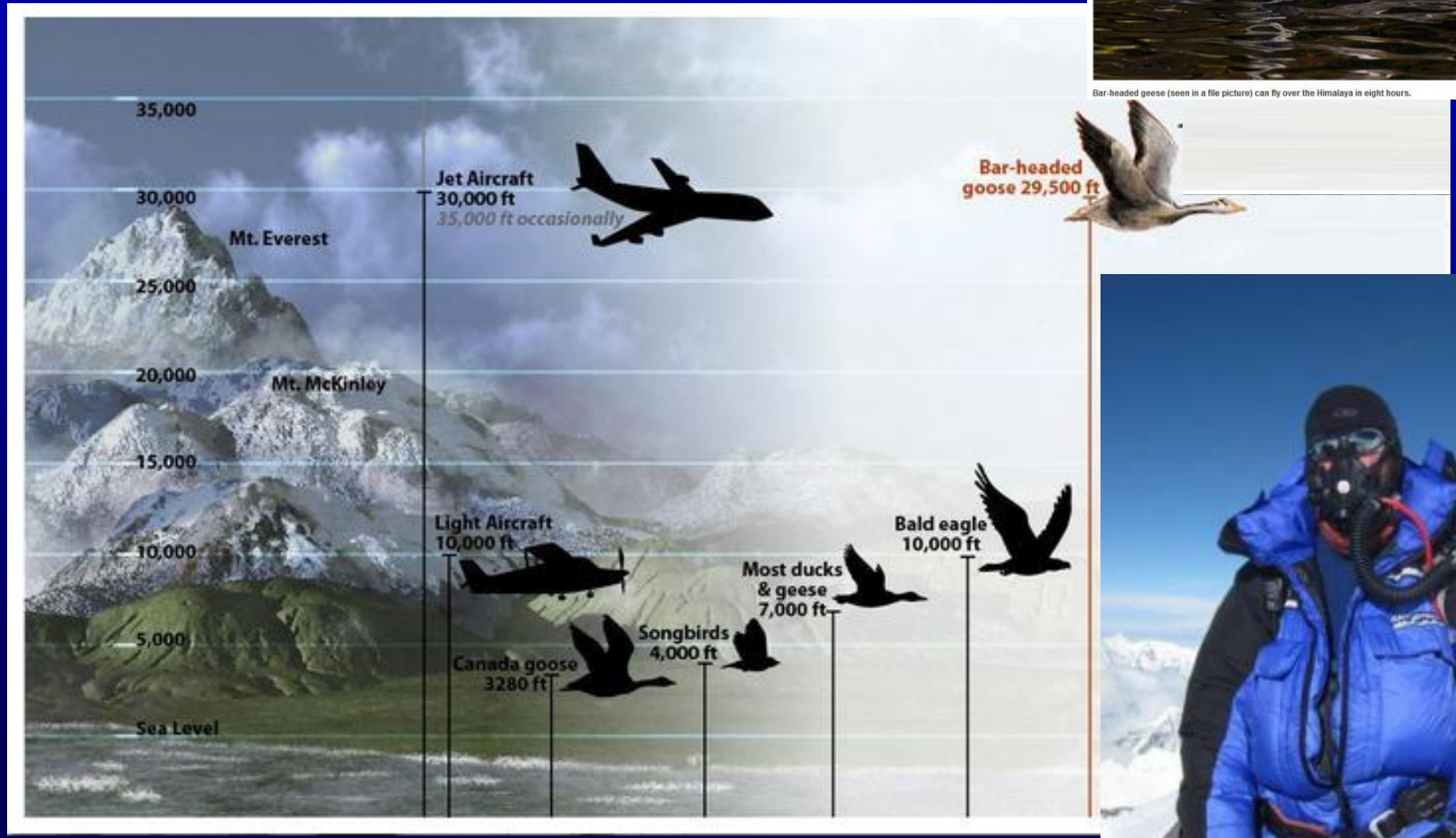
13-33. Evolution of the Lung.

BirdResp.gif
388 × 448 - Avian lungs and **air sacs**
cas.bellarmine.edu
Similar - More sizes

Highest Flying Bird Found; Can Scale Himalaya

The bar-headed goose can reach nearly 21,120 feet, new study shows.

Bar-headed geese (seen in a file picture) can fly over the Himalaya in eight hours.



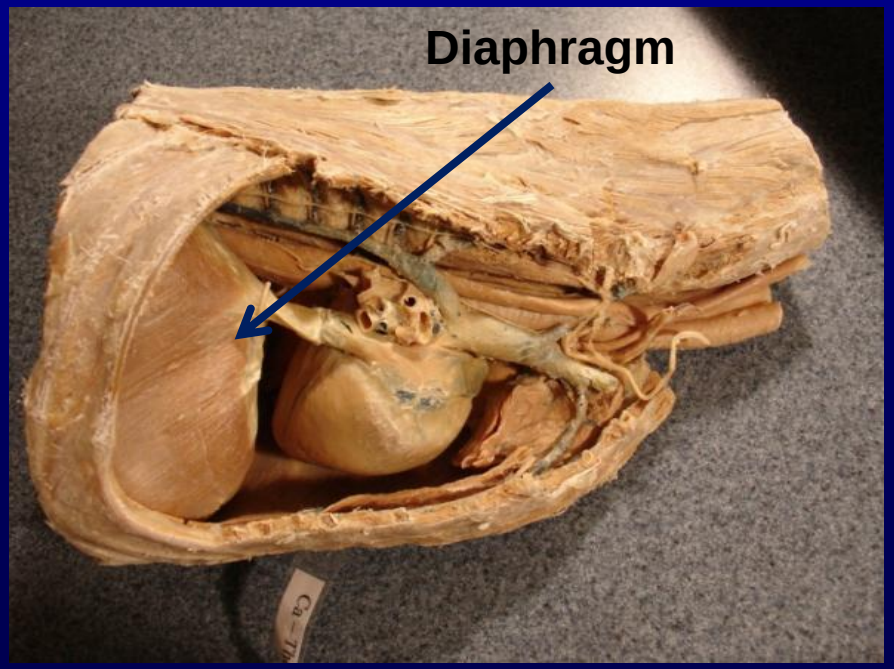
Ventilation Mechanisms

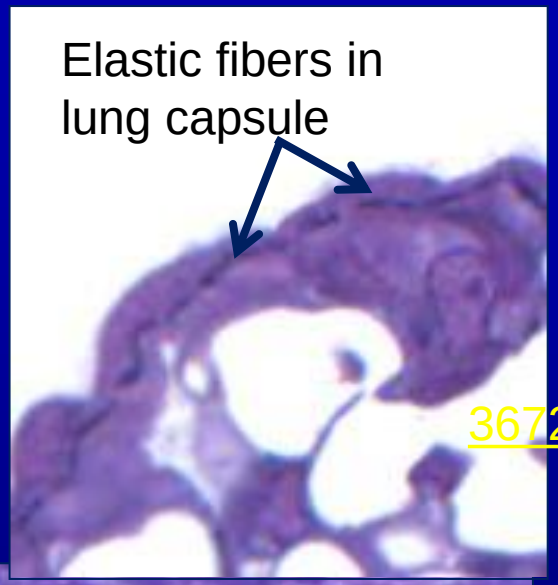
Thoracic cage (boney cavity)

Intercostal muscles
(inspiration and expiration)

Diaphragm (inspiration only)

Elastic components of lungs (lungs to partialy deflate)





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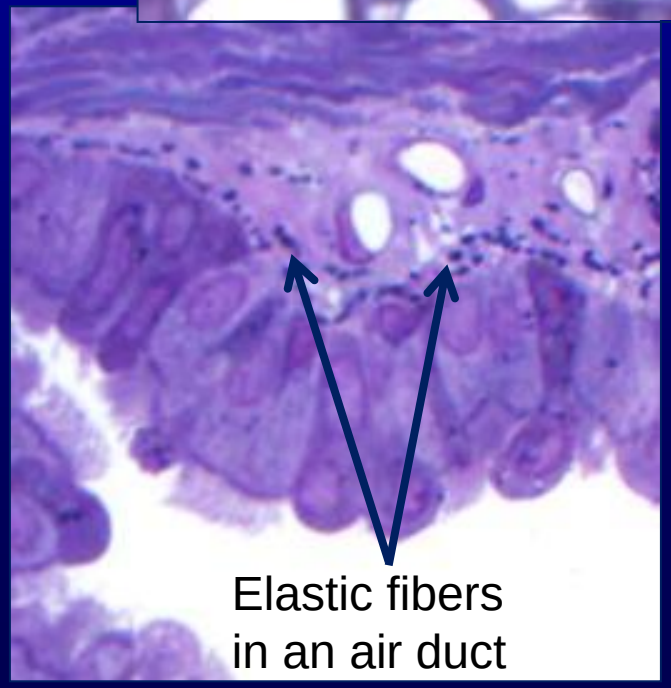
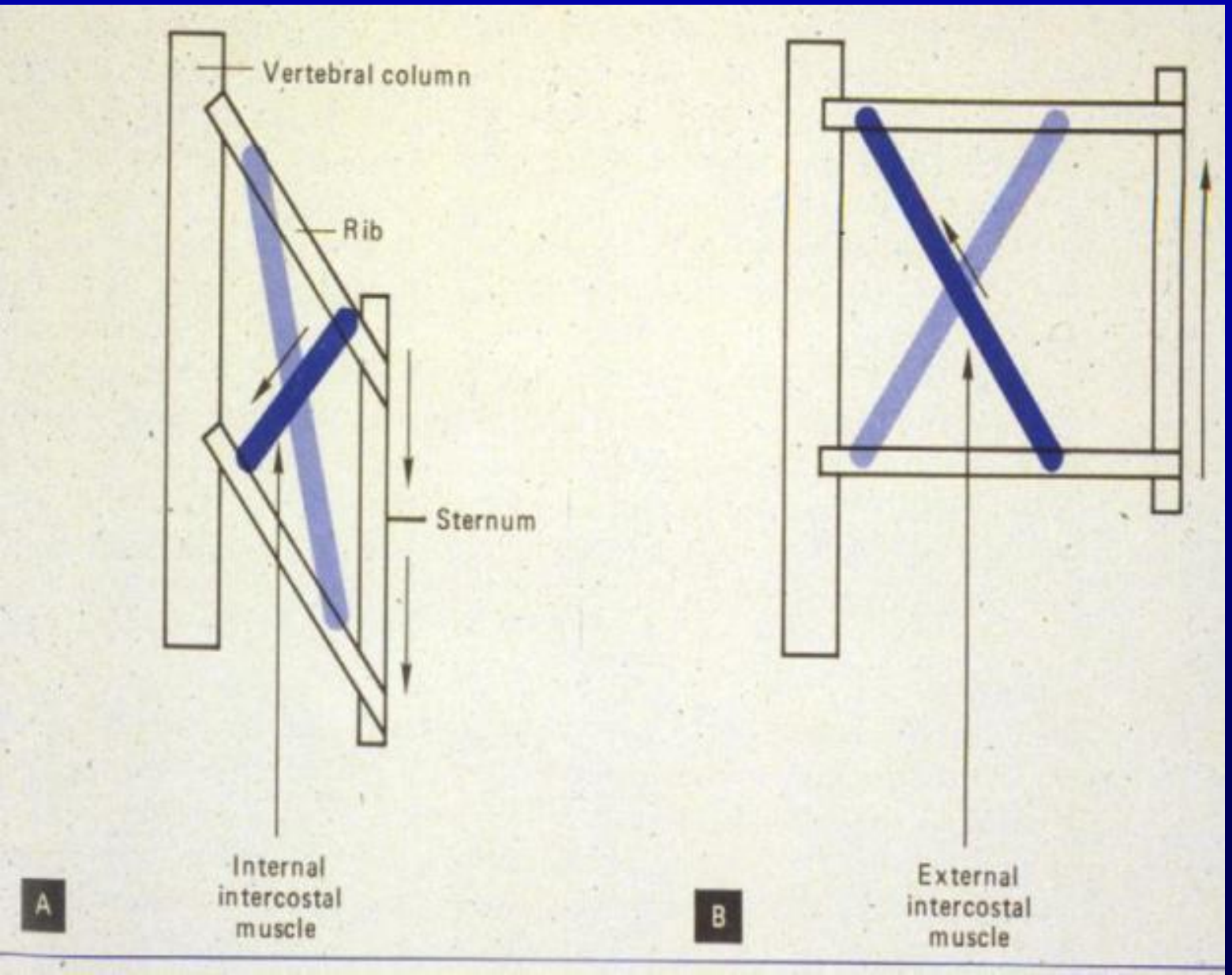


Ventilation Mechanisms

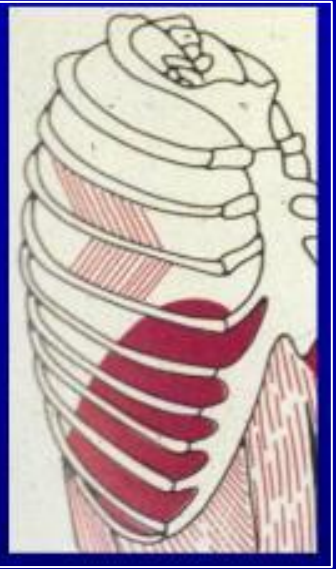


Thoracic cage

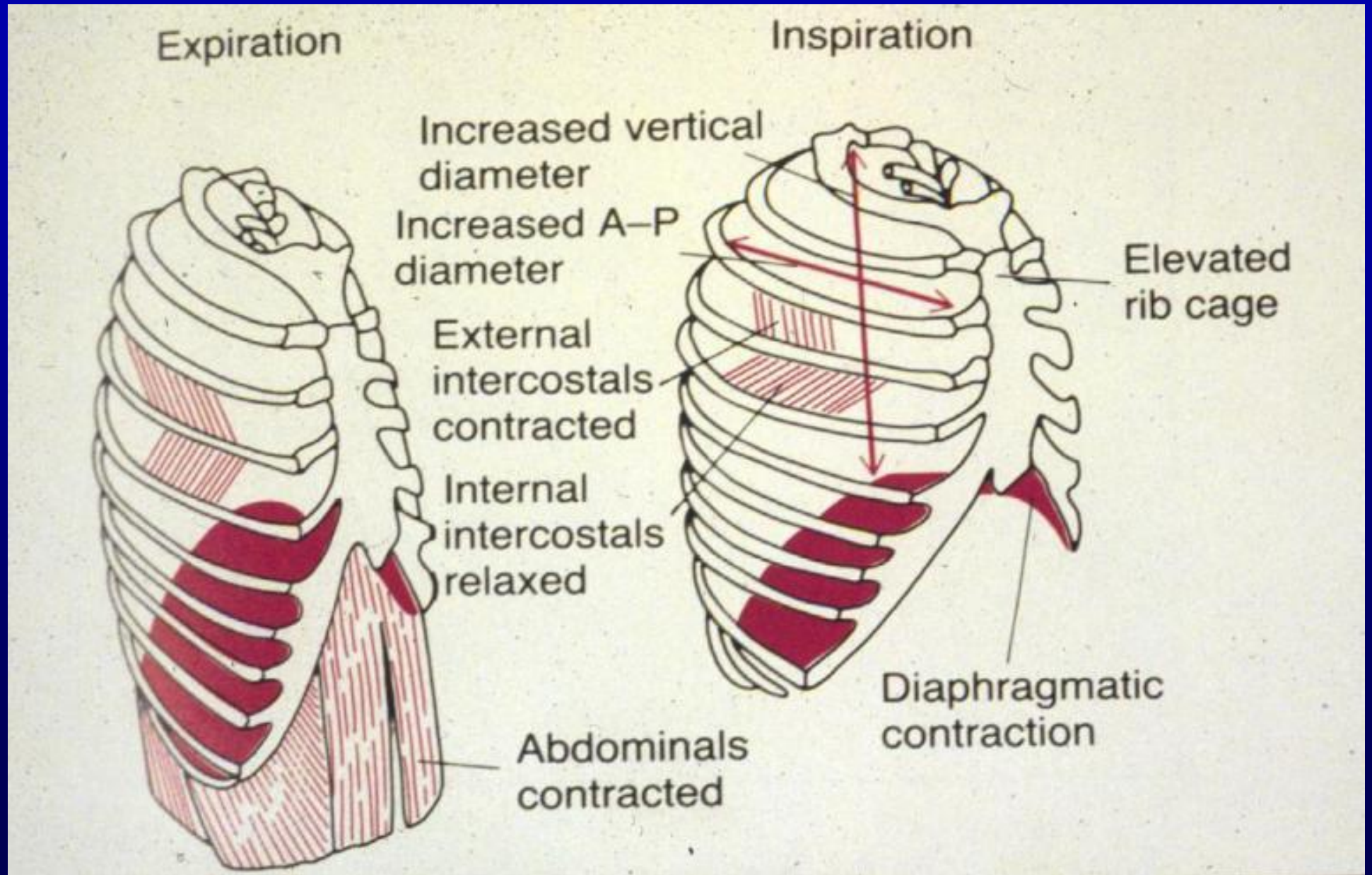
Intercostal muscles

Diaphragm

Elastic and collagen components of lungs



Ventilation Mechanisms



Boyle's law =
states the inverse proportional relationship between the pressure and volume of a gas

Boyle's law =
as diaphragm is pulled down the volume is increased with a decrease in pressure (vacuum)

Breathing

What happens when I inhale?

Your ribs come up.

Your diaphragm drops down.

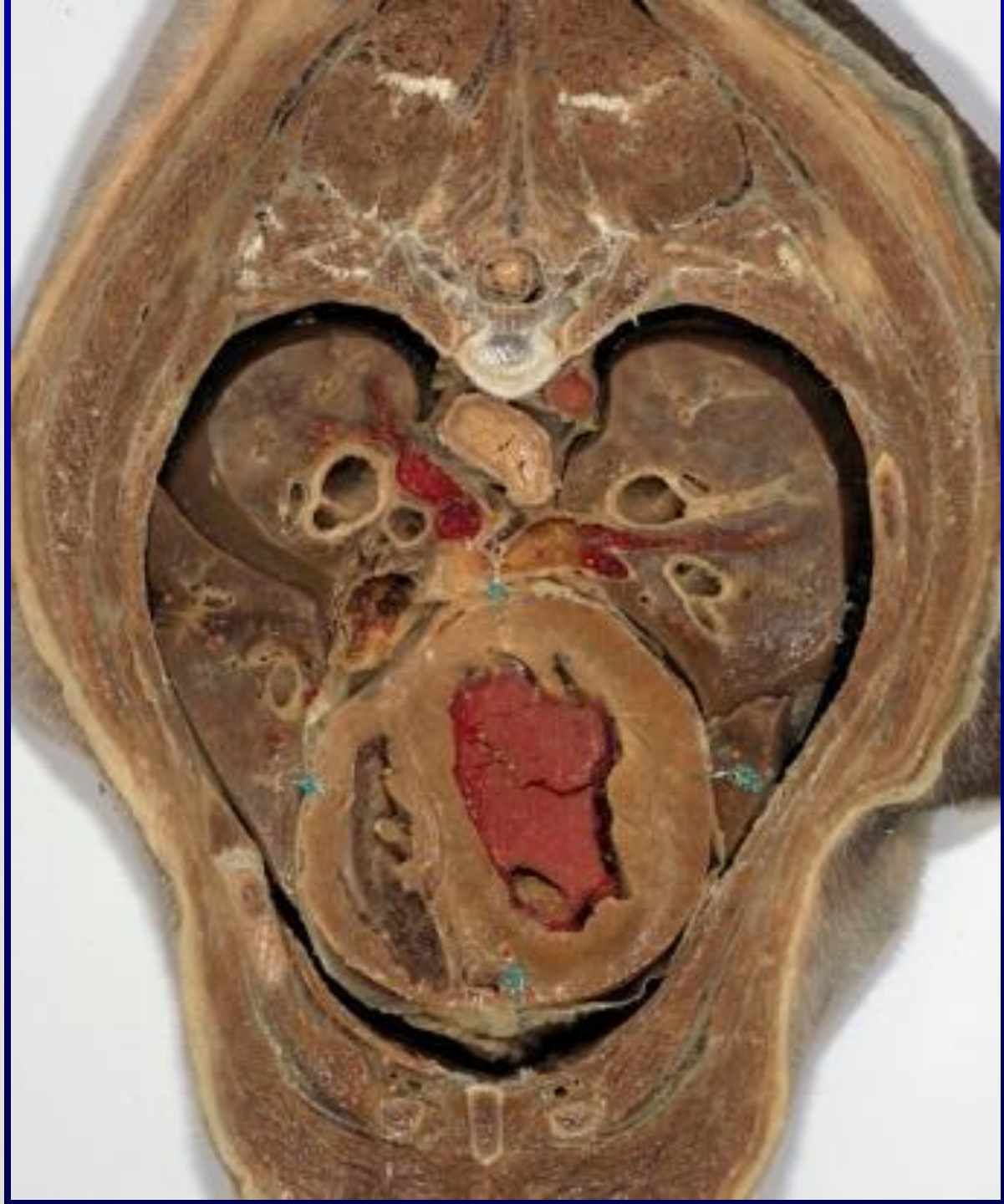
These movements increase volume and decrease pressure.

What happens when I exhale?

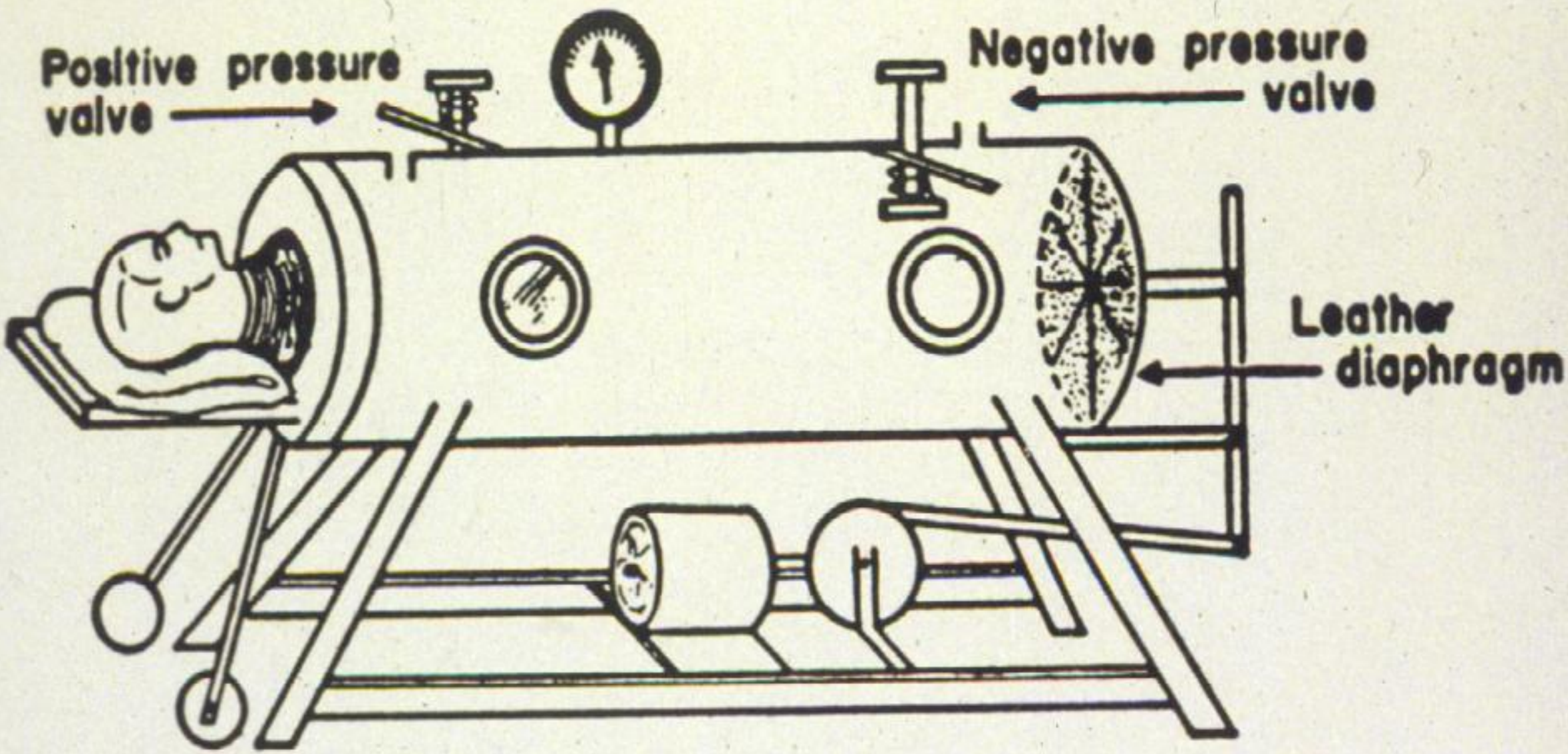
Your ribs move down.

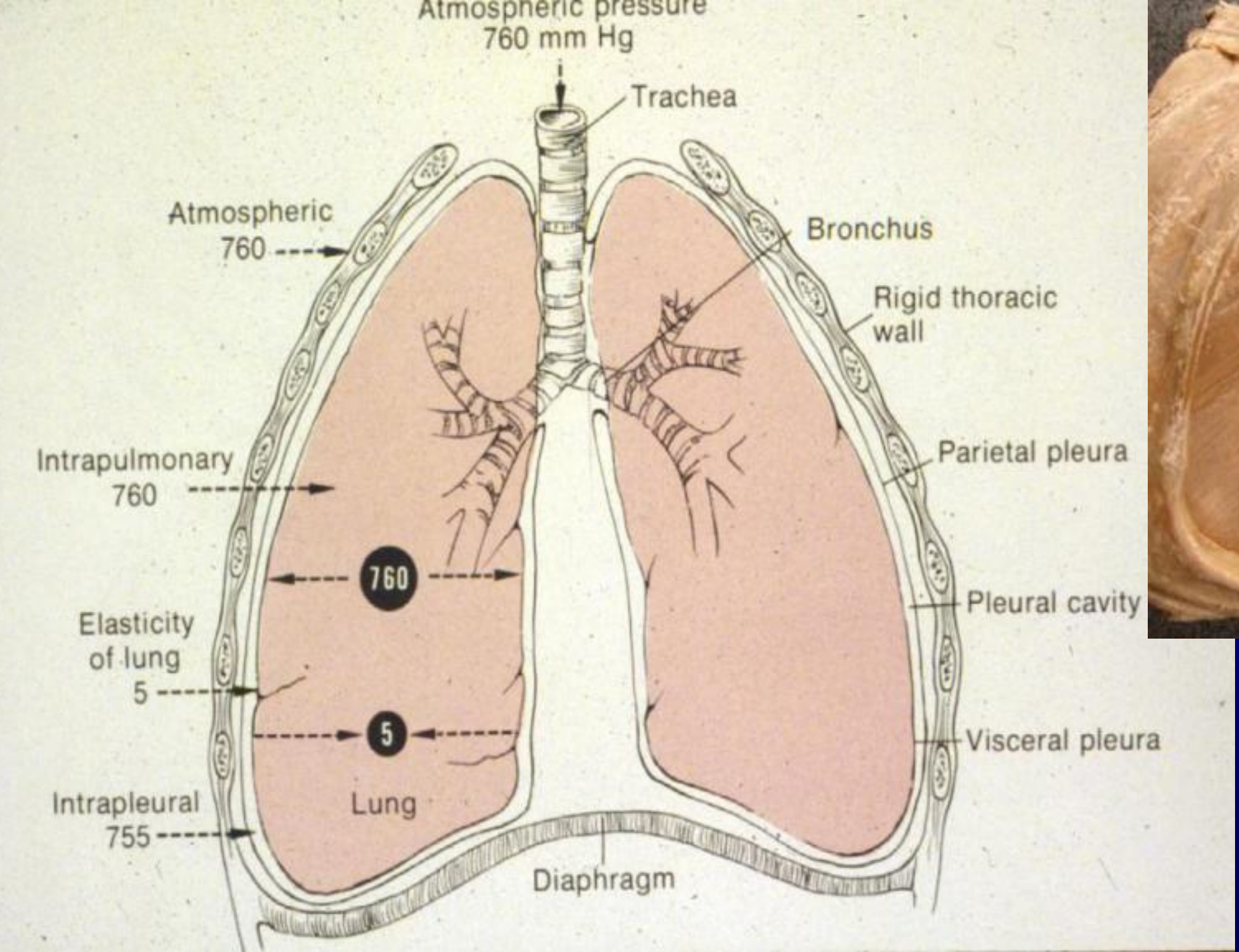
Your diaphragm moves up.

These movements decrease volume and increase pressure.

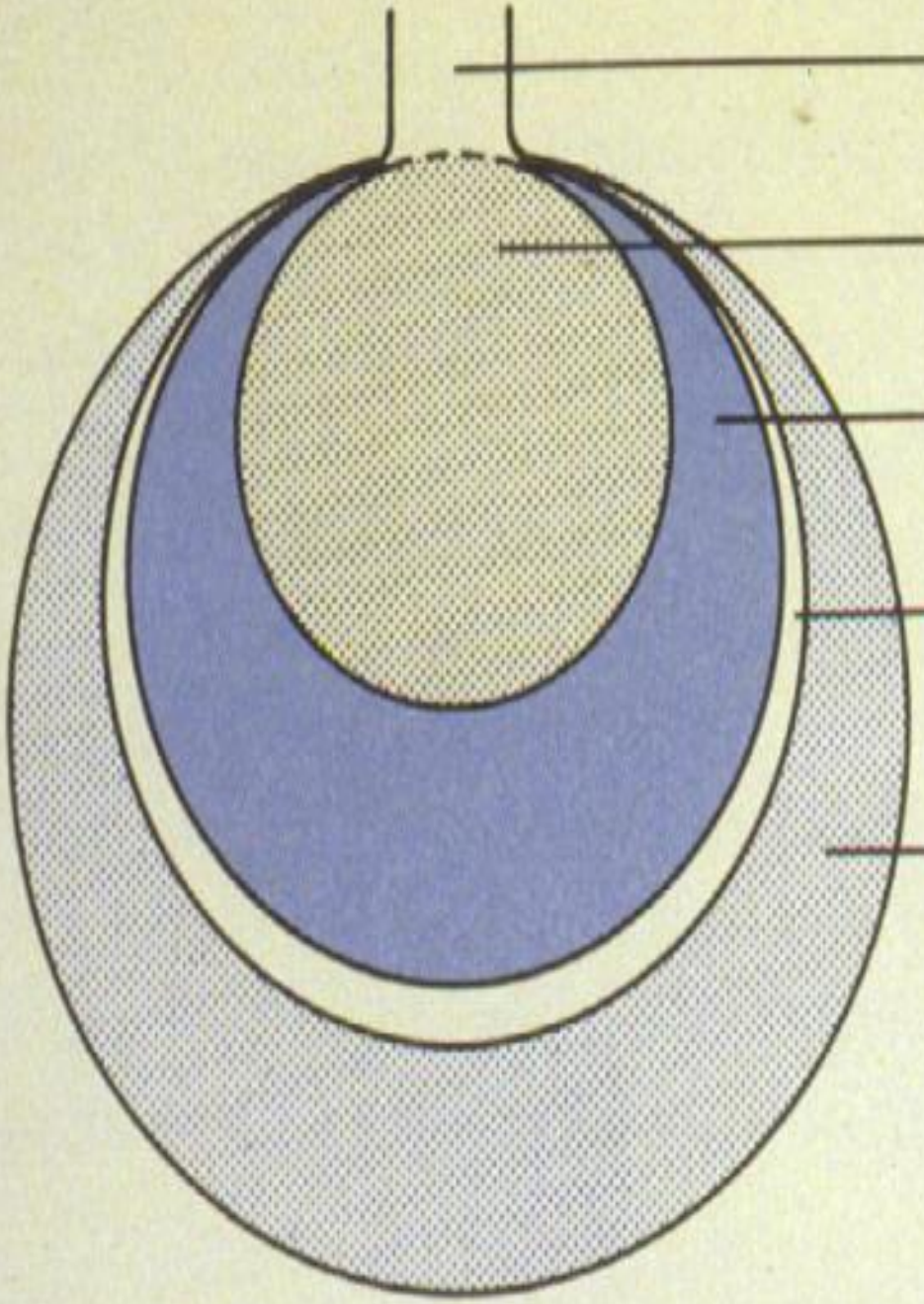


Iron Lung


Positive pressure valve
Negative pressure valve
Leather diaphragm


Atmospheric pressure
760 mm Hg
Trachea
Atmospheric
760
Bronchus
Rigid thoracic
wall
Intrapulmonary
760
Parietal pleura
760
Pleural cavity
Elasticity
of lung
5
5
Visceral pleura
Intrapleural
755
Lung
Diaphragm

Volumes of the Lung



Dead space

Residual volume

Expiratory reserve volume

Tidal volume

Inspiratory reserve volume

Vital capacity

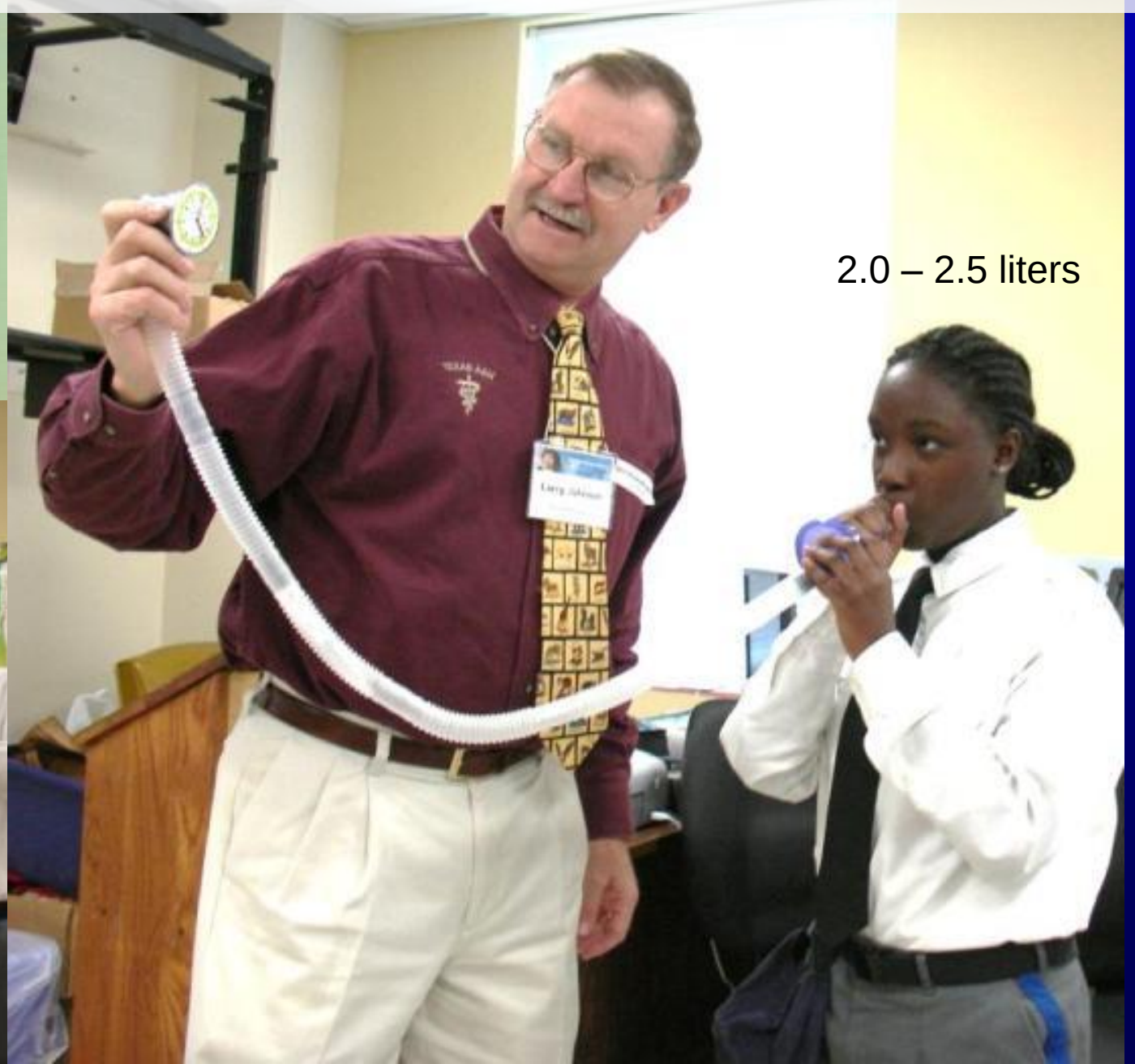
Functional residual capacity

Inspiratory capacity

Total lung capacity

Spirometer = Measures Lung Capacity

3.0 – 3.5 liters



2.0 – 2.5 liters

Routes of exposure to toxic materials in your environment

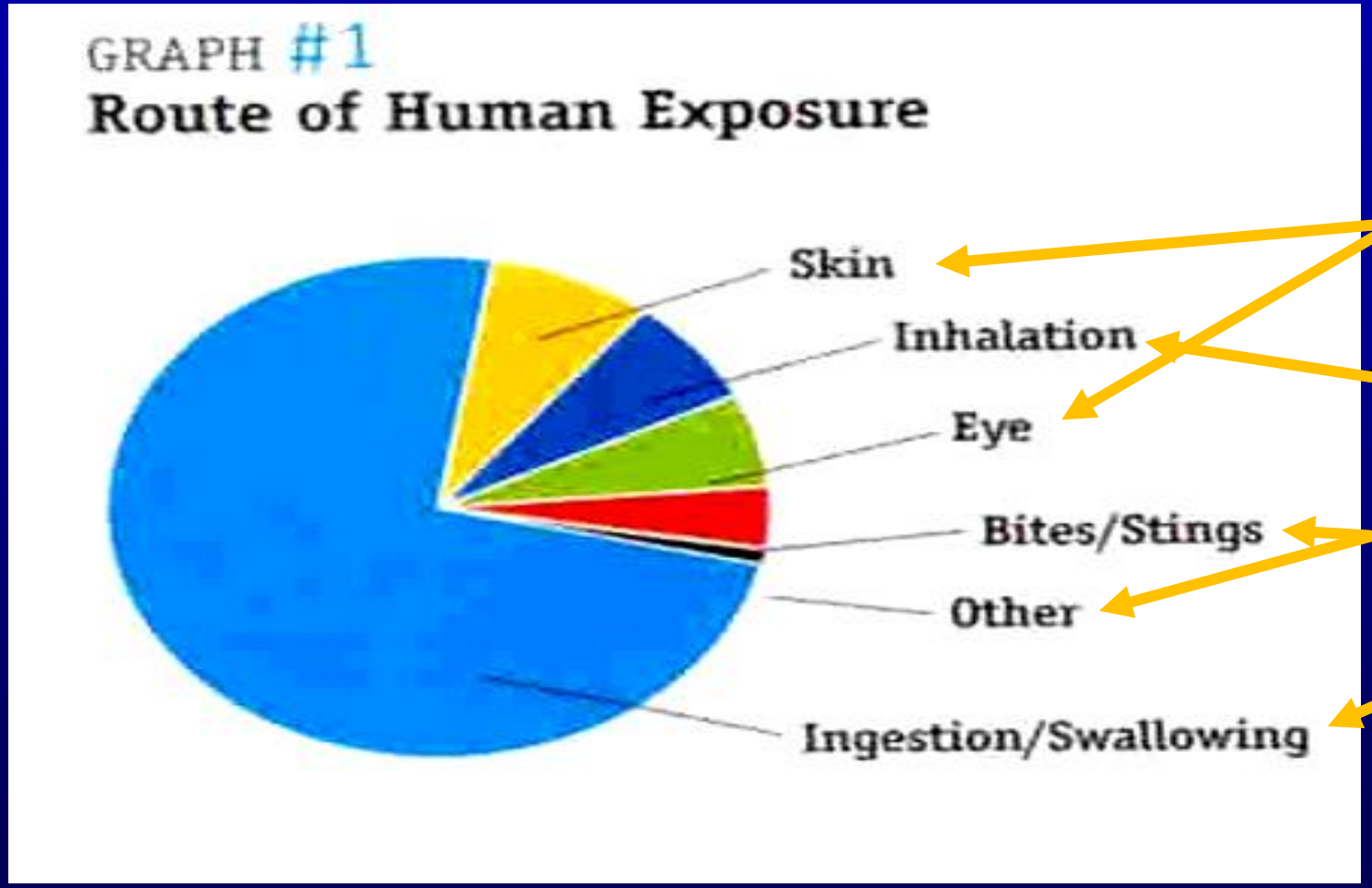
Ingestion (water and food)

Absorption (skin or eye)

Injection (bite, puncture, or cut)

Inhalation (air)

Routes of Environmental Exposure



“Dose Makes the Poison”

1. Too much of a good thing is bad
2. A low enough dose of a poison does not hurt

Lethal Doses

Approximate Lethal Doses of Common Chemicals (Calculated for a 160 lb. human from data on rats)	
Chemical	**Lethal Dose**
Sugar (sucrose)	3 quarts
Alcohol (ethyl alcohol)	3 quarts
Salt (sodium chloride)	1 quart
Herbicide (2, 4-D)	one half cup
Arsenic (arsenic acid)	1-2 teaspoons
Nicotine	one half teaspoon
Food poison (botulism)	microscopic

The magnitude of risk is proportional to both the potency of the chemical and the extent (amount) of exposure.

Toxicology Terms

Toxicity –

The adverse effects that a chemical may produce.

Dose –

The amount of a chemical that gains access to the body.

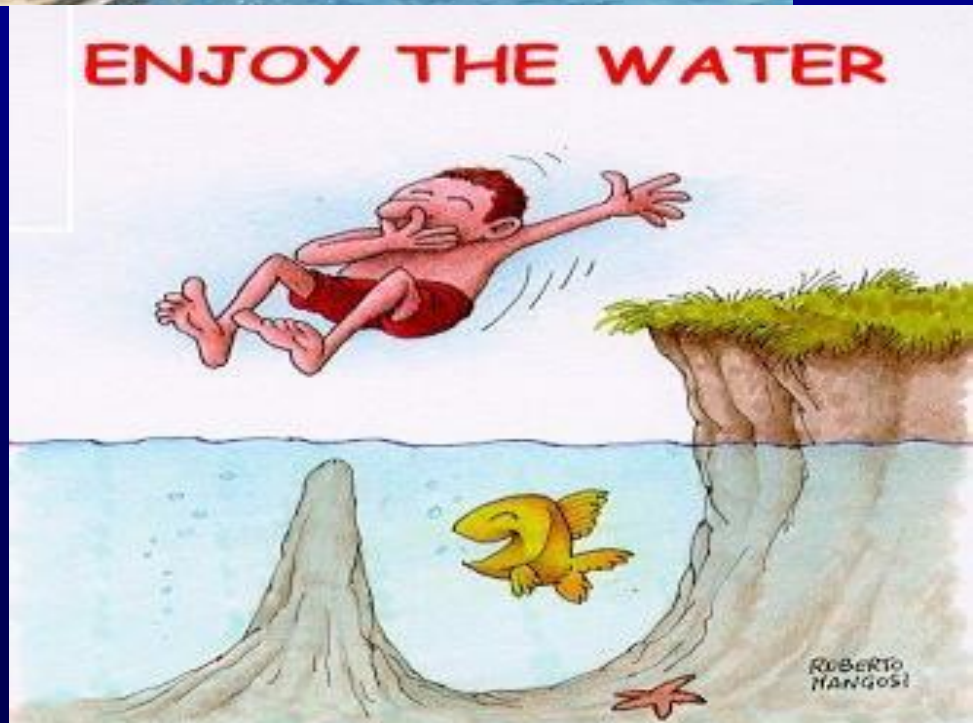
Toxicology Terms

Exposure

Contact providing opportunity of obtaining a poisonous dose.

Hazard

The likelihood that the toxicity will be expressed.



Fundamental Concepts Of Toxicology

Exposure must first occur for the chemical to present a risk.

The magnitude of risk is proportional to both the potency of the chemical and the extent of exposure.

"The dose makes the poison" (amount of chemical at the target site determines toxicity).

Approximate Lethal Doses of Common Chemicals
(Calculated for a 160 lb. human from data on rats)

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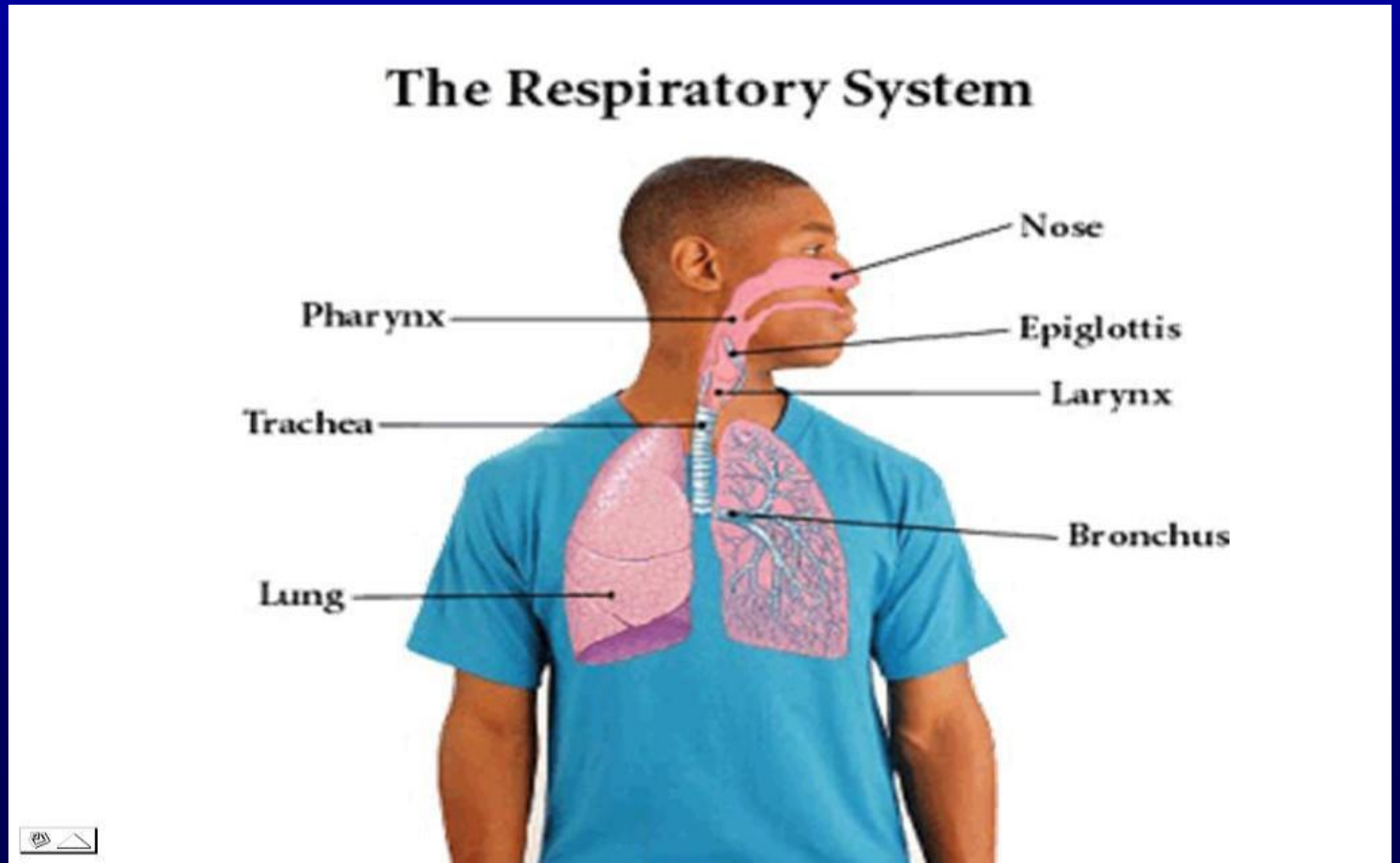
The Respiratory System:

Conducting portion

Respiratory portion

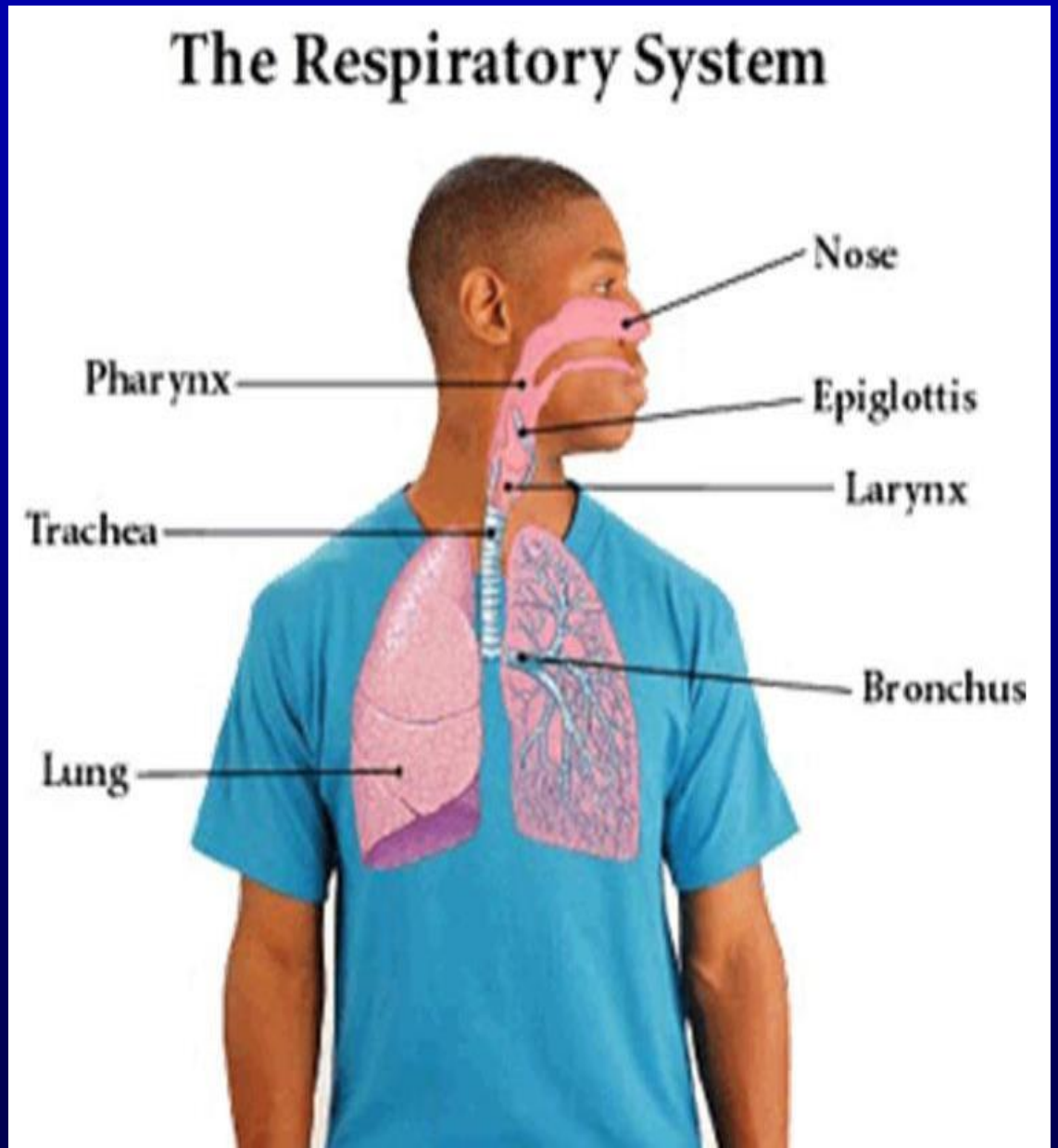


Conducting Portion

Cleans air

Warms air

Humidifies air



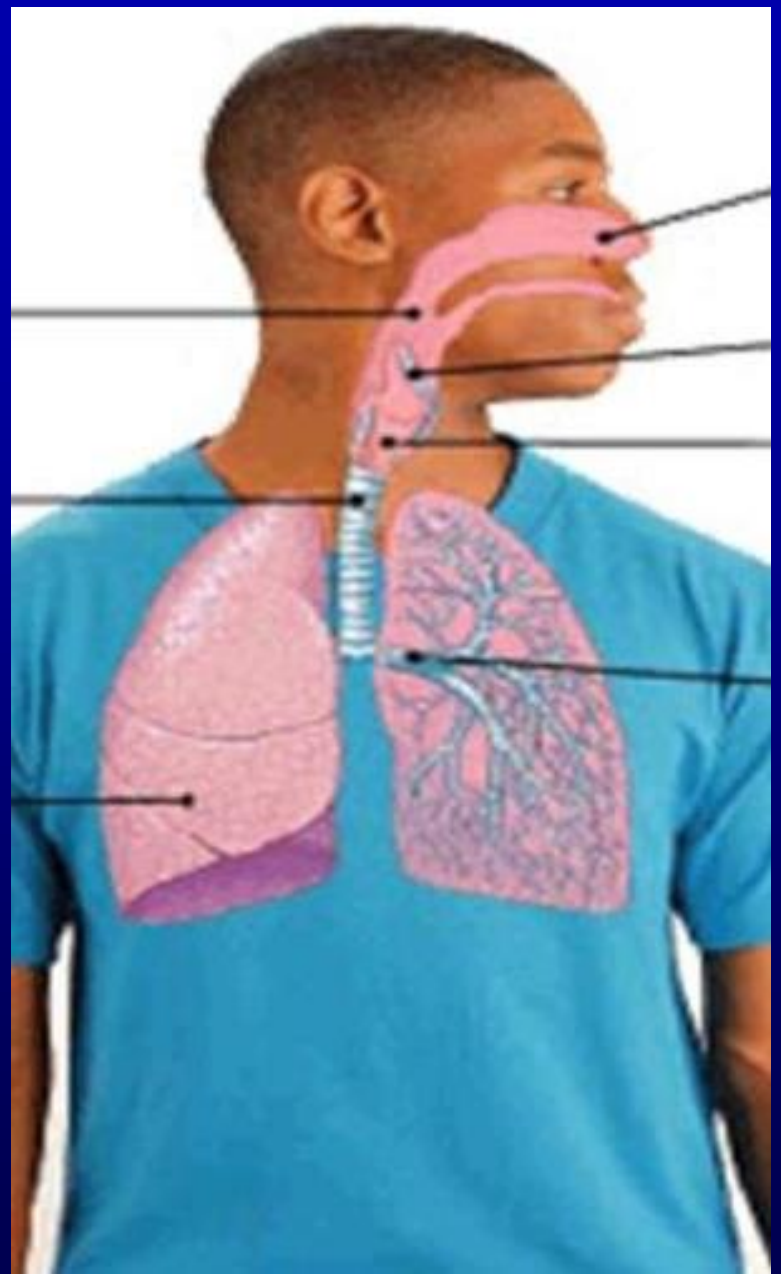
“Conditioning Air” by the Conducting Portion

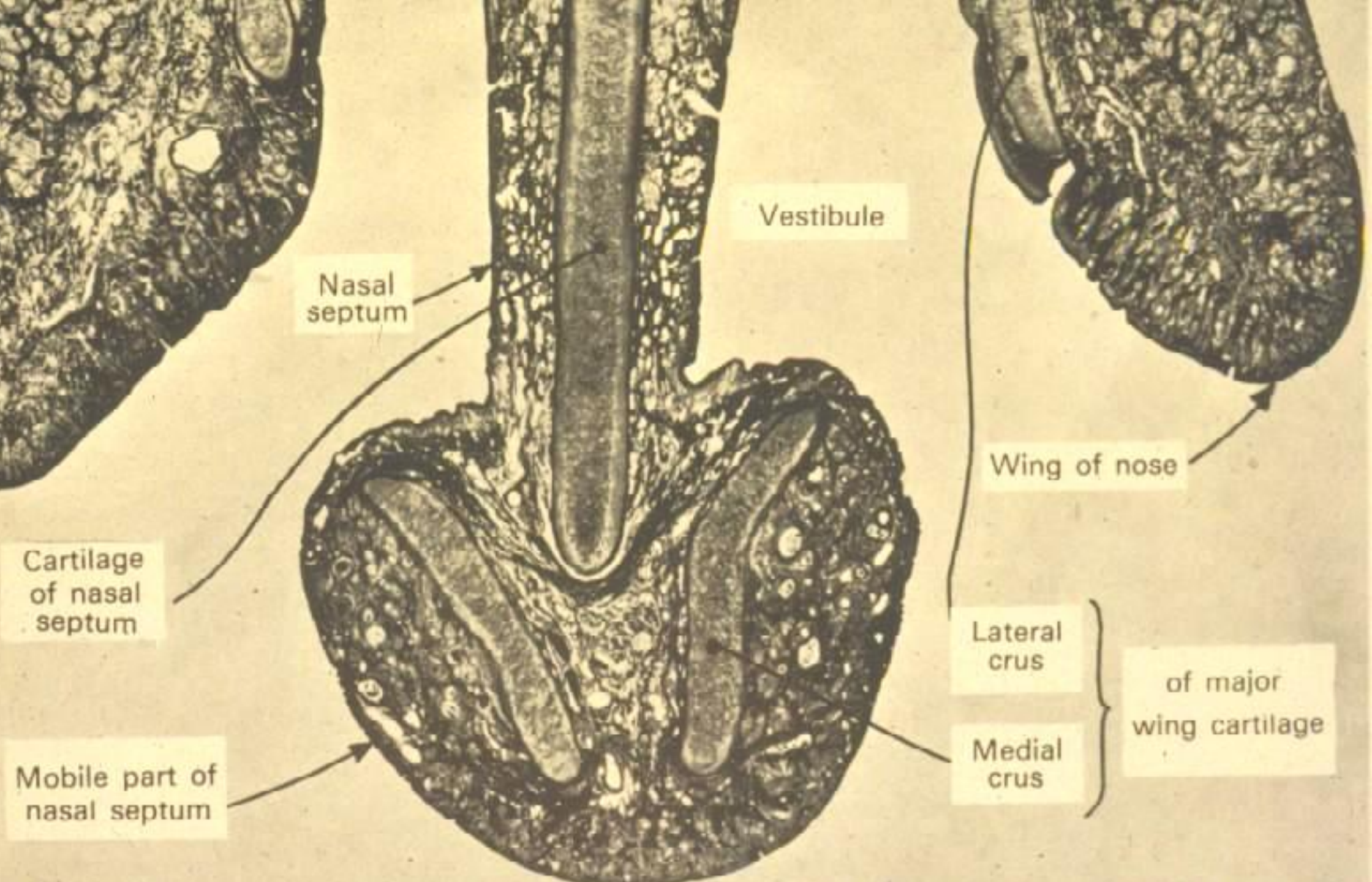
Specialized respiratory epithelium

Numerous mucous and serous gland

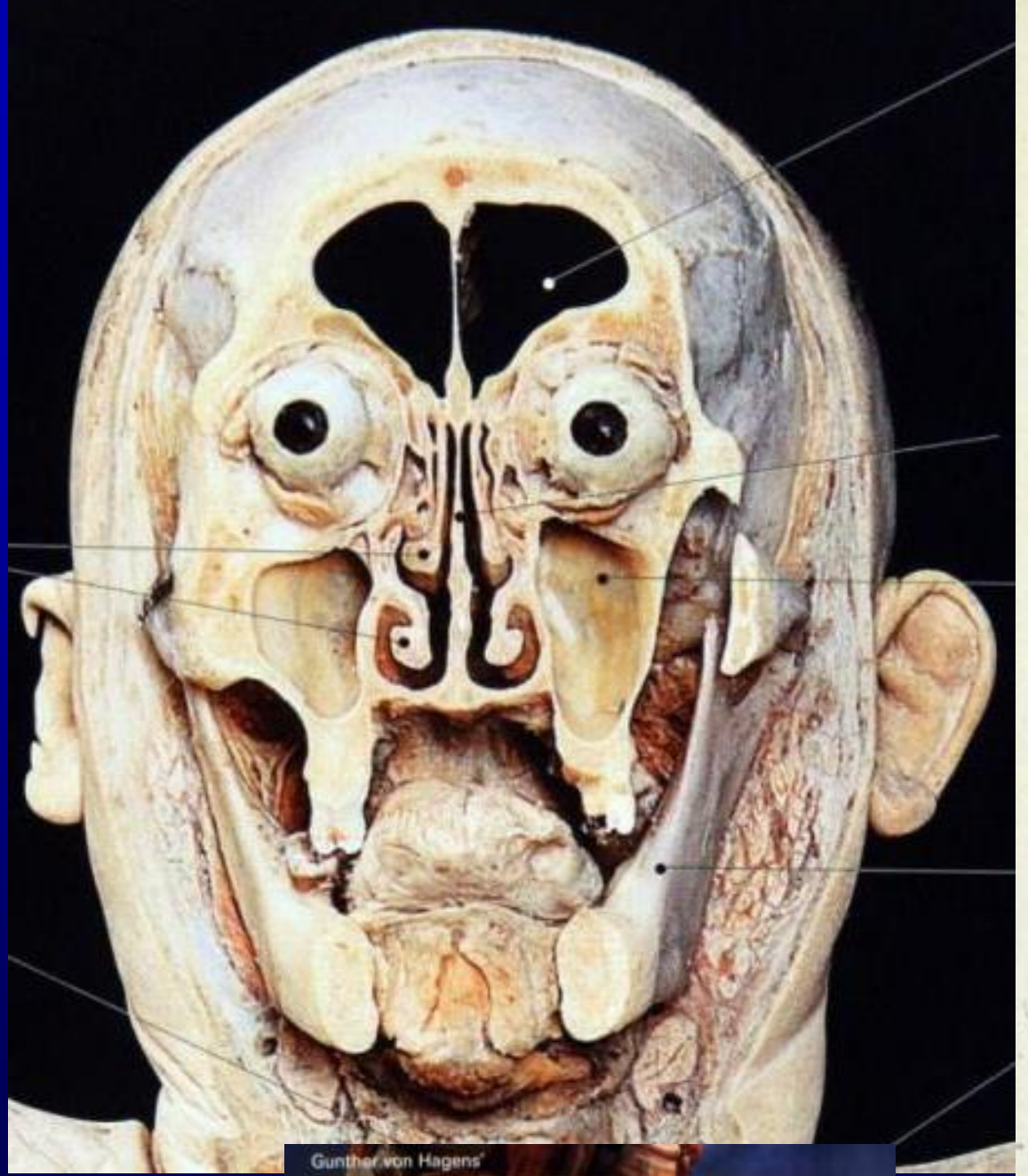
- **Traps particulate and gaseous impurities**
- **Prevents alveolar lining from desiccation**

Rich superficial vascular network in lamina propria - warms blood in a counter current system (blood flows against inspired air)




Vestibule
Nasal septum
Wing of nose
Cartilage of nasal septum
Lateral crus
of major wing cartilage
Medial crus
Mobile part of nasal septum

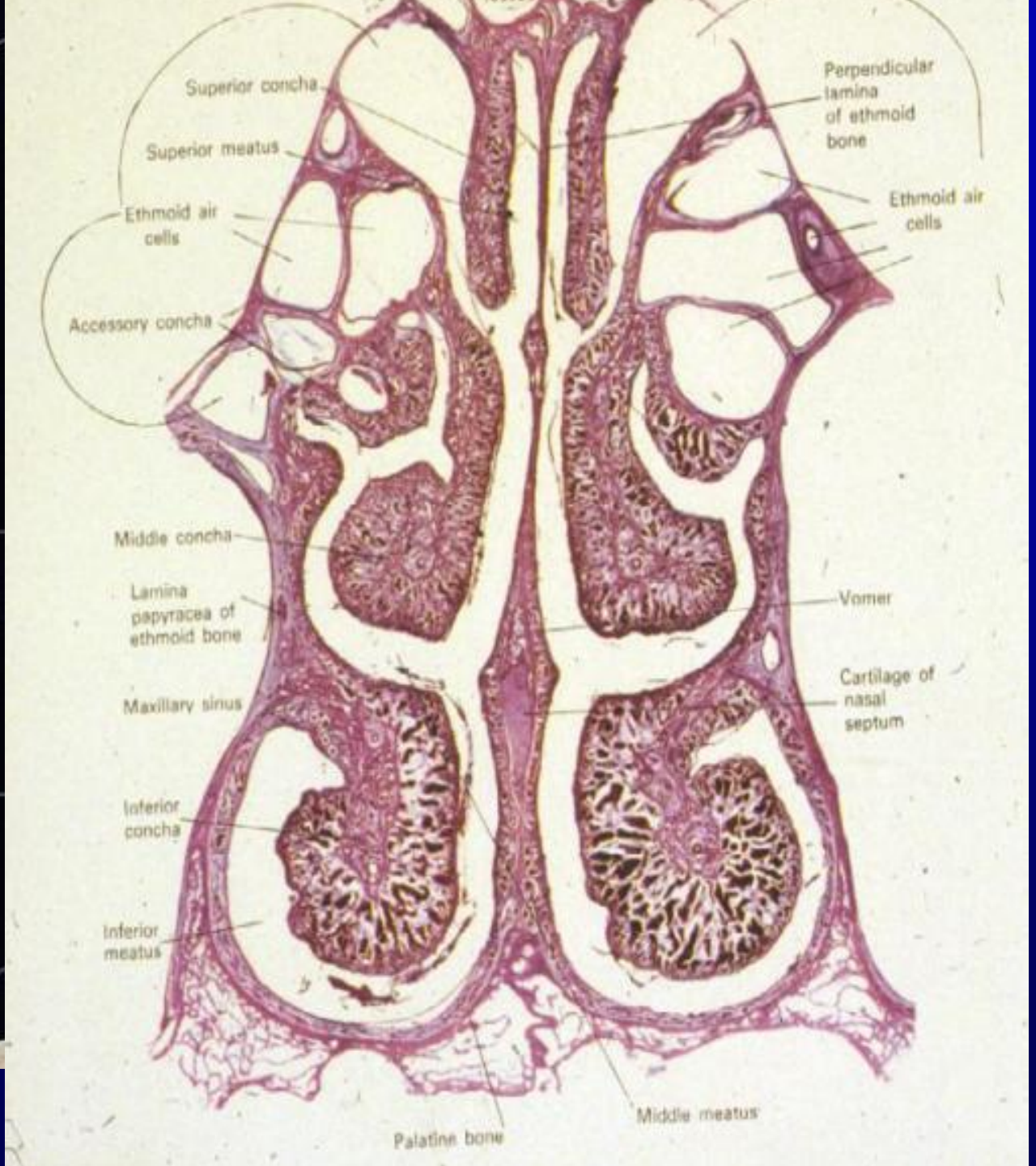

out



Gunther von Hagens'

BODY WORLDS

The Anatomical Exhibition of Real Human Bodies



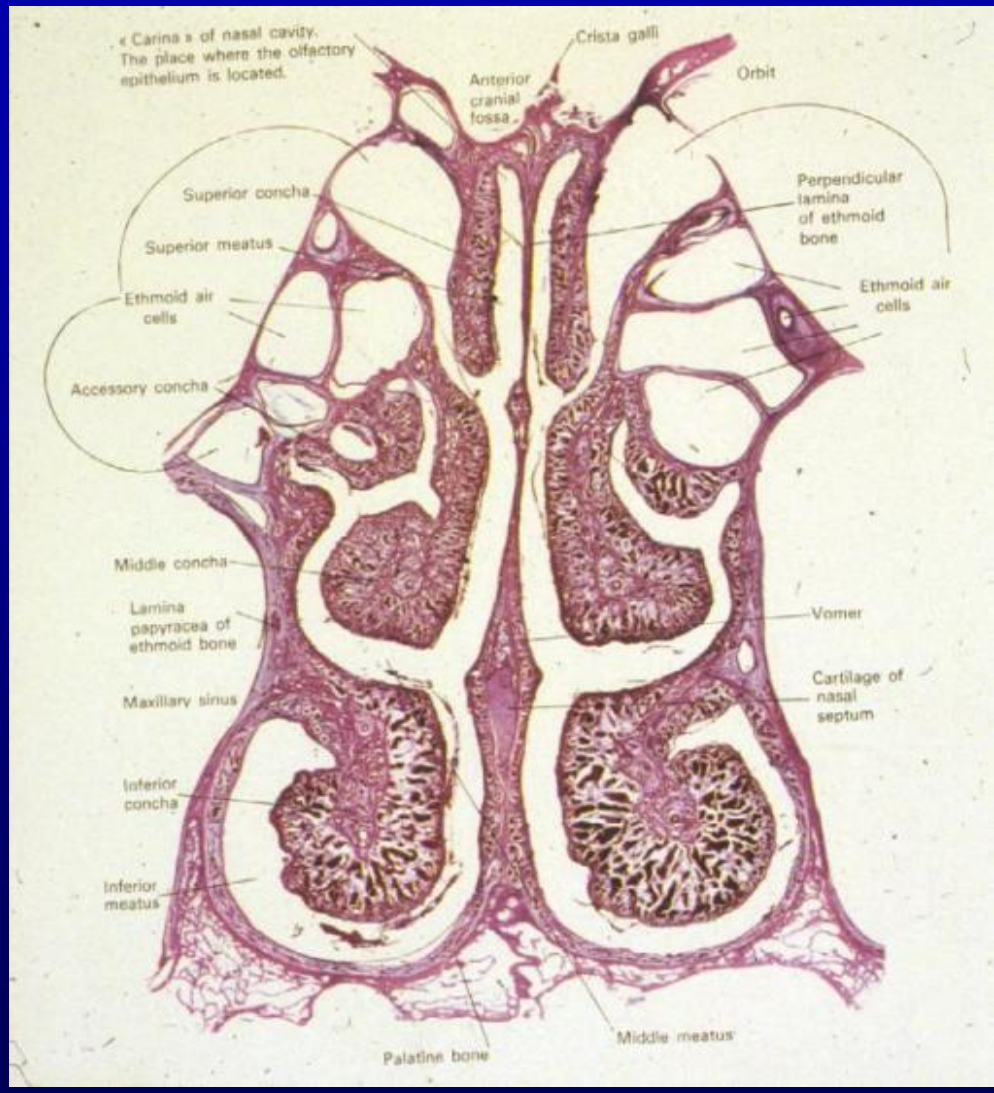
Conditioning Air By The Conducting Portion

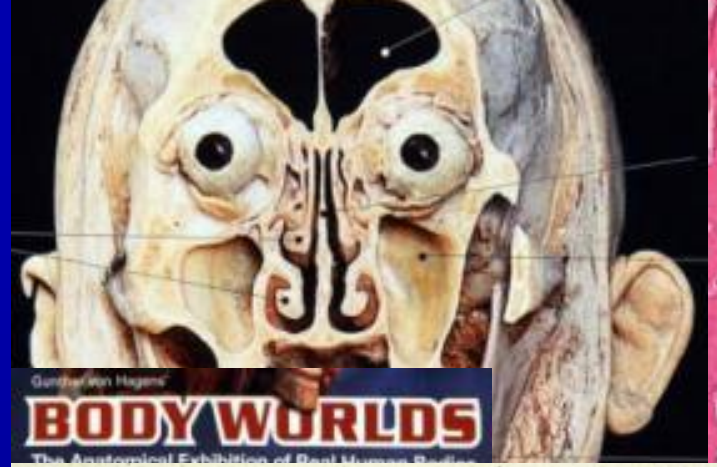
Nasal fossae

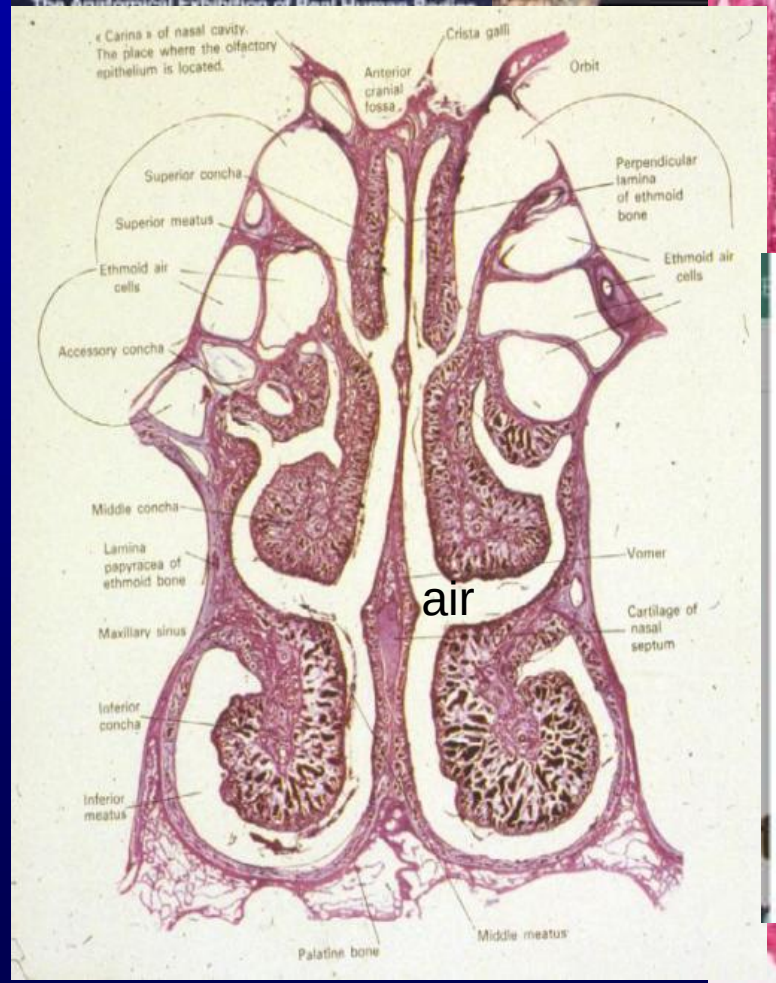
- Superior conchae - olfactory epithelium long cilia, nervous cells
- Middle conchae - respiratory epithelium
- Inferior conchae - respiratory epithelium

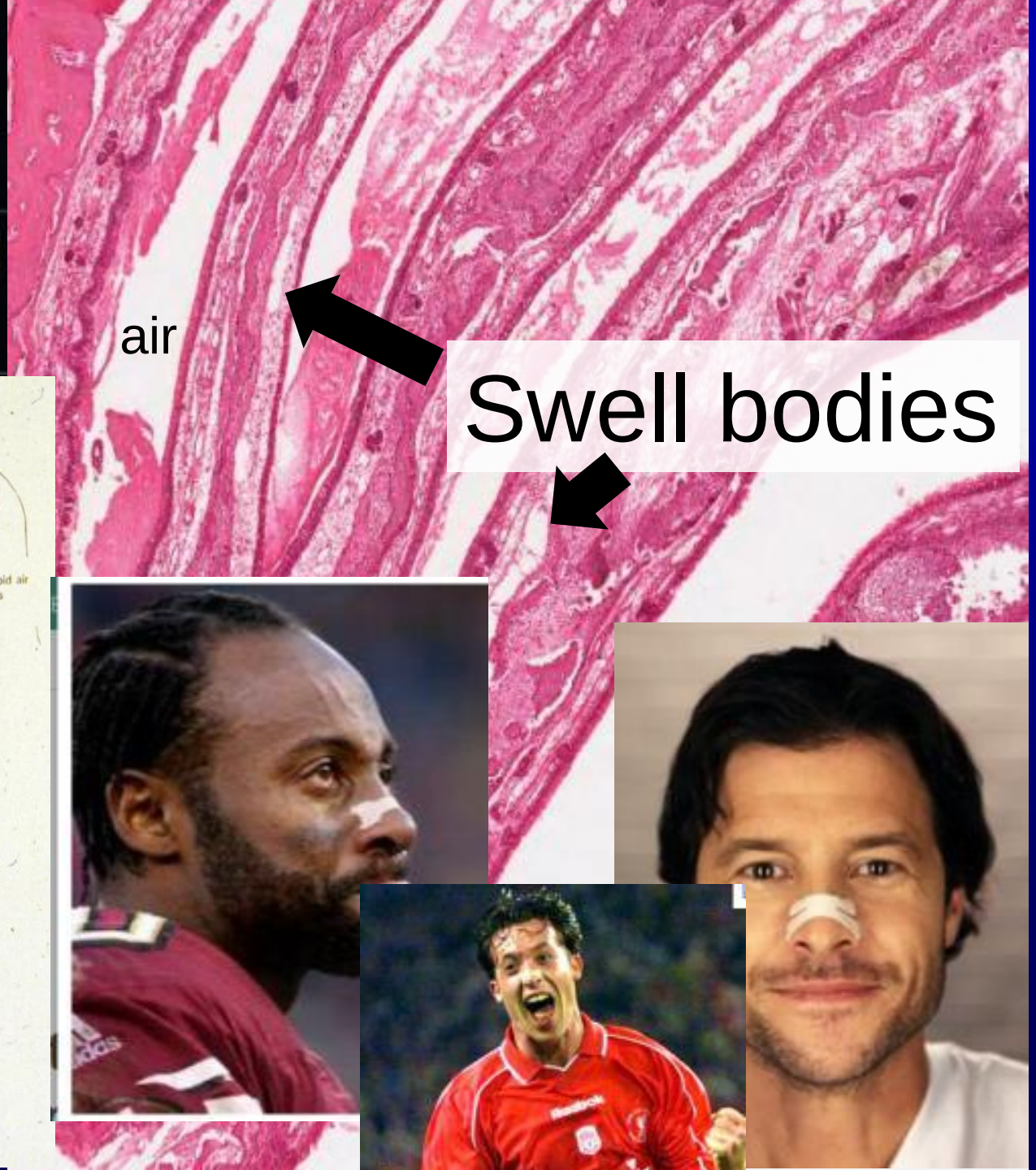
Swell bodies

- large venous plexus that direct air (occludes air way)
- Allergic reaction or inflammation restrict air flow
- counter current system warms air



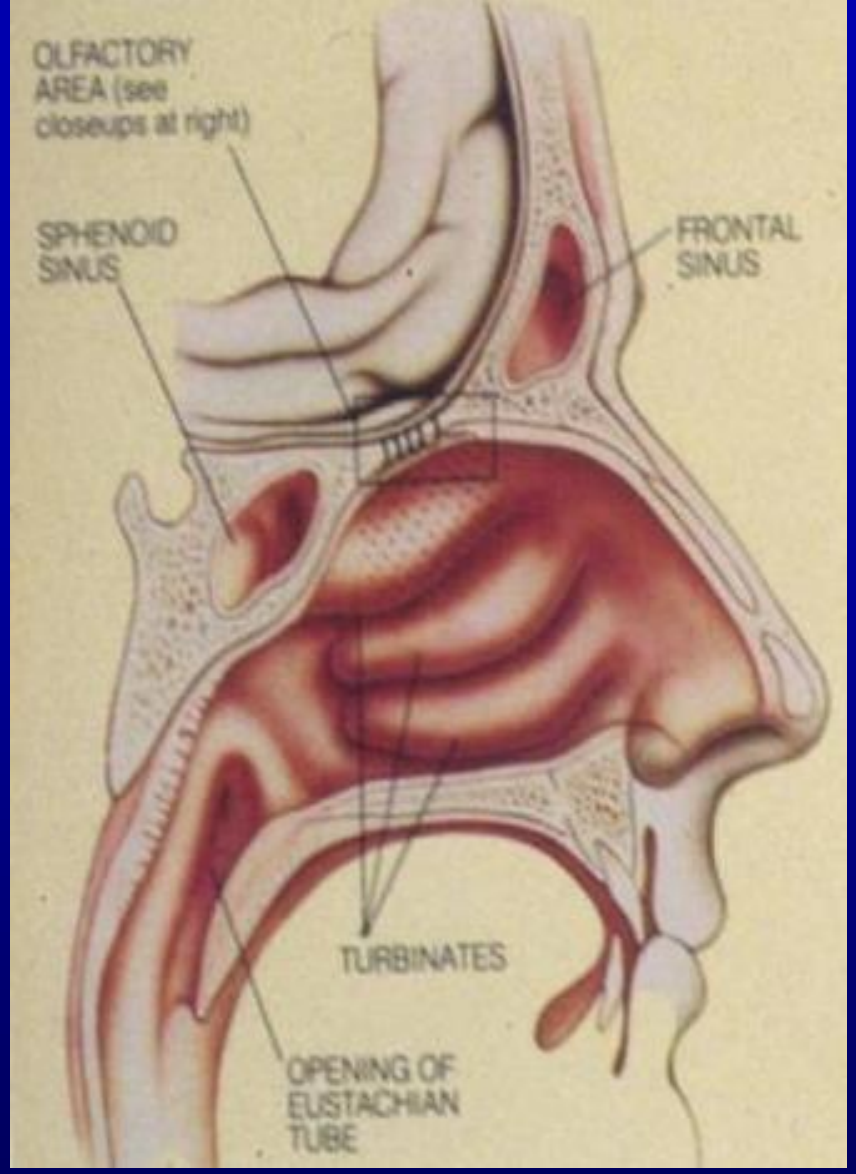

BODY WORLDS


« Carina » of nasal cavity. The place where the olfactory epithelium is located.
Crista galli
Anterior cranial fossa
Orbit
Superior concha
Superior meatus
Perpendicular lamina of ethmoid bone
Ethmoid air cells
Ethmoid air cells
Accessory concha
Middle concha
Lamina papyracea of ethmoid bone
Vomer
air
Maxillary sinus
Cartilage of nasal septum
Inferior concha
Inferior meatus
Palatine bone
Middle meatus

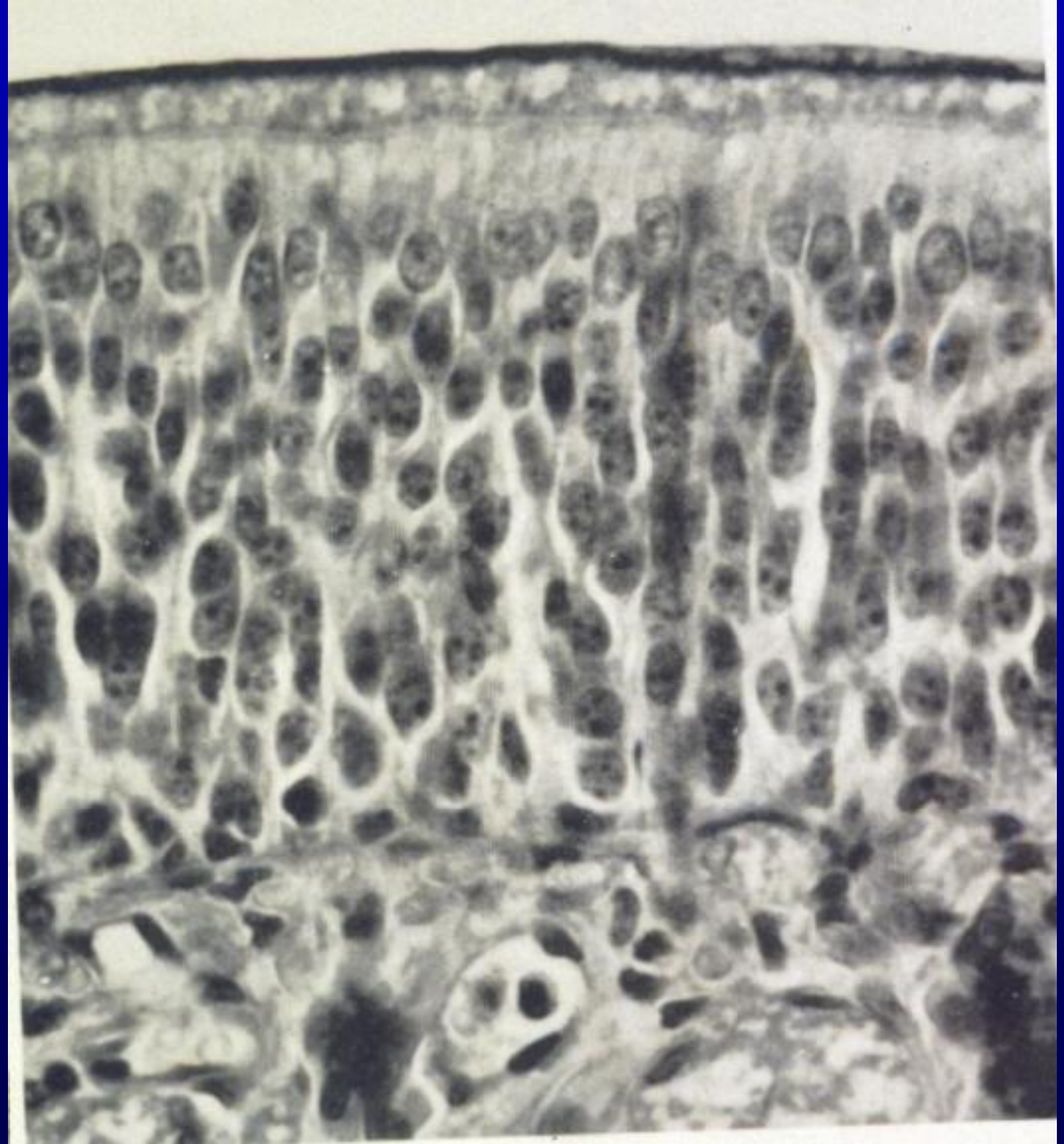

air
Swell bodies

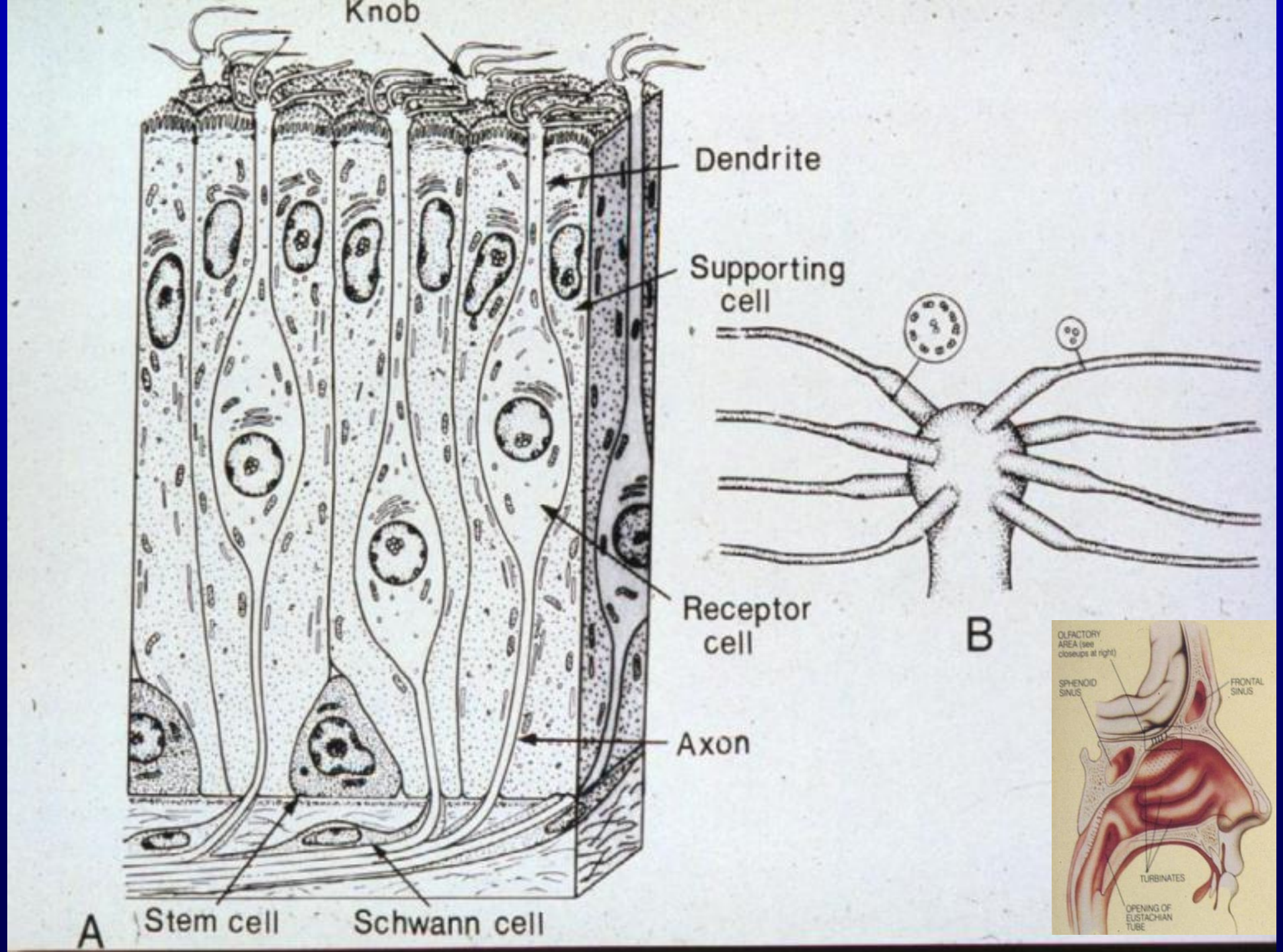
The highly vascular nature of the lamina propria is important for conditioning inhaled air. A complex vasculature with loops of capillaries near the epithelial surface carries blood in a general direction counter to the flow of inspired air and releases heat to warm that air. Also, the swell bodies reduce the flow of air on either side of the nose and switches every 30 min to allow rehydration on one side as air flow is shifted to the other side.

Respiratory epithelium



Olfactory epithelium




Knob
Dendrite
Supporting cell
Receptor cell
Axon
Stem cell
Schwann cell
A
B
OLFACTORY AREA (see closeups at right)
SPHENOID SINUS
FRONTAL SINUS
TURBINATES
OPENING OF EUSTACHIAN TUBE

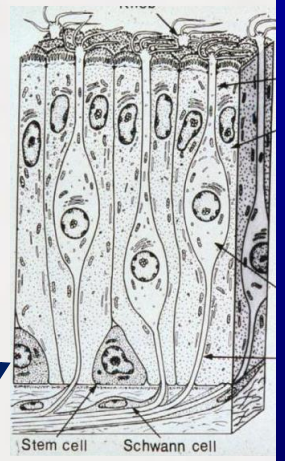
Animal Respiratory (Olfactory) mucosa and nasal septum

Respiratory epithelium

Highly vascular lamina propria
Swell bodies

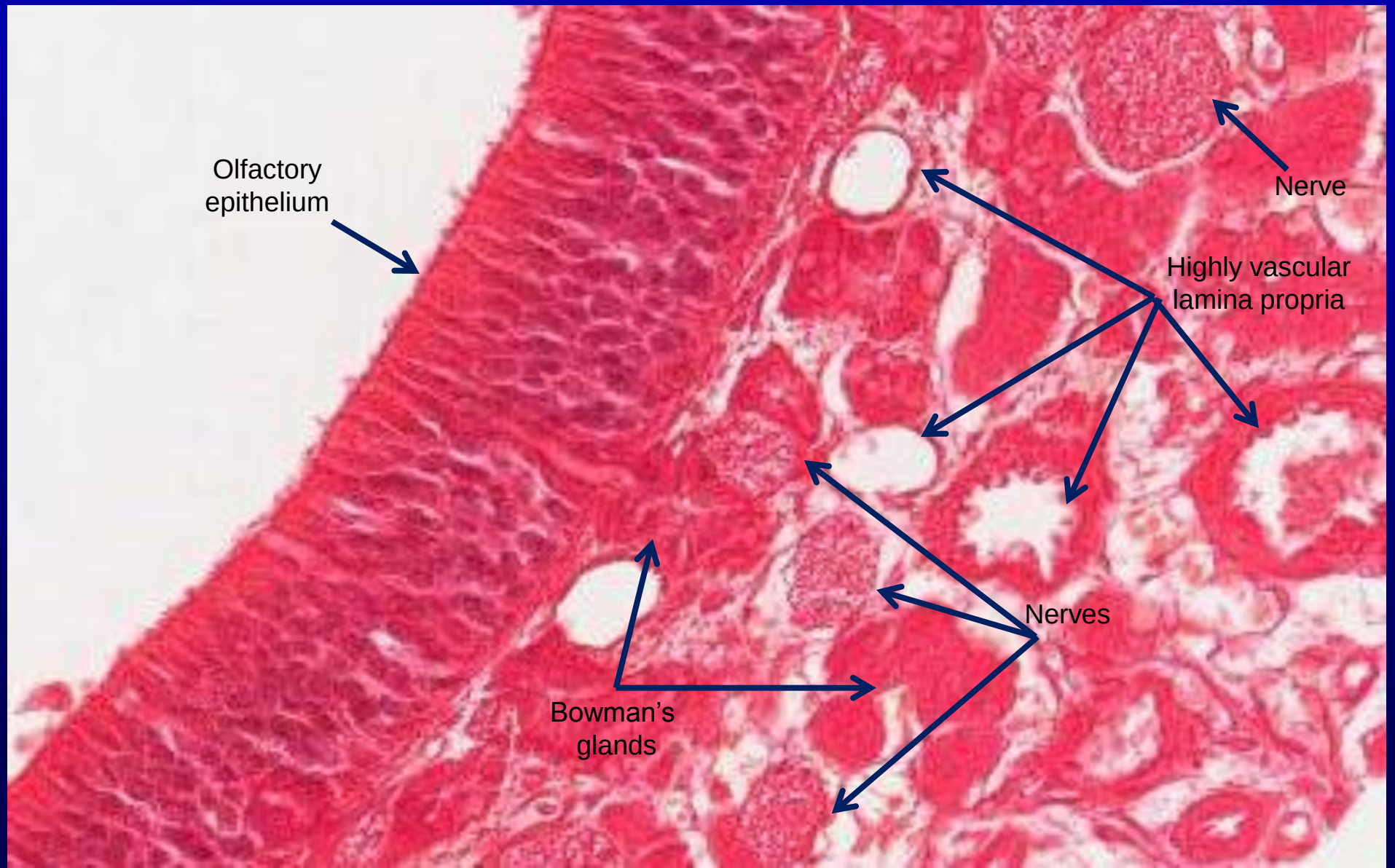
Histo 036 001

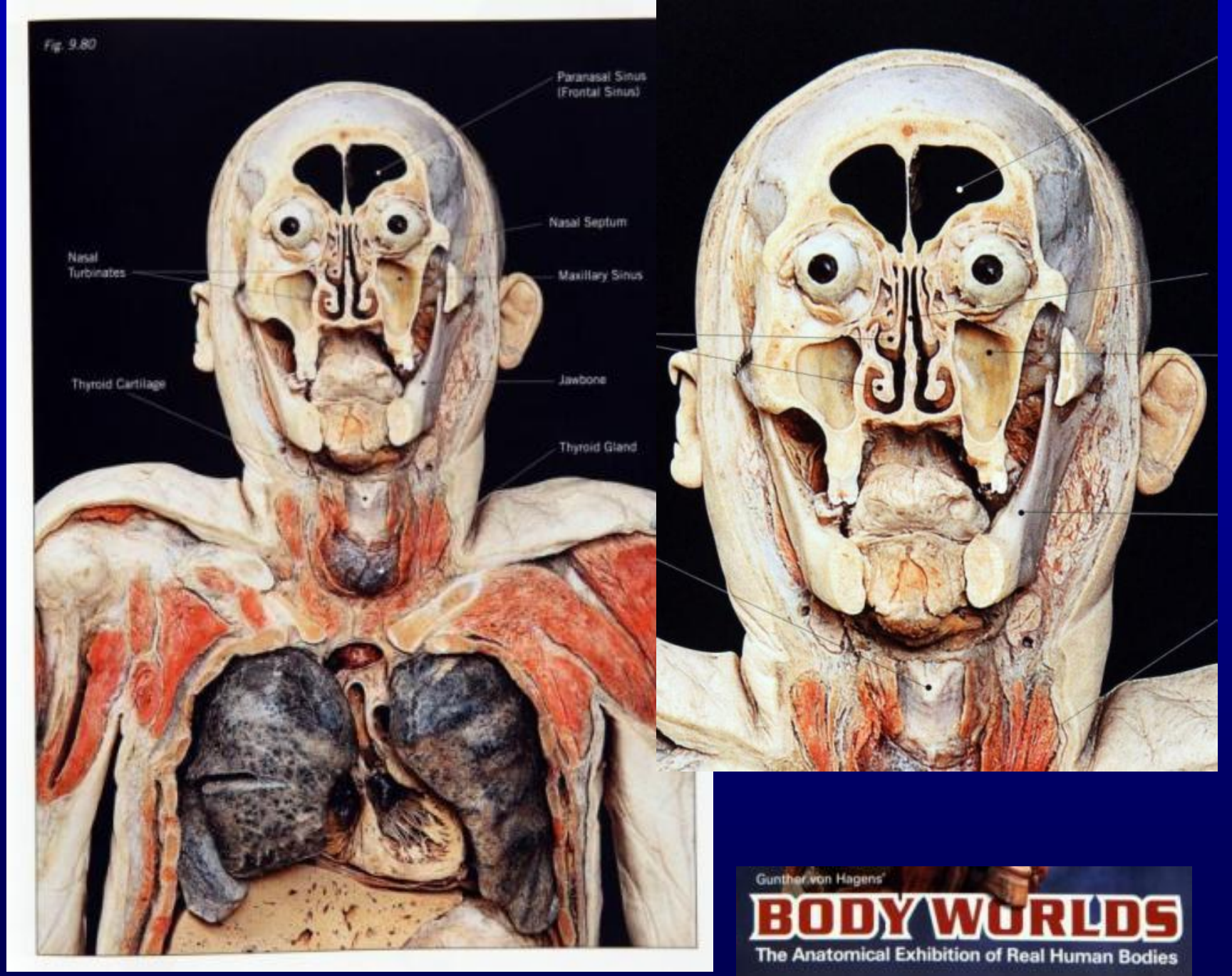
Olfactory epithelium



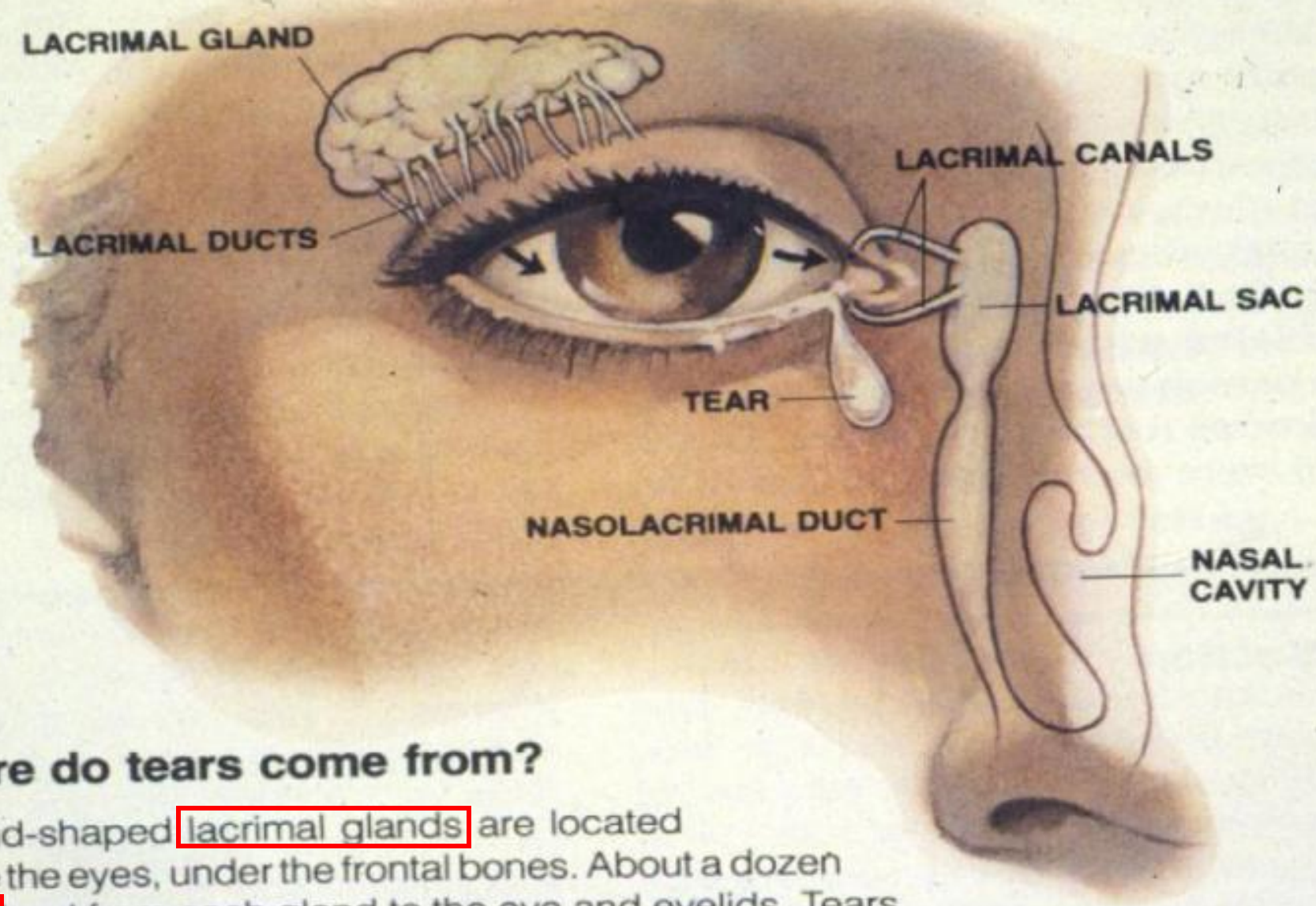
Bowman's glands

Histo 36 001: Respiratory (Olfactory) mucosa and nasal septum





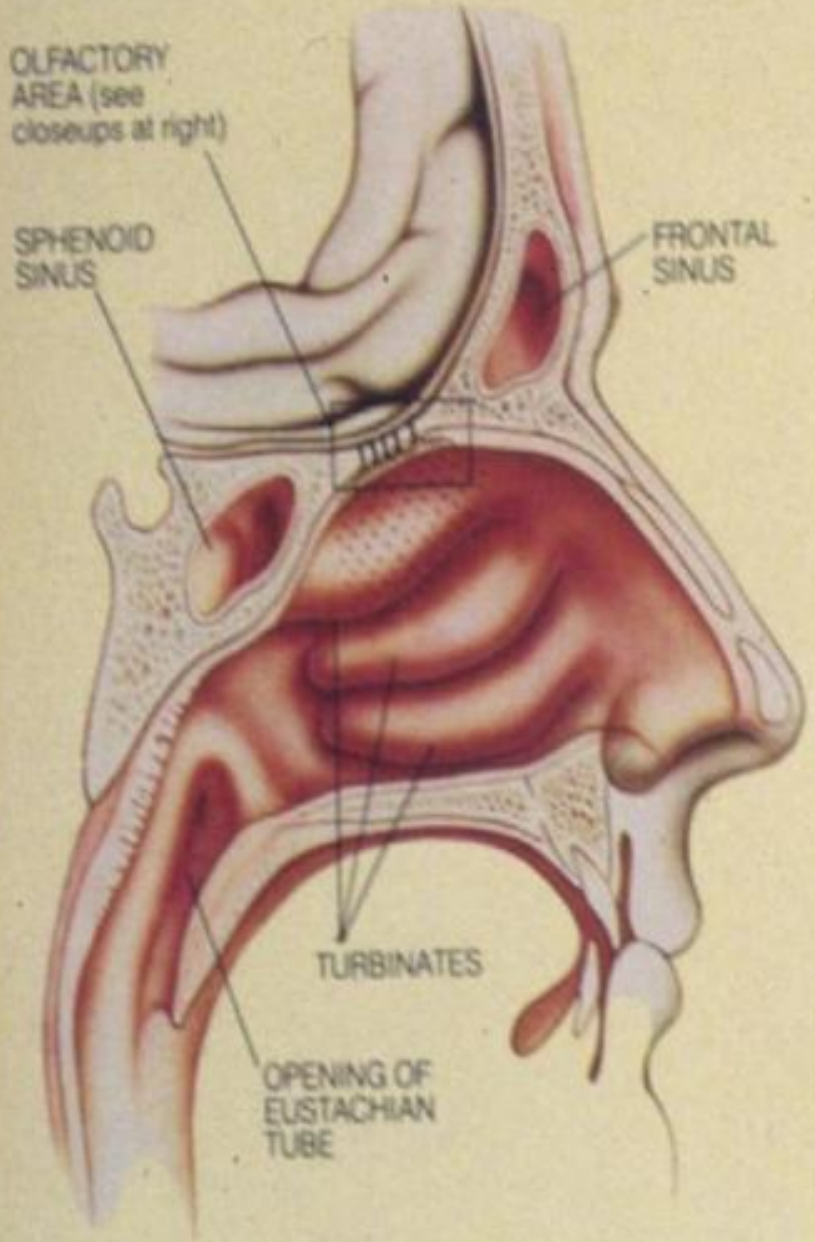
Gunther von Hagens'
BODY WORLDS
The Anatomical Exhibition of Real Human Bodies



Where do tears come from?

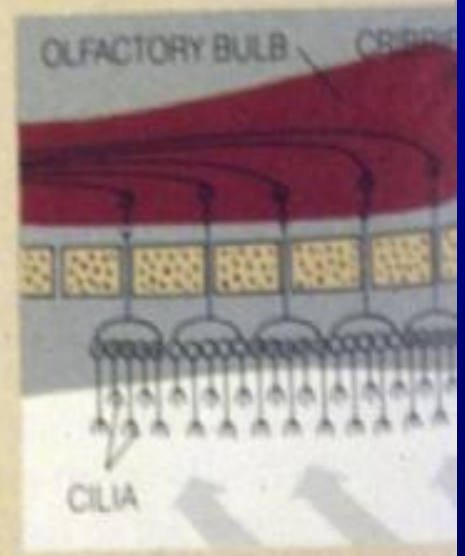
Almond-shaped lacrimal glands are located above the eyes, under the frontal bones. About a dozen ducts lead from each gland to the eye and eyelids. Tears are normally salty because they are derived from the circulatory system, which has a salt composition of about 0.9 percent. Tears are also sterile because they contain bacteria-destroying enzymes, which provide a measure of protection from infection. When you blink, tears bathe the eyes, keeping the cornea moist. The fluid drains down through the inside corner of the eye into a lacrimal sac and from

What does your nose do for you?



Beyond its important role as the collector of olfactory information – such as whiffs of smoke that warn of impending danger or smells that whet the appetite – the nose acts as an air conditioner for the respiratory system. Everyday, it treats approximately 500 cubic feet of air, the amount enclosed in a small room .It filters dust, traps bacteria from the air, brings air to the temperature of the body and also adds moisture. And then, the nose has some lesser-known functions. Among them it gives your voice resonance, adding a richness of tone that would otherwise be lacking.

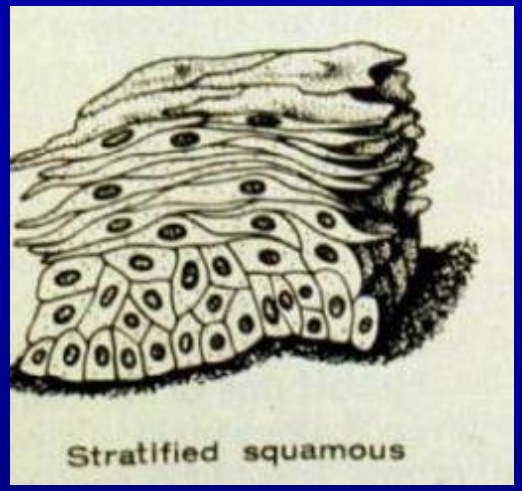
Odor receptors on the roof of the nasal passages communicate through a bony plate to the olfactory bulbs, which lead directly to the brain.

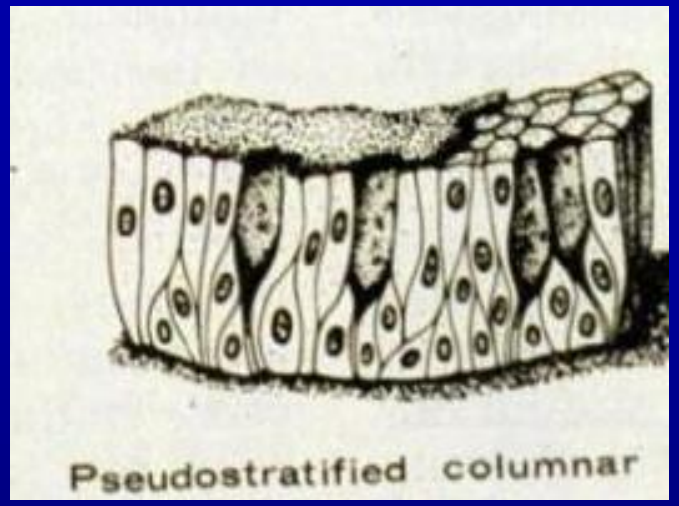


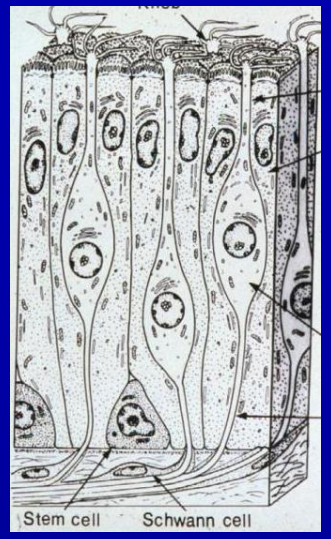
Hairlike cilia in the smell pat messages upward. There such patches, together takin much space as a postage s

Epithelium in the respiratory system

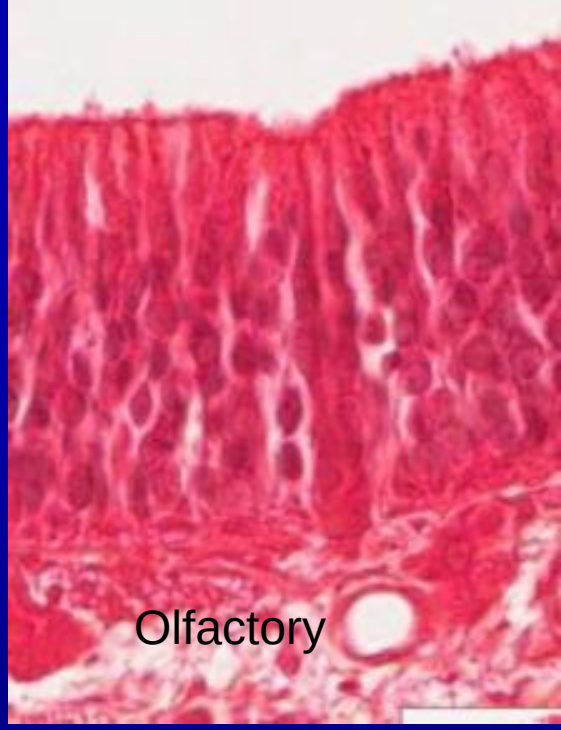
Respiratory epithelium



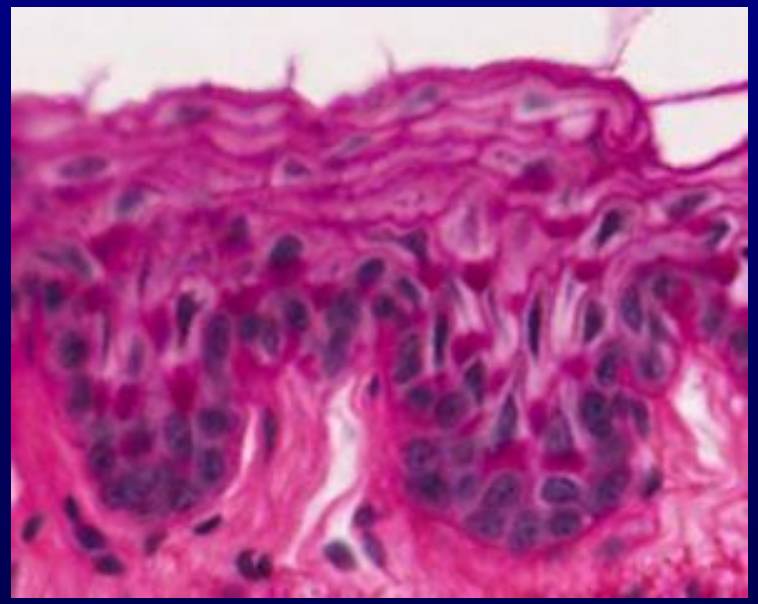


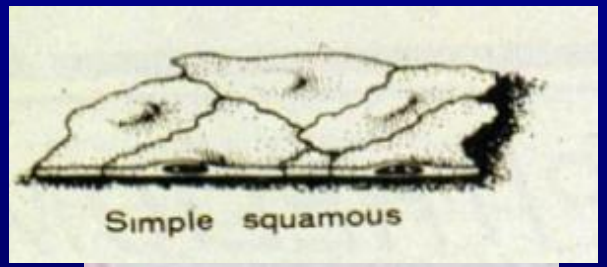


Olfactory epithelium

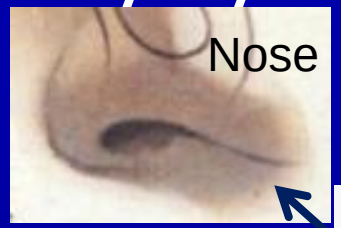


Olfactory



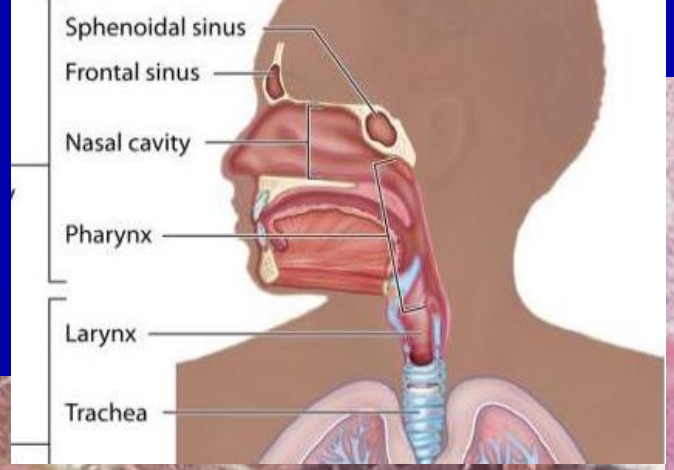


Epithelium in the respiratory system

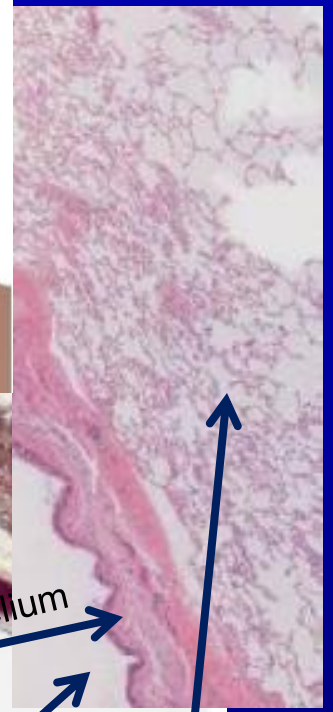


Nose

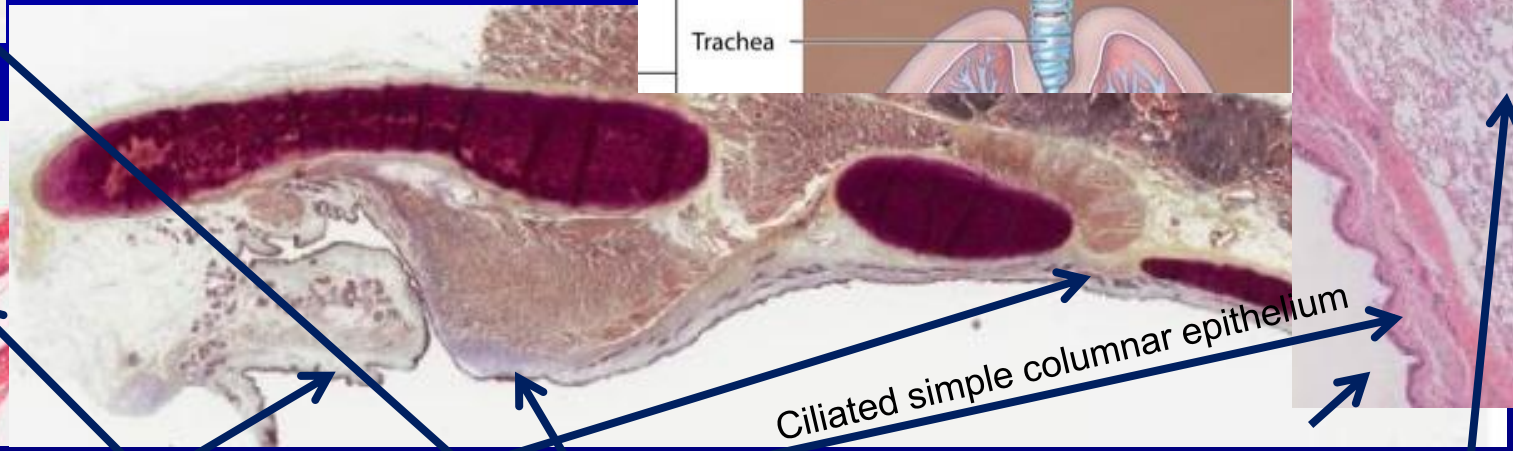
Skin junction



Air sacs



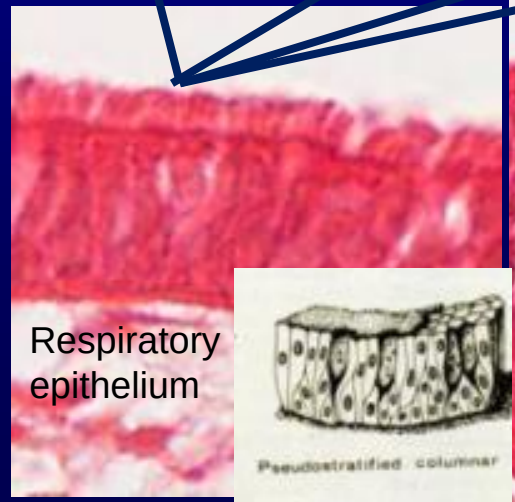
Nasal cavity



Ciliated simple columnar epithelium

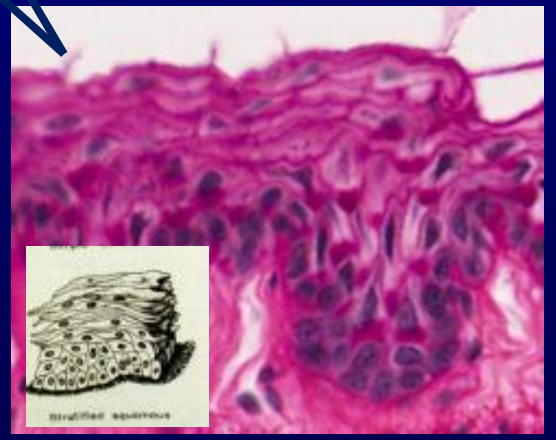
Histo 36

Conducting bronchiole



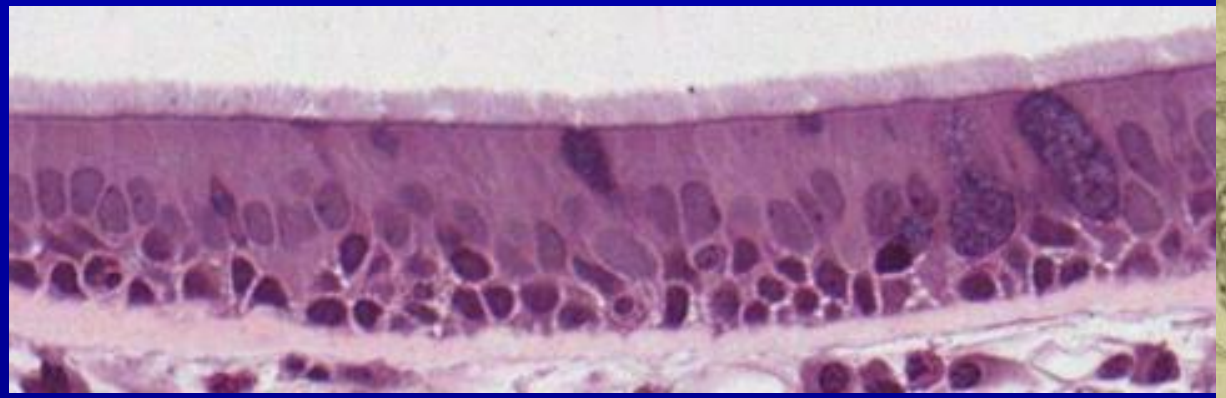
Respiratory epithelium

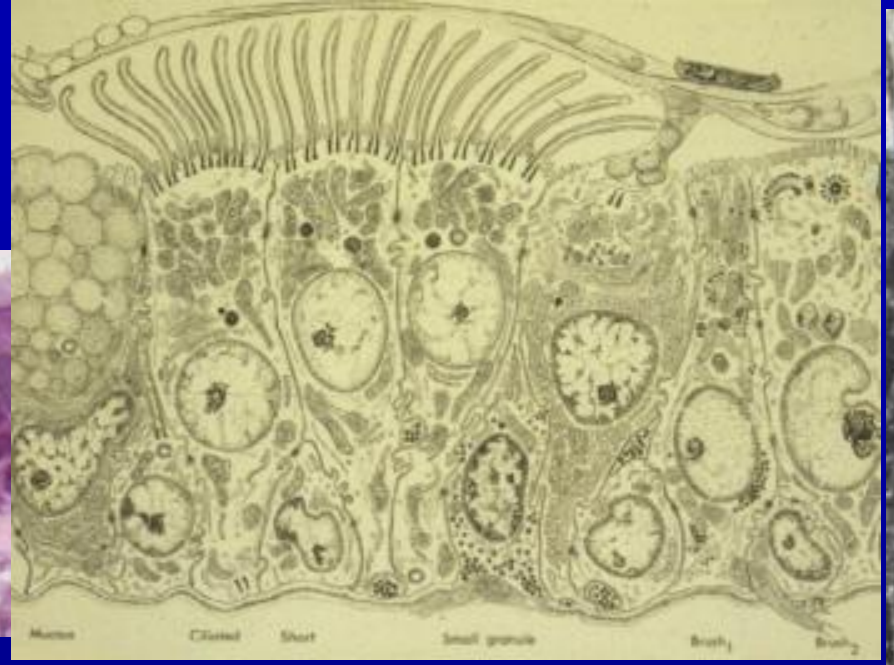
Olfactory

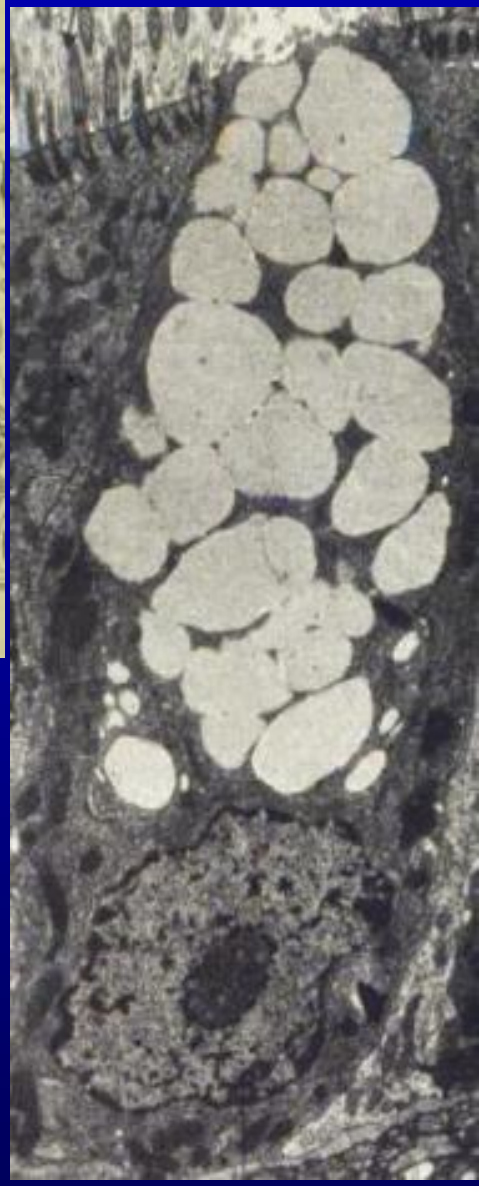


Air sac

Function of Mucus in the Respiratory System







Goblet cell in respiratory epithelium

- Detoxifies gases
- Has protein that presents odor chemicals to receptors of olfactory cells
- Washes away current chemicals to allow one to smell the next chemical odor
- Traps dust and washes it away
- Contains IgA antibodies to guard against infection

Conducting Portion – Conduit to External Environment and Conditions Expired Air

- Nasal cavity (nasal fossae)
- Nasopharynx
- Larynx
- Trachea
- Bronchi
- Bronchioles
- Terminal
  - bronchioles

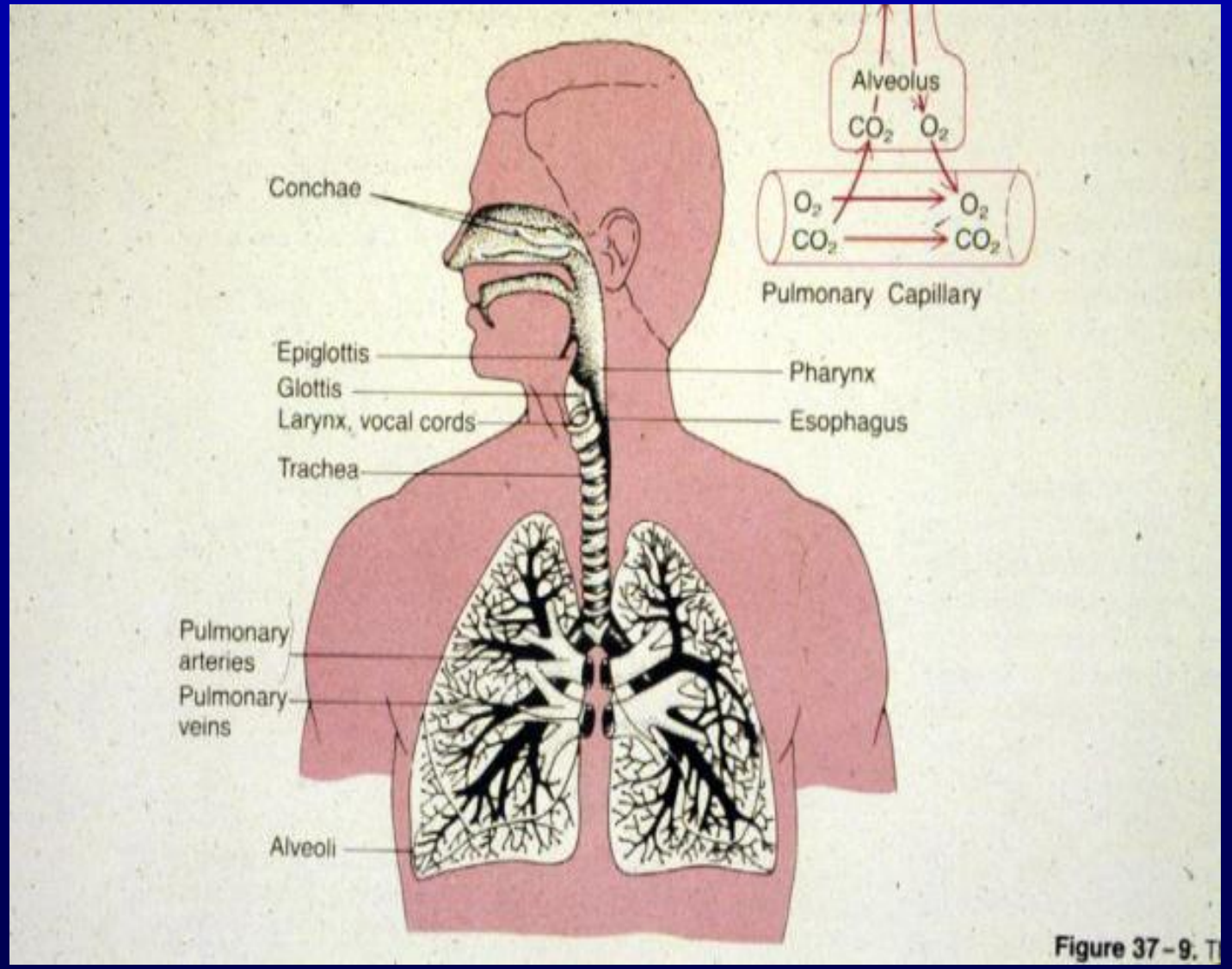
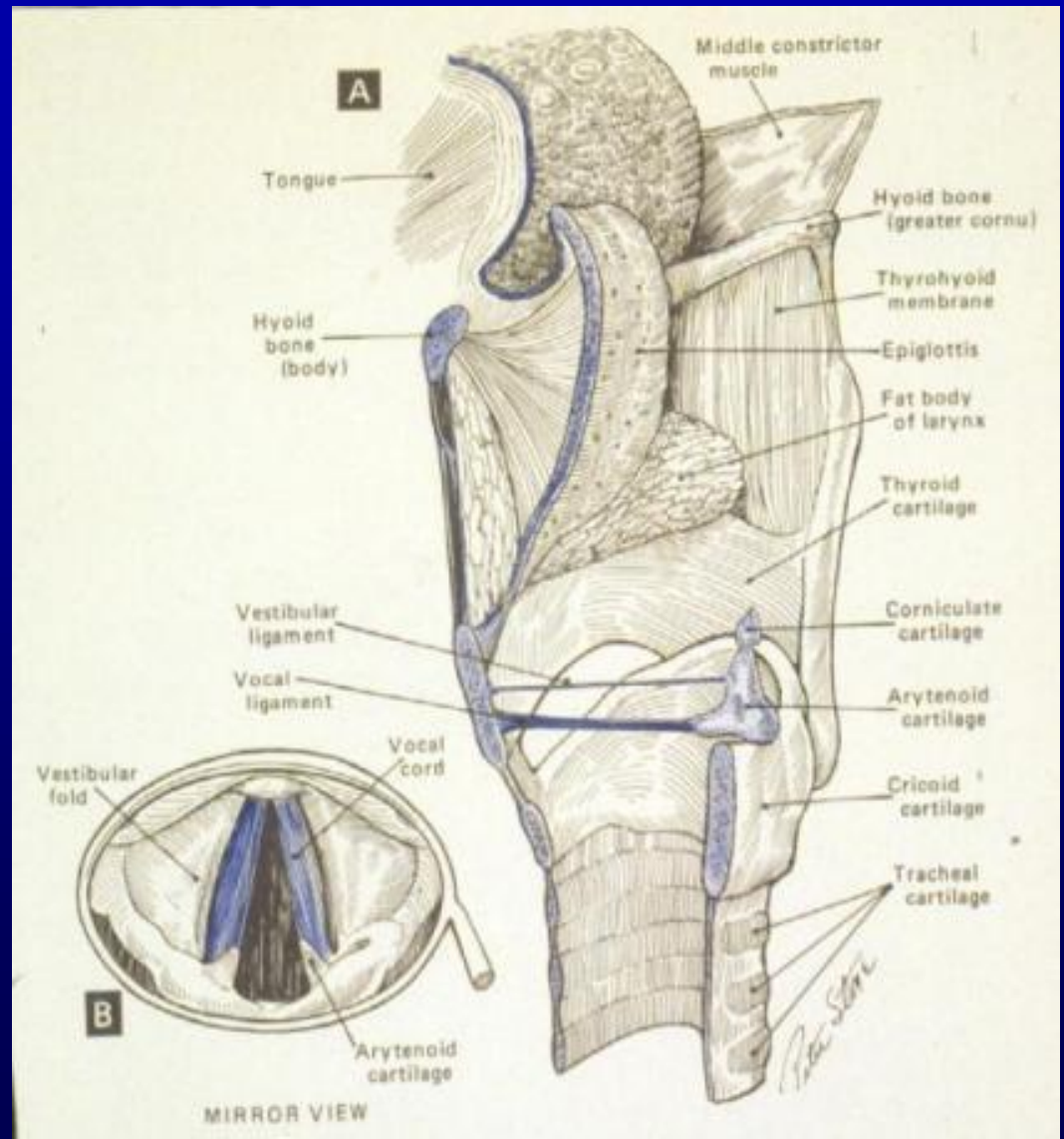


Figure 37-9. T

Larynx - Irregular Tube Connects Pharynx to Trachea

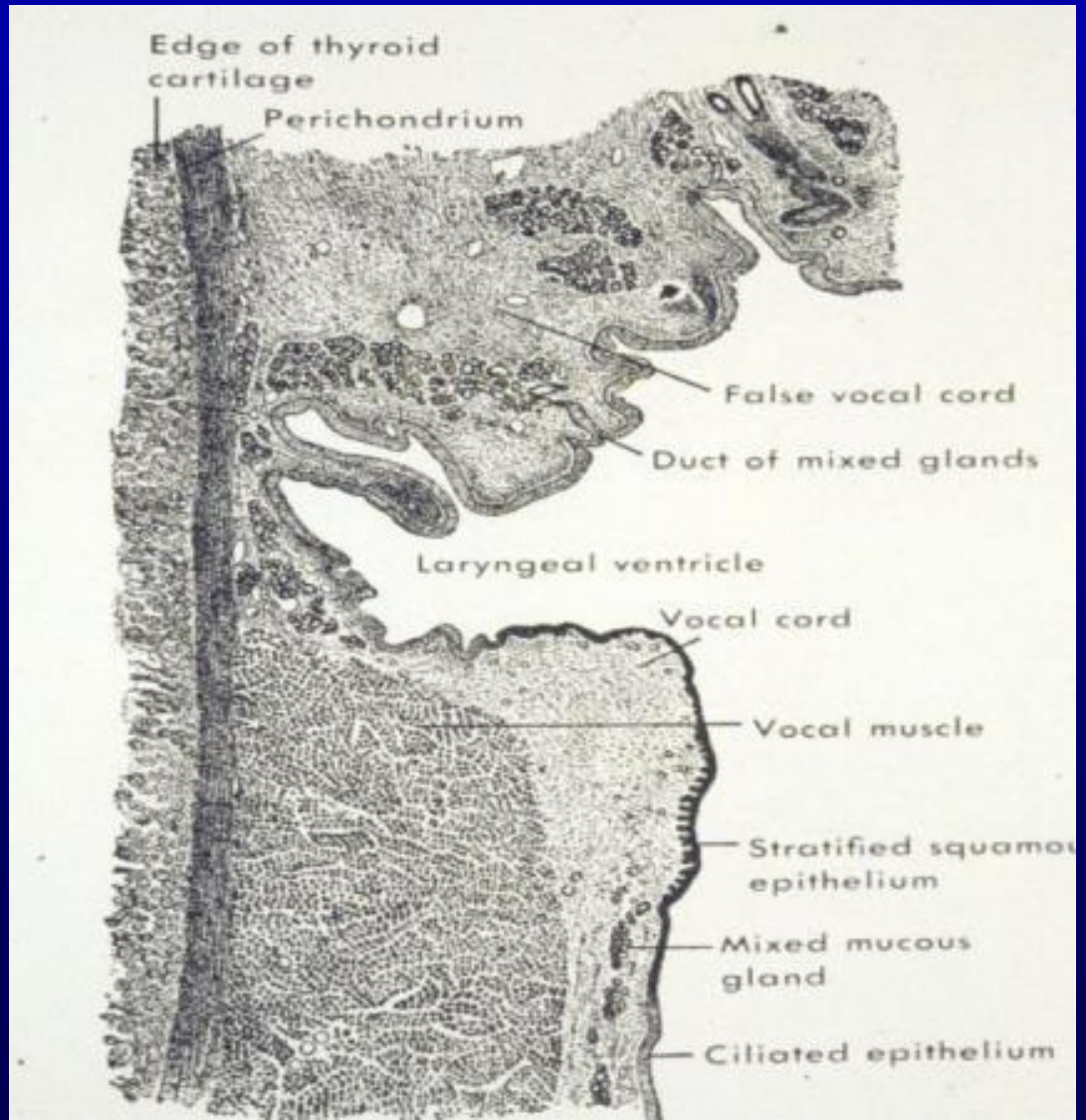
Cartilage

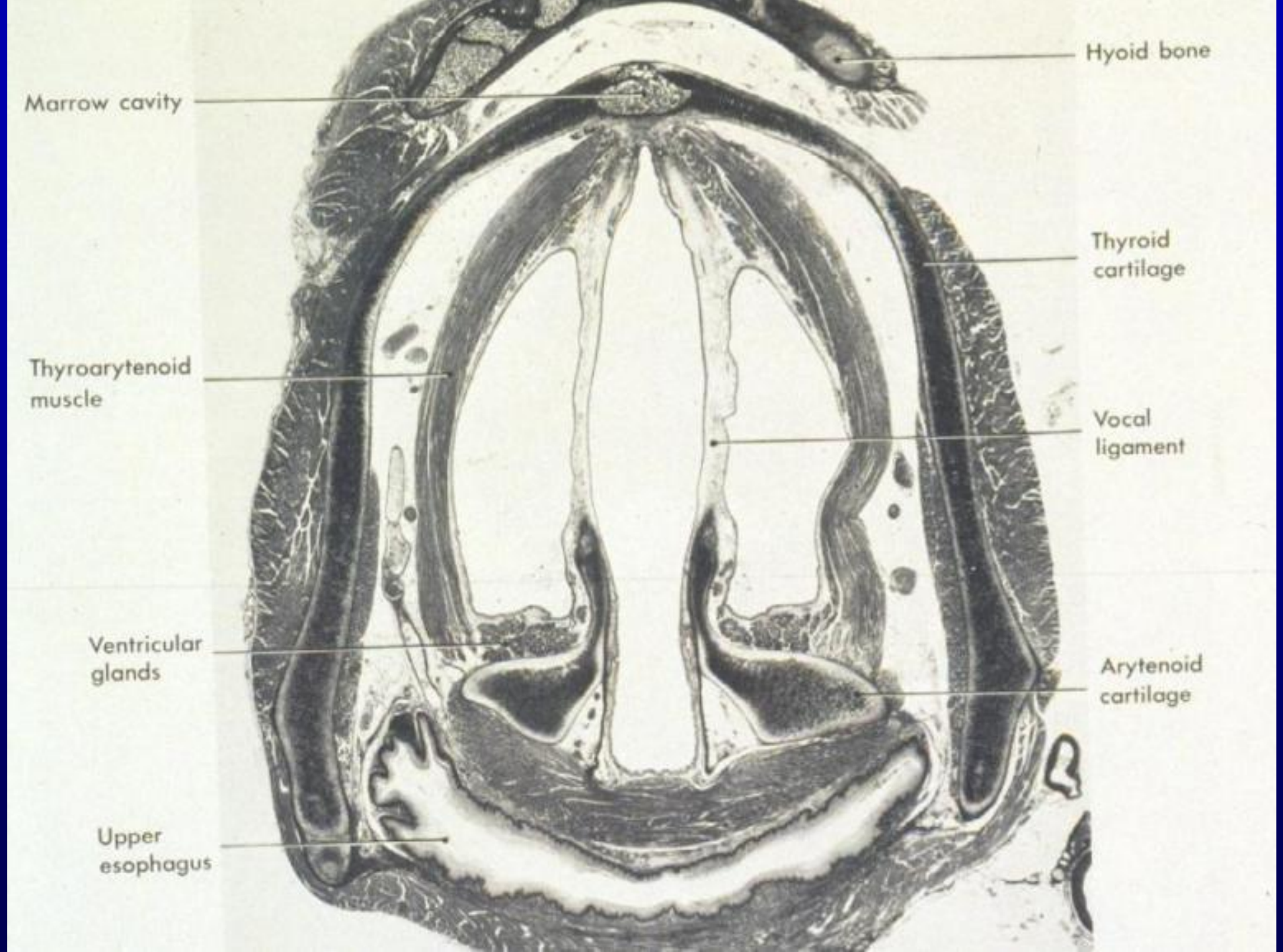
- Large: hyaline at thyroid, cricoid
- Smaller: elastic at epiglottis

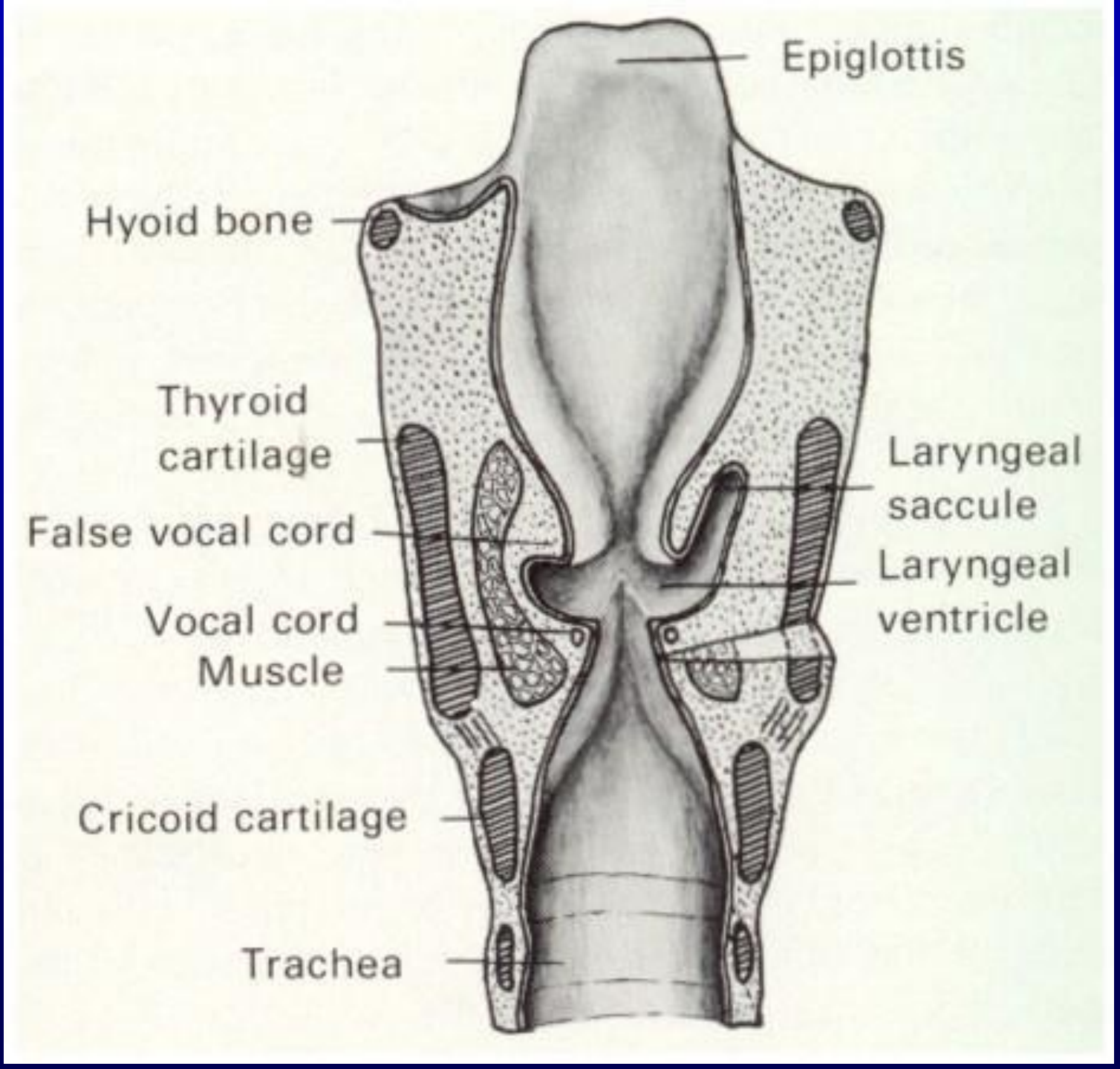


Larynx - Irregular Tube Connects Pharynx to Trachea

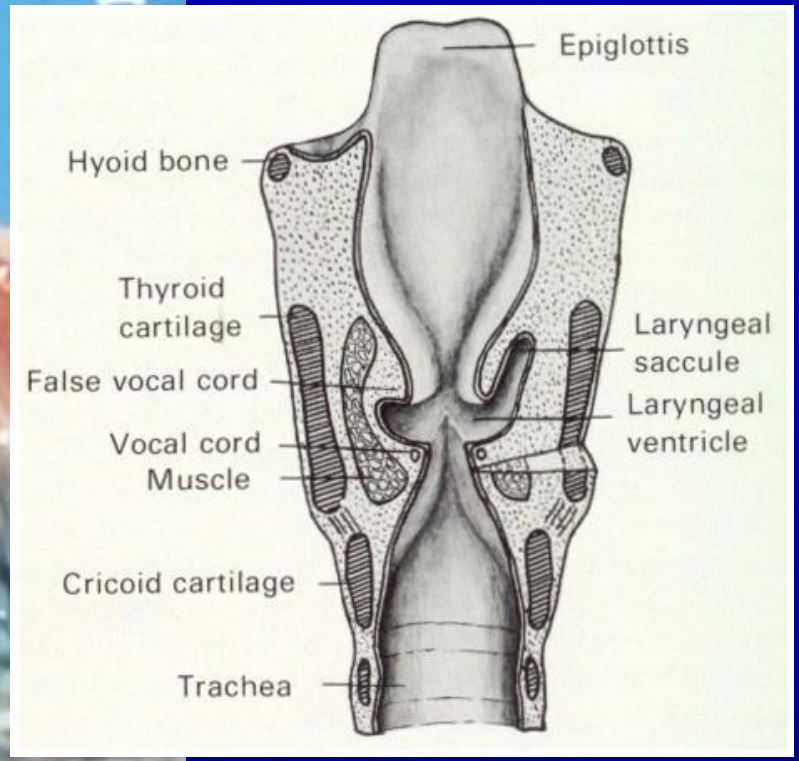
- Vocal cords
  - False
  - True
    - Vocal ligaments
    - Vocalis muscle - skeletal muscle




Hyoid bone
Marrow cavity
Thyroid cartilage
Thyroarytenoid muscle
Vocal ligament
Ventricular glands
Arytenoid cartilage
Upper esophagus


Epiglottis
Hyoid bone
Thyroid cartilage
False vocal cord
Vocal cord
Muscle
Cricoid cartilage
Trachea
Laryngeal saccule
Laryngeal ventricle


METRIC


Epiglottis
Hyoid bone
Thyroid cartilage
False vocal cord
Vocal cord
Muscle
Cricoid cartilage
Trachea
Laryngeal saccule
Laryngeal ventricle

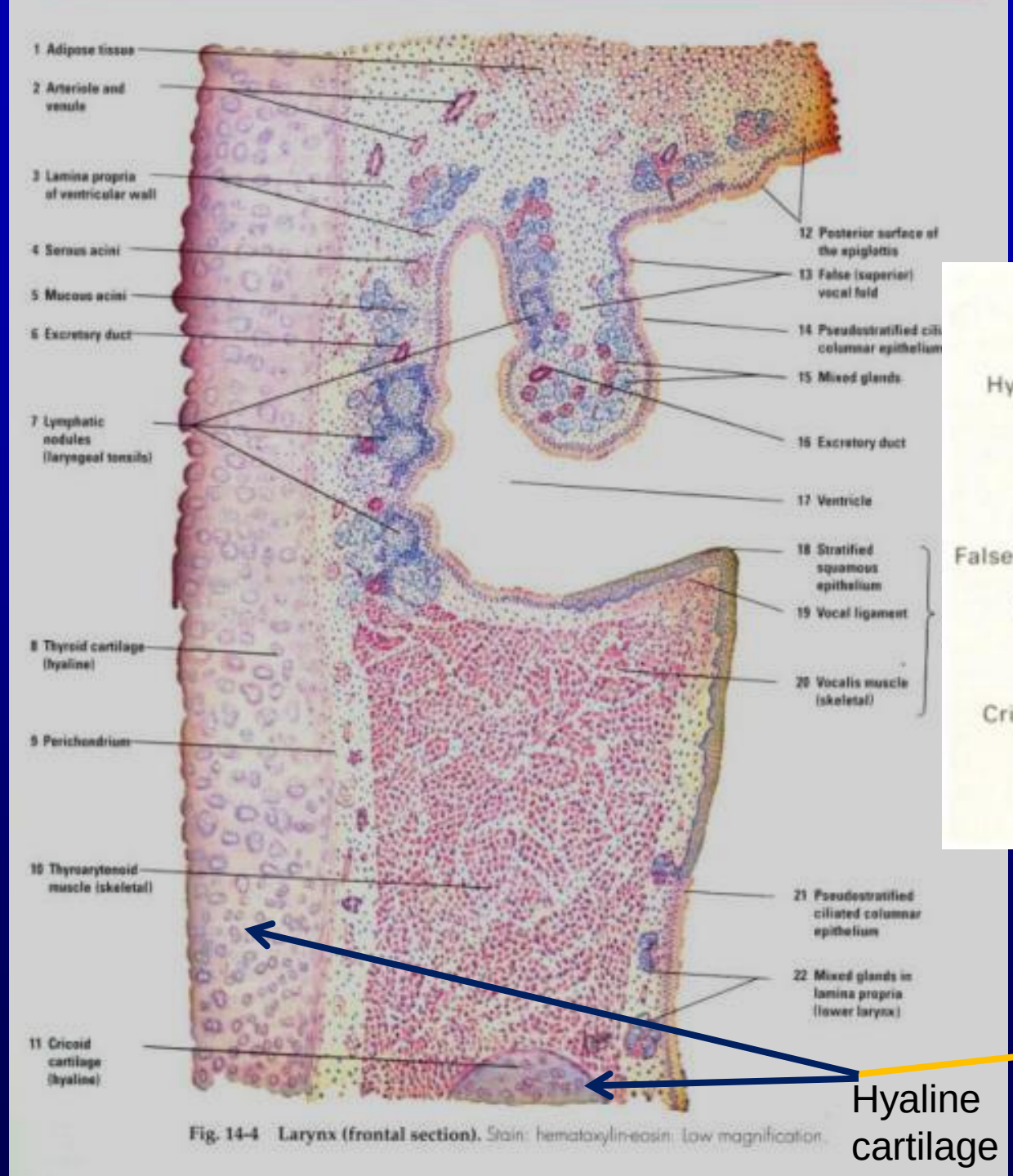
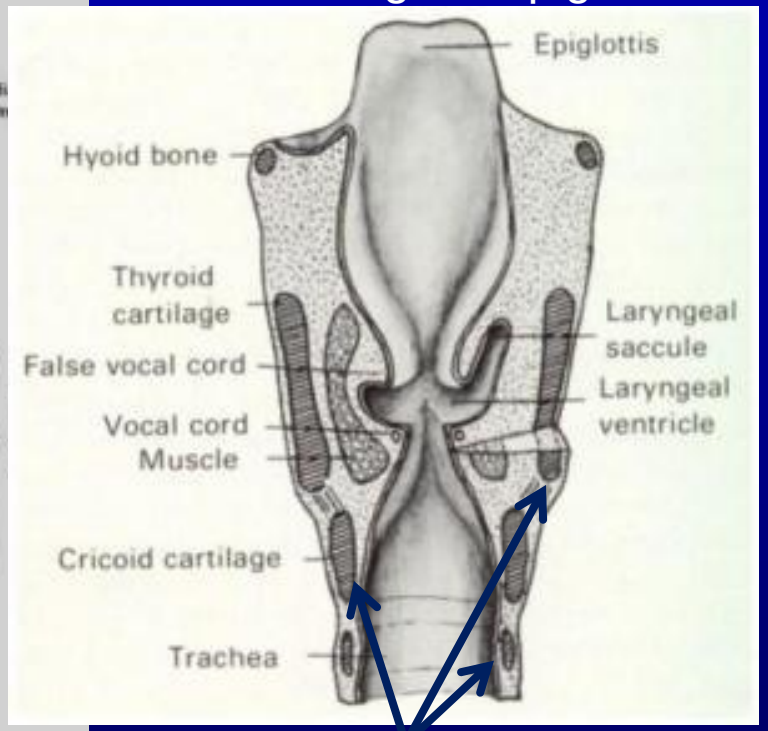


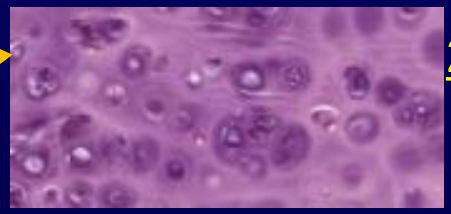
Fig. 14-4 **Larynx (frontal section).** Stain: hematoxylin-eosin. Low magnification.

404

Elastic cartilage in epiglottis



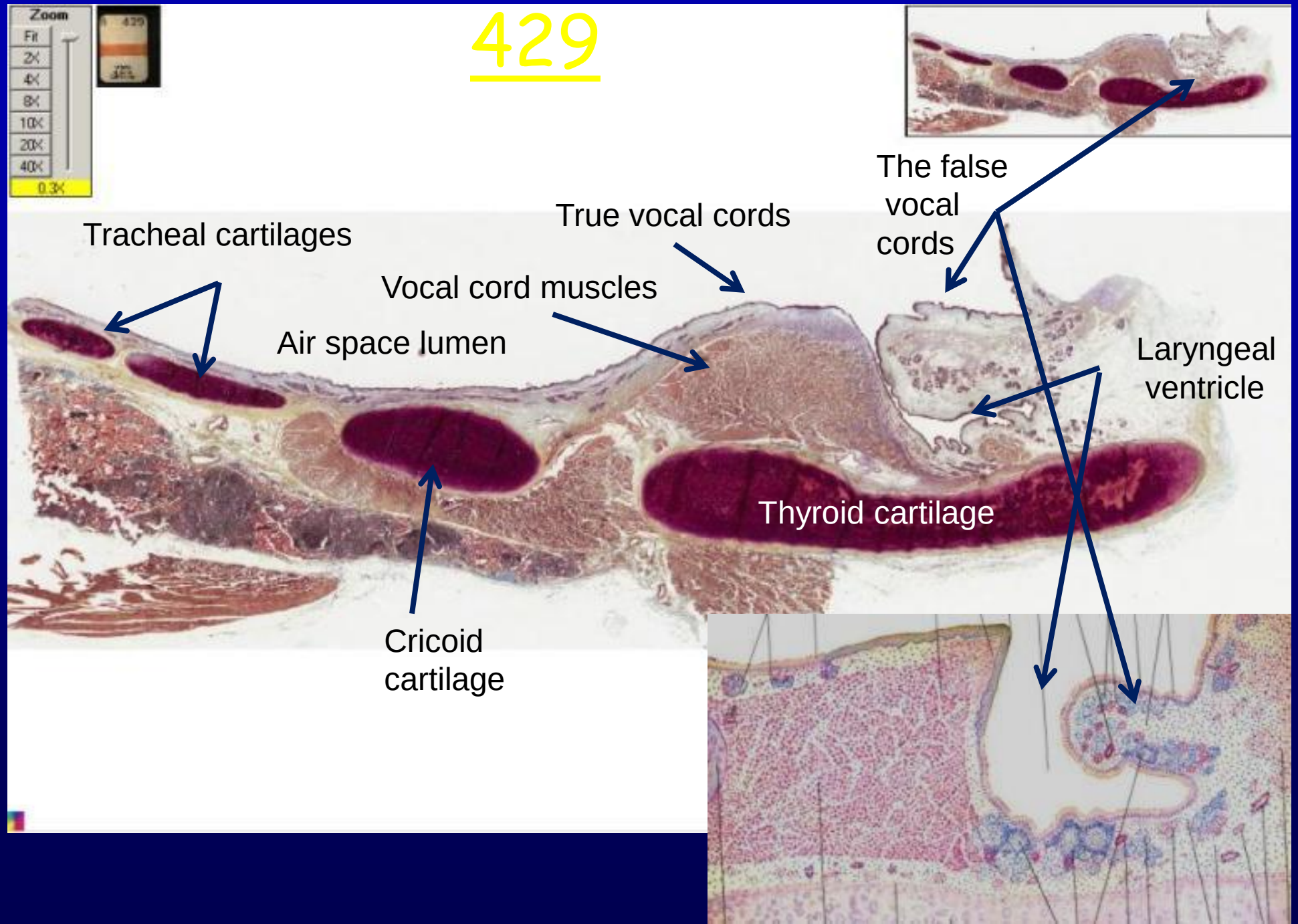
Hyaline cartilage provides flexible support in the respiratory system to hold the air way open.



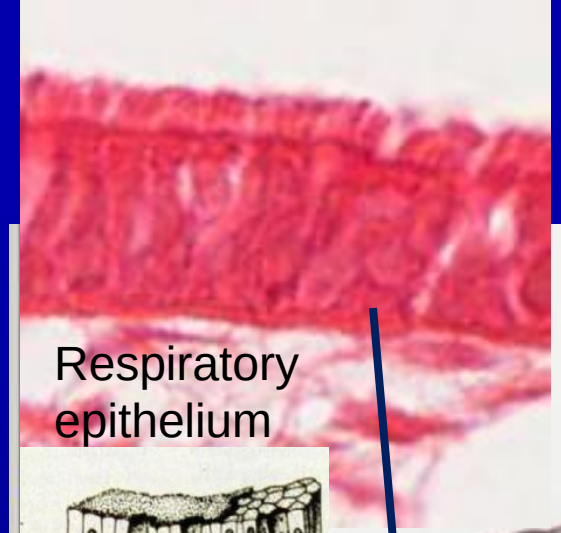
242

Hyaline cartilage

429

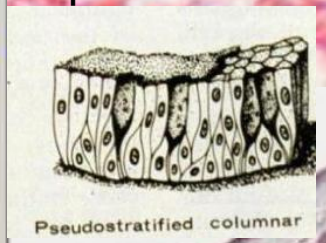

Zoom
Fit
2X
4X
8X
10X
20X
40X
0.3X
Tracheal cartilages
True vocal cords
The false vocal cords
Vocal cord muscles
Air space lumen
Laryngeal ventricle
Thyroid cartilage
Cricoid cartilage

429 Larynx



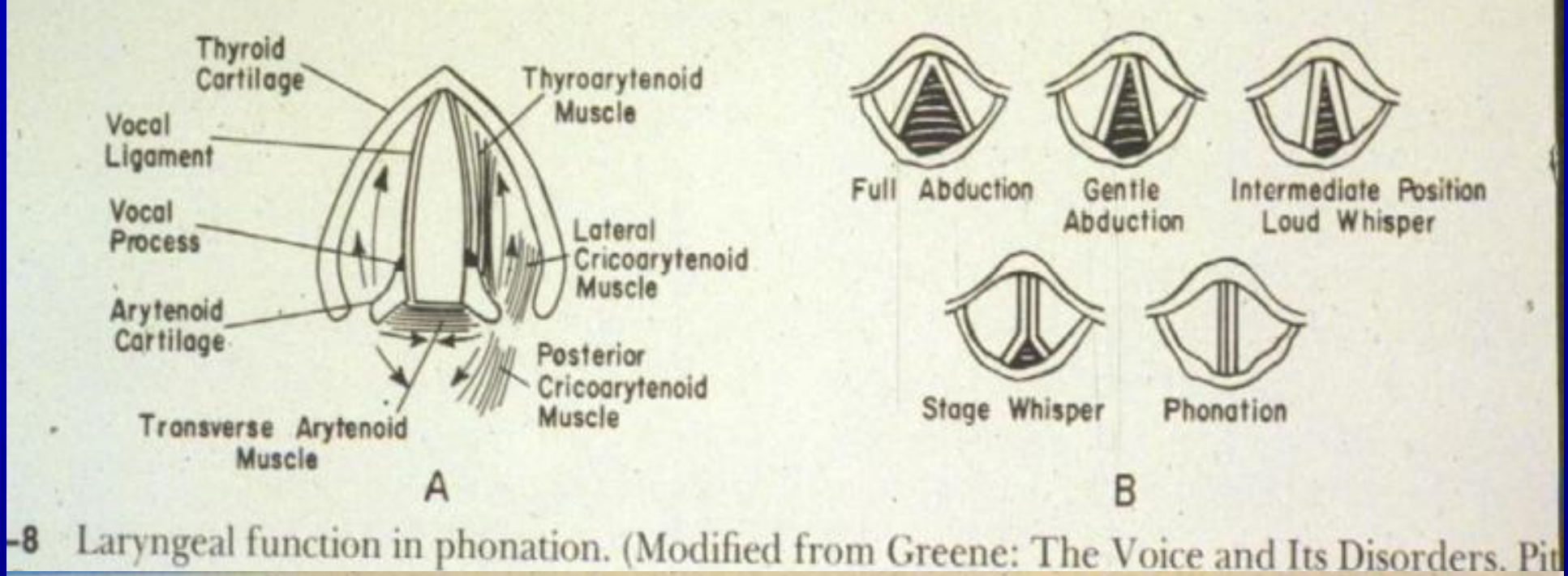
Respiratory epithelium

Stratified squamous epithelium

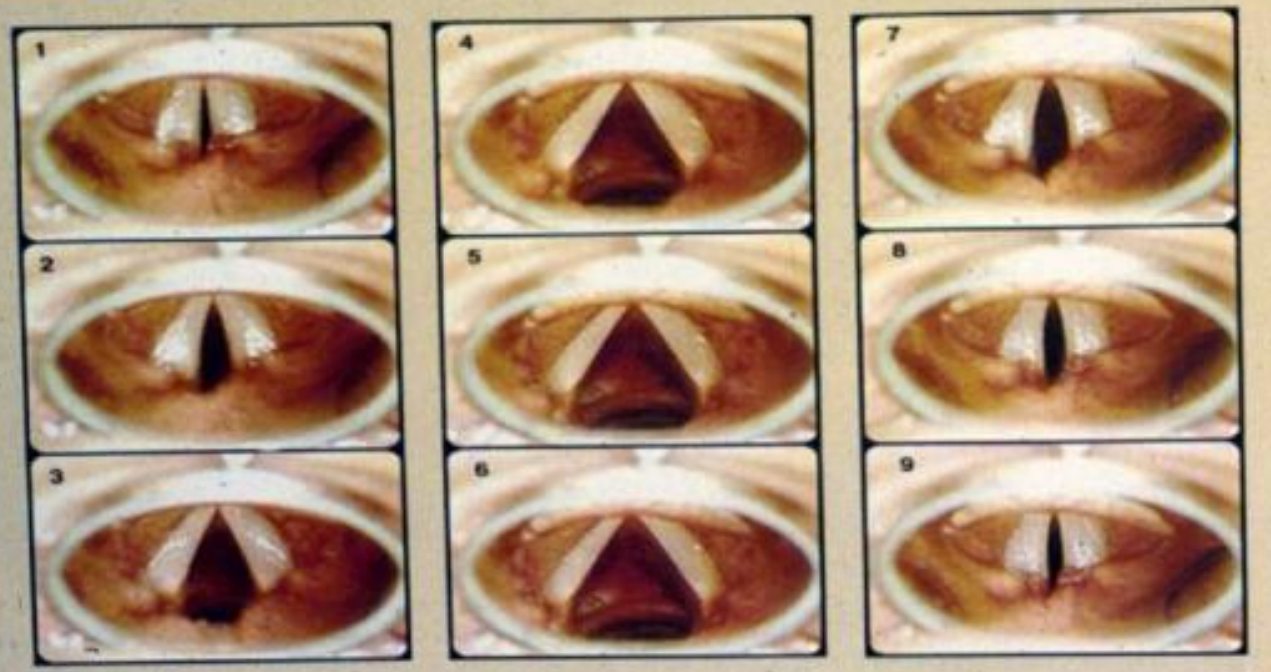


Vocal cord muscles

Thyroid cartilage



-8 Laryngeal function in phonation. (Modified from Greene: The Voice and Its Disorders. Pit

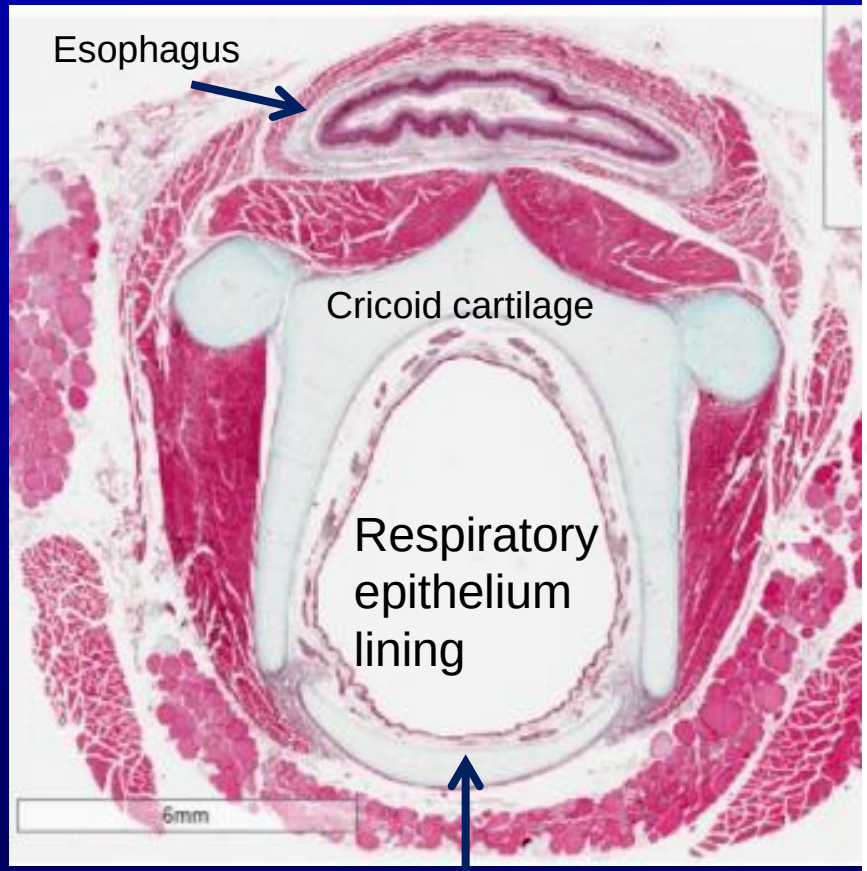


How Vocal Cords Move to Produce Speech

These pictures show vocal cords at work. The slitlike opening between the cords is the glottis. Its size and shape change according to your activity. When you breathe, the cords draw apart, allowing passage of air to and from the lungs. If you speak or sing, the folds draw closer together. Speech is produced when you breathe out. The airflow through the glottis causes the vocal cords to vibrate, producing waves of sound. The tautness of the cords determines the frequency of the vibrations and the pitch of the sound.

Following from top to bottom, left to right, you can see vocal cords change in a one-second progression. In pictures 1 to 6, speech stops, cords gradually open. In pictures 7 to 9, speech resumes.

Larynx
(lower portion)



HISTO039

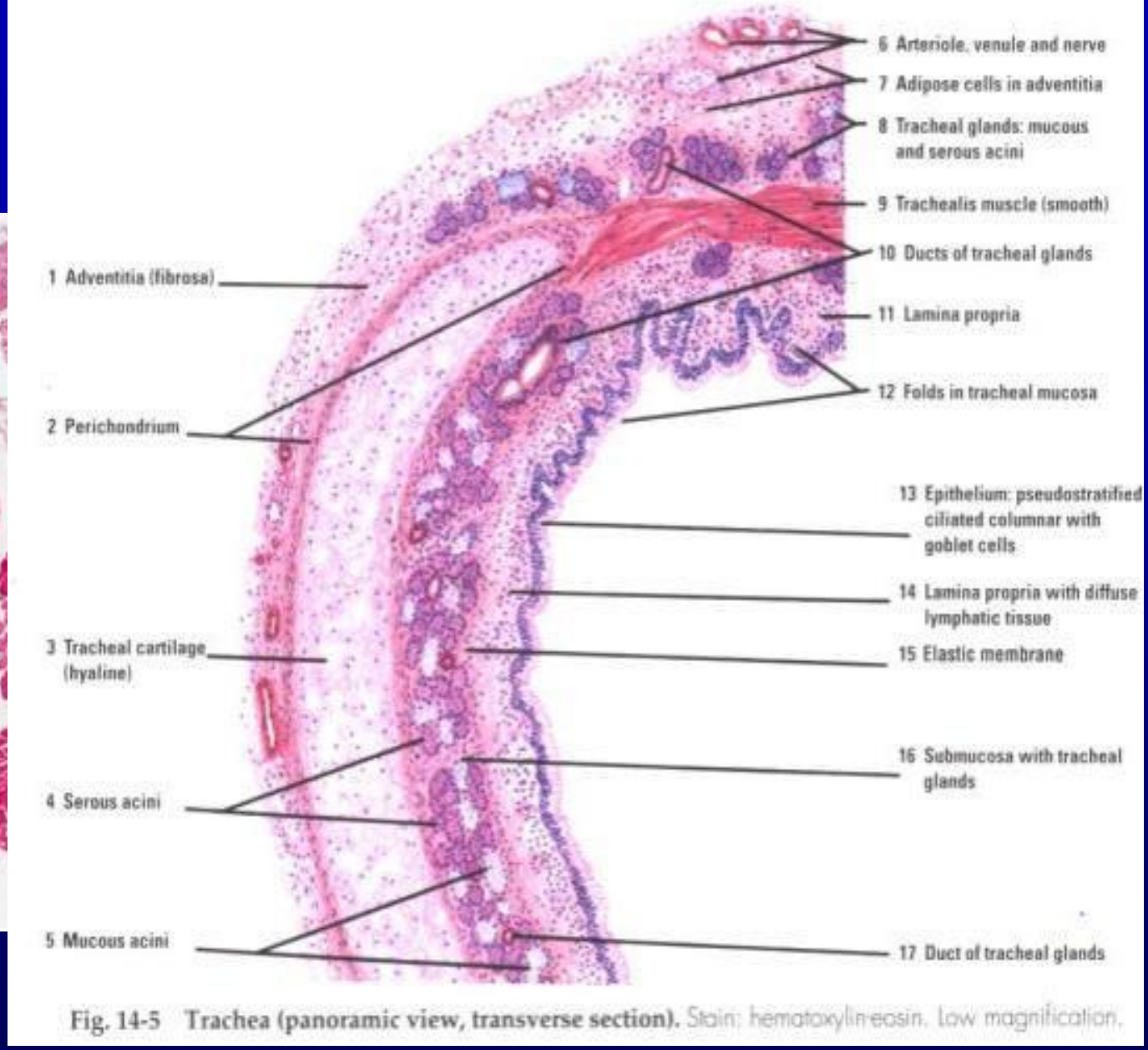
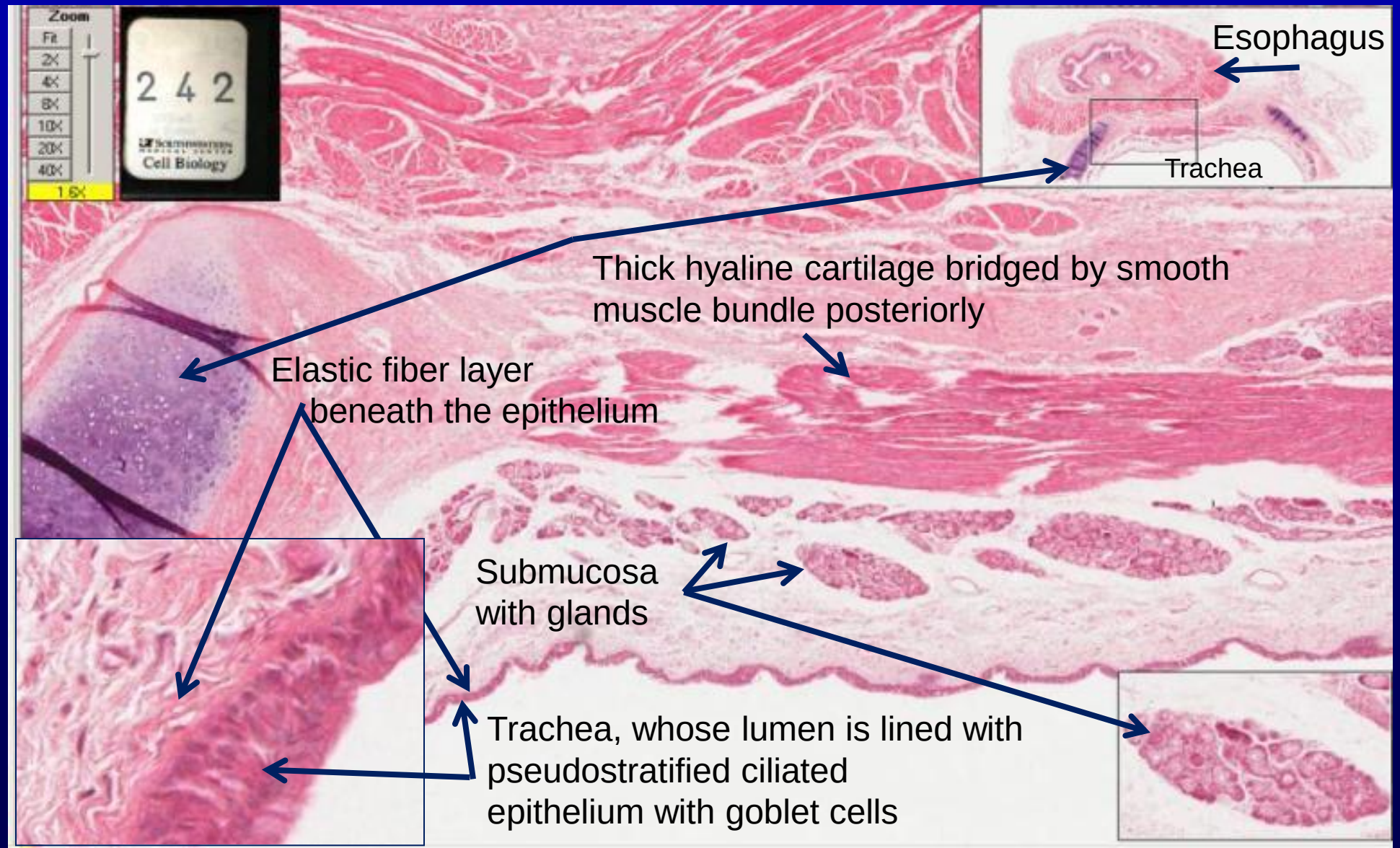


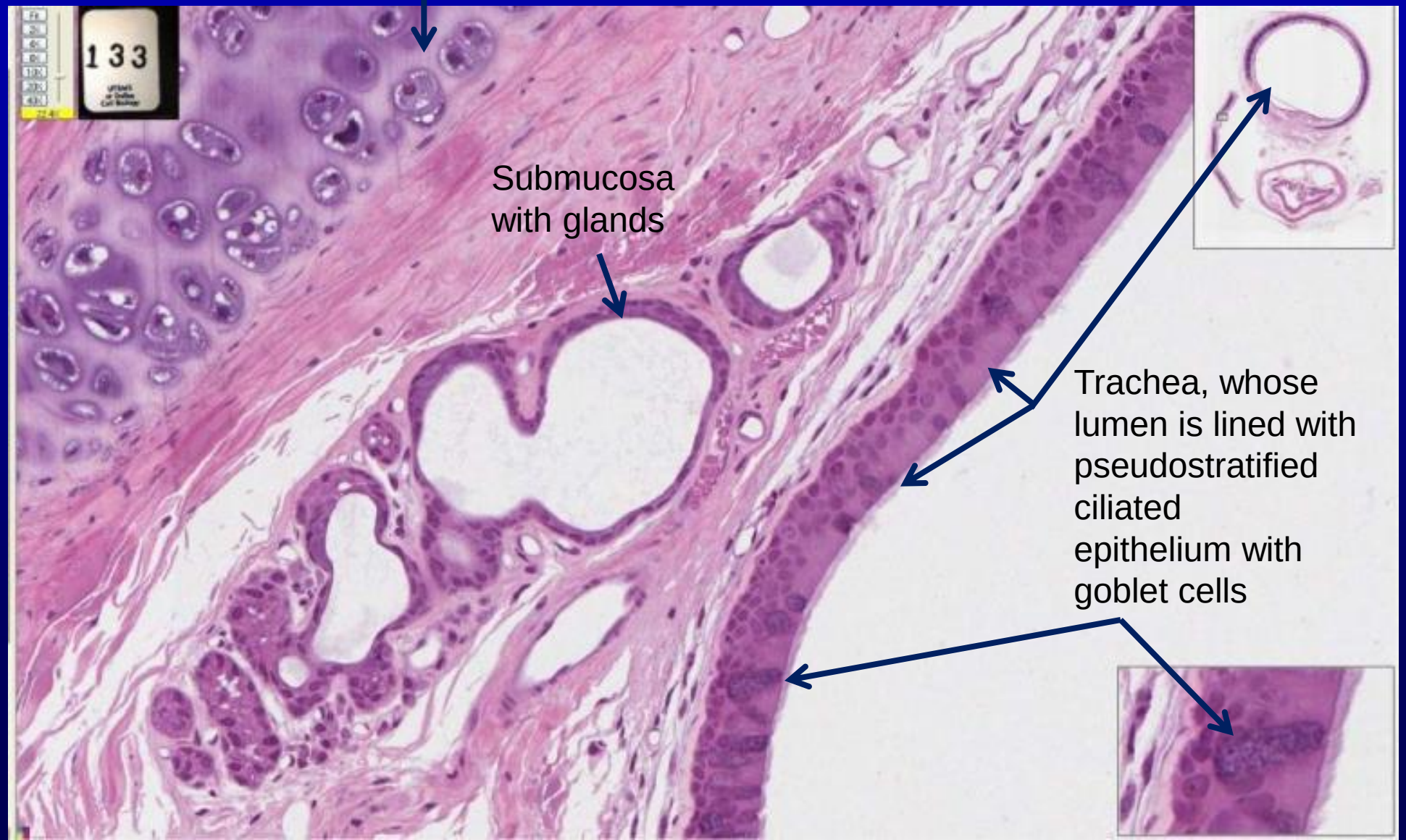
Fig. 14-5 **Trachea (panoramic view, transverse section).** Stain: hematoxylin-eosin. Low magnification.

Esophagus and trachea, monkey - glands in trachea

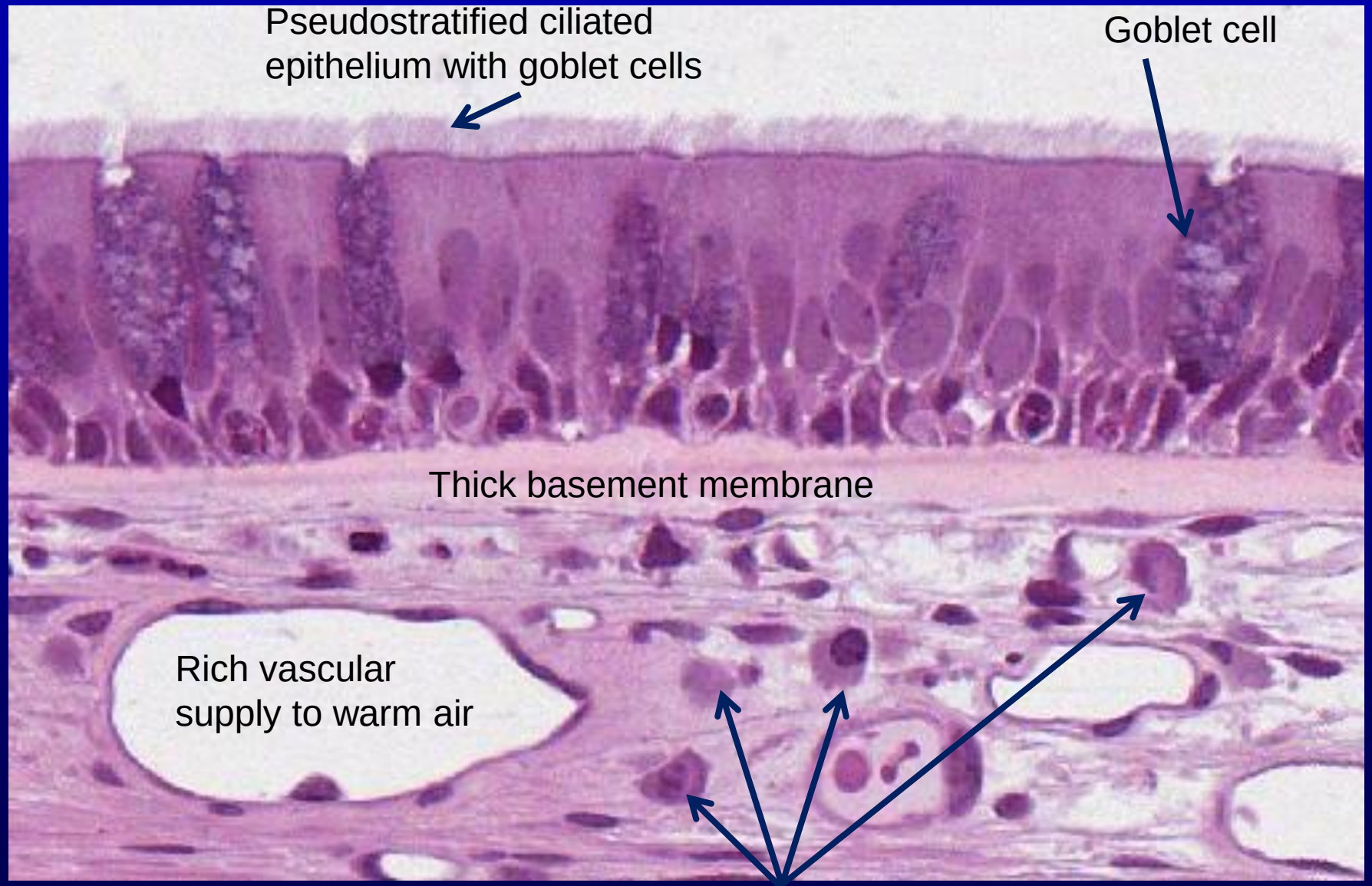


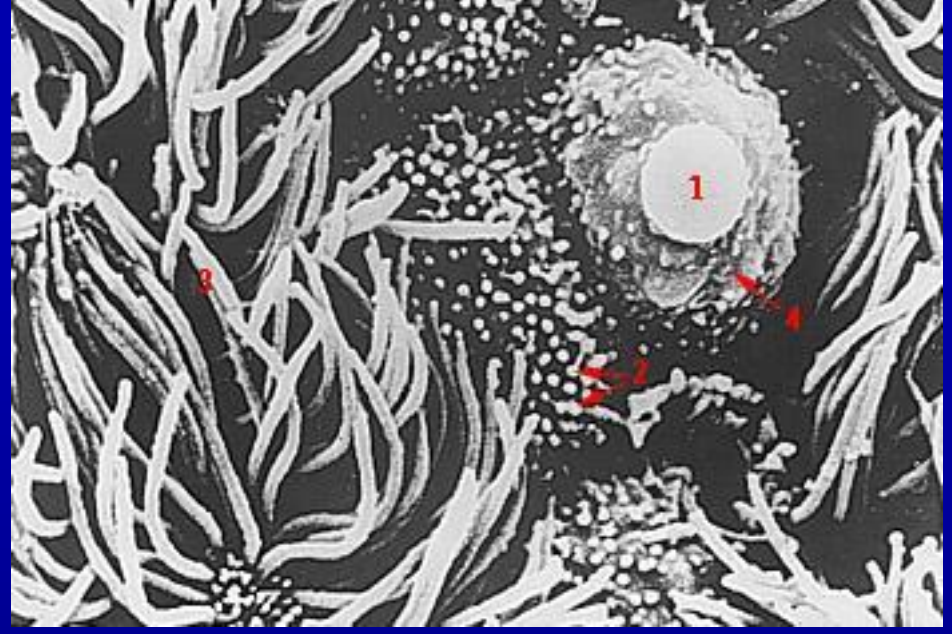
242

133 Trachea, monkey



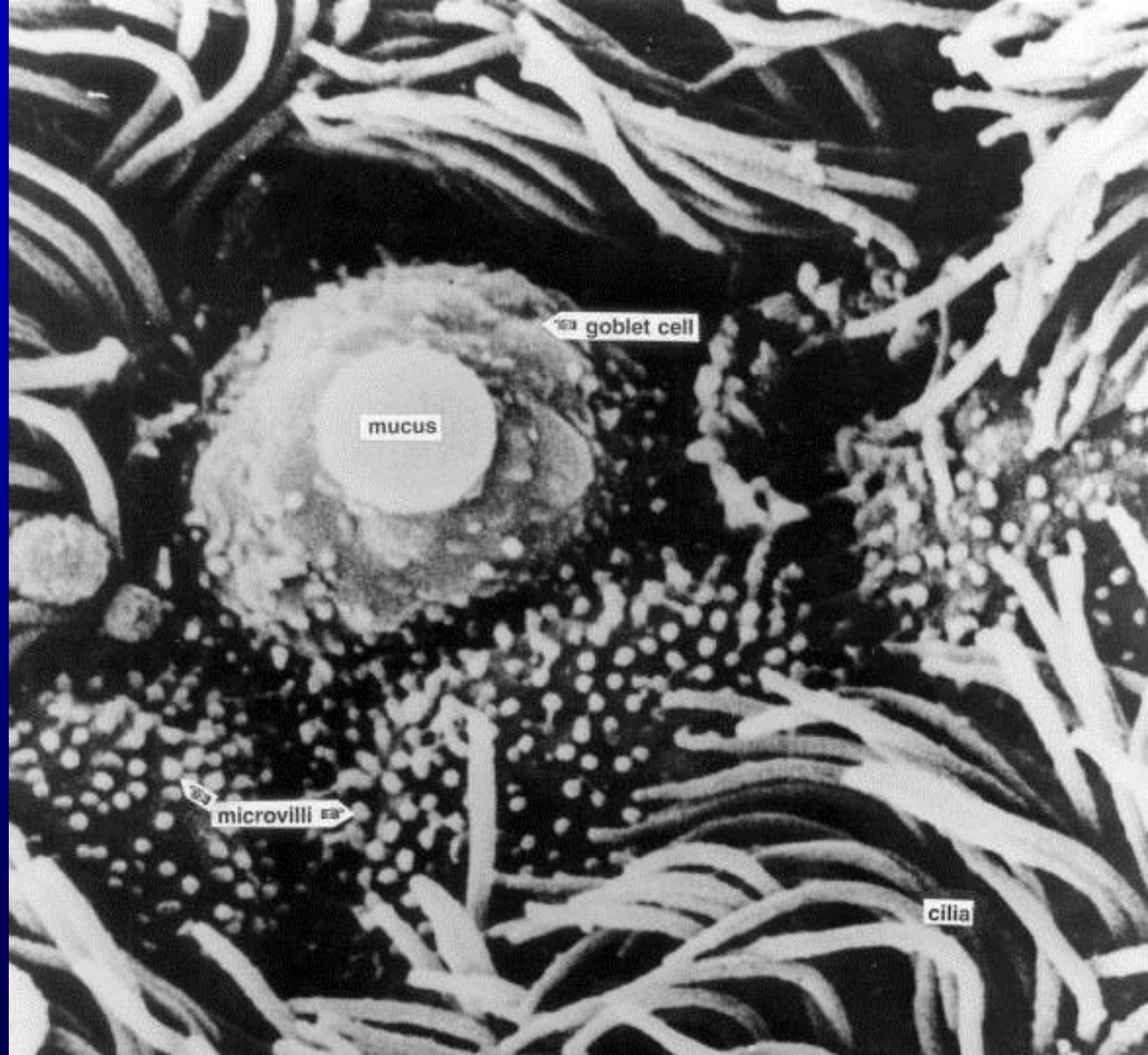
133 Trachea, monkey

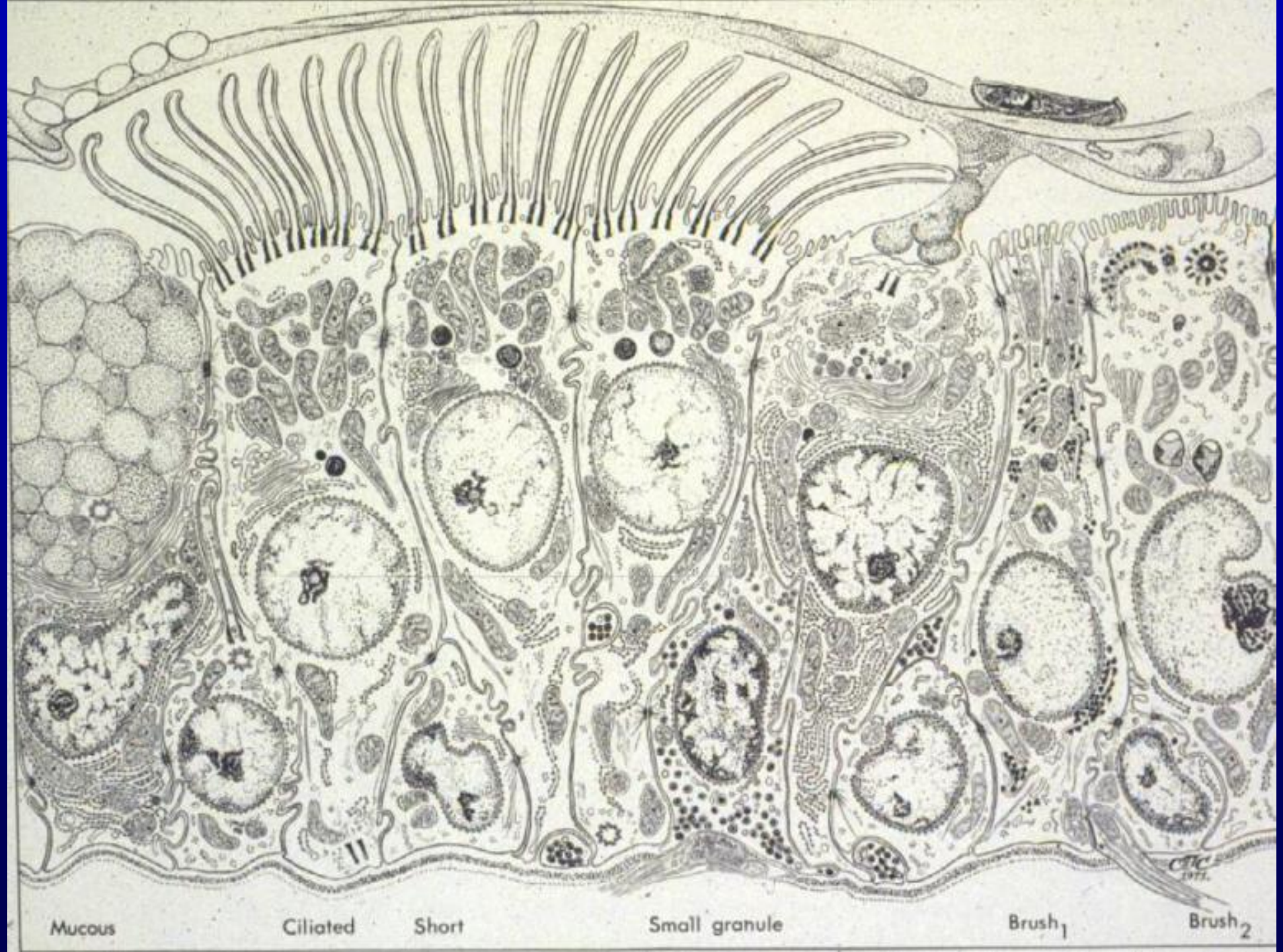


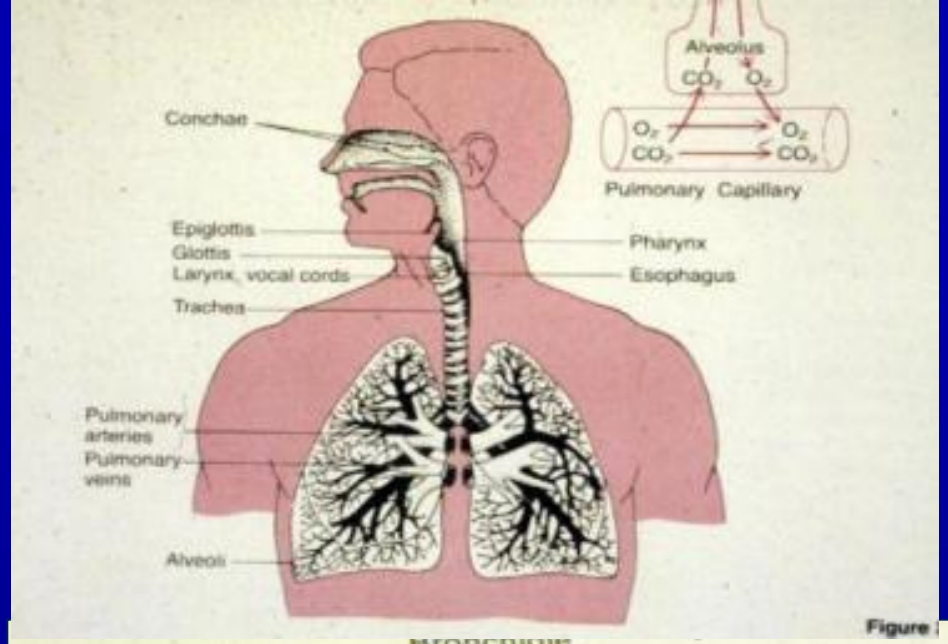


EM 8 trachea;
20630x

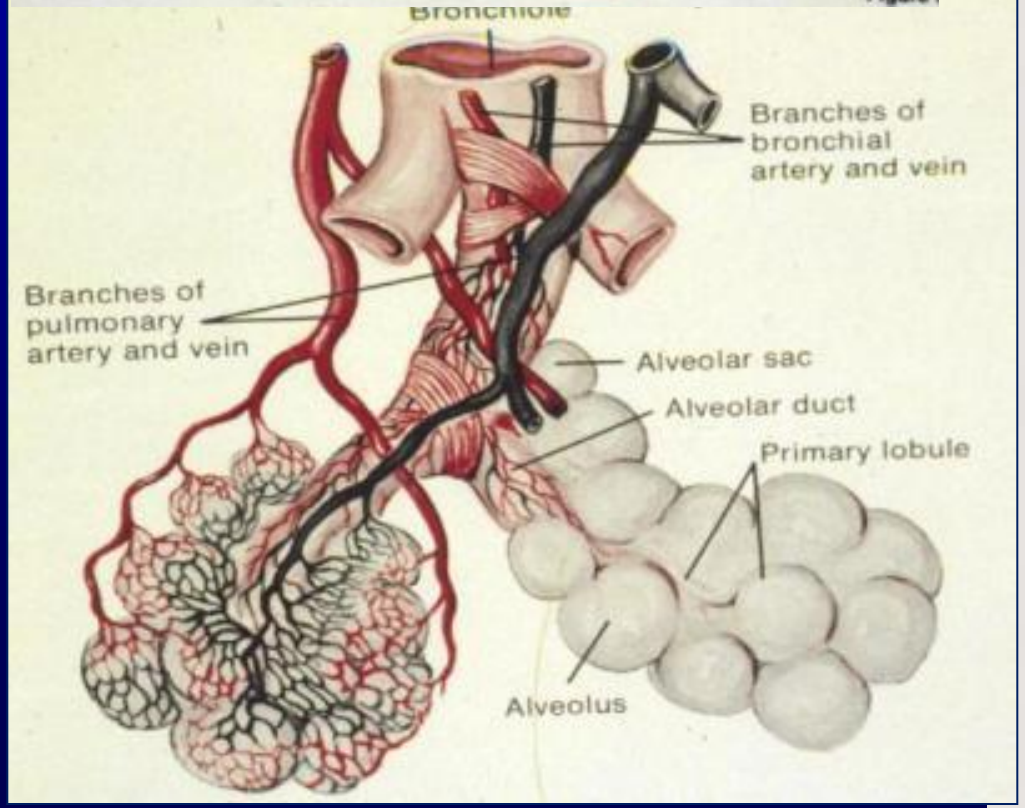
1. Mucous
2. Microvilli
3. Cilia
4. Goblet cell




Mucous
Ciliated
Short
Small granule
Brush$_1$
Brush$_2$



Figure



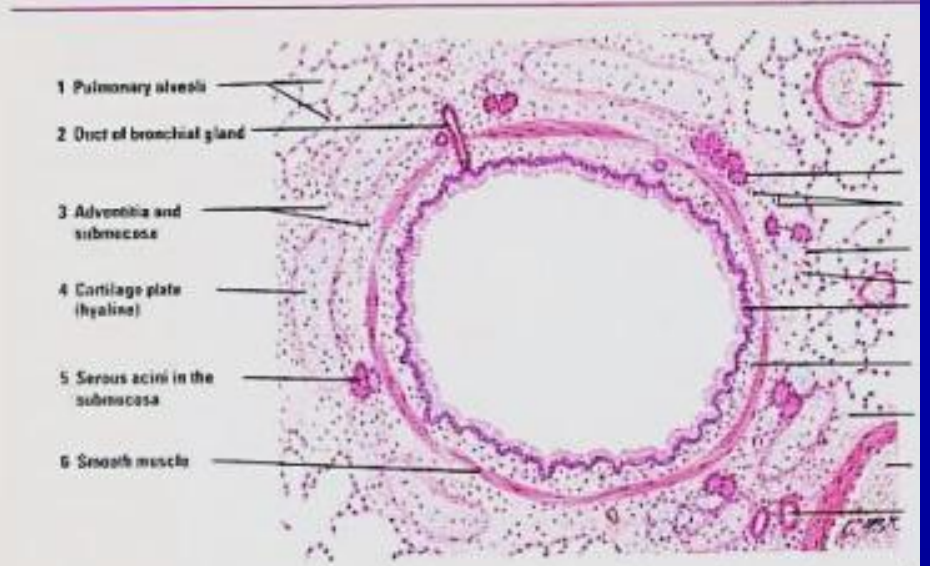


Fig. 14-9 **Intrapulmonary Bronchus.** Stain: hematoxylin-eosin. Low magnifi

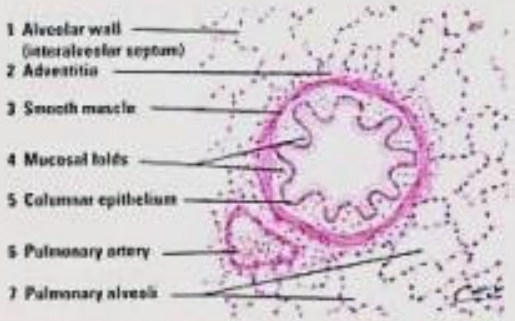
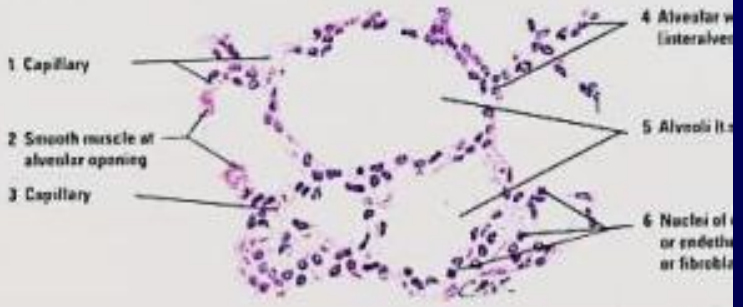
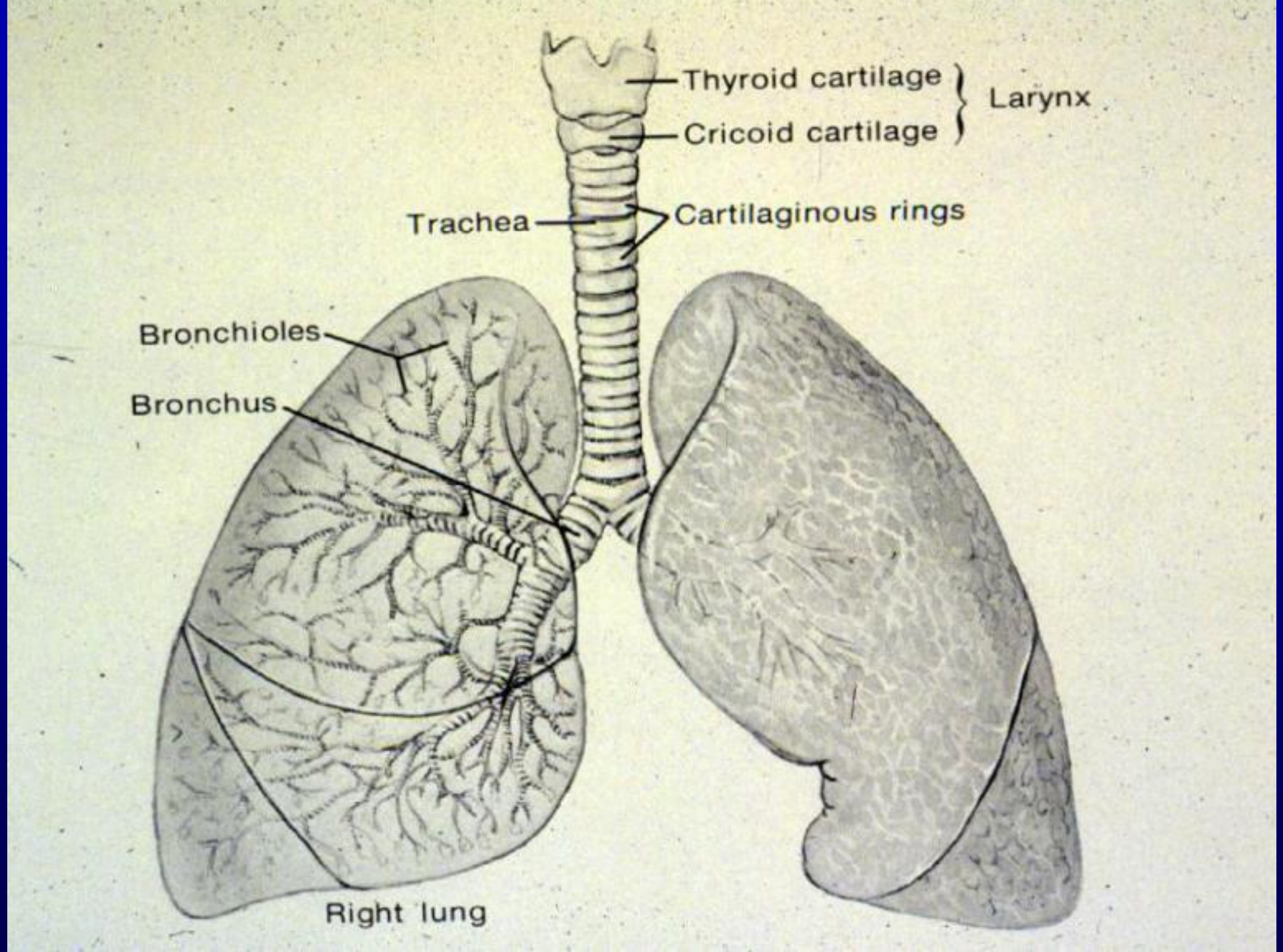


Fig. 14-10 **Terminal Bronchiole.** Stain: hematoxylin-eosin. Low magnification.

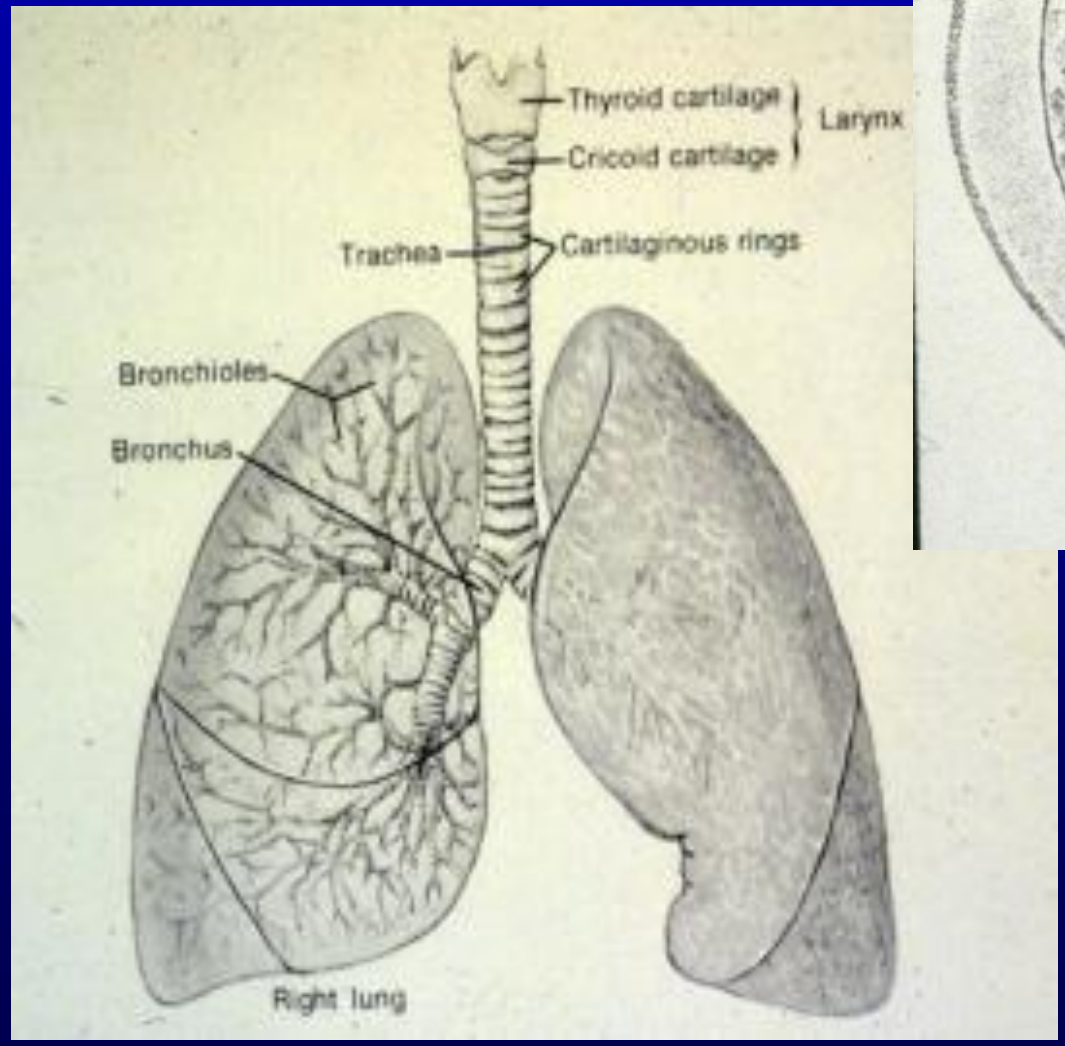
Fig. 14-11 **Respiratory Bronch**
eosin. Low magnification.

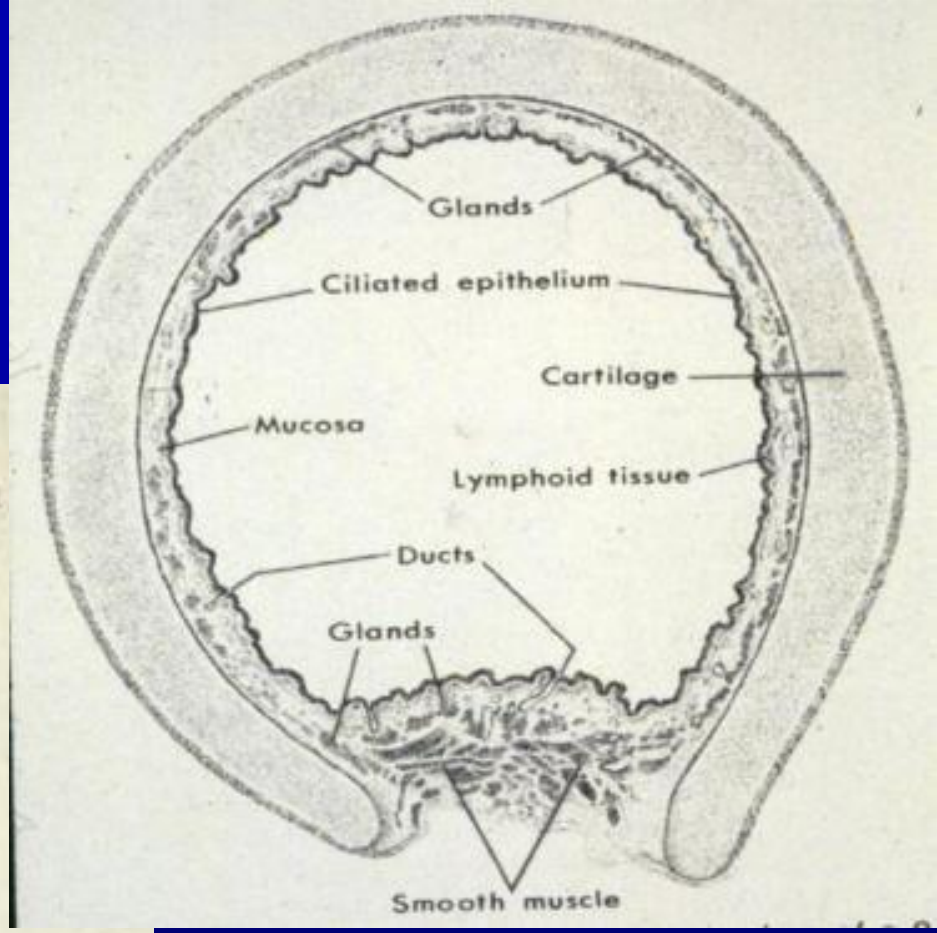


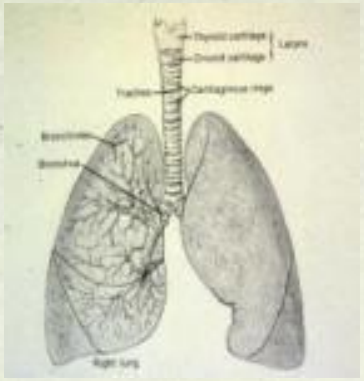

Thyroid cartilage
Cricoid cartilage
Larynx
Trachea
Cartilaginous rings
Bronchioles
Bronchus
Right lung

Trachea

- **Thin walled tube**
- **16-20 C-shaped rings of hyaline**
- **Trachealis muscle**
  - **Smooth muscle**
  - **Allows for regulation of size of lumen for cough reflex**







Trachea

bronchus

bronchus

Glands

Cartilages

Smooth muscle

Artery

Bronchi in lungs

heart

The bronchus has cartilage plates

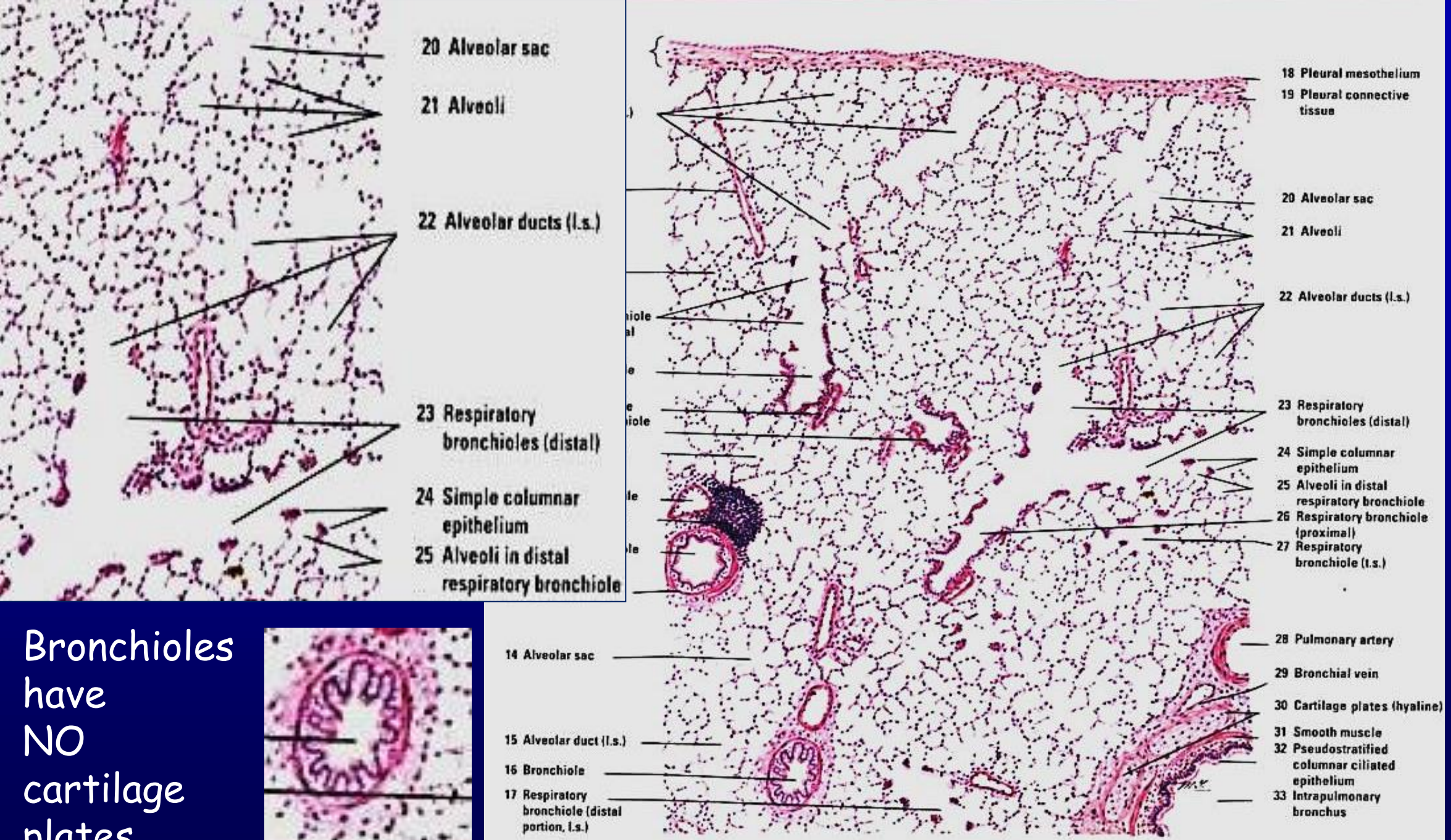
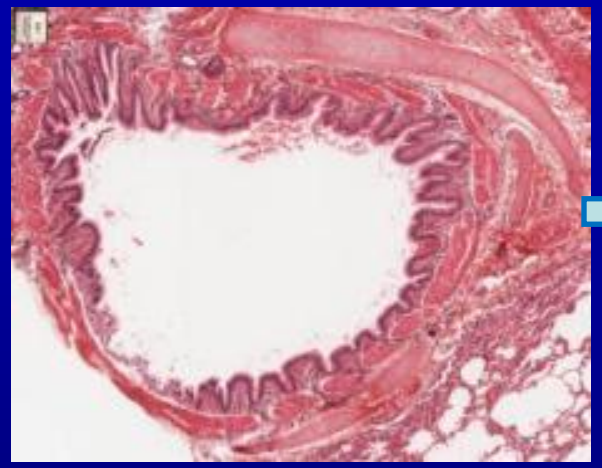


Fig. 14-8 **Lung (panoramic view).** Stain: hematoxylin-eosin. Low magnification.

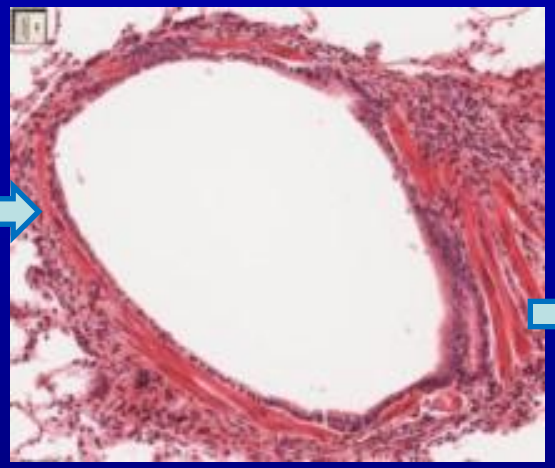
Bronchioles have NO cartilage plates

Histo 041: Lung

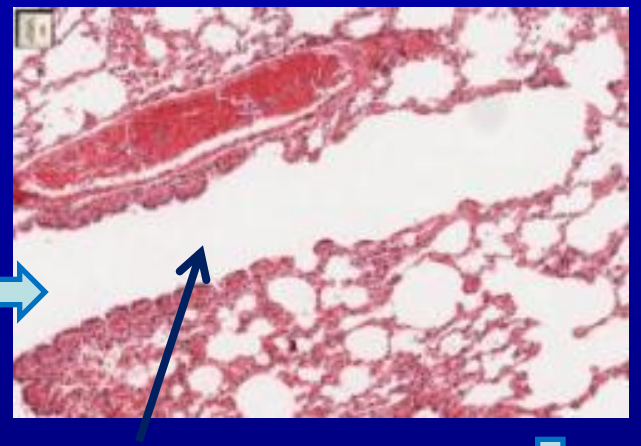
The air-conducting tubes of the respiratory system can be thought of as a series of ducts which carry air to the sites of gaseous exchange - the alveoli



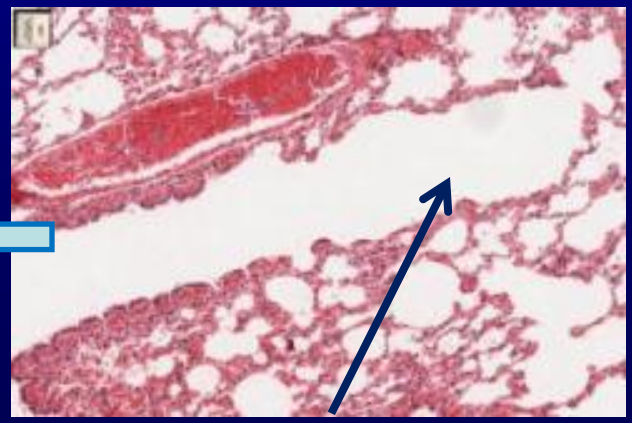
Bronchus



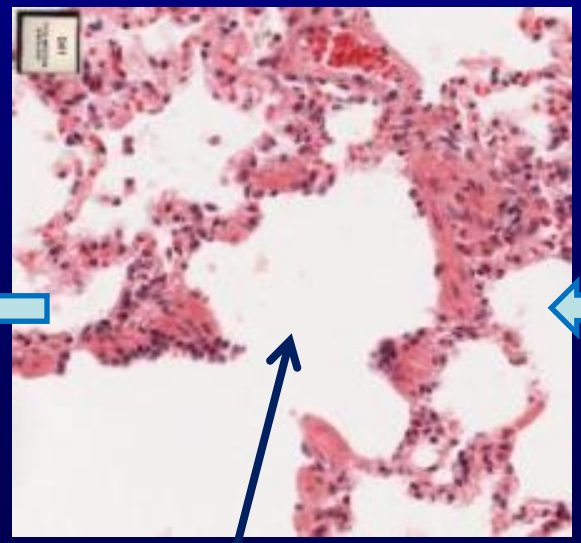
Conducting bronchiole



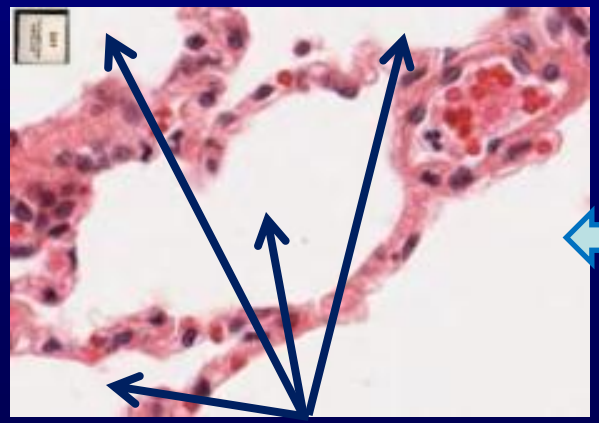
Respiratory bronchioles



Alveolar duct

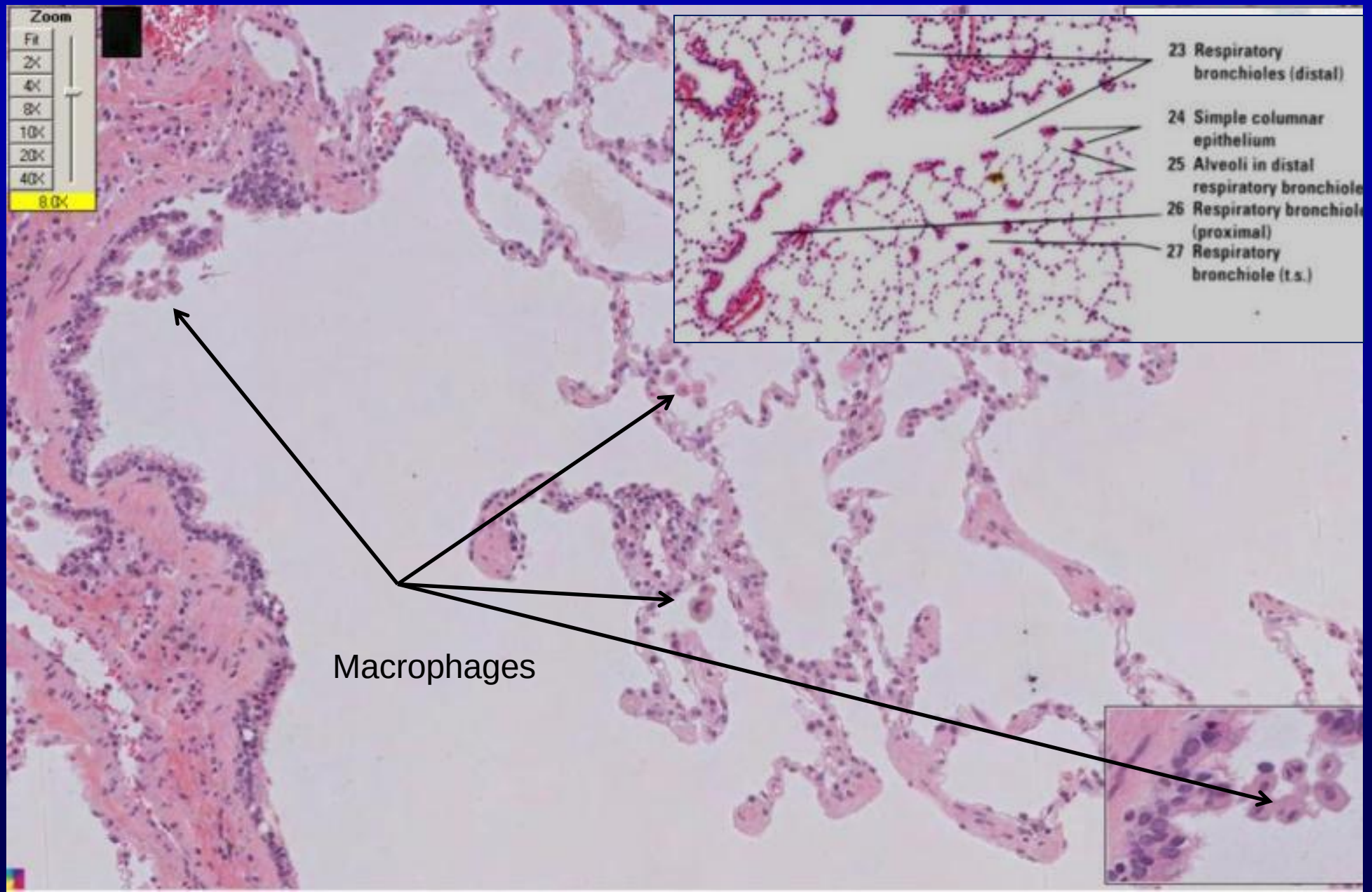


Alveolar sac

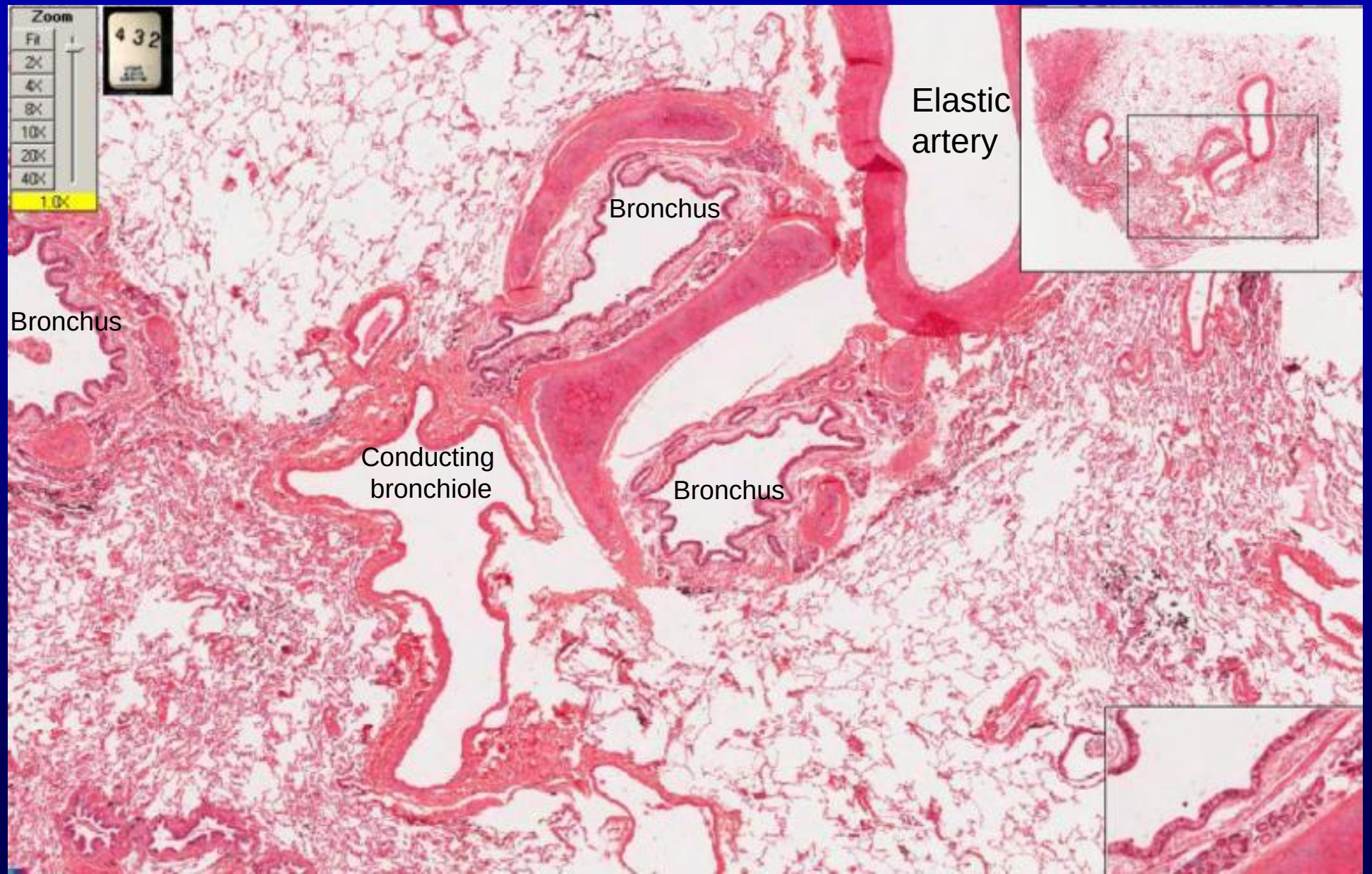


Alveoli

19714 lung macrophages

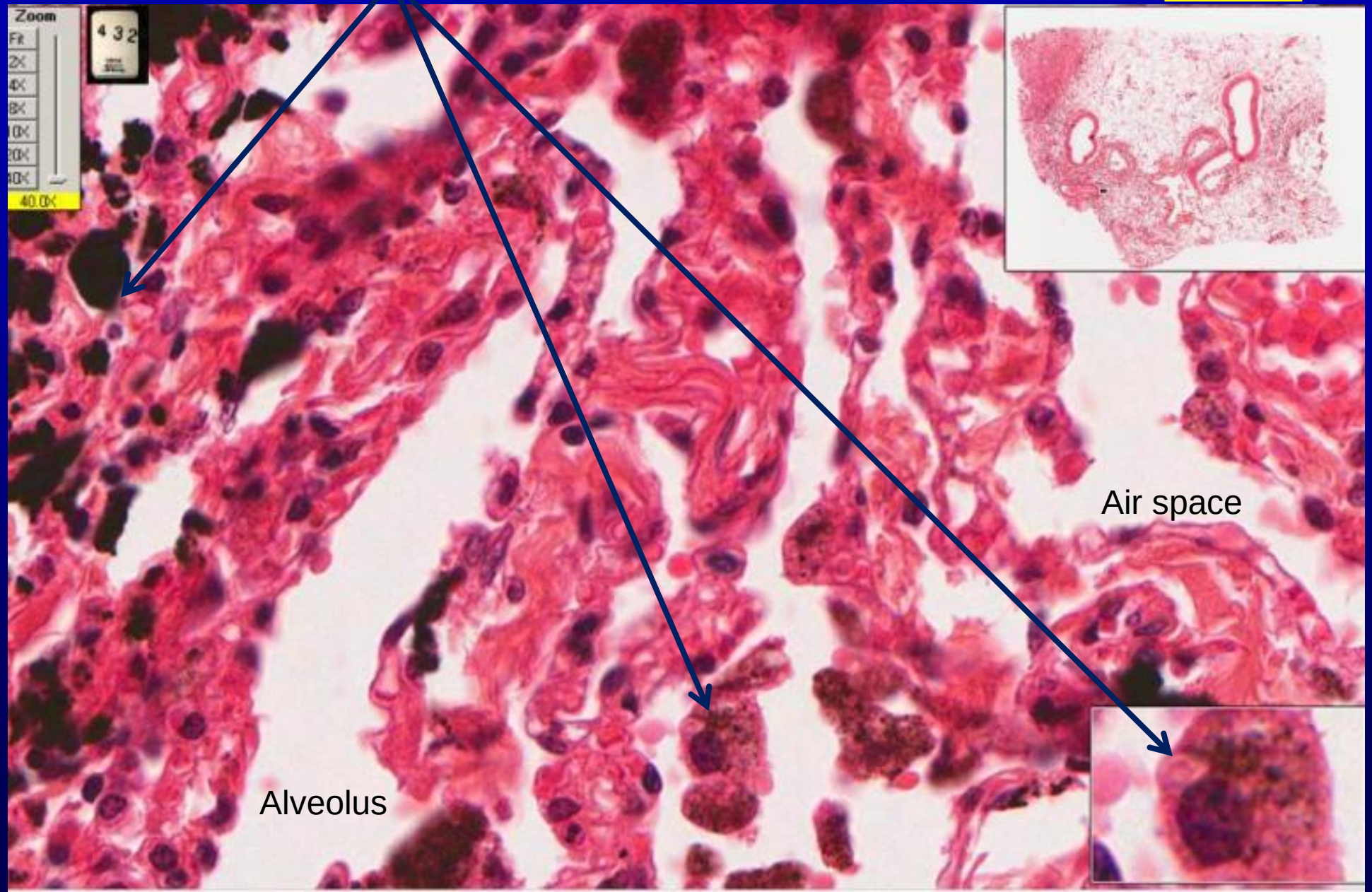


432 Lung with bronchi



Macrophages in Air Space of Alveoli

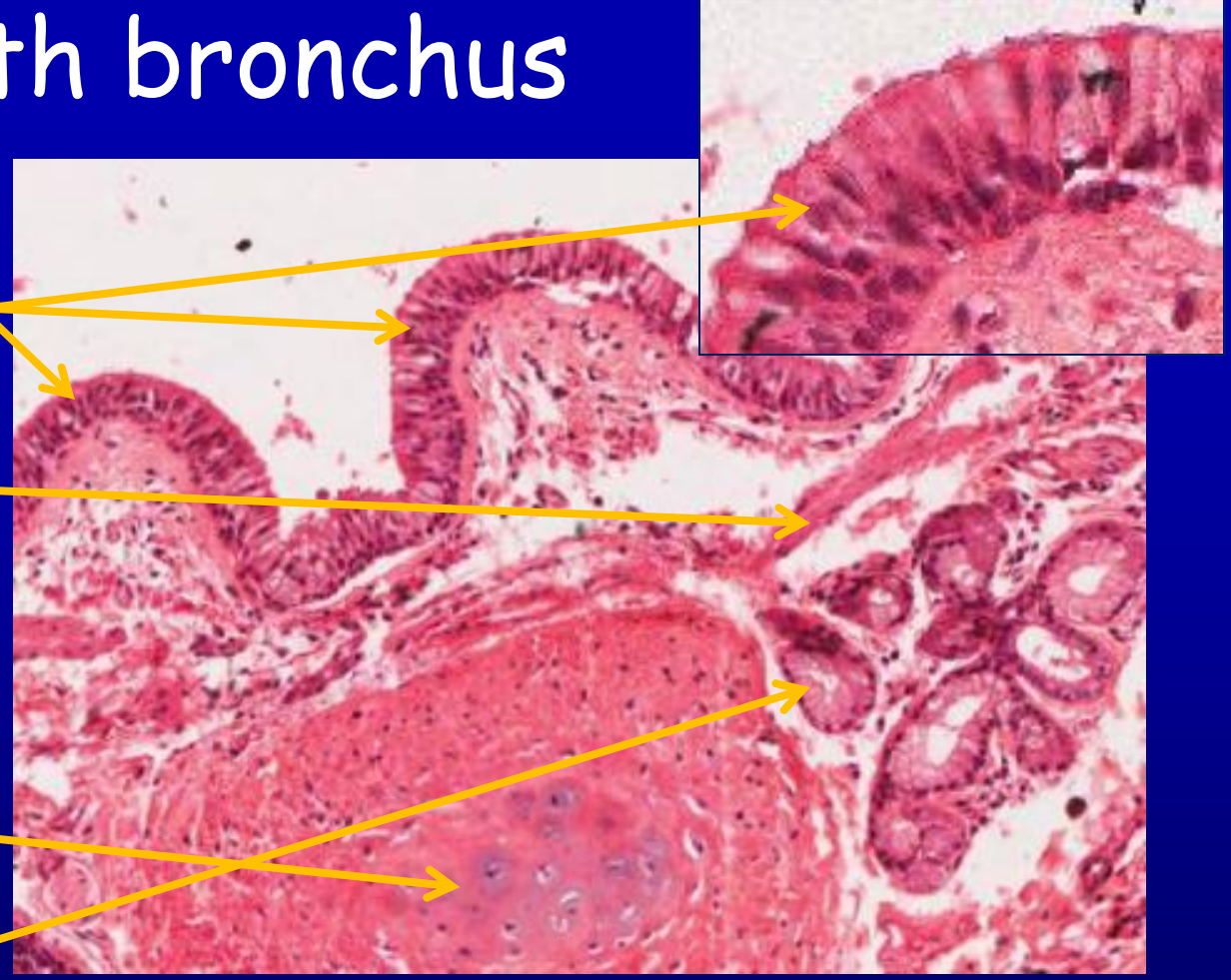
432



432 Lung with bronchus

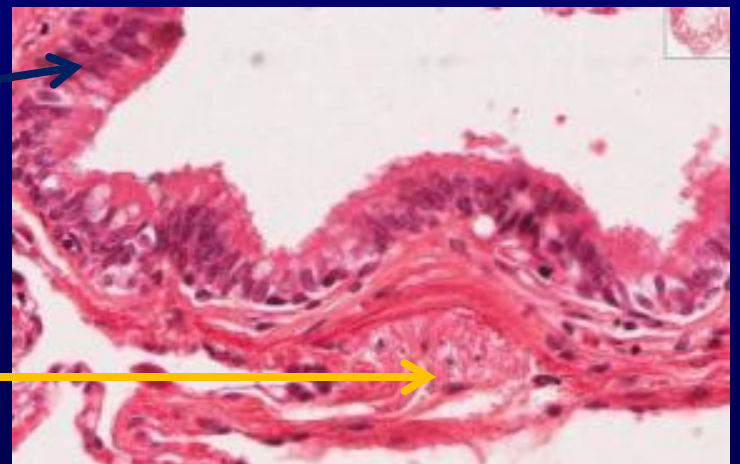
Bronchus:

1) pseudostratified ciliated columnar epithelium with goblet-cells;
2) smooth muscle band between the lamina propria and the cartilage. The smooth muscle is not continuous around the bronchus as it spirals.
3) a change from cartilage rings to cartilage plates surrounding the tube;
4) glands in the submucosa.

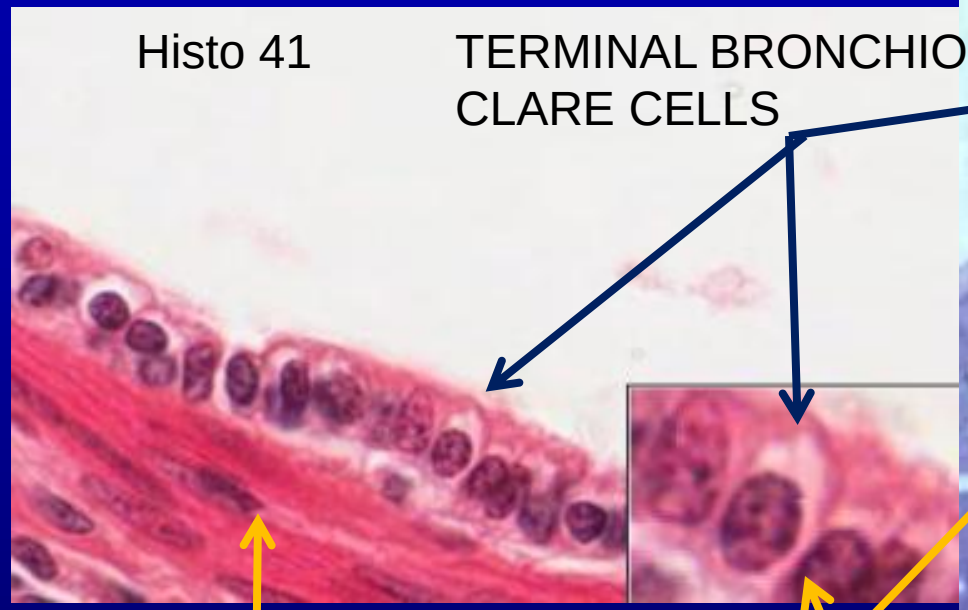


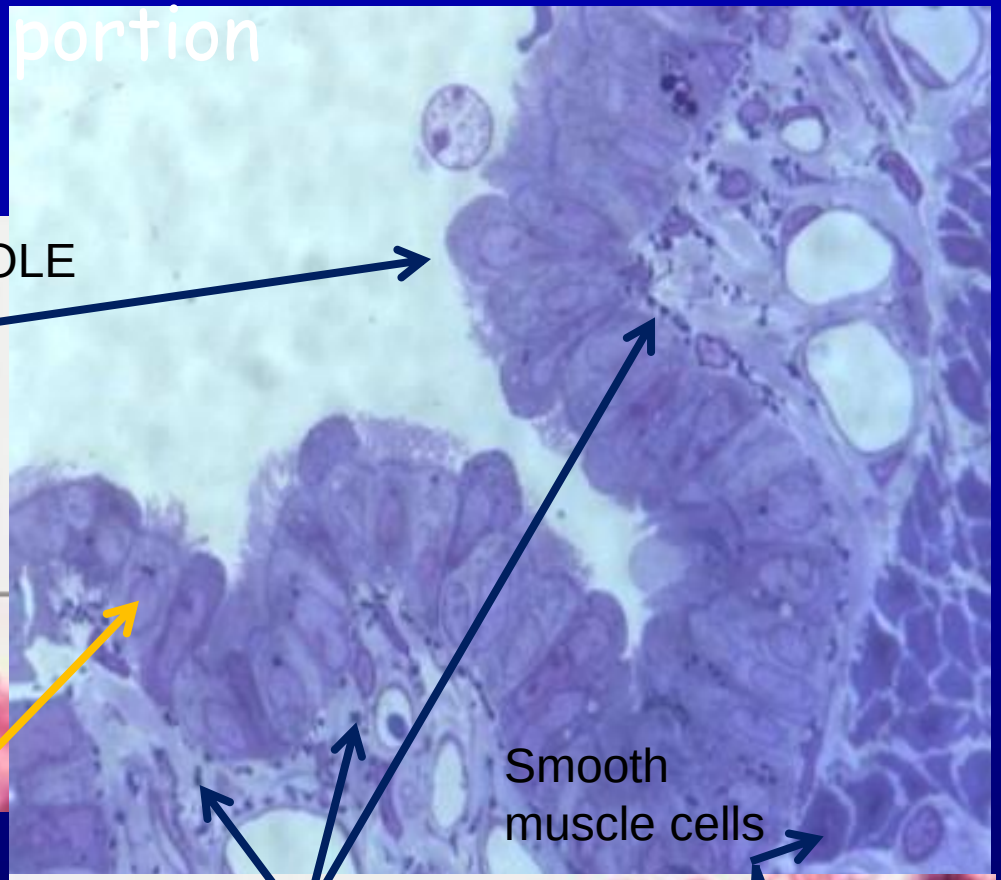
Bronchioles:

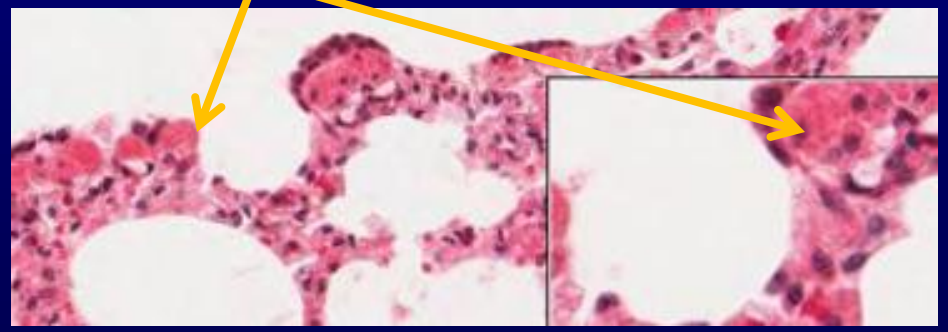
1) have a ciliated columnar epithelium;
2) do not have cartilage plates or glands;
3) have well organized muscle layers.



Cells in the respiratory portion

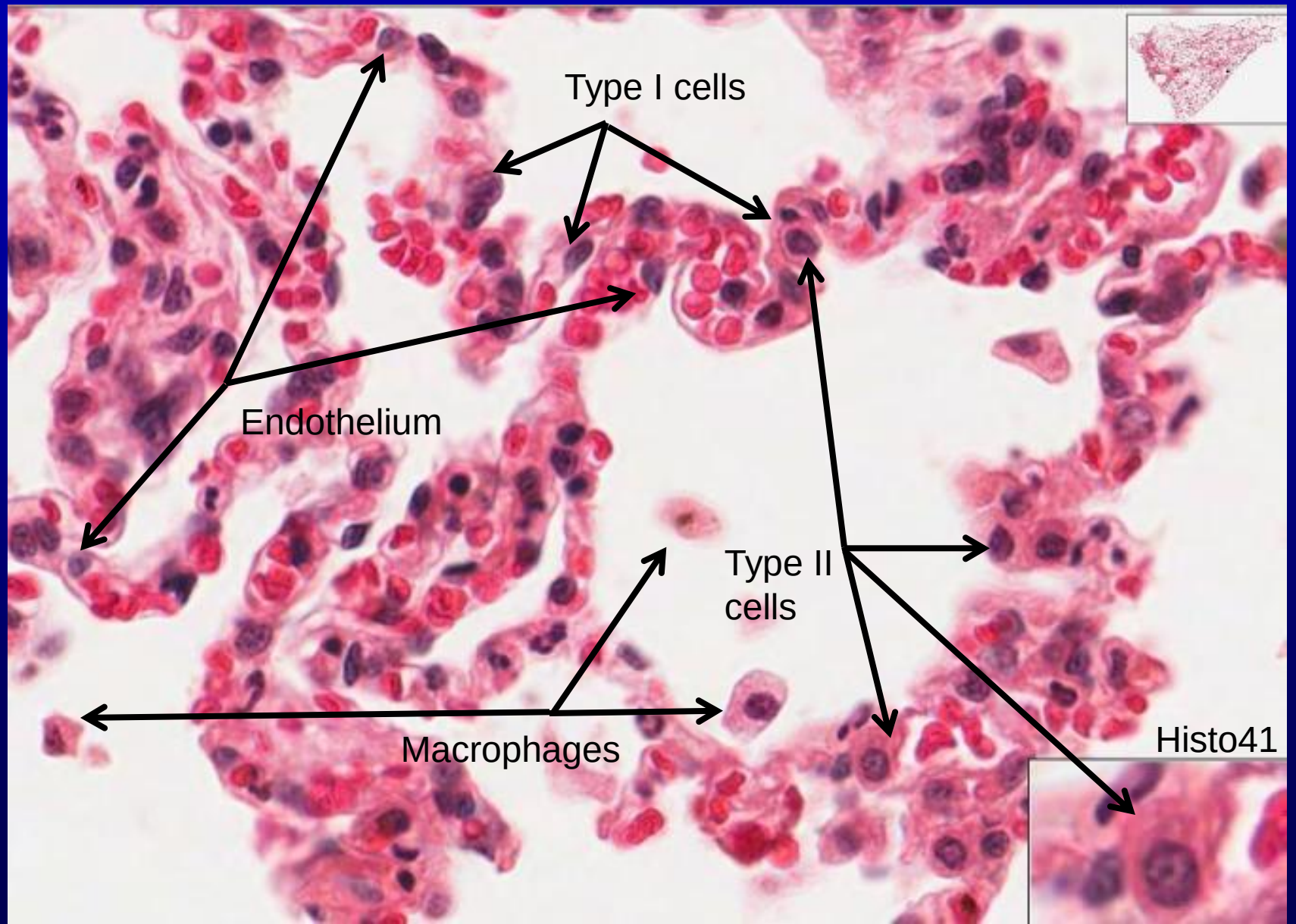




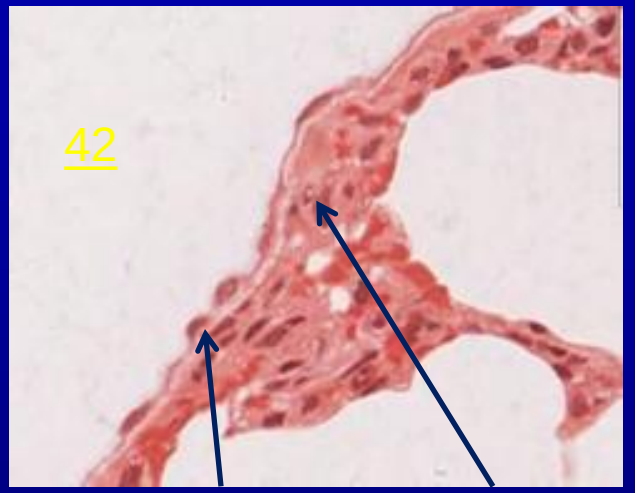


Respiratory BRONCHIOLE

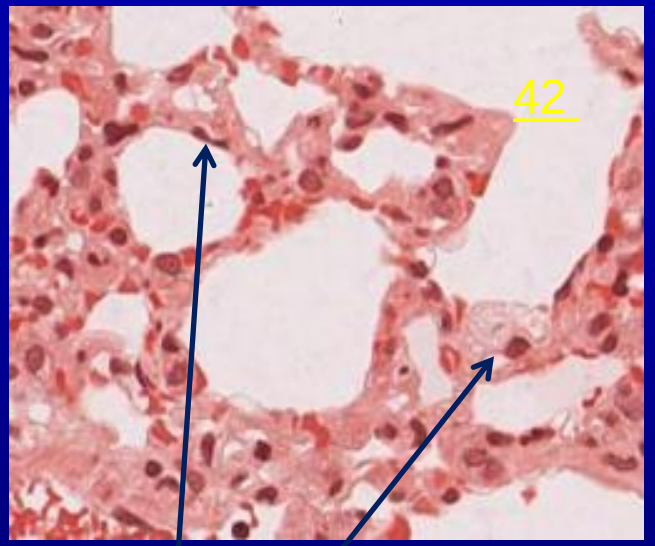
Cells in the respiratory portion



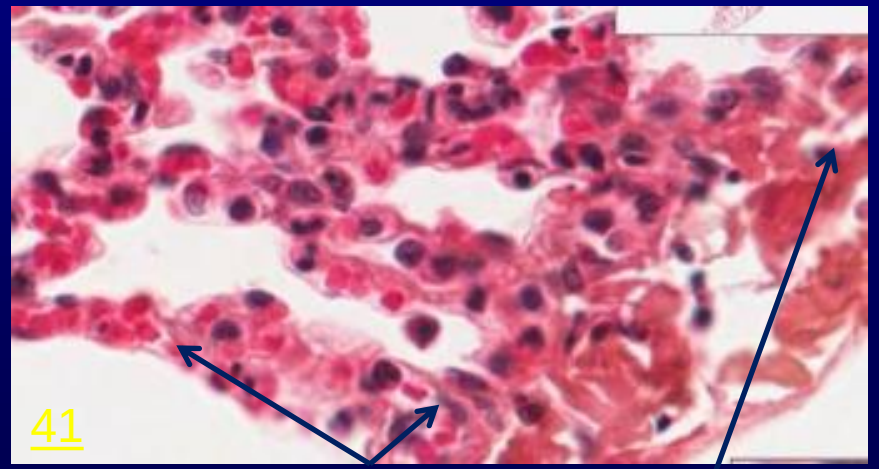
Slide Histo 41 and Histo 42: Lung



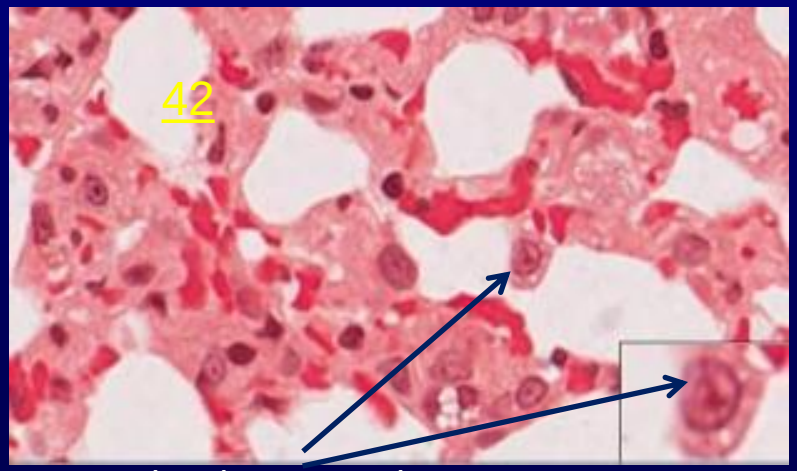
Mesothelium and connective tissue of lung capsule



Type I & Type II pneumocytes



Capillary endothelial cells and fibroblasts



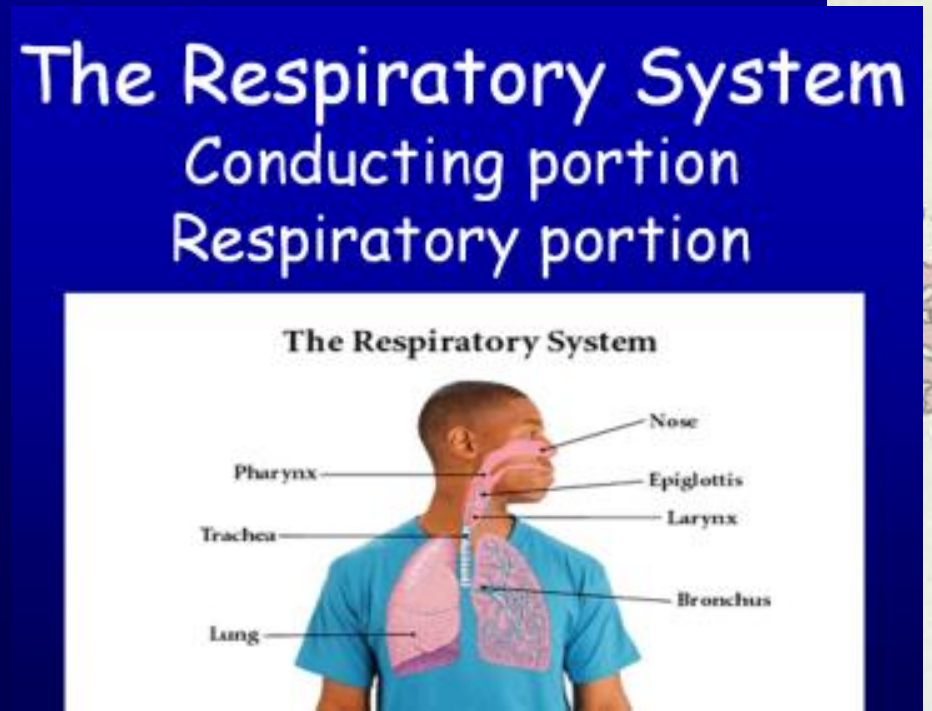
Alveolar macrophage

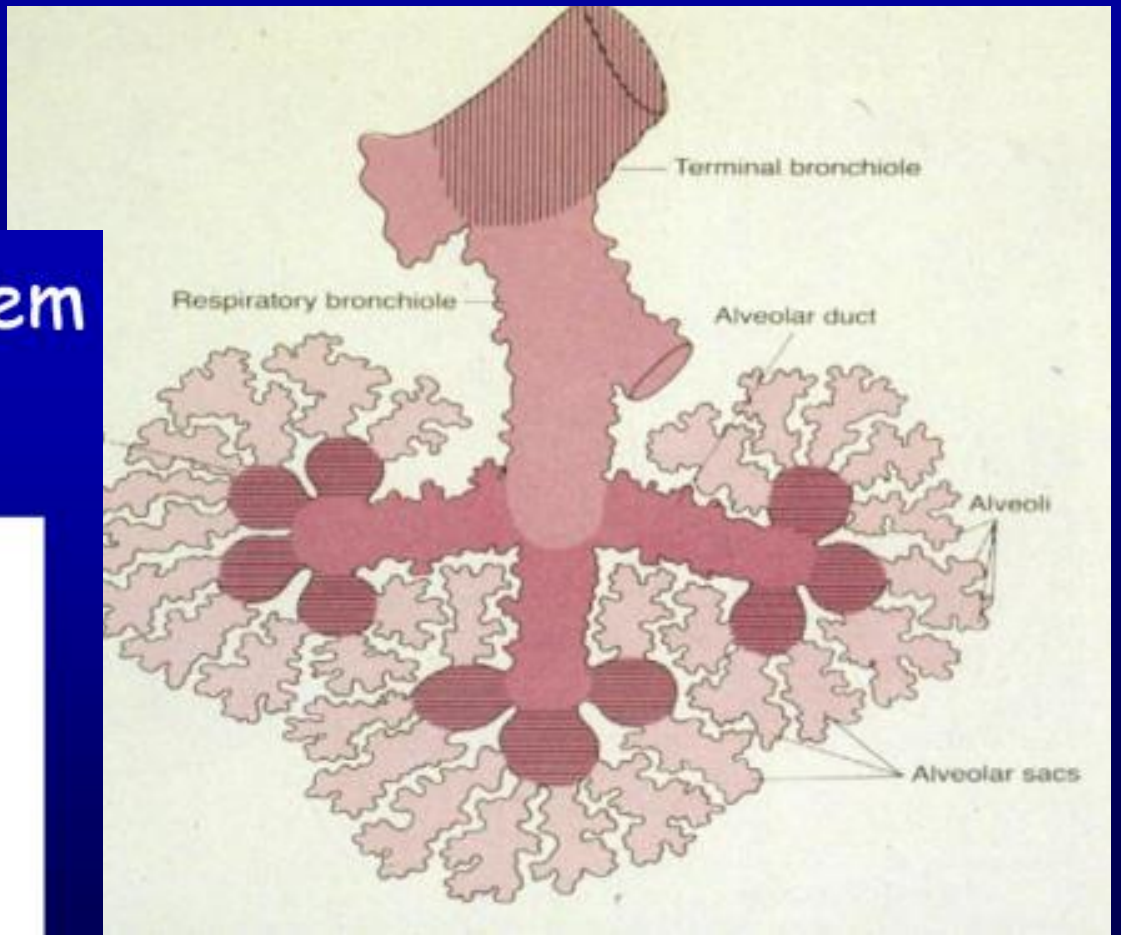
Respiratory Portion - Site Of Gases Exchange

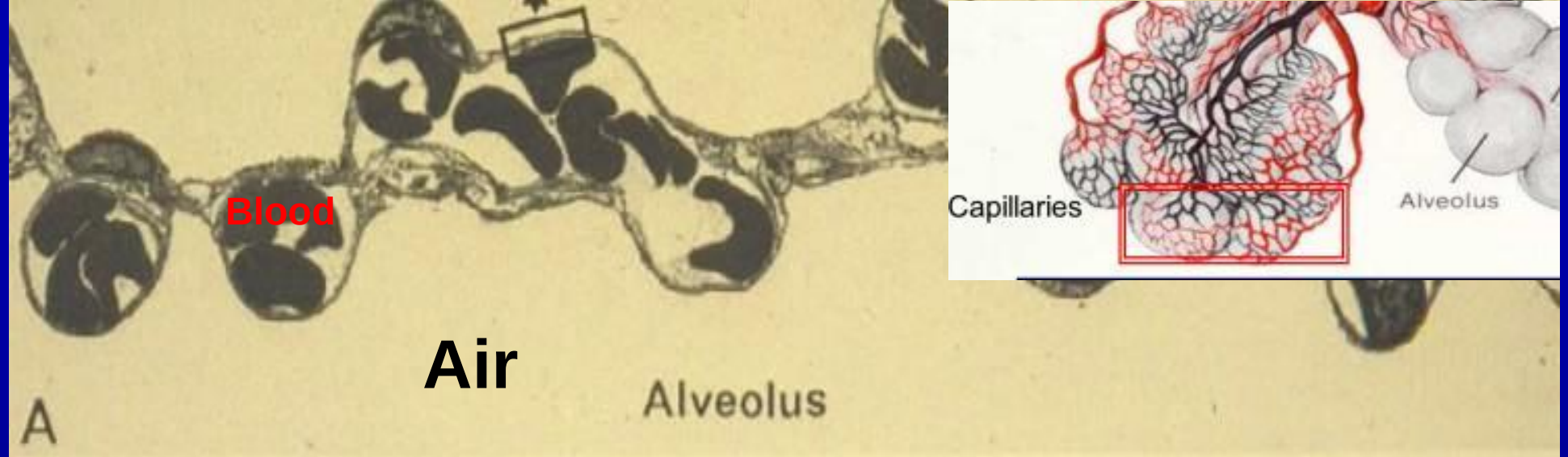
Respiratory bronchioles

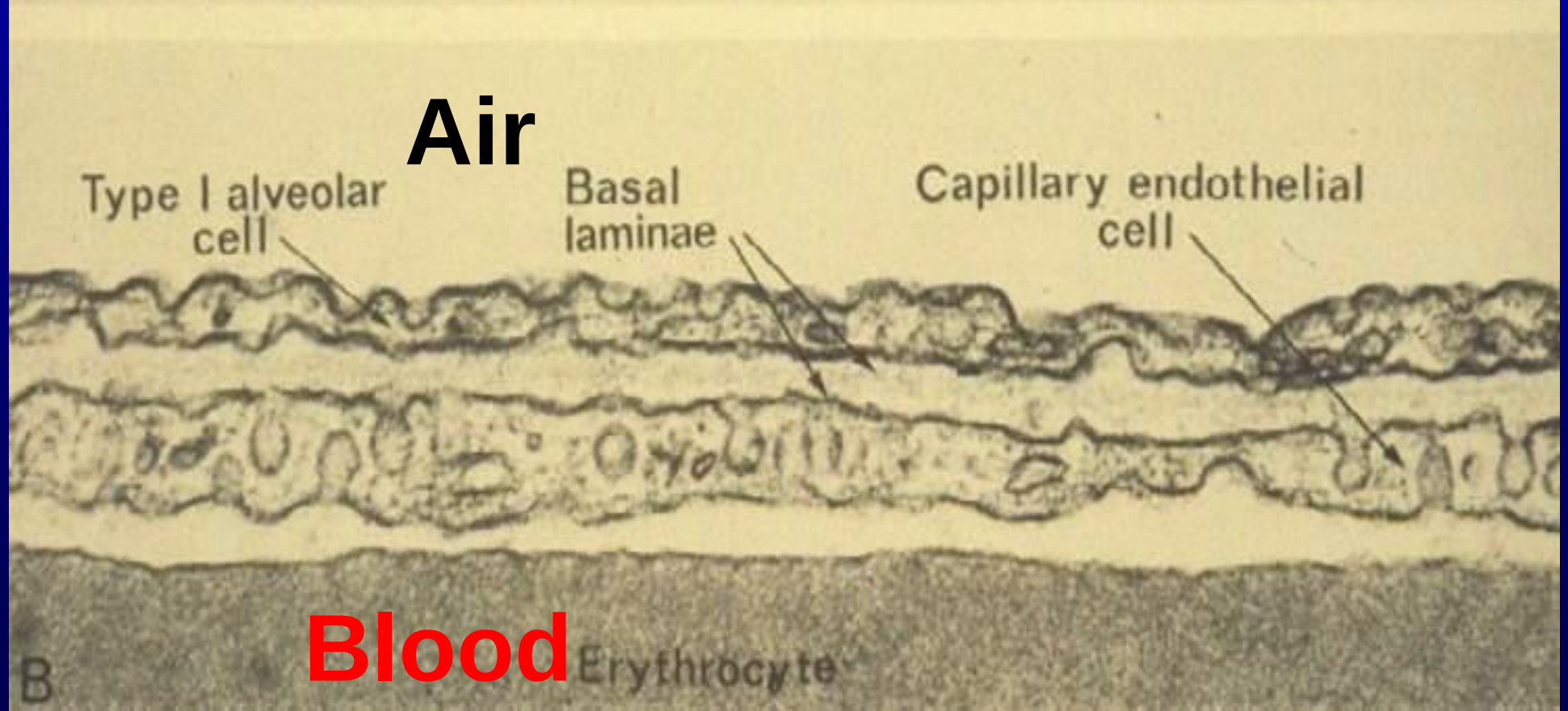
Alveolar ducts

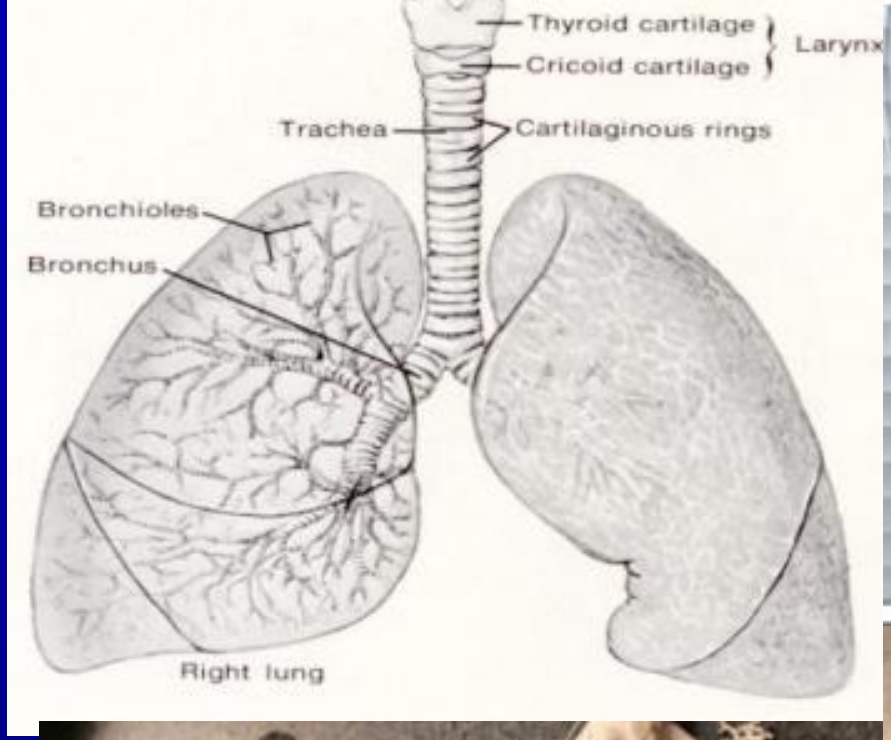
Alveoli





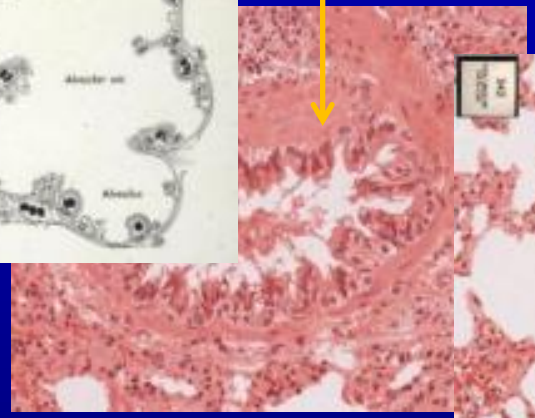

Blood
Air
Alveolus
A
Capillaries
Alveolus


Air
Type I alveolar cell
Basal laminae
Capillary endothelial cell
Blood
Erythrocyte
B


Thyroid cartilage
Cricoid cartilage
Larynx
Trachea
Cartilaginous rings
Bronchioles
Bronchus
Right lung

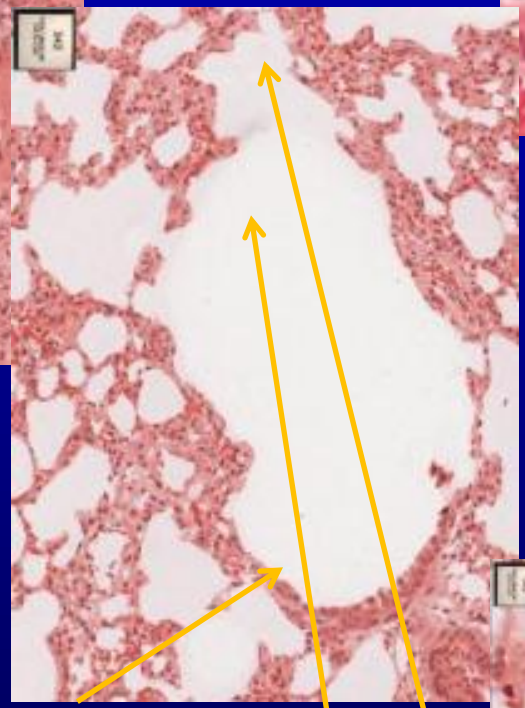
Histo 42: Lung (mast cells)

Terminal bronchiole



Bronchus

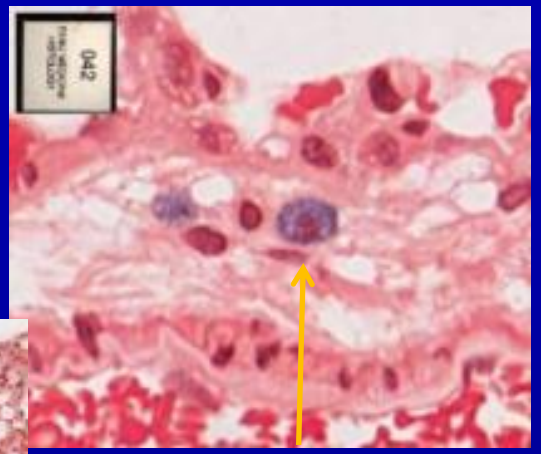
Conducting bronchiole



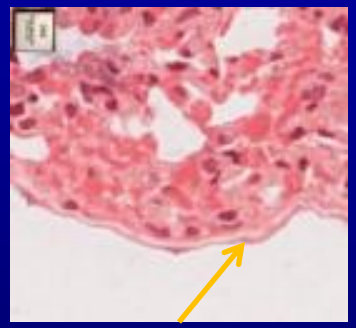
Respiratory bronchiole

Alveolar duct

Alveolar sac

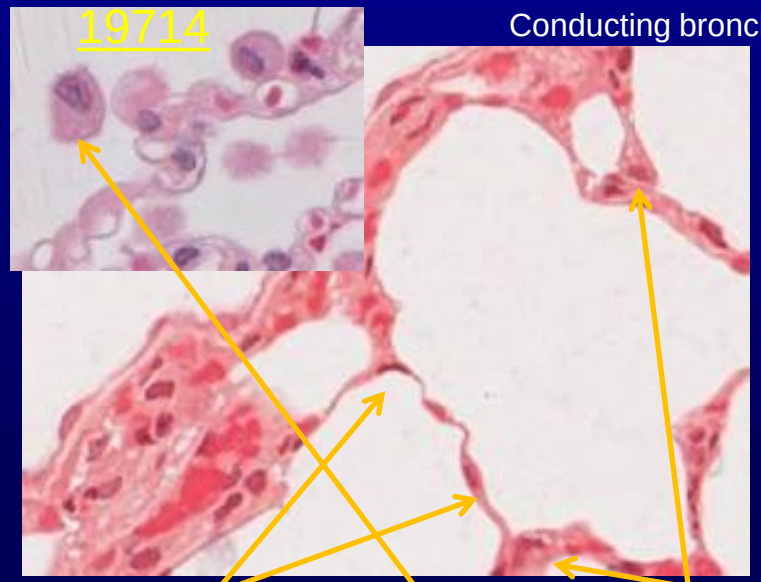


Mast cell



Mesothelium

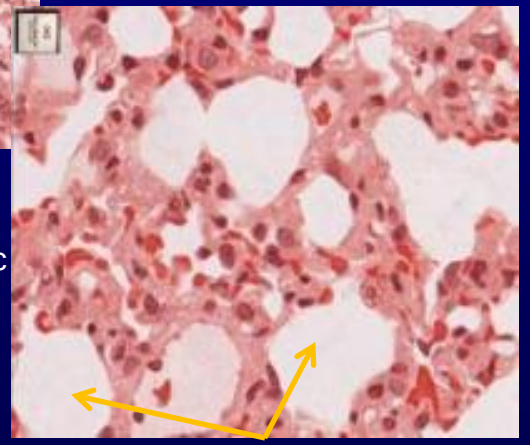
19714



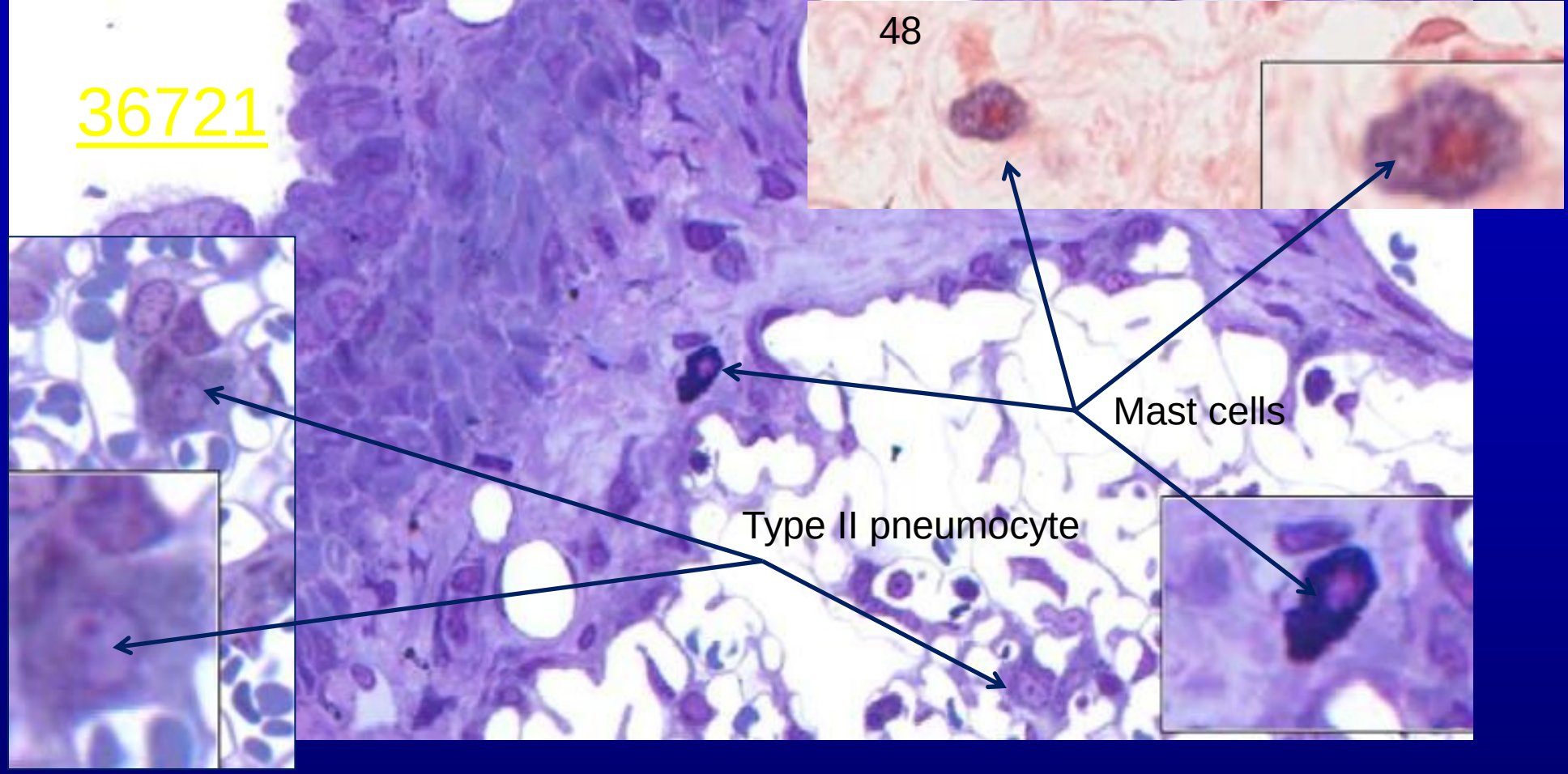
Type I pneumocyte

Alveolar macrophage

Type II pneumocyte

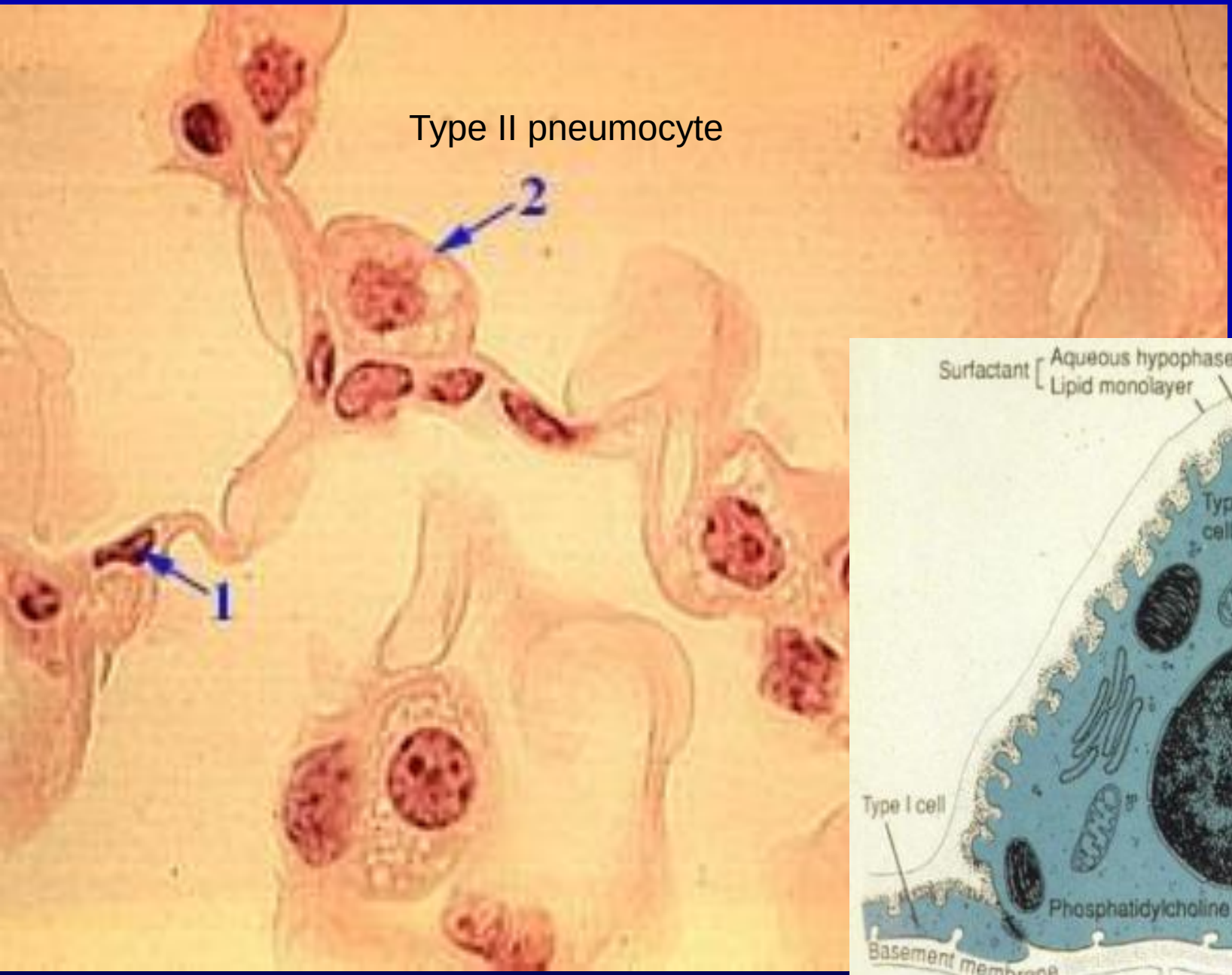


Alveoli

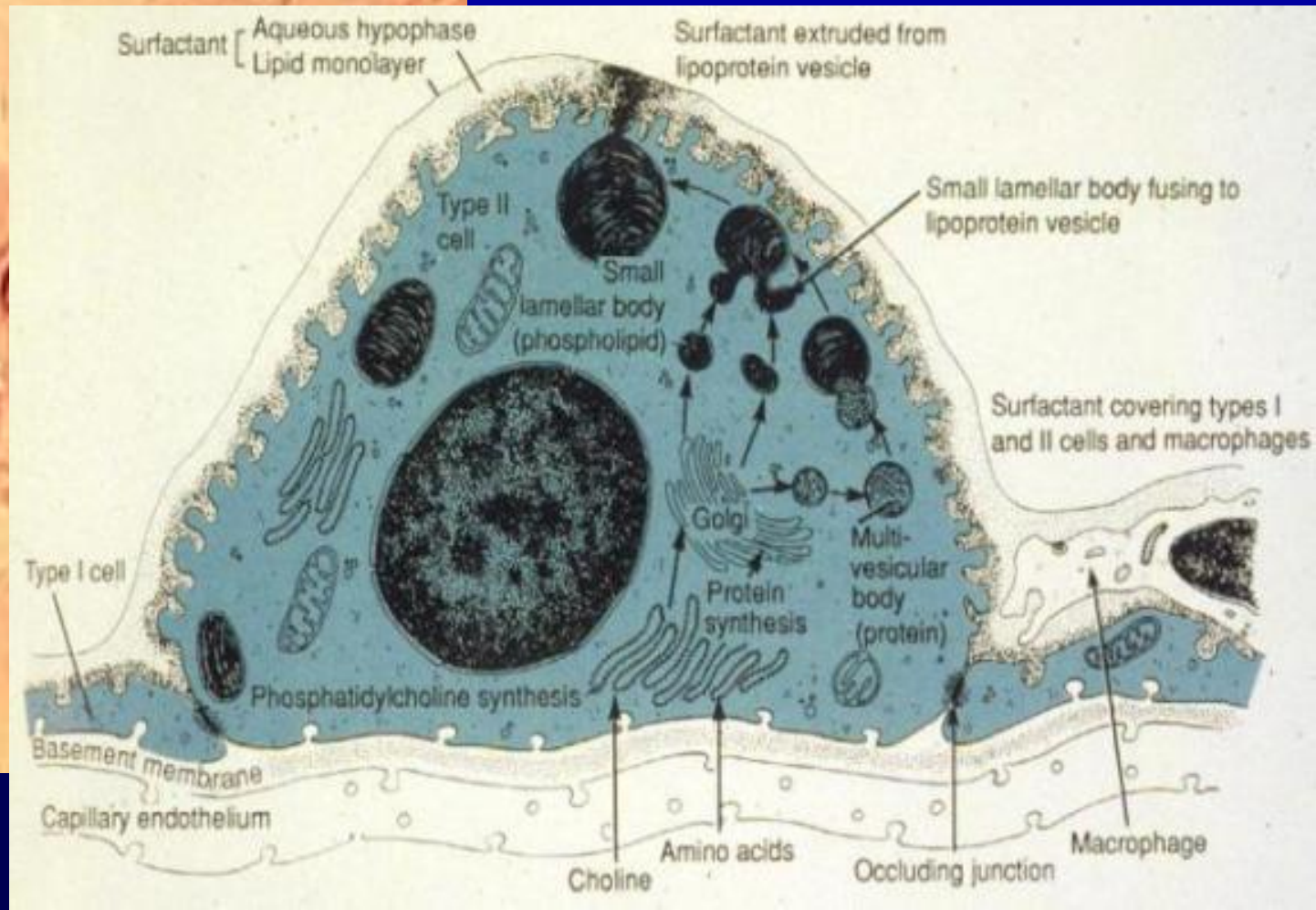


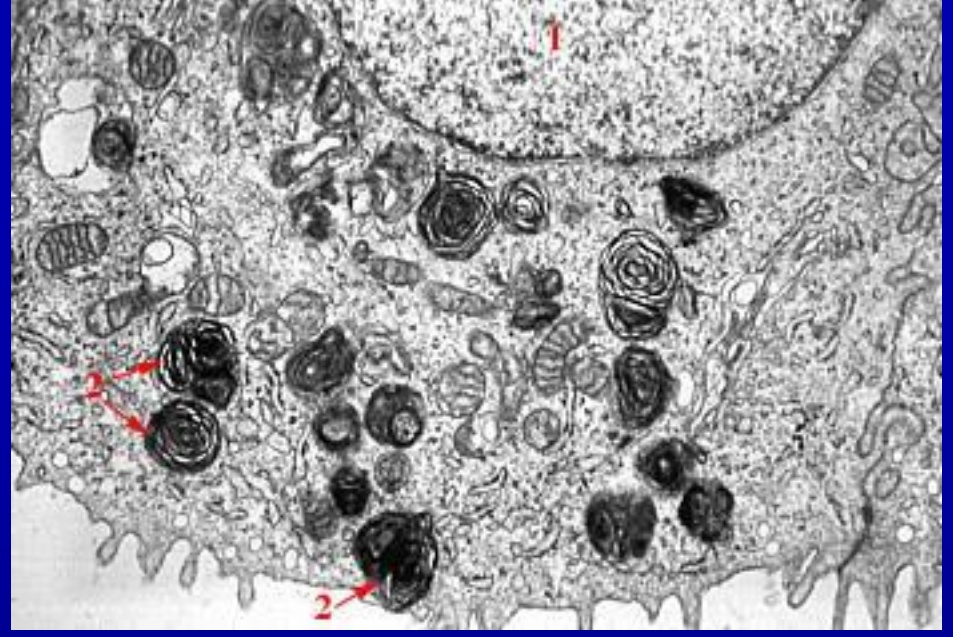
- Mast cells function in the localized release of many bioactive substances with roles in the local inflammatory response, innate immunity, and tissue repair.
- Mast cell granules normally contain: heparin, histamine, serine proteases, eosinophil and neutrophil chemotactic factors, cytokines, etc.

Type II pneumocyte



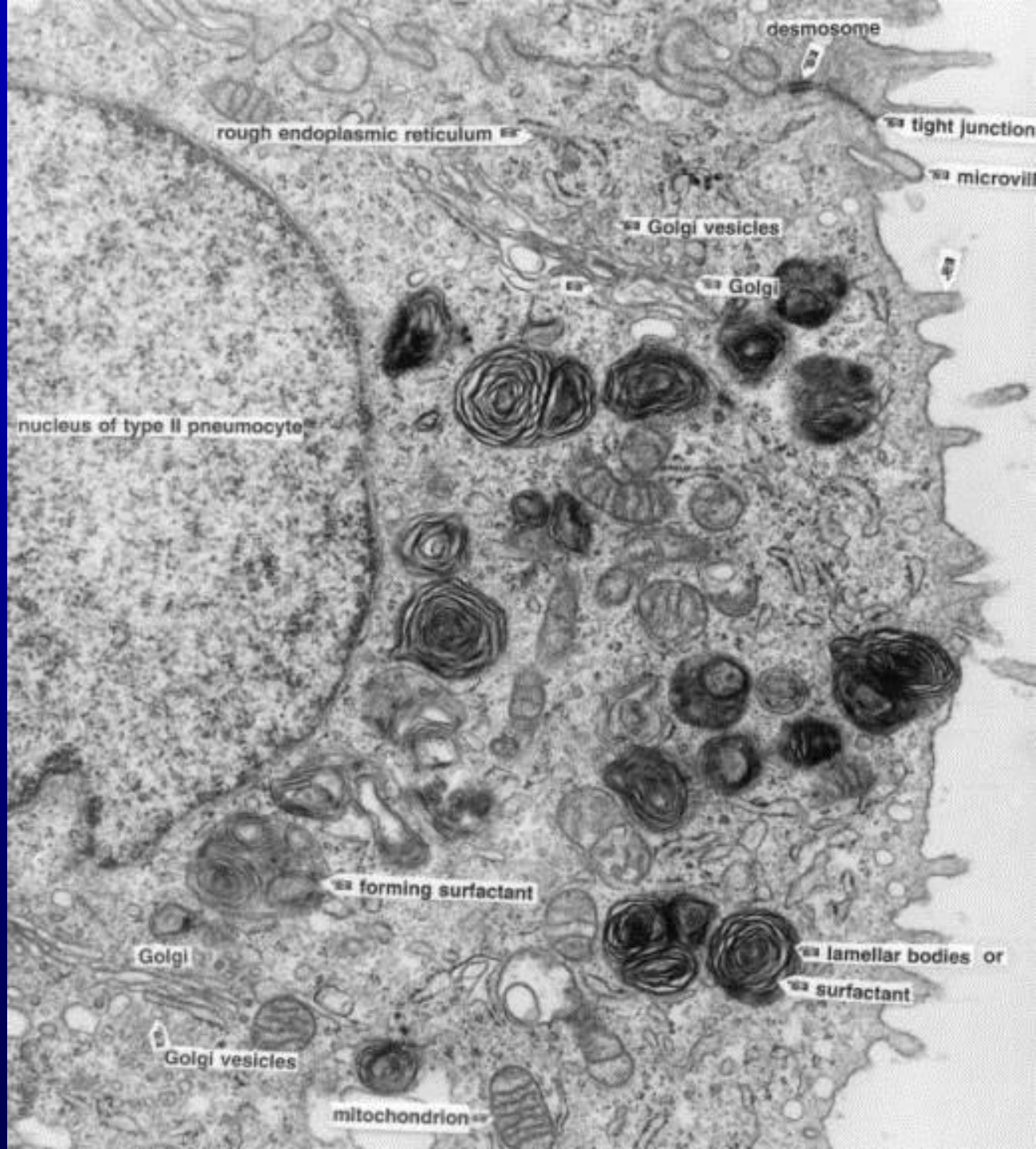
1. Type I pneumonocyte
2. Type II pneumonocyte



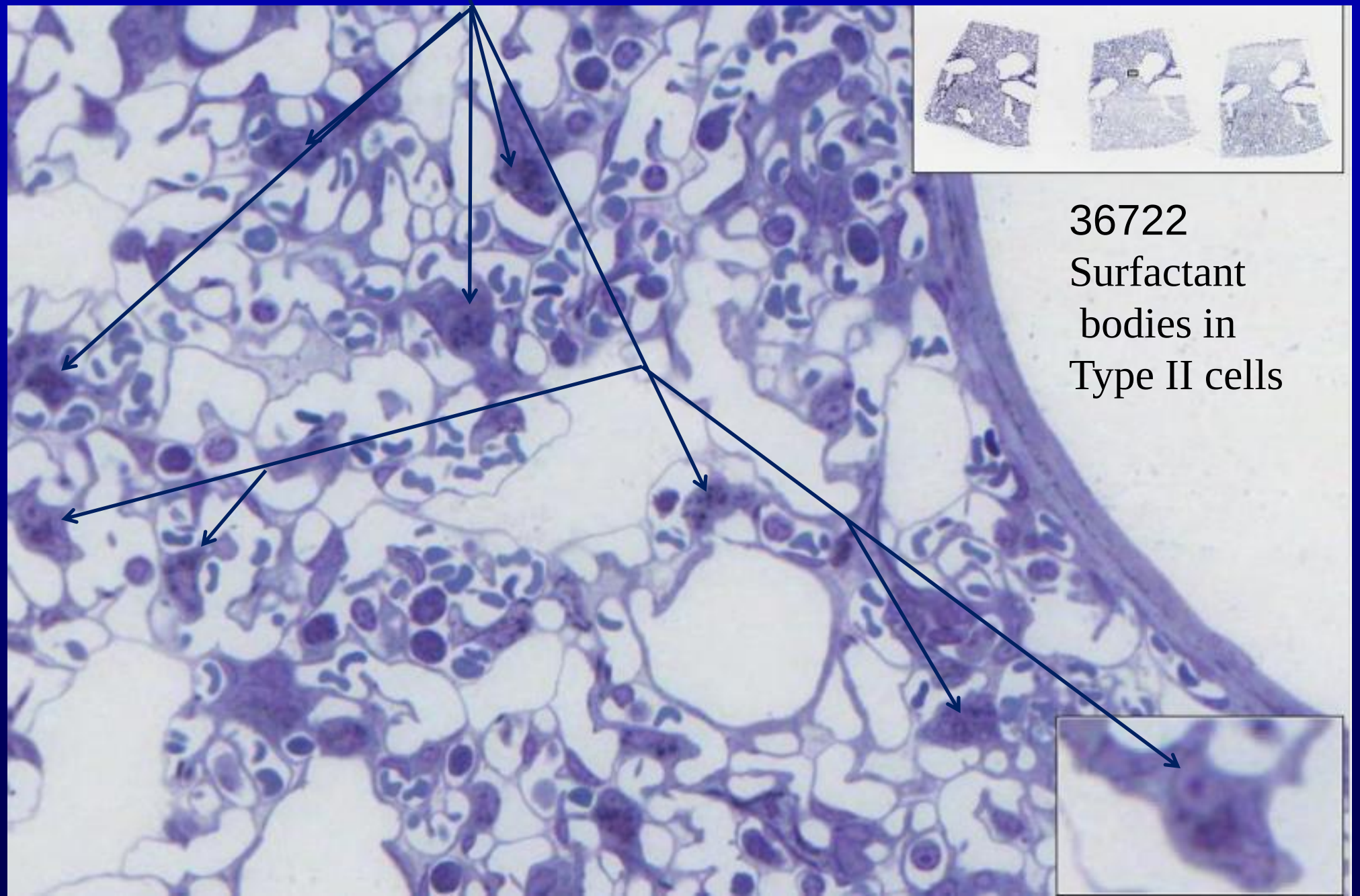


Type II pneumonocyte (EM 18c).

1. Nucleus
2. Surfactant bodies

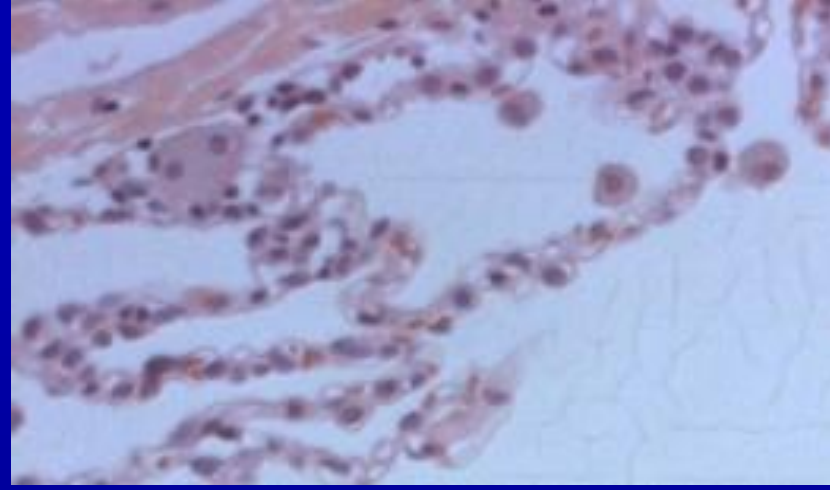


Type II pneumocytes



36722
Surfactant
bodies in
Type II cells

Respiratory Physiology

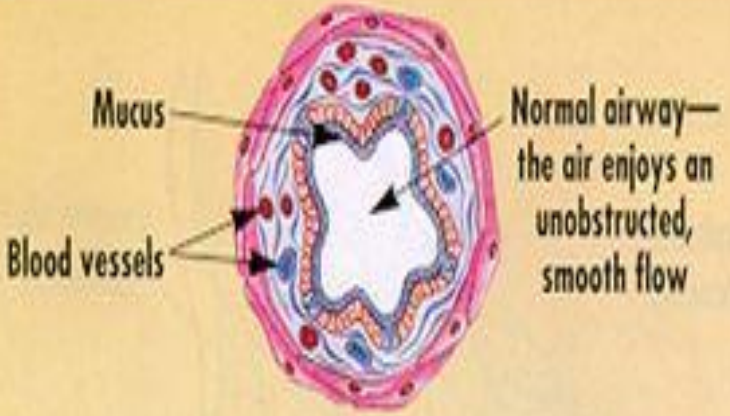


Surfactant functions in reducing surface tension, reduces work of breathing, and helps keep alveoli open and may have a bactericidal effect.

Hyaline membrane disease - premature infants cannot get or make sufficient surfactant.

Bronchoalveolar fluid - cleared by ciliary action toward oral cavity (contain lysosome, collagenase, glucuronidase, and antibodies).

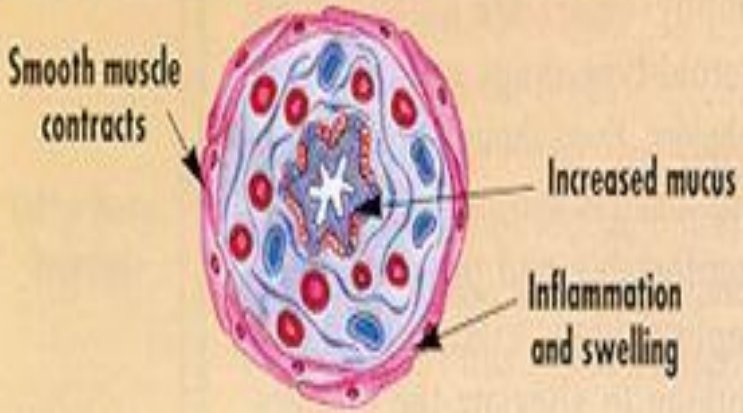
Macrophages - contain hemosiderin, produce lytic enzymes in bronchoalveolar fluid.



Normal Airways

The bronchial tubes normally allow air to flow easily to reach the alveoli and to be returned and exhaled. To protect the lungs from inhaling poisonous particles and gases, the lining of the bronchial tubes is very sensitive. When the sensitivity is too high, the bronchials respond to particles and gases that are not poisonous. This is why about two-thirds of asthma cases occur in children whose sensitivity is much higher than many adults.

Normal



Obstructed Airways

When you have asthma, pollutants and allergens cause an increase in the production of mucus in the lining of the bronchials, and often cause the muscle surrounding the bronchials to constrict. When you have bronchitis, pollutants cause irritation and inflammation. This condition causes swelling of the bronchials, which narrows the air passageways. In older people, who have less mucus protecting the lining of the bronchials, an asthmatic constriction may occur with bronchitis.

Asthma

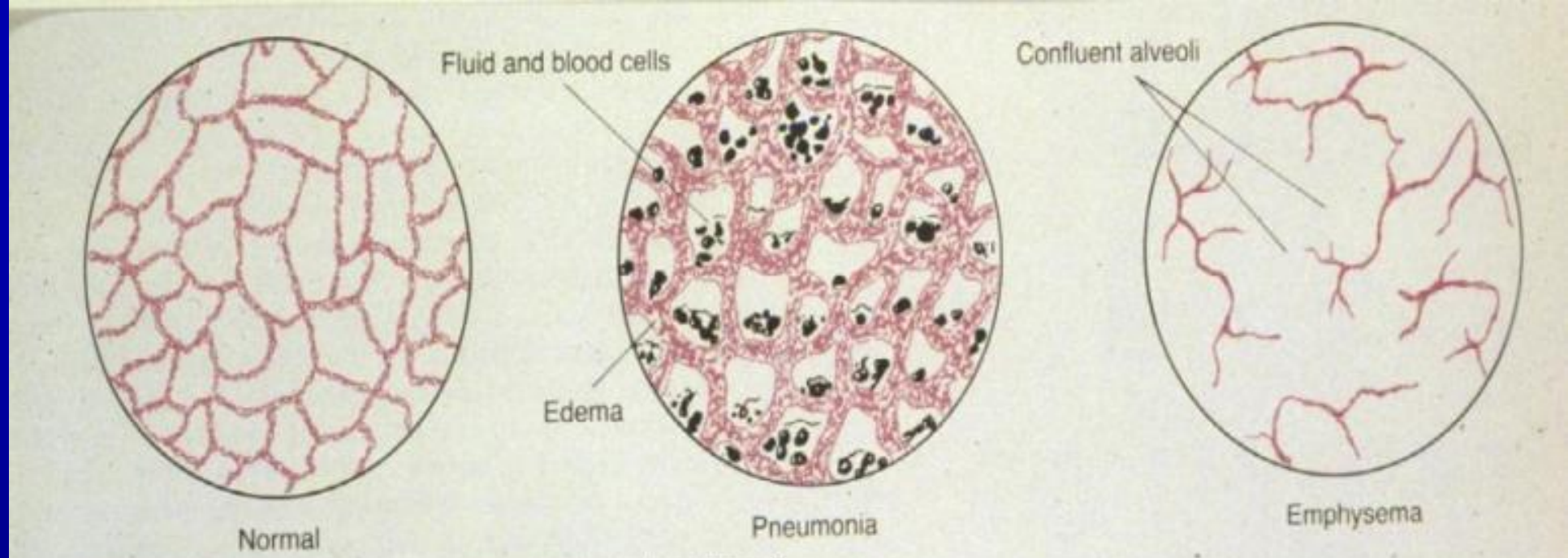
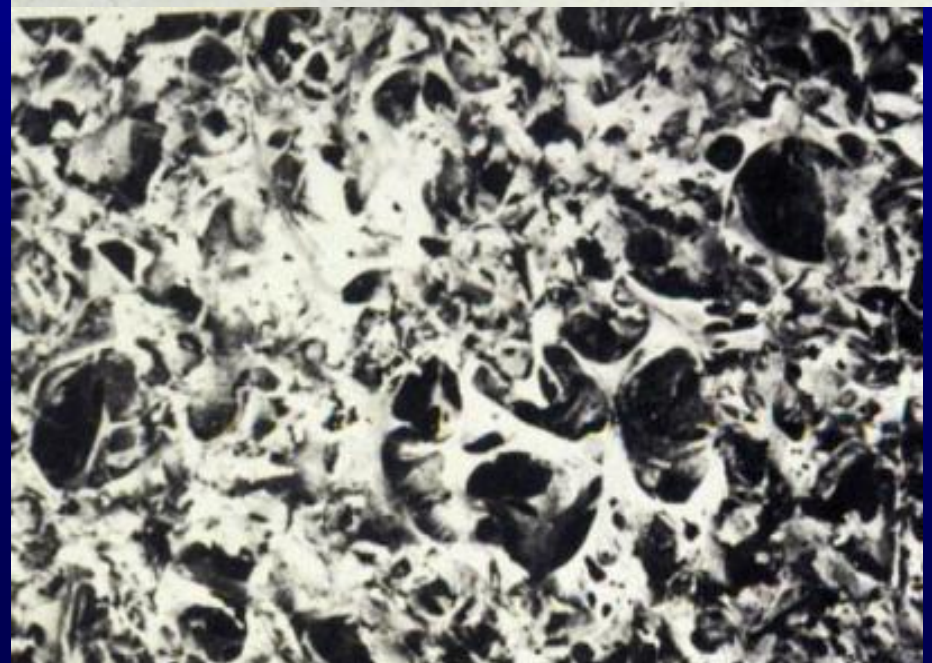
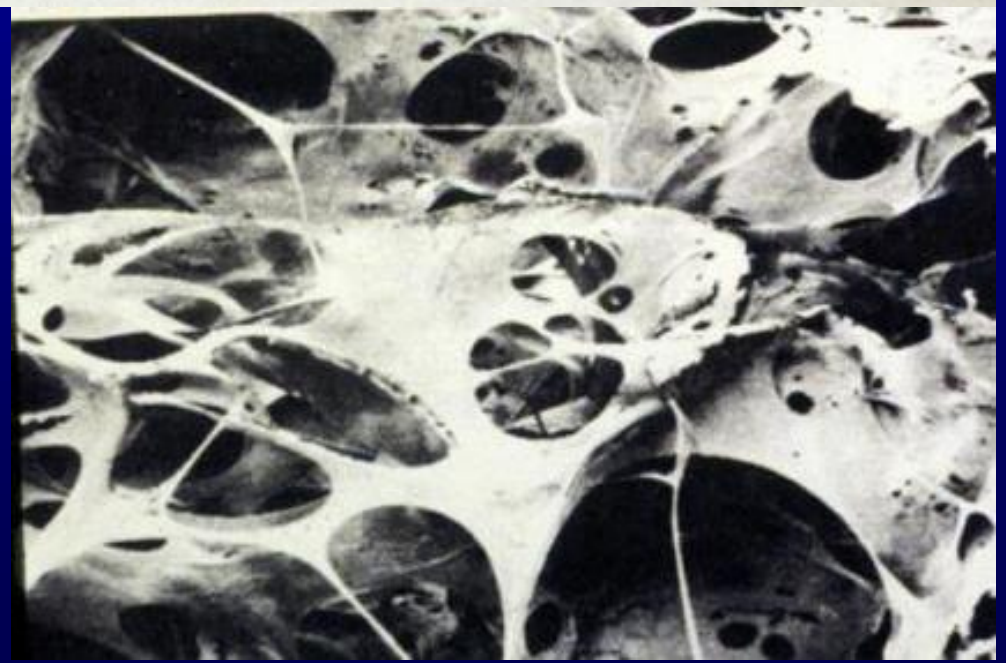


Figure 42–5. Pulmonary changes in pneumonia and emphysema.

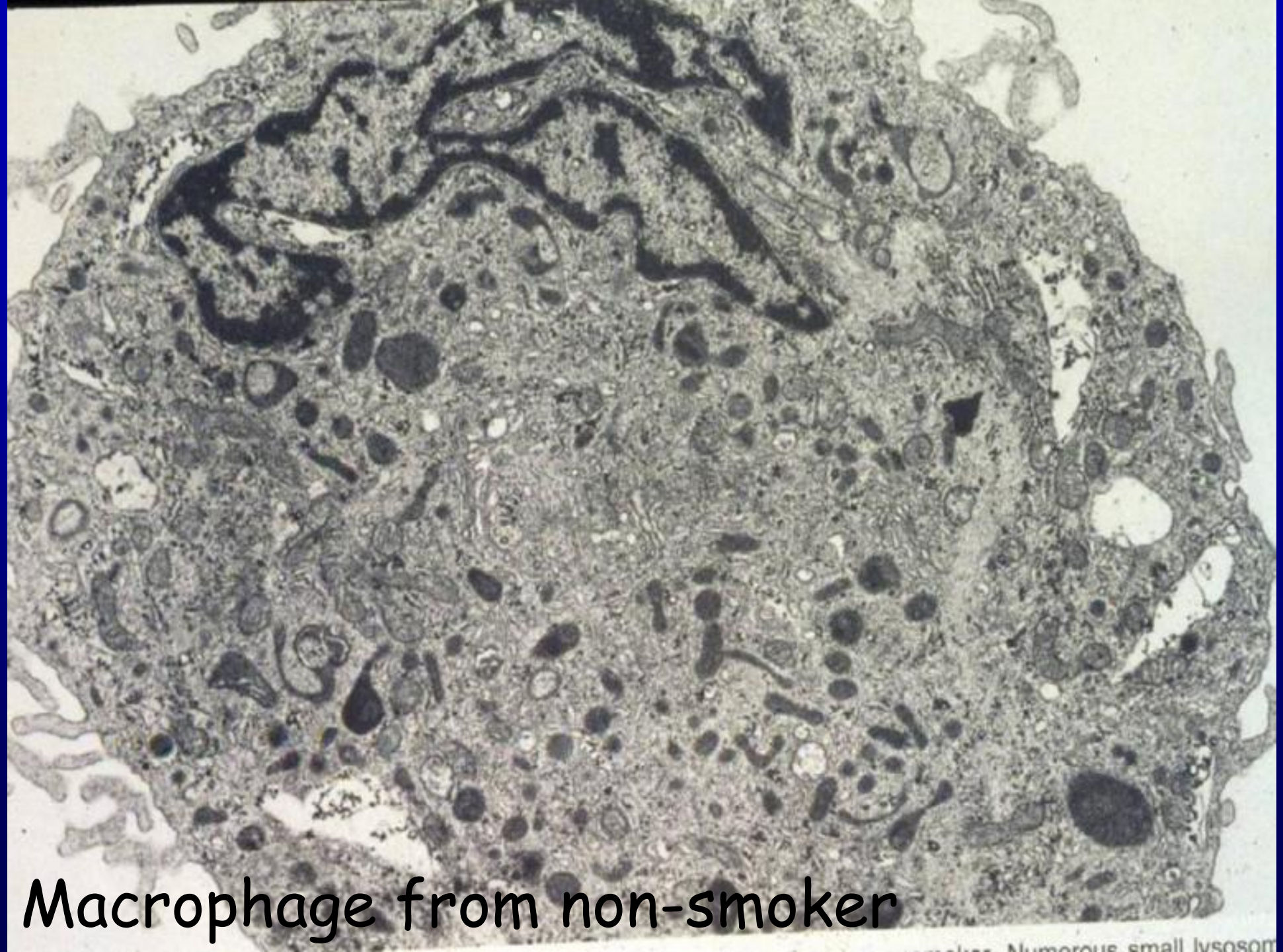




Respiratory Physiology Con't

Emphysema - destruction of alveolar wall

Means too much air in the lungs.



Macrophage from non-smoker

Macrophage
from Smoker

Small pieces of lungs from a non-smoker

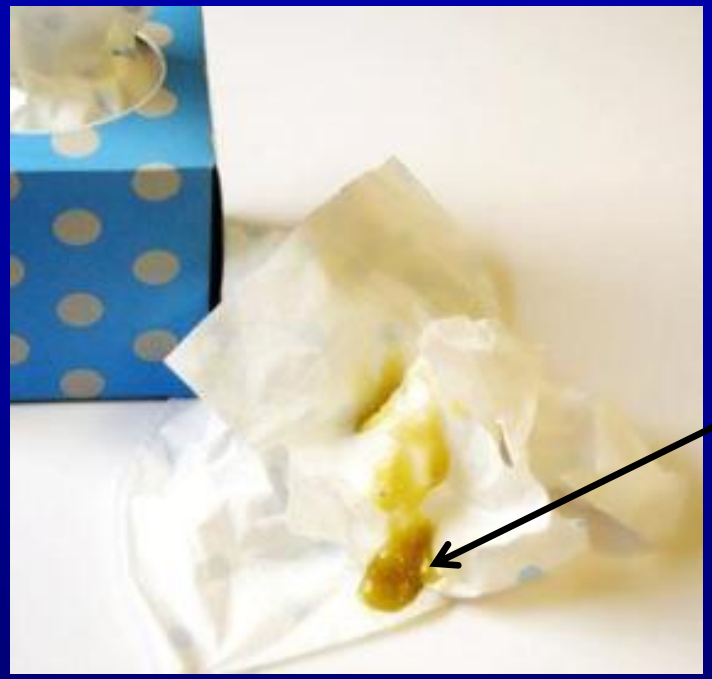
and from a smoker

The Lungs on the left have Empysema.
The one on the right has cancer - both from Smoking

"Dose Makes the Poison"

The Lungs on the left have Empysema.
The one on the right has cancer - both from Smoking

Natural Defenses of Our Respiratory System



Large particles get trapped by **nose hairs**.

Smaller particles are trapped in **mucus** that lines our respiratory system. The mucous keeps harmful particles out of the lungs.

Coughing forcibly expels foreign particles trapped in our lungs and airways.

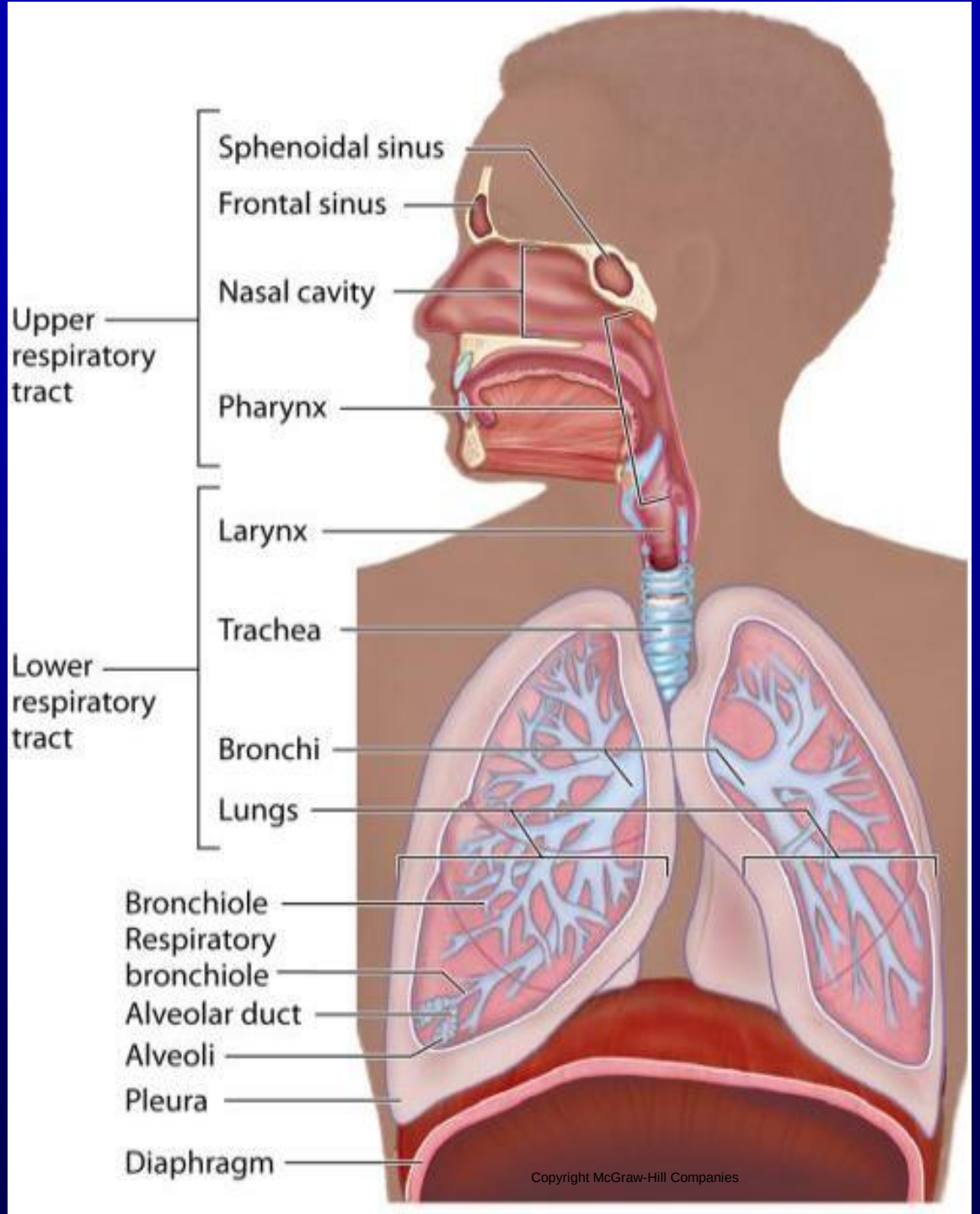
Sneezing removes bacteria trapped in mucus from our nasal passages. Sneezes travel at about 100 miles per hour and remove 100,000 bacteria)

Respiratory System

- Conduction
  - Maintenance of an open lumen
  - Ability to accommodate expansion and contraction,
  - Warming, moisturizing and filtering of the inspired air

- Respiration
  - Rapid exchange of atmospheric gases
  - Alveolar wall cells secrete **surfactant**

- Structure
  - Skeletal components (cartilage, etc.)
  - Vascularization
  - Glands in lamina propria



In summary

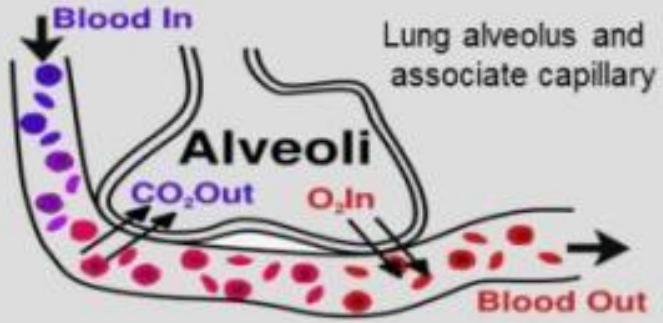
Function of the Respiratory System

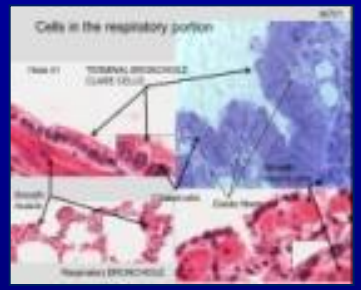
All higher animals require a mechanism to:

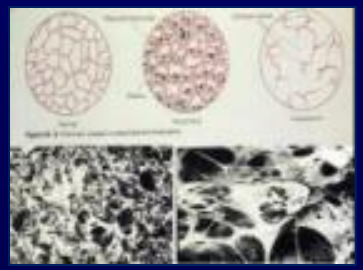
1. Obtain O_2 from the environment
2. and get rid of CO_2

This "gas exchange" is the function of the respiratory system.

Oxygen diffuses out and Carbon Dioxide diffuses into the air space of the alveolus.







Questions on the Respiratory System

The conducting portion of the respiratory system modifies the air in the following way(s):

a. warms
b. cleans
c. dries
d. a and b
e. a, b, and c

Which of the following are involved in both inspiration and expiration? Contraction of

a. intercostal skeletal muscle between the ribs
b. diaphragm
c. smooth muscle
d. a and b
e. a, b, and c

Variation in the epithelium lining the respiratory system facilitates varied functions.
Which epithelium-function does not match?

a. simple squamous - alveolar ducts
b. goblet cells - humidifies air
c. **stratified squamous - false vocal cords**
d. ciliated cells - move dust-laden mucus
e. hair follicle - filtration of air

Many illustrations in these VIBS Histology YouTube videos were modified from the following books and sources: Many thanks to original sources!

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