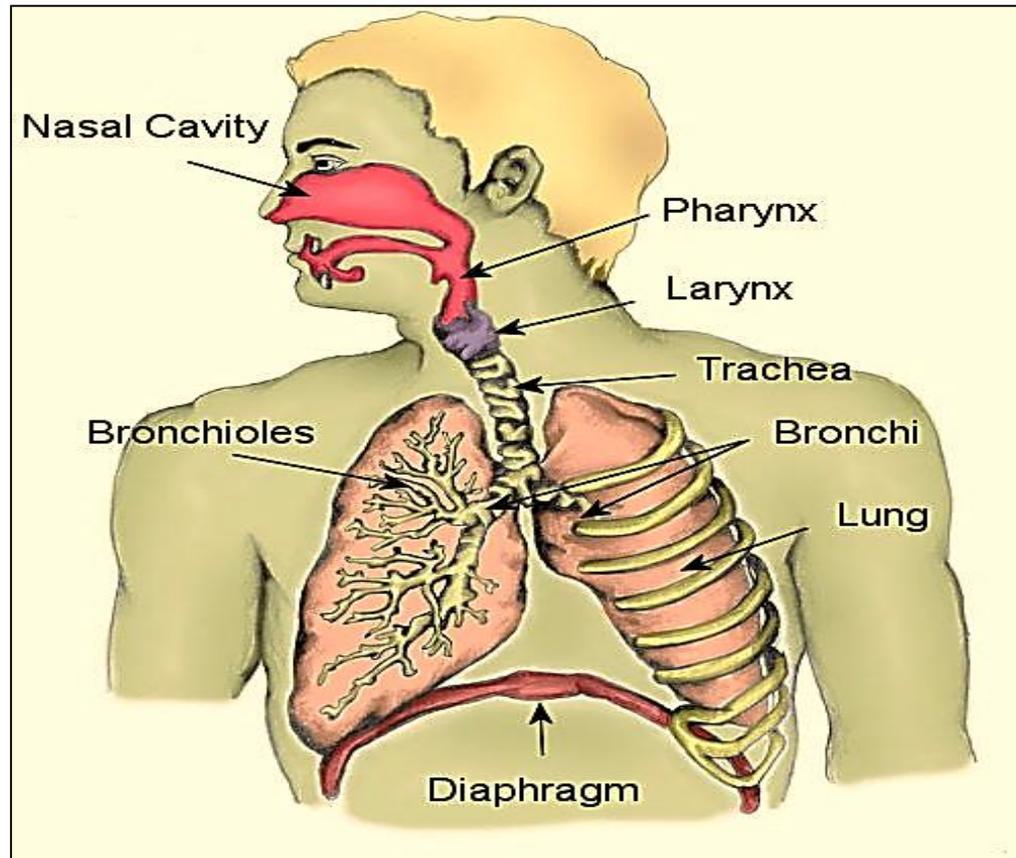


# WELCOME THIRD YEAR CLASS



45

# The Respiratory system



## Objectives of studying the respiratory system:

- Understand the structure and function of air ways , lungs, the role of their lining epithelium in clearing the inspired air and in gas exchange



- Understand the structure of epithelium & chemoreceptors involved in the sense of smell



- Understand structures responsible for production of sounds (Phonation)



## Learning objectives:

- 1- Recognize & describe the cellular components of respiratory epithelium
- 2- Understand the structure & function of conchae
- 3- Recognize & describe the cellular components of olfactory epithelium
- 4- Describe components of the vocal cords
- 5- Recognize & understand function of epiglottis
- 6- List the tubes that make up the conducting and respiratory portions
- 7- Distinguish between a bronchus, bronchioles & respiratory bronchiole
- 8- List all components that make up the interalveolar septum
- 9- Distinguish between type I & type II alveolar cells , macrophage and endothelium

# Respiratory system



```
graph TD; A[Respiratory system] --> B[Conducting portion]; A --> C[Respiratory portion]; B --> D["Conduct, filters, warms & moistens air"]; C --> E["Gas exchange & secretion of Surfactant"]
```

## Conducting portion

Conduct, filters, warms & moistens  
**air**

## Respiratory portion

**Gas exchange &**  
secretion of  
**Surfactant**

- **Types of epithelium in the respiratory system:**

**1- Non- K stratified squamous epith.** → found at nostrils, lingual surface of epiglottis, & true vocal cords

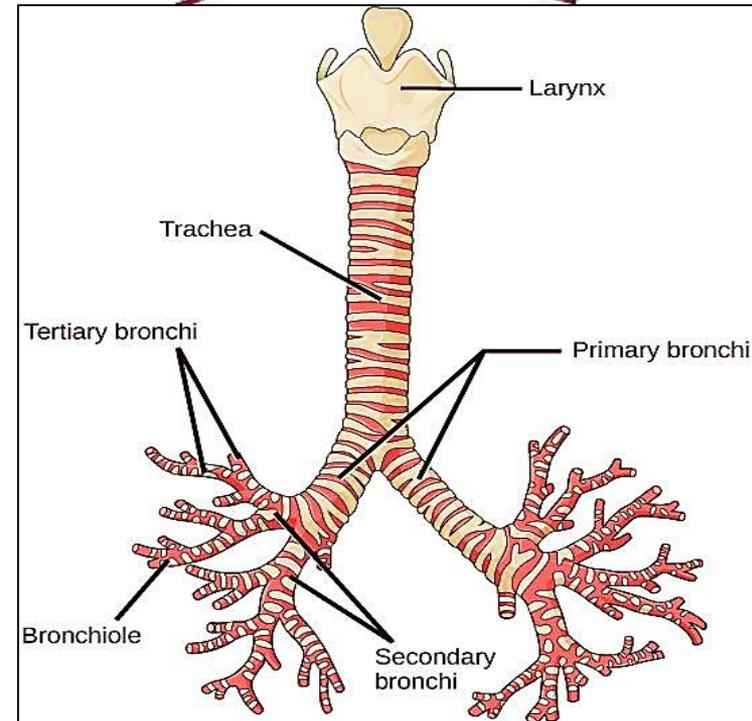
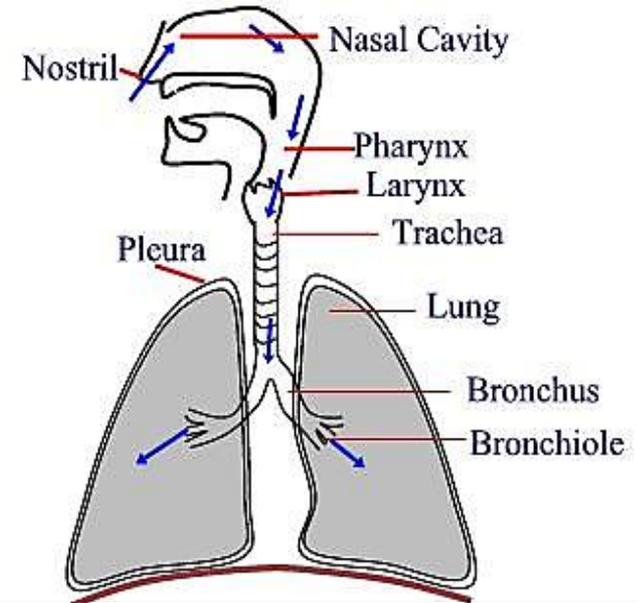
**2- Respiratory epith.** Cover most of the conducting portion of the respiratory tract

**3- Olfactory epith.** Contains chemoreceptors of smell sensation → superior conchae

**4- Alveolar epith.** Found in Respiratory portion / alveoli where gas exchange

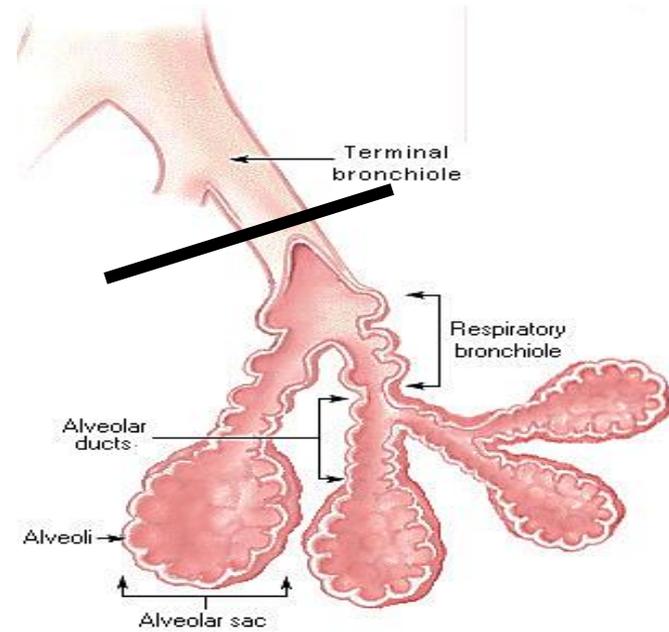
## ➤ A- Parts of The conducting portion :

- Nasal cavities & sinuses
- Nasopharynx
- Larynx
- Trachea
- Bronchi (Rt & Lf)
- 2ry , 3ry bronchi
- Bronchioles
- Terminal bronchioles *last*



## ➤ B- Parts of The respiratory portion :

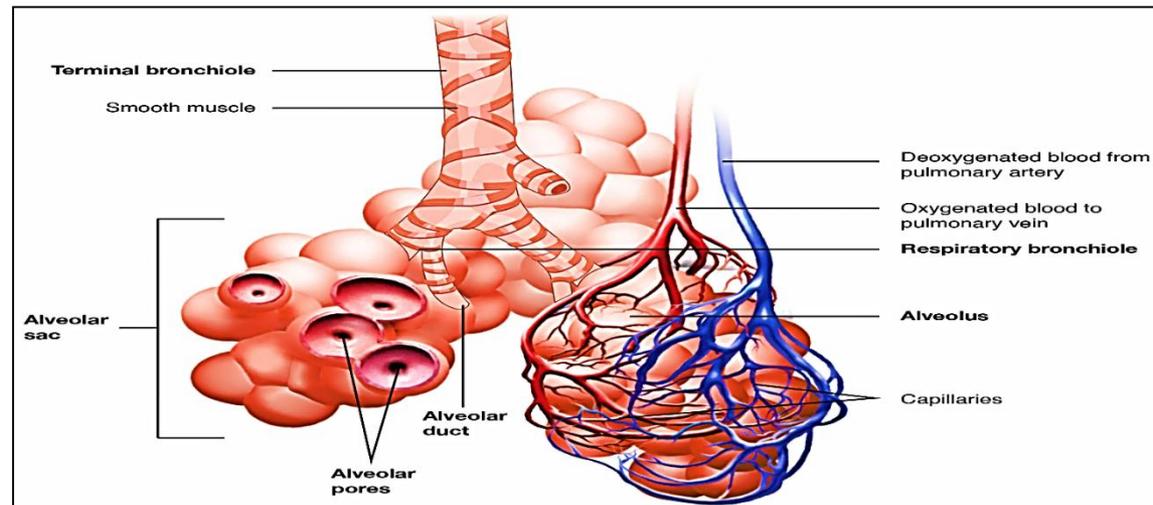
- Respiratory bronchioles
- Alveolar ducts
- Alveolar sacs
- Alveoli



## Function of respiratory portion:

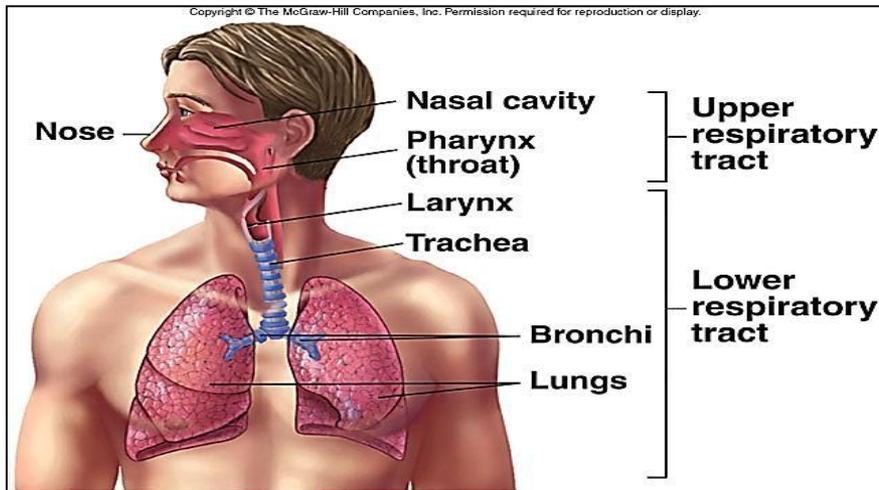
Gas (O<sub>2</sub>/CO<sub>2</sub>) exchange between blood & inspired air

Production of surfactant



# Structure / Function relation in Conducting portion

- **Cartilage** to prevent collapse → Maintain an open lumen  
*سفنجي*  
*Inner*  
*مفتوح*
- **Elastic fibers & smooth ms. fibers** for flexibility →  
*افتح افضل*  
Ability to accommodate expansion & contraction
- **Respiratory epithelium** → Filtering, moisturizing & warming of inspired air



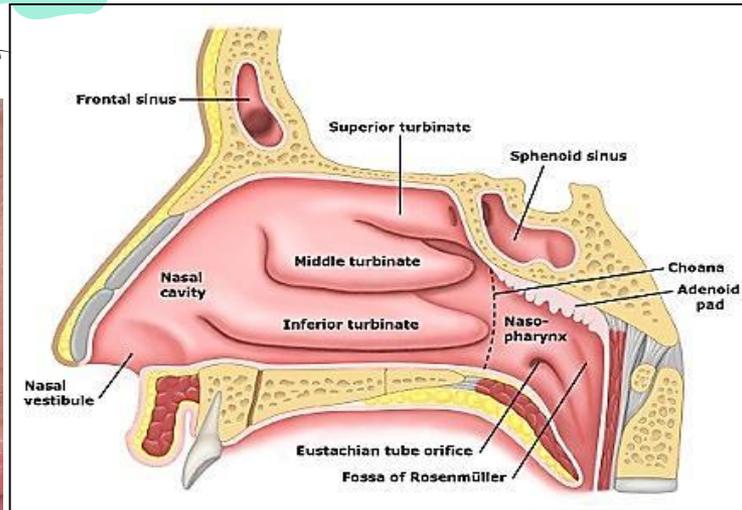
# A- Conducting portion

## Nasal cavities:

separated by a septum (cartilaginous & bony) parts  
each consists of: **vestibule & nasal fossa**

قسم من تجويف nasal cavity

تجويف (1) nasal cavity



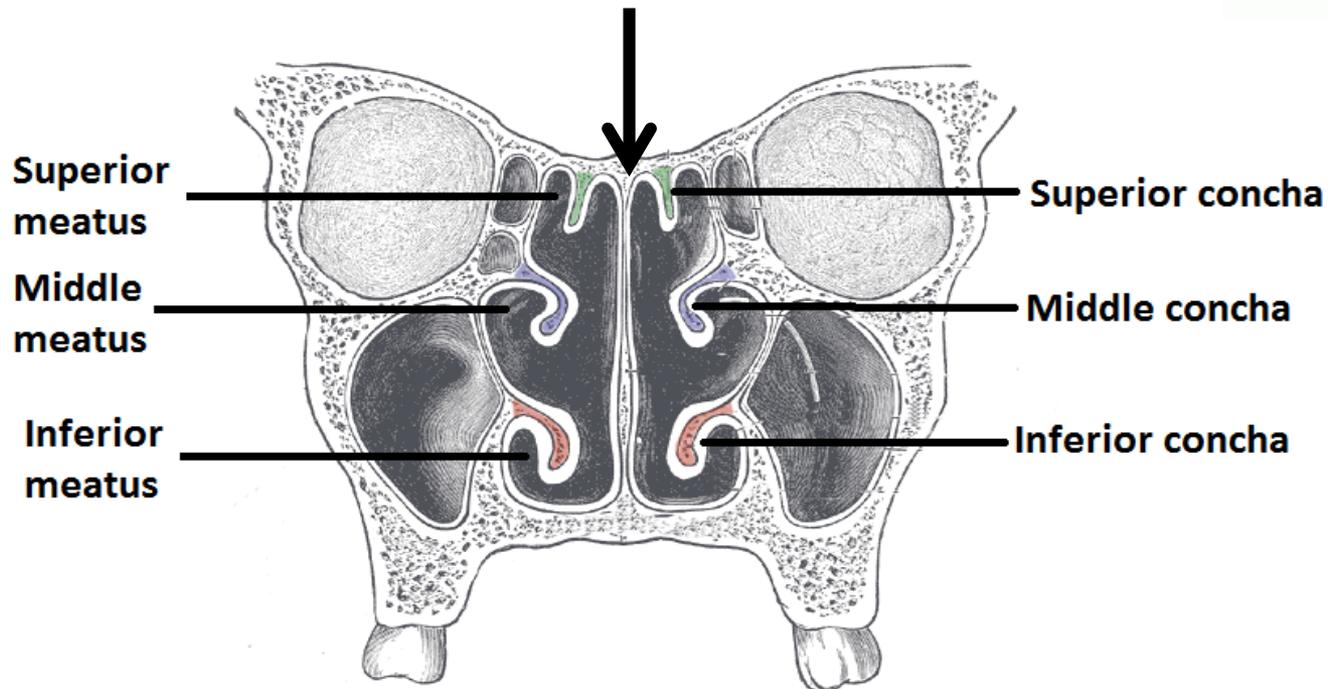
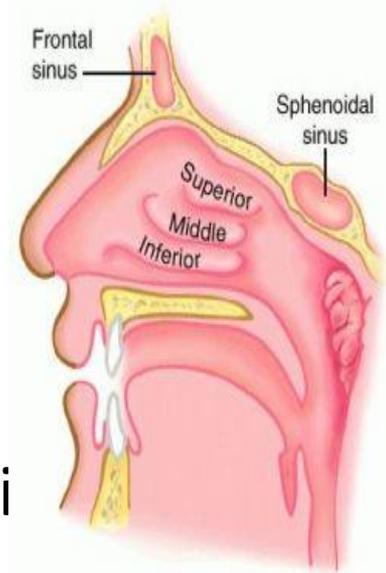
## Vestibule:

- Is the **anterior part**

- Lined e **thin skin** → as going deeper changes into → **non - K st. squ. epithelium** → then to **Respiratory epithelium**
- hair filters out large dust particles

## Nasal fossae:

- 2 cavities separated by nasal septum
- Their lateral walls contain 3 bony projections (conchae / turbinates) superior, middle, inferior



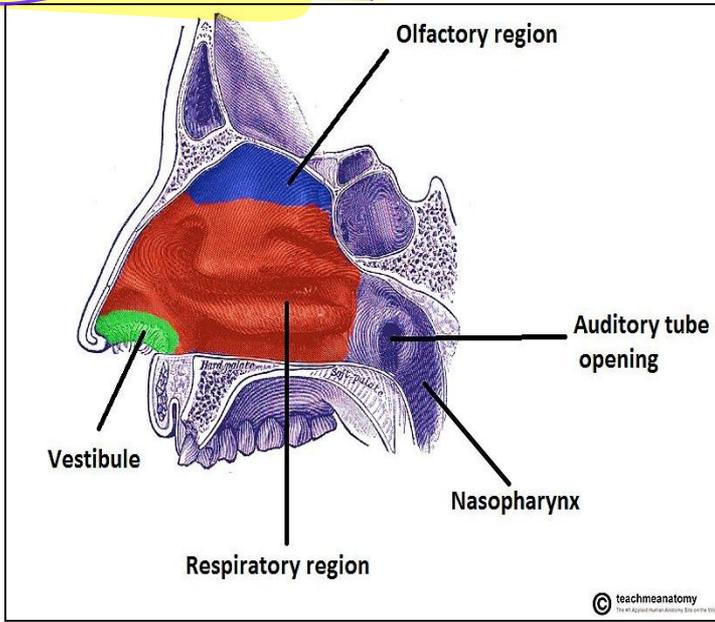
- Superior one covered e **Olfactory epithelium** → *smell sensation*

- Middle & inferior covered e **Respiratory epithelium**

- The **conchae** slow the flow of air & increase the surface area of the epithelium for conditioning of the inspired air

*condition*

انامي ازيد مساحة سطح عستان هولا ينفذ  
 عن طريق اتقال حبة عستان تنزبط كمواسر  
 Good conditioning

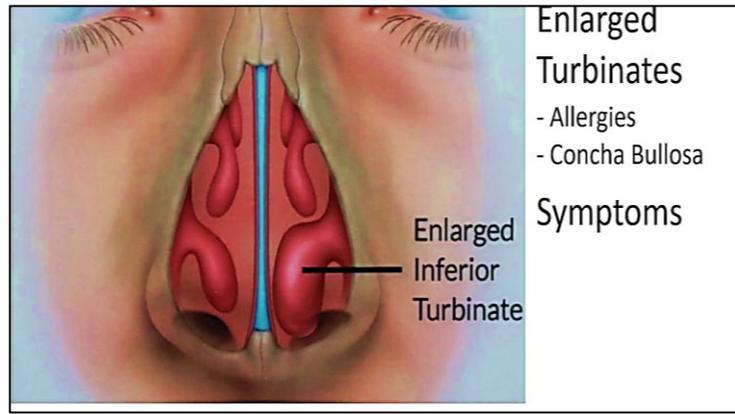


- (lamina propria) beneath RS epith. rich with superficial **venous plexus**

**(swell bodies)**

بتعطى حرارة : هاي حرارة قنيط  
 بالهواء اللي داخل فتعمل اليه تدمية

*middle and inf. concha*





اجتقان في العصب  
Hodley  
التي ما نلينا نتففس

# Nasal cycle:

normal انو ريسر وقتل كل  
20 • 30

Decompression  
ناحية تقفل وناحية تفتح بعض ناصية يرس فيها congestion وناحية

Every 20-30 min. rhythmic cycles of physiological congestion & decompression occurs in the mucosa of nasal cavities. Normally we are not aware of it

- When Swell bodies in lamina propria of one nasal become engorged with blood → distention of congested mucosa → ↓ flow of air → allowing the engorged Epith. to recover from dryness

- The cycle under the control of autonomic nervous system

ChatGPT

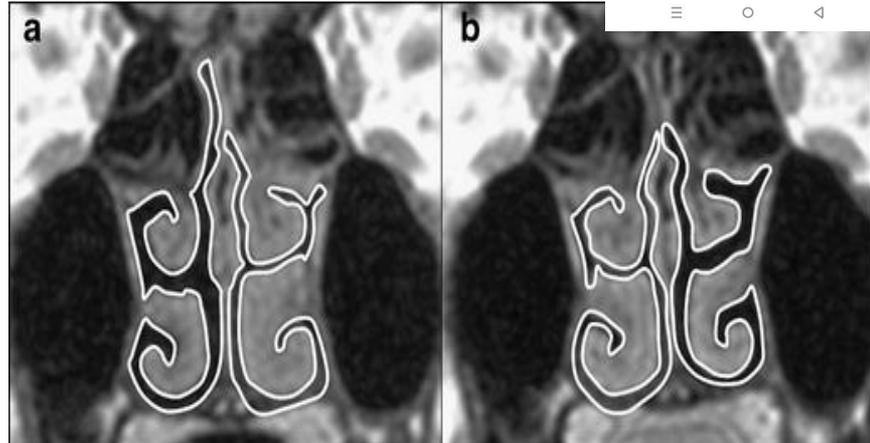
ما الذي يحدث خلال الدورة الأضيقية؟

- داخل جدار الأنف توجد تراكيب تسمى الأجسام المتوزمة (swell bodies) داخل الطبقة الخاصة (lamina propria) من الغشاء المخاطي.
- هذه الأجسام تغطى بالدم بشكل متناوب في جهة من الأنف، مما يؤدي إلى:
  - احتقان الغشاء المخاطي في تلك الجهة 'n'
  - انخفاض تدفق الهواء منها.
  - في المقابل، الجهة الأخرى تفرغ من الدم 'n' يزداد تدفق الهواء منها.

لماذا يحدث ذلك؟

- الفرض هو منح كل جهة من الأنف فترة راحة ليستعيد الغشاء المخاطي رطوبته ويشفى من الجفاف الناتج عن مرور الهواء.
- هذه الدورة تحدث تلقائياً وتحت تحكم الجهاز العصبي اللاإرادي (autonomic nervous system)، لذلك نحن عادة لا نشعر بها.

اسأل عن أي شيء



Nasal cycle using MRI imaging

# Why eating ice-cream causing pain & headache ?

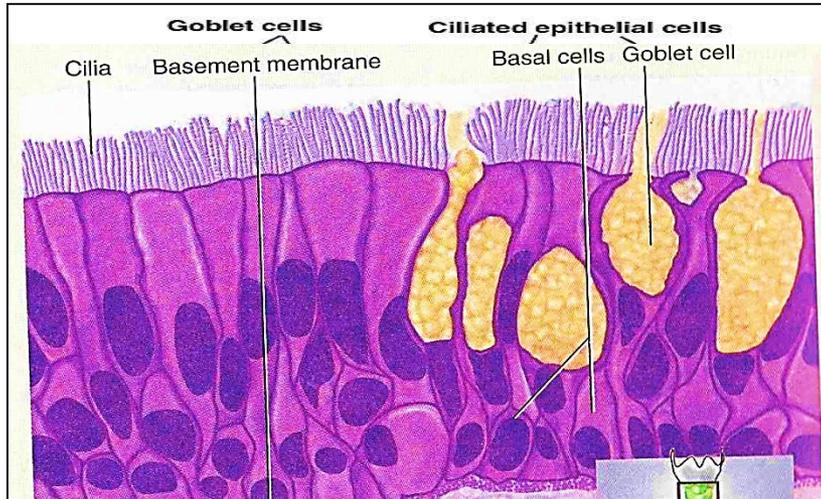
- Also called Brain freeze, or cold neuralgia or sphenopalatine ganglio-neuroalgia
- We experience this pain in the head or behind your eyes
- Happen When the cold substance like ice or ice-cream touches the palate cause drop in the temperature which subsequently cause vasoconstriction of the blood vessels, the body responds by rapidly dilating those vessels to restore the normal temperature
- These quick changes activates pain receptors
- The brain interprets tis pain as headache

*congestion = V.C  
decongestion = V.D*

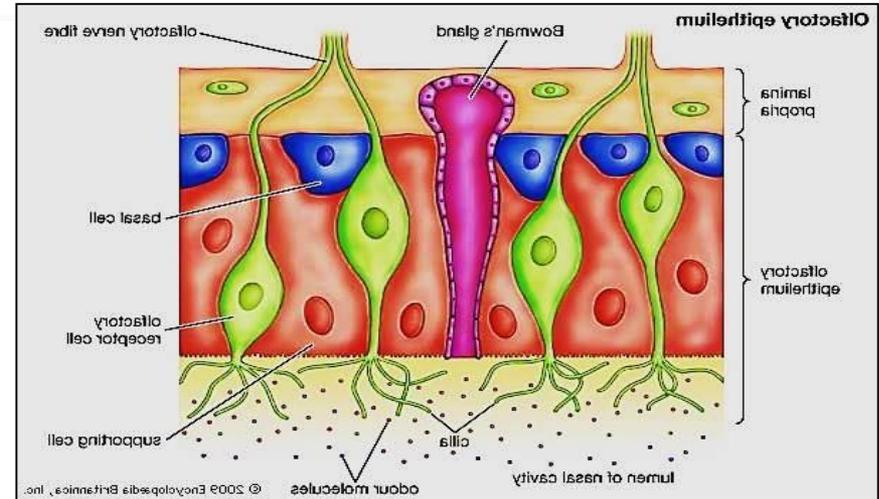


# Q: What is the difference between the respiratory & olfactory epithelium?

## RESPIRATORY



## OLFACTORY



## The respiratory epithelium:

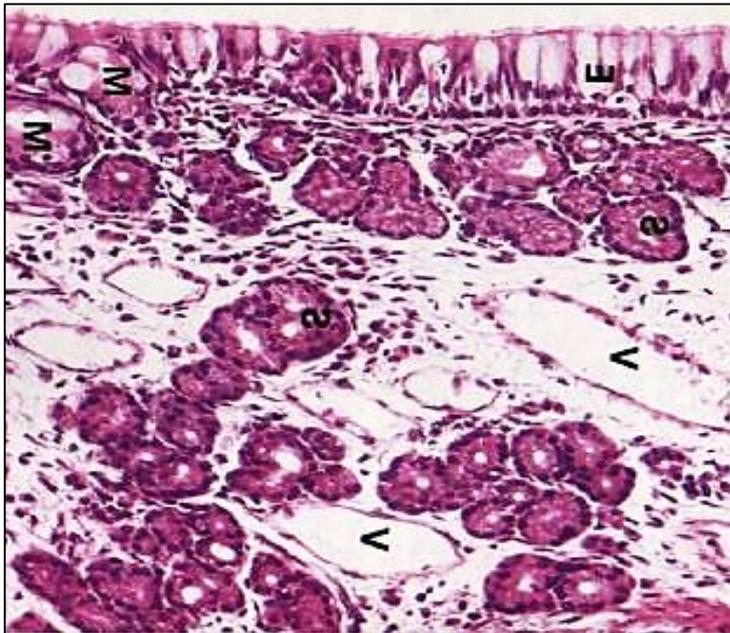
- Pseudostratified columnar ciliated e goblet cells

## The olfactory epithelium:

- Pseudostratified columnar e chemoreceptors & NO goblet cells

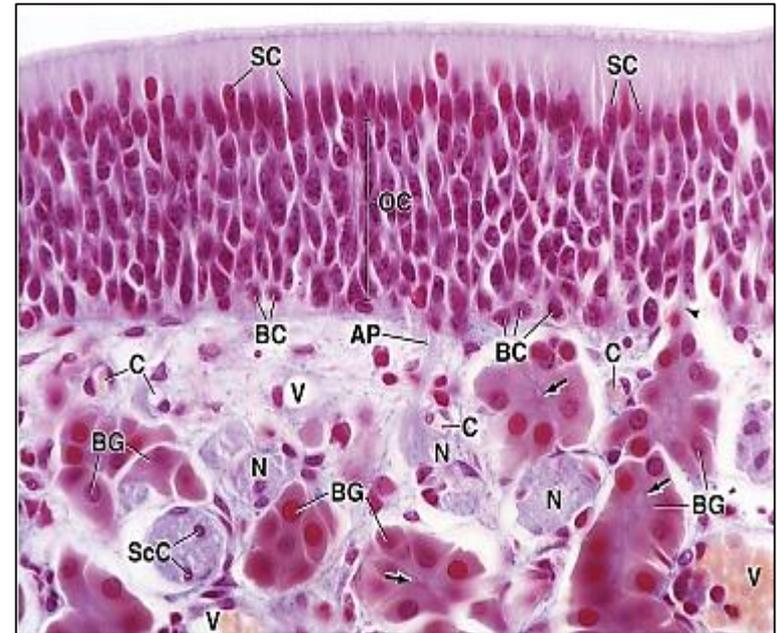
## Respiratory mucosa

- Epithelium
- Lamina propria
- Nasal glands (M & S)
- Blood vessels



## Olfactory mucosa

- Epithelium
- Lamina propria
- Olfactory glands (S only)
- Blood vessels



# The respiratory epithelium

- Lines most of the conducting portion

- 5 types of cells are present:

1- Columnar ciliated cells

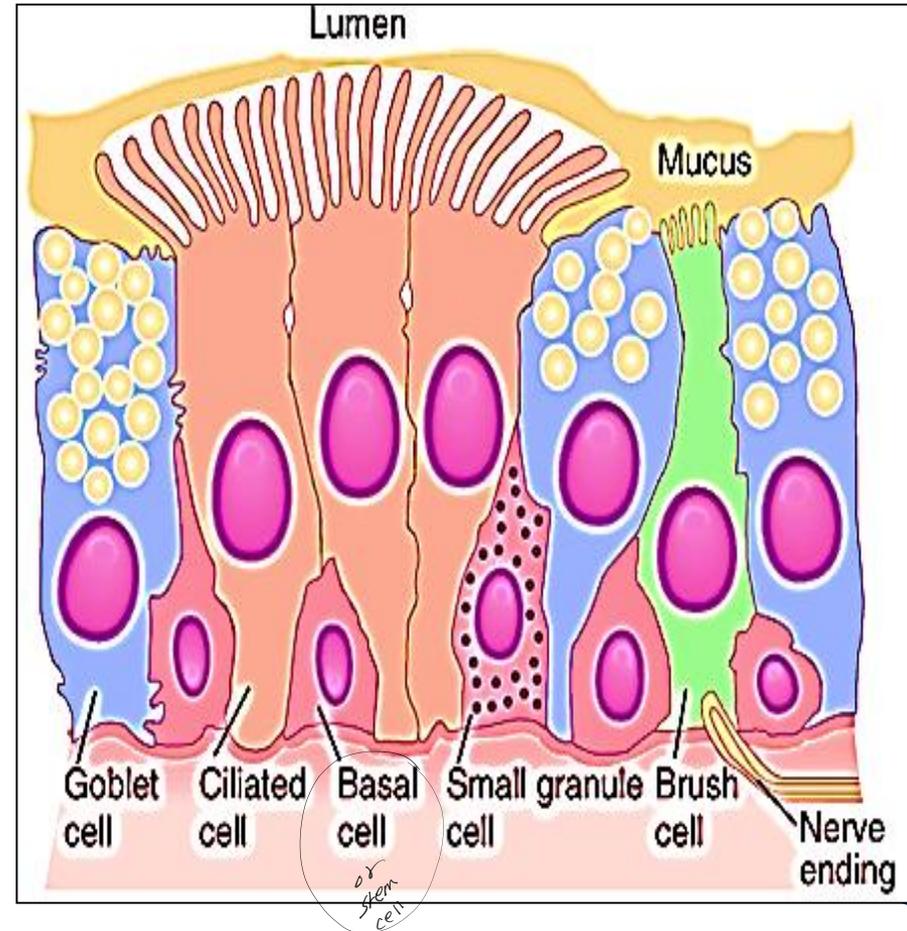
2- Goblet cells

3- Brush cells

4- Basal (stem) cells

5- Granule cells (NE cells)

B  
B  
G  
G } C





- Granular cells:
- Prenatal: they have a local mitogenic effect, influence the lung growth & branching morphogenesis
- Postnatal: they provide local regulation for airway muscle tone, response to hypoxia, repair after injury

انواعها تابعة لبعض

### Role of Serotonin

يزيد من سرعة حركتها  
cilia  
ويزيد حركتها [frequency]

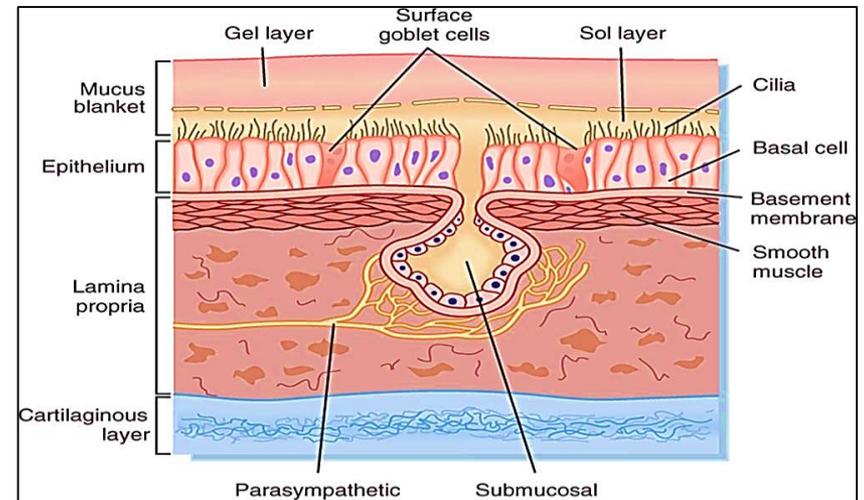
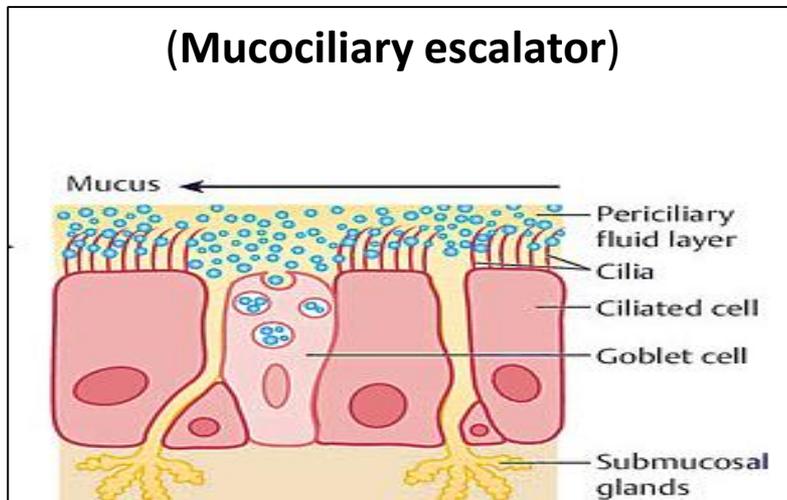
- **Serotonin**: is a cilio-stimulatory i.e. ↑ ciliary beat frequency
- **Serotonin**: induces the release of Ach from columnar ciliated release of Ca & ATP → ↑ CBF.
- **Serotonin**: cause ↑ in per-ciliary liquid & thus facilitate mucociliary clearance
- **Serotonin**: induces vasoconstriction in pulmonary vasculature → role in Pulmonary hypertension (through its action on 5HT-1B receptors)

في حينه



The respiratory epithelium Rests on lamina propria contain many Nasal glands (*serous & mucous*) + BV + immune cells

- The serous glands secretions : serve to facilitate movement of cilia
- mucous glands secretions: serve to catch inhaled dirt & bacteria particles inhaled & prevent dryness of RS mucosa  
( both secretions form the mucous blanket)





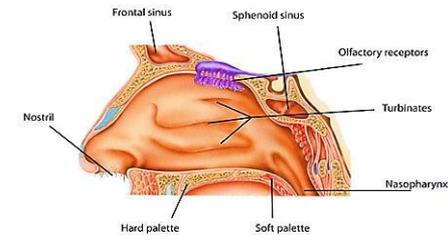
فيه مناسية  
مرفها رلكل عتاتن هيلك  
immun cells

- Lamina propria contains many immune cells e.g. mast cells , plasma cells & lymphoid nodules as part of mucosa associated lymphoid follicles (MALT) to protect the RS from airborne microbes  
(explains the allergic reactions in upper respirator tract)
- Lamina propria rich in BV serve to warm the inspired air (maintain humidity )  
(mechanism is called counter-current exchange)
- In smokers the proportion of ciliated cells to goblet cells is altered (↑ goblet cells) to trap gaseous pollutants

هه

# The olfactory epithelium

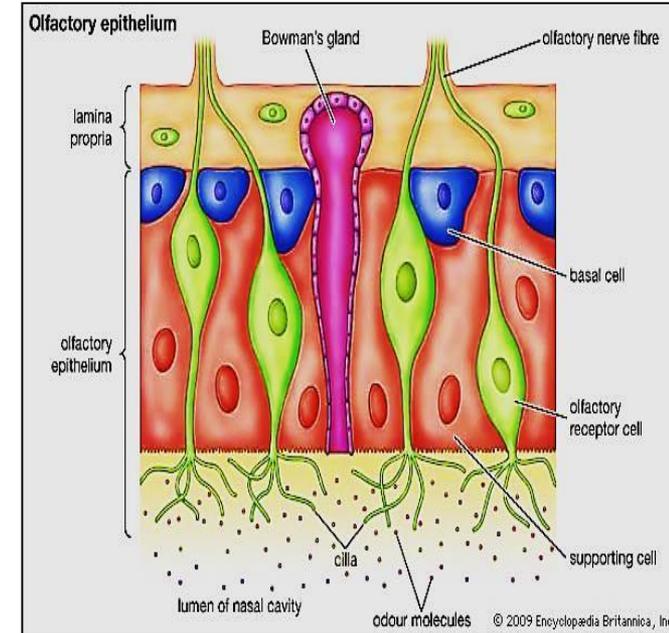
- Covers the roof of nasal cavities & superior conchae.



- Contains **chemoreceptors of smell**

- 3 types of cells** are present:

- Olfactory neurons** *عصبون*
- Supporting (sustentacular) cells**
- Basal cells** *stem*



- The olfactory epithelium rests on lamina propria contains:

- ✓ **BV & unmyelinated olfactory nerve fibers** → **CN 1**
- ✓ **Bowman's glands** secrete constant flow of serous fluid → surface → facilitate dissolve of odorants

بطلع مادة بنزوب  
التي ستمش  
عقبها  
انها تلتصق

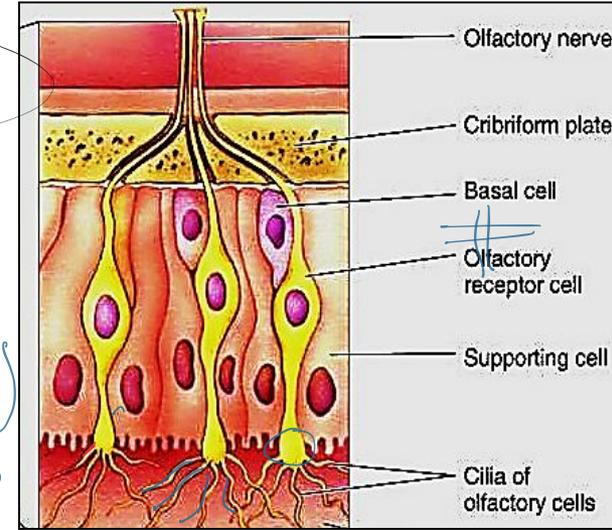
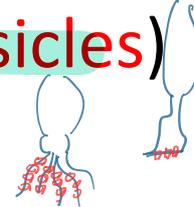
# 1- Olfactory neurons:

- Bipolar nerve cells (renew 30- 60 days)

cell واحد (Axon) و  
Dendrites

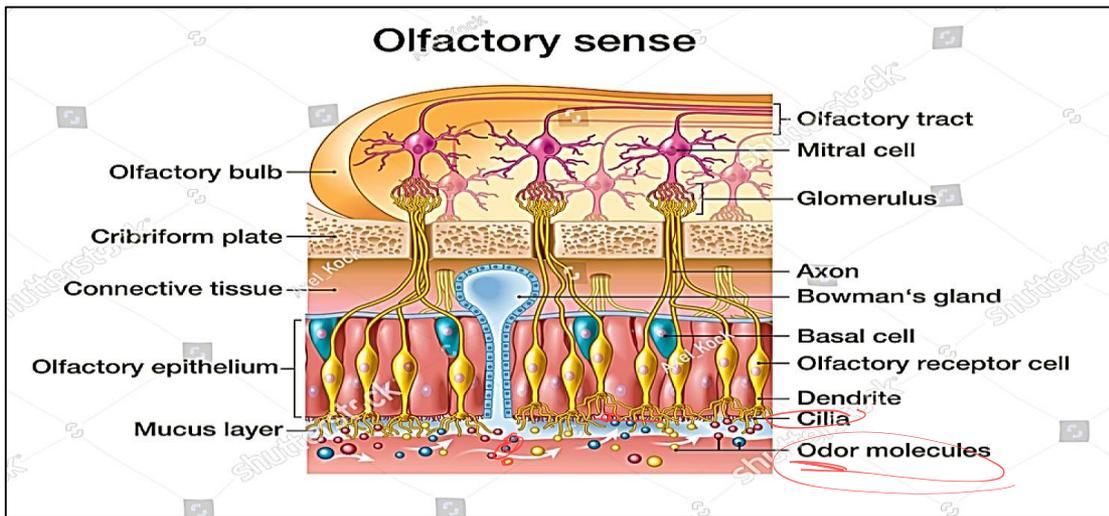
i.e. ( regenerative neuronal tissue !! )

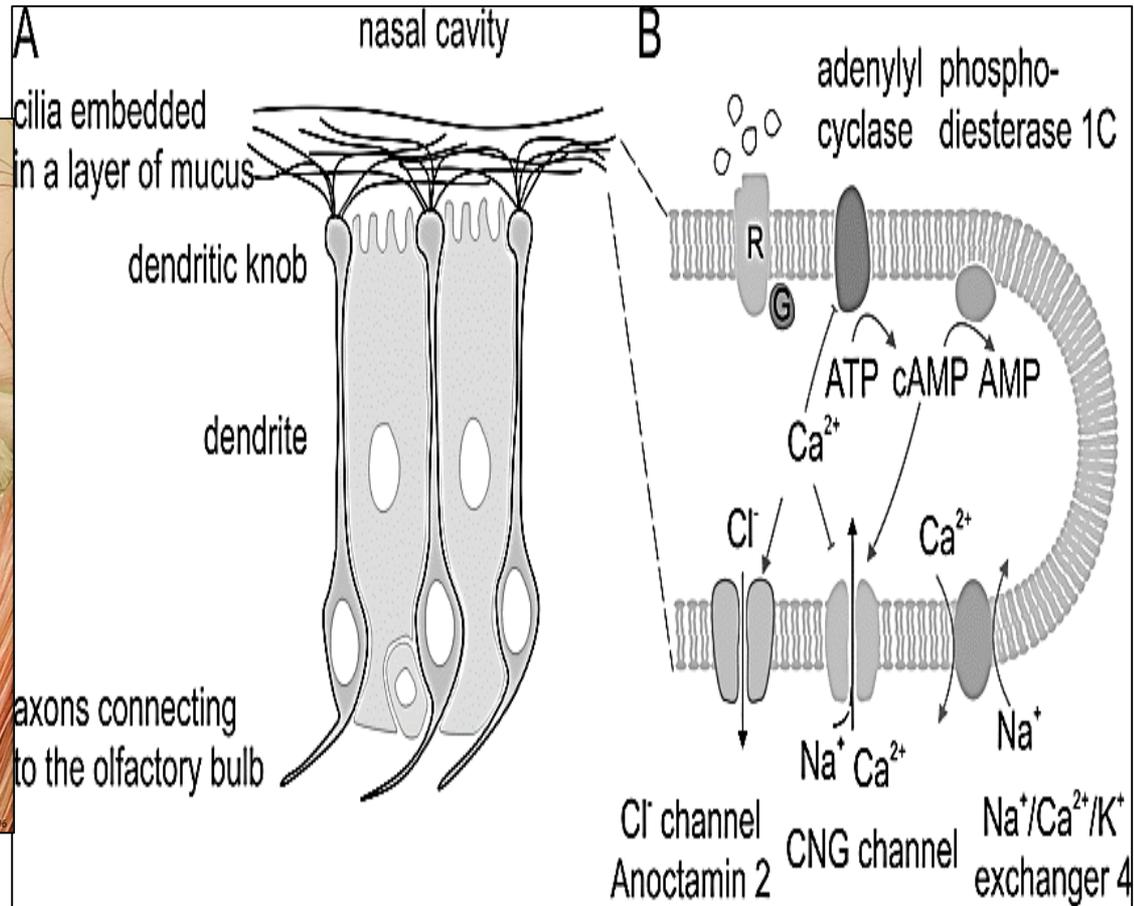
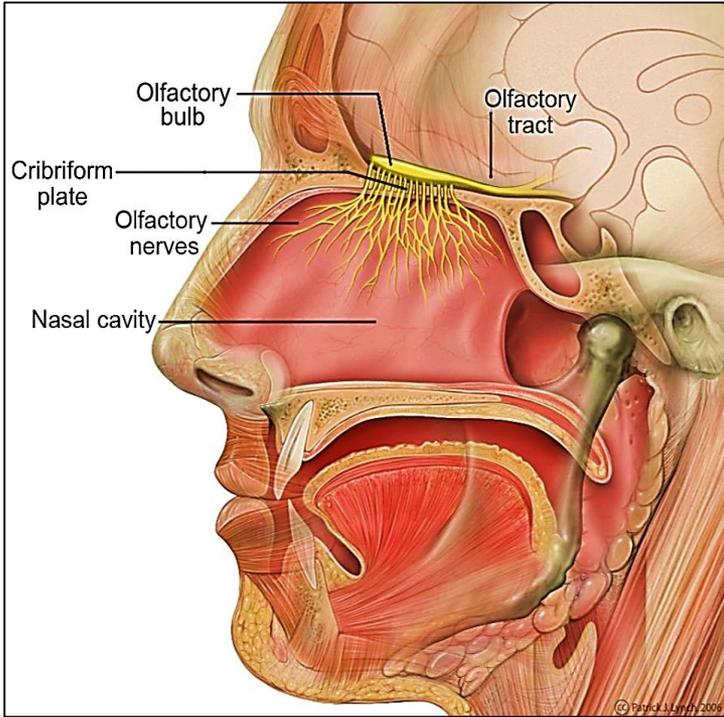
- Their dendrites extend toward surface  
→ end in swellings (olfactory vesicles)  
from which cilia arise



- These cilia (10-20) are very long & non motile. It provides large surface for transmembrane chemoreceptors
- Their axons pass to lamina propria to form olfactory n. fibers

*G-protein coupled ion channel*

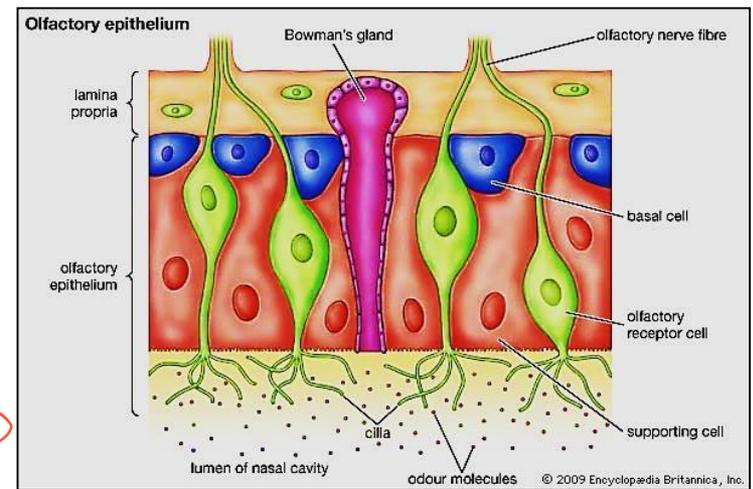




**Schematic illustration of the of the olfactory epithelium with olfactory receptors**

## 2- Supporting cells (neuroglia):

- Tall columnar cells e wide apex  
narrow base
- Their free surface has microvilli
- Tight junctions bind these cells e olfactory cells.
- They secrete odorant binding proteins & express abundant ion channels → role in signal conduction of smell sensation. These cells played main role in smell loss (anosmia) in COVID 19



## 3- Basal cells: *regeneration/ stem cell*

- Small pyramidal cells e basophilic cytoplasm
- Act as stem cells for both olfactory & supporting cells

# Paranasal sinuses (Bilateral)

- Frontal, Ethmoidal, Sphenoidal Maxillary

- These cavities open in nasal cavities

- Lined e thin respiratory epith.

e few goblet cells *so mucosa يتكون أفل*

**Chronic sinusitis** = immotile cilia syndrome

## Nasopharynx

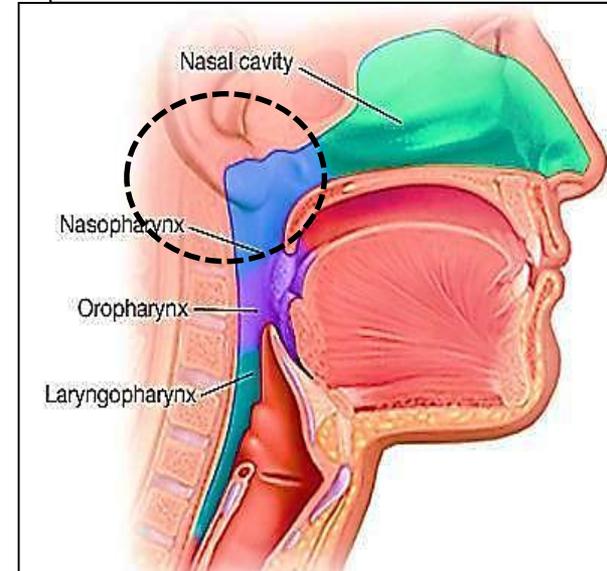
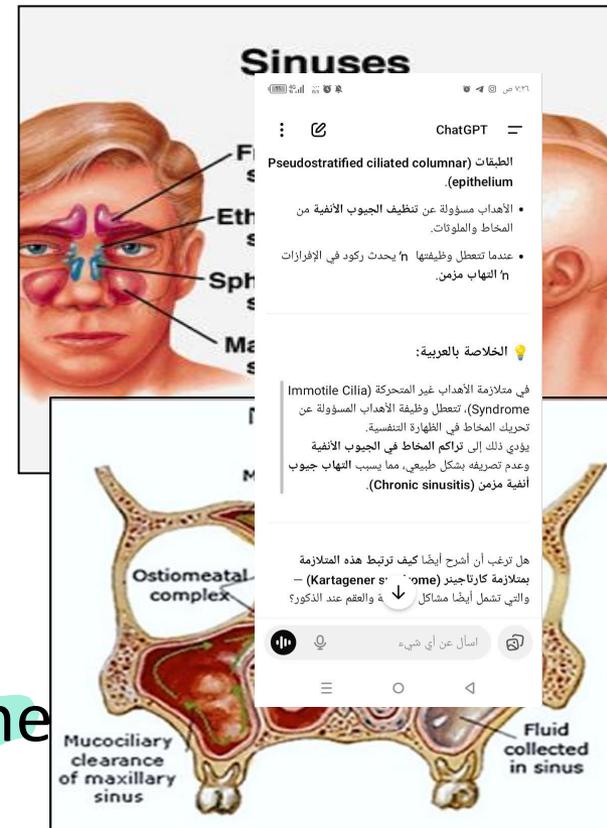
- Lined e respiratory epithelium
- Its lamina propria contains

① **pharyngeal tonsil** & openings of

② **Eustachian tubes**

*تحتوي على الغدد الليمفاوية*

*مخط على حافة فيه اقل من 8 نيو فتحة ضيقة*



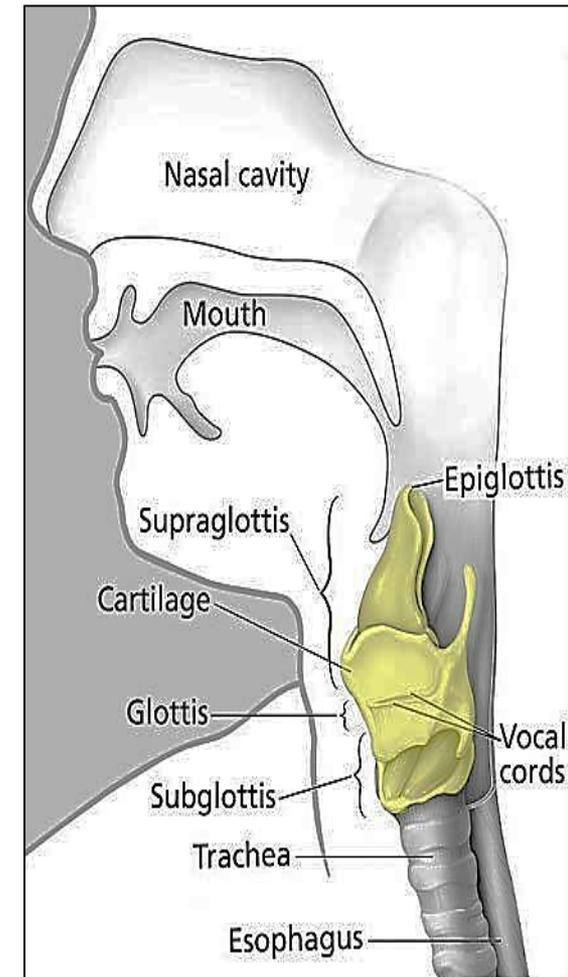


(Enlarged pharyngeal tonsil = adenoids)

*lymphoid*

# Larynx:

- At the beginning of trachea (4x4cm)  
*Larynx = صوت عروق ←*
- Its beginning is guarded by epiglottis  
*مؤدية لـ لارنجس (فحصه)*
- Has 2 functions:
  - ✓ production of voice (vocal cords)
  - ✓ Prevent food & fluid from entering the Trachea through the epiglottis  
(Epiglottis has **elastic** cartilage)
- It is lined with **respiratory epithelium**



# Vocal cords:

• 2 pairs of mucosal folds extend in lumen of larynx

• False vocal cords (Upper pair)

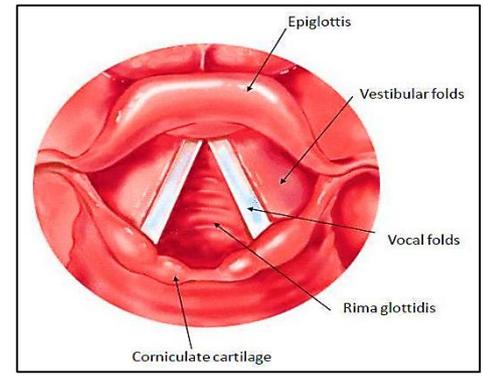
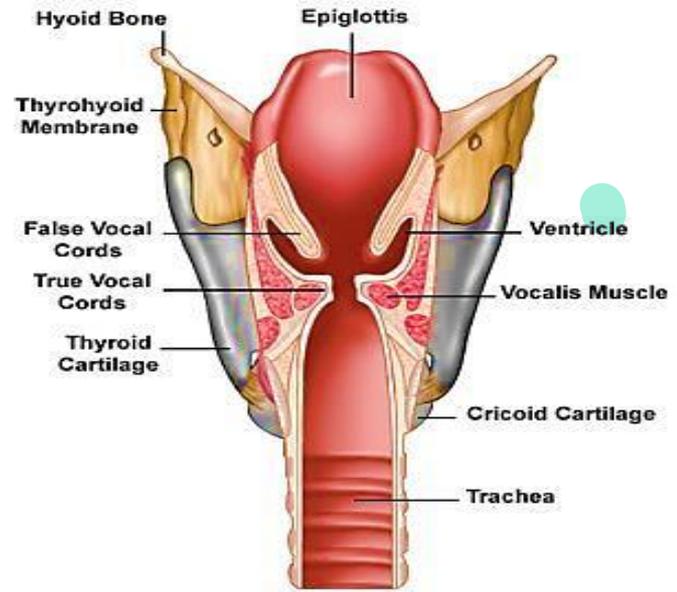
- called (vestibular folds) →
- covered e respiratory epith.
- guard against entrance of food into larynx (made of vestibular ligament)

بالفصحة ووظيفة  
التي يحمي الحنجرة + تراخي  
مقبولت عنقا ما يفتوح لسان  
protective

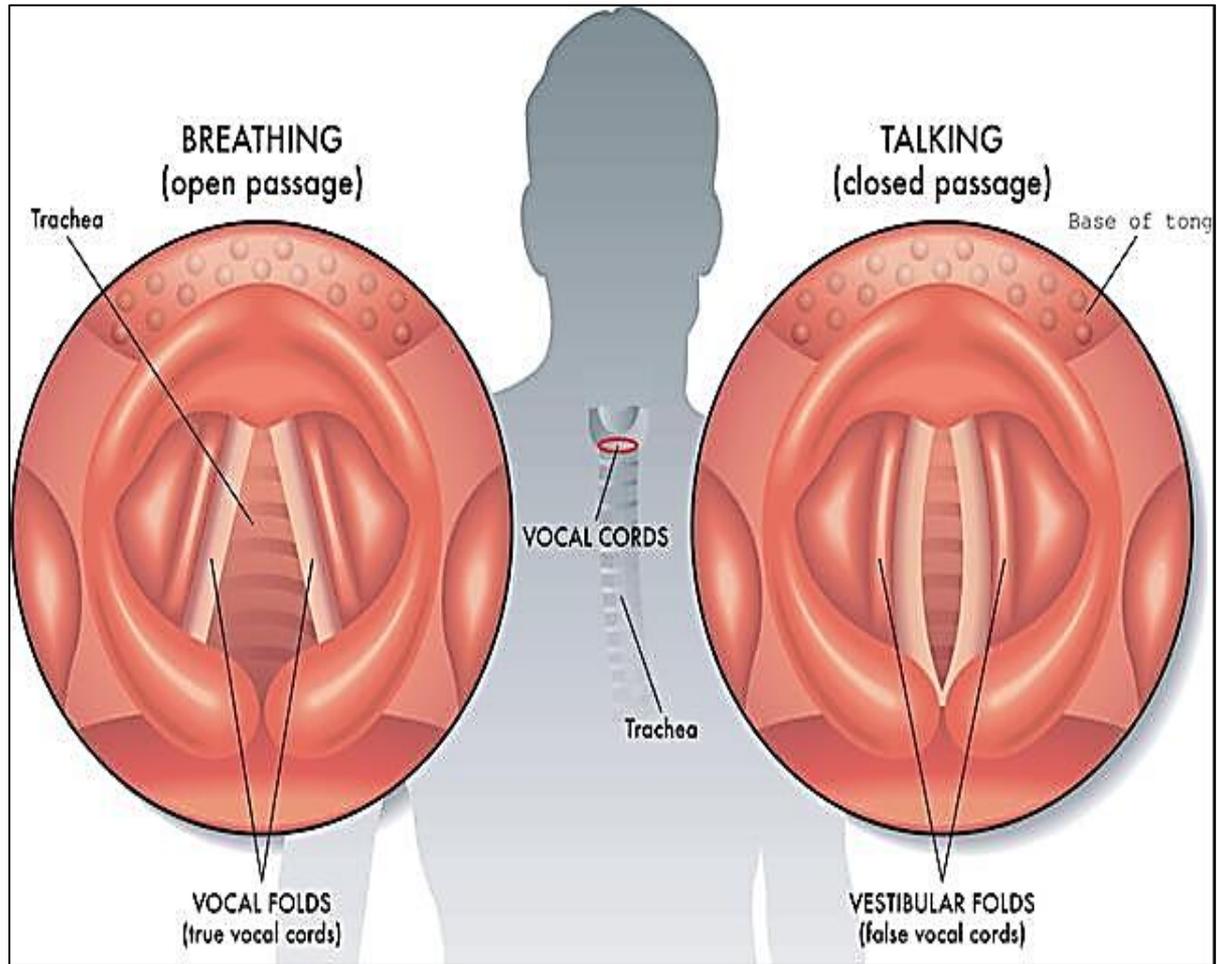
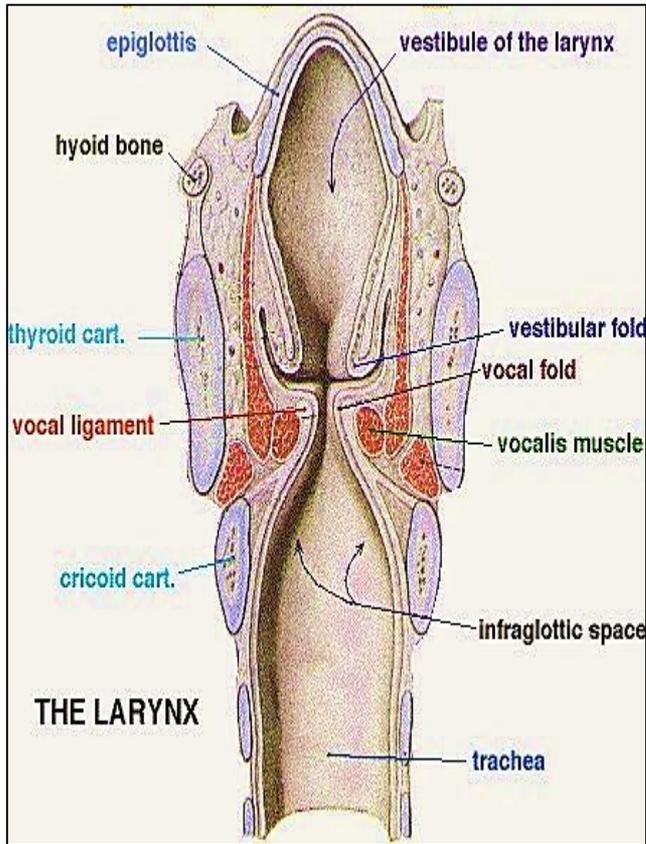
• True vocal cords (Lower pair)

- covered e non-keratinized stratified squamous epith.
- made of ligaments (vocal lig.) & skeletal ms. (Vocalis ms.)
- tension of cords & distance between them produce sound

lig+muscle ← ?  
التي يجعل vocal cord  
Vocalis



True and false vocal cords  
ventricle ← →



**True and false vocal cords and the importance of the ventricle**

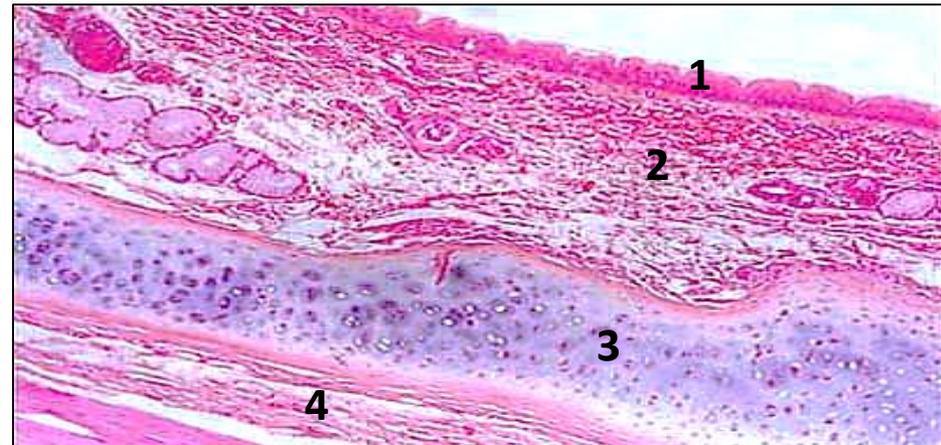
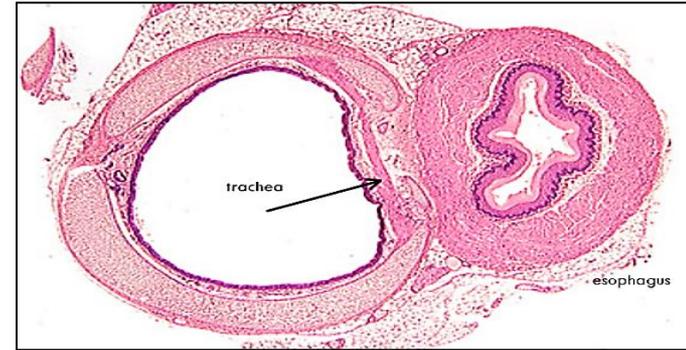
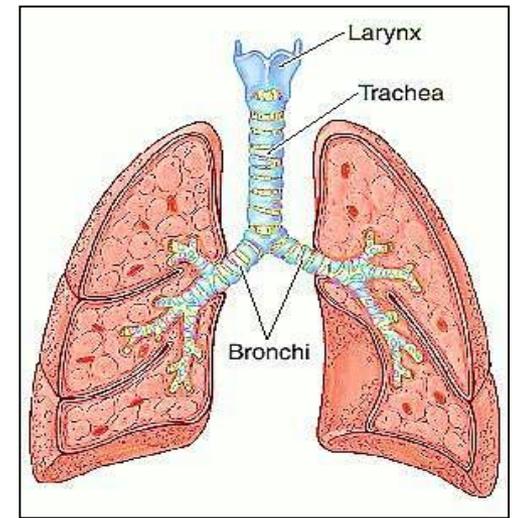
# Trachea

- Tube (12- 14 cm) extends from larynx to bifurcation of bronchi
- Kept open by about 20 C- shaped (horse shoe) cartilage rings (hyaline cartilage)

*C-shaped not complete.  
Esophagus لا يسد؟*

- Its wall is formed of 4 layers:

1. Mucosa
2. Submucosa
3. Hyaline cartilage
4. Adventitia

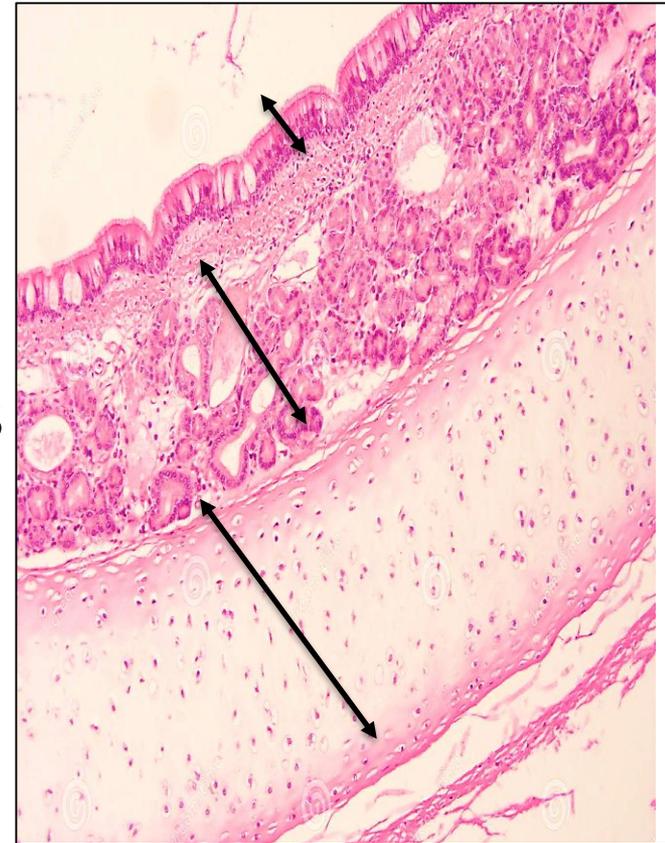


## Wall of trachea:

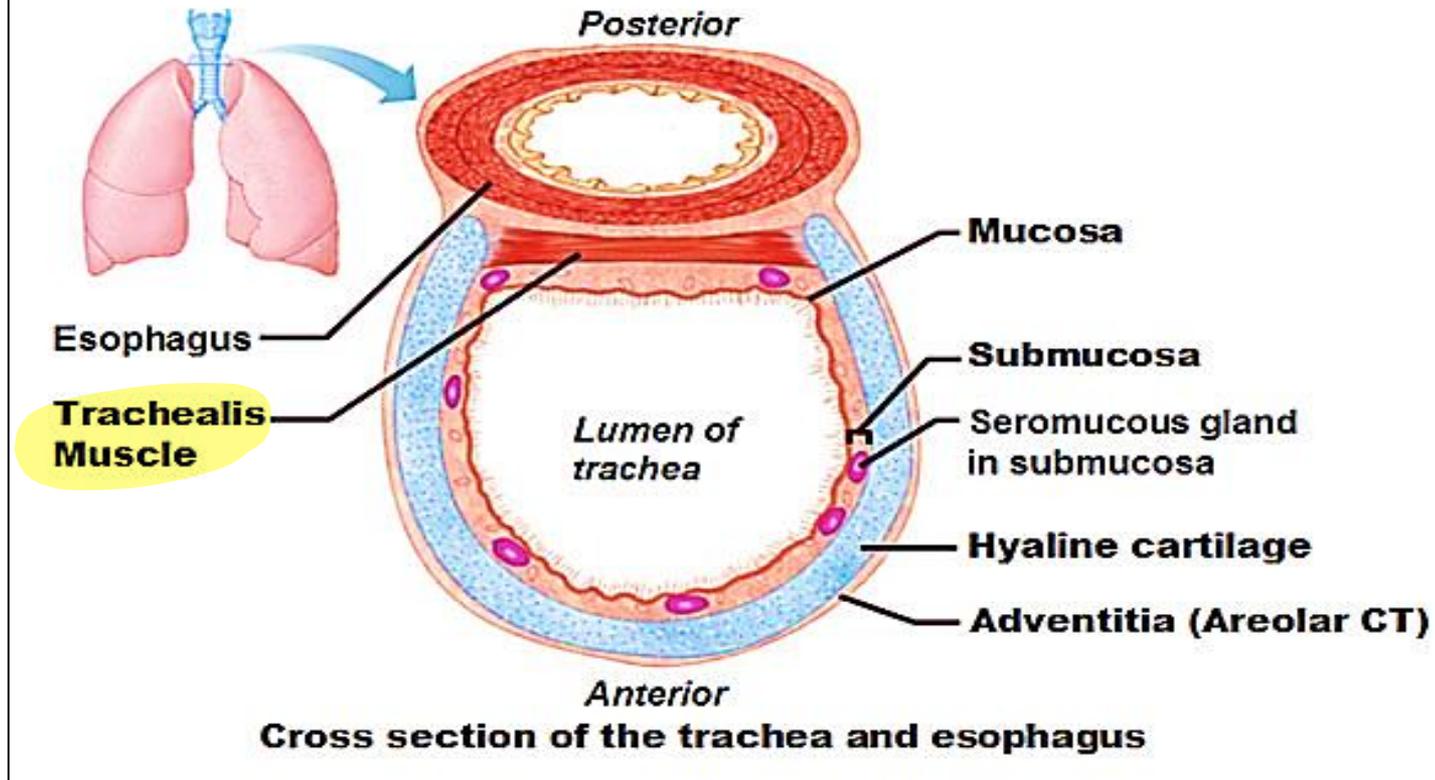
- **Mucosa:** epithelium – lamina propria – elastic fibers

**Epithelium:** respiratory epithelium

- **Submucosa:** BV, nerves, elastic fibers  
Lymphoid nodules, Tracheal glands
- **Cartilage layer:** C- shaped cartilage rings, the gap between cartilage ends connected by elastic ligament & **Trachealis ms (smooth ms)**
- **Adventitia:** loose CT



# The Trachea



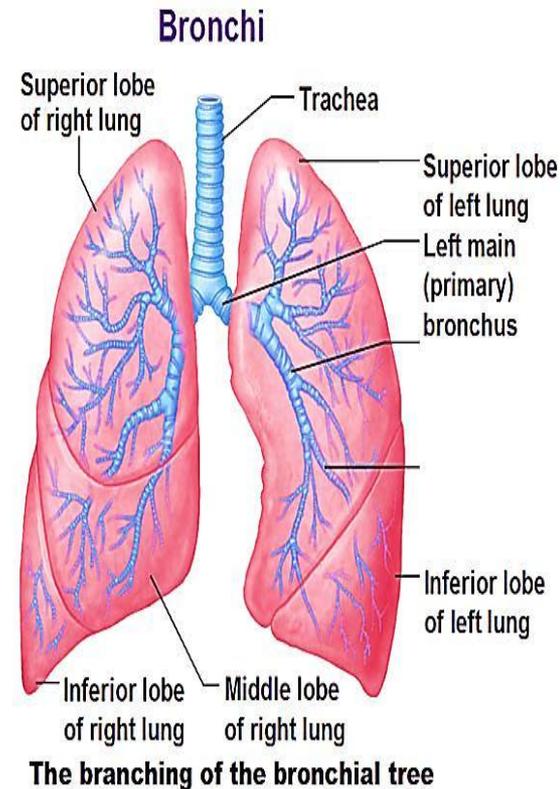
**Contraction of the trachealis ms. is important for the Cough Reflex**

**Contraction → narrowing the tracheal lumen → ↑ the velocity of the expelled air → squeezed out → cough**

Rt + Lt Bronchus  
Trachea  
Cartilage  
complete ring

# Bronchial tree

- ✓ Primary (Extra pulmonary) bronchi
  - ✓ Secondary (Intra-pulmonary) bronchi
  - ✓ Bronchioles
  - ✓ Terminal bronchioles
- 1ry bronchi: RT & LF → similar to trachea  
(but cartilage is a complete ring)

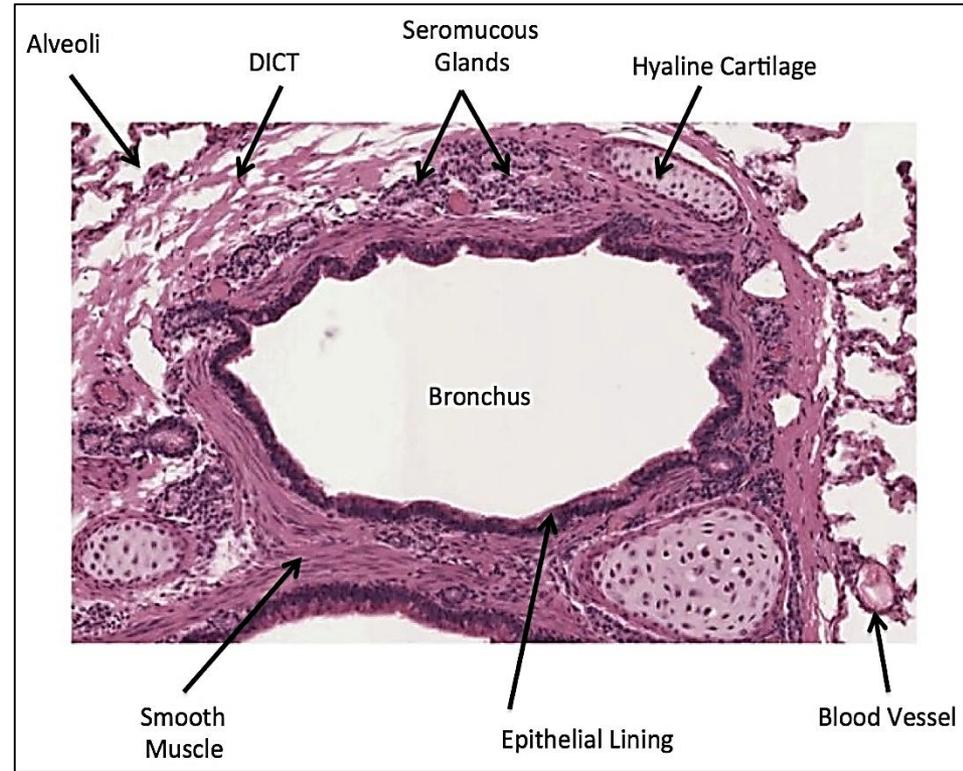


- 2ry bronchi: within the lung → divide to give 3ry bronchi  
Its wall is formed of 4 layers (NO Submucosa):
- Mucosa
- Muscularis
- Cartilage plates (isolated plates)
- Adventitia

- **Mucosa**: ↑folded, respiratory epith., ↓goblet cells, lamina propria has elastic fibers & **MALT (mucosa associated lymphatic tissue)**

- **Musculosa**: spiral layers of smooth ms. encircling the **mucosa**

طبقة من العضلات الملساء  
واللحمية هون عشان تحللها عن اللي تانيه  
• cartilage



Structure of 2ry, 3ry bronchi

muco-serous glands & lymph nodules found between cartilage plates

→ complete عن كل

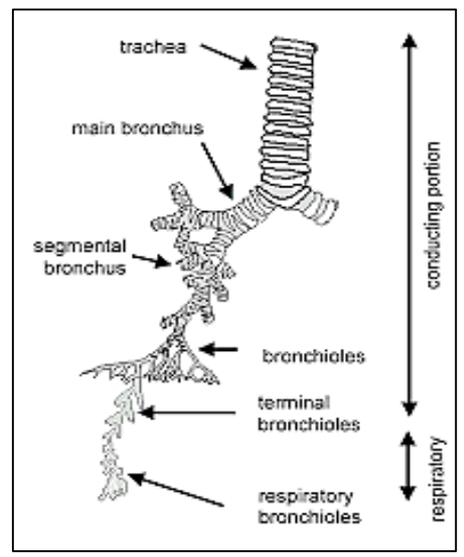
- **Adventitia**: نسيج ضام  
من Bronchi

# Bronchioles

- Small airways 5 - ↓ mm
- Its wall has (**No submucosa**, **No cartilage**, **No glands**, **No lymphatic nodules**)
- Its wall formed of 3 layers

نشيد متوصلي انتظري  
 muscle  
 عرسو  
 circular  
 not spiral

3 طبقات  
 1) Clara cells  
 2) simple cuboidal Res. Epi  
 3) طبقة حبيبية صافية



## Mucosa:

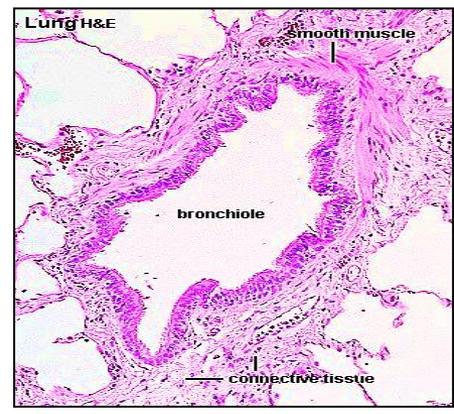
- **Simple columnar ciliated** epithelium e
- **Clara cells & NE cells / neuroepithelial bodies**  
 (chemosensory receptors → O<sub>2</sub> level)

Exam

Goblet cells

neuroendocrine cell

بشغلوا



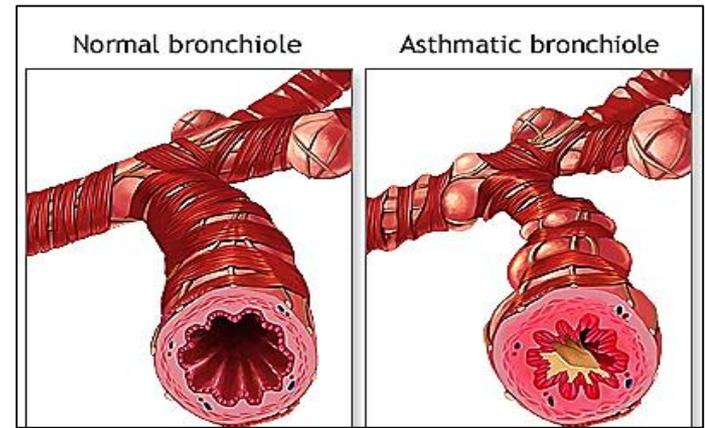
## Musculosa:

complete layer of **circularly** arranged smooth ms. (**Asthma attacks**)

spirally

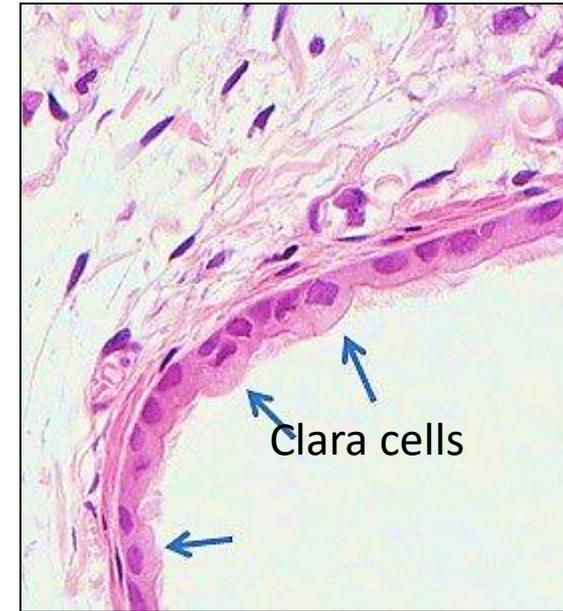
## Adventitia

؟



# Clara Cells :

- Also called club cells or bronchiolar exocrine cells
- Dome-shaped, non-ciliated
- Cytoplasm has lots of secretory granules (not mucus) basal rER, apical sER



## Function:

1. Defensive role : glycoprotein granules (contain proteolyase & oxidase & cytokines)
2. Degradation of inhaled toxins (sER)
3. Secretion of surfactant-like substance to prevent collapse of bronchioles
4. Act as stem cells
5. Mutation → adenocarcinoma of lung

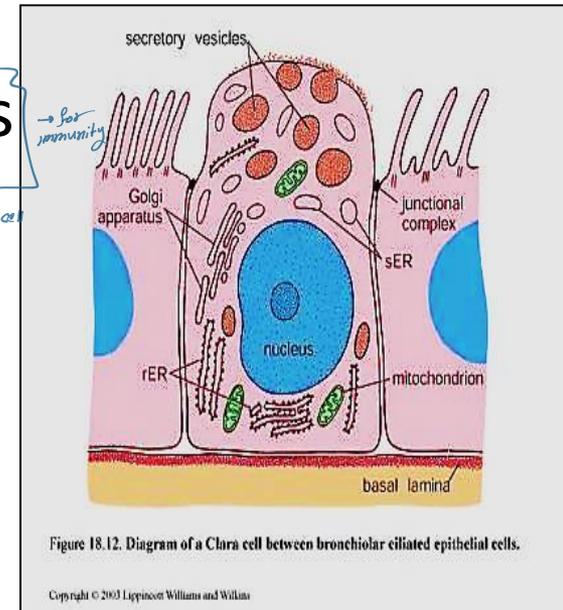
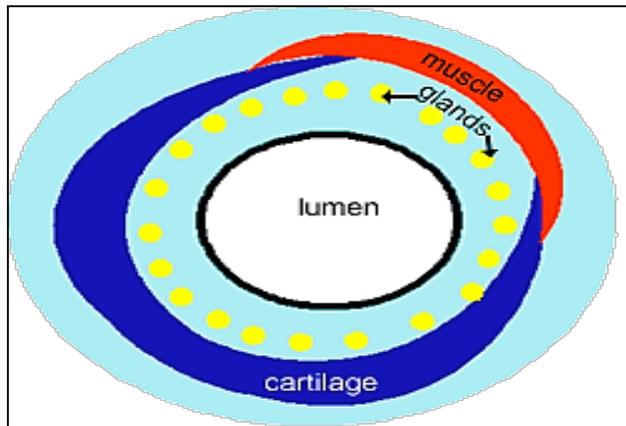


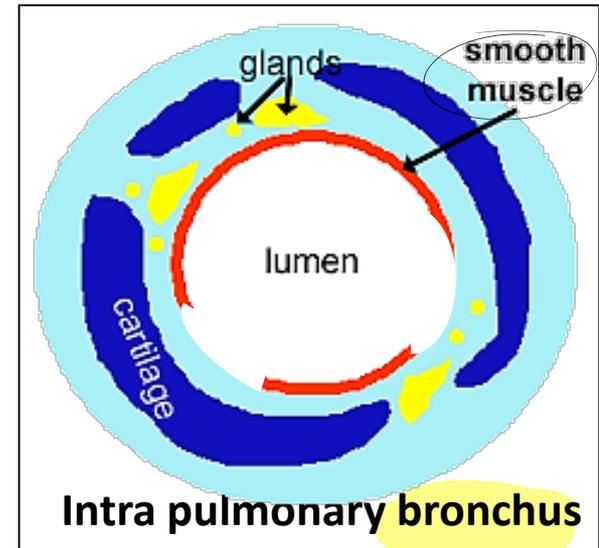
Figure 18.12. Diagram of a Clara cell between bronchiolar ciliated epithelial cells.

Copyright © 2003 Lippincott Williams and Wilkins

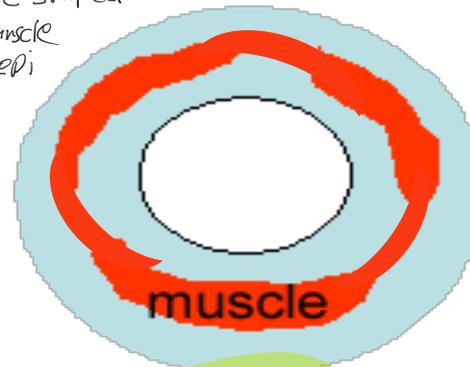
# Difference between structure of wall of trachea vs. Wall of intra-pulmonary bronchi & bronchiole



**Trachea** → cartilg: C-shaped  
no smooth muscle  
Res. Epi



**Intra pulmonary bronchus**



**Bronchiole**

(circular) complete  
no smooth muscle  
simple columnar  
clara cell

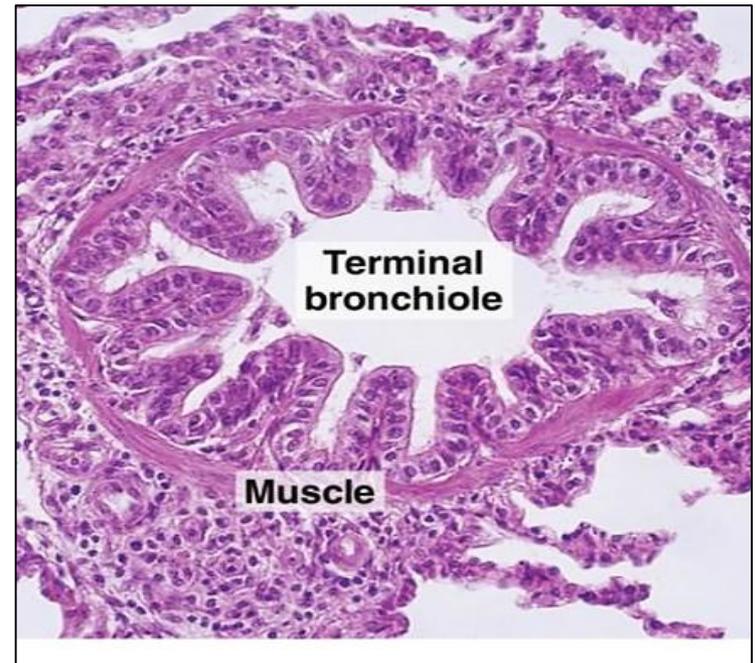
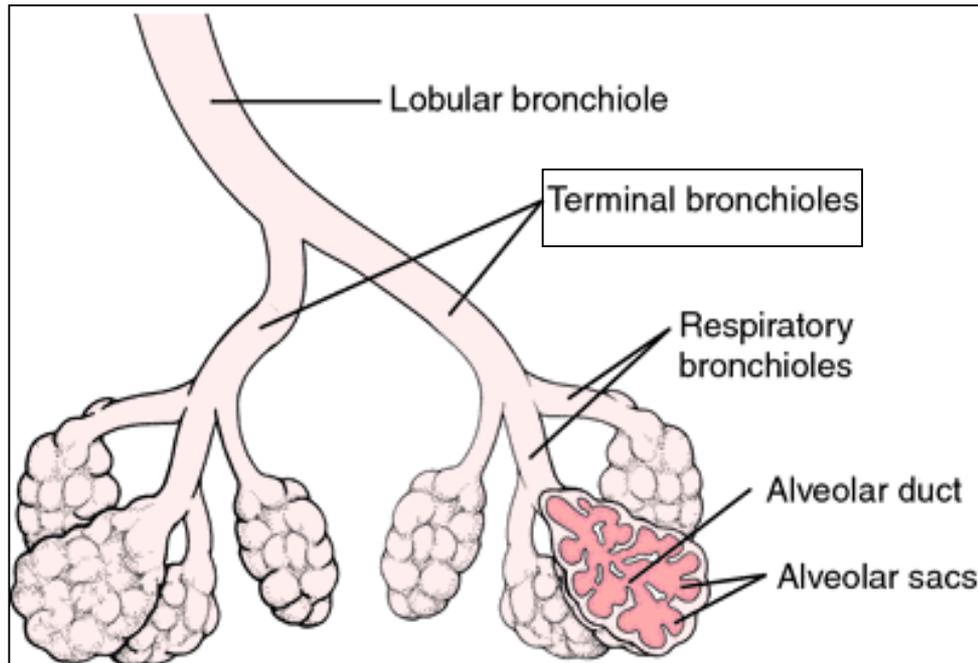
**N.B:** Smooth muscle component increases in proportion and continuity as the air passage decreases in size. Then decrease again till disappear in the respiratory portion

(plates) of cartilage  
spiral ← smooth muscle  
Res. Epi

**N. B:** if cartilage is present, it is a "bronchus," but if cartilage is absent the airway is a "bronchiole."

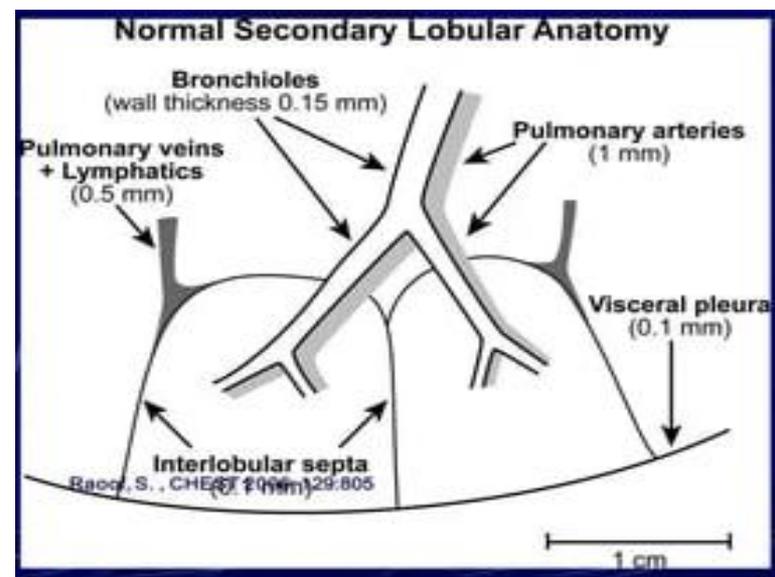
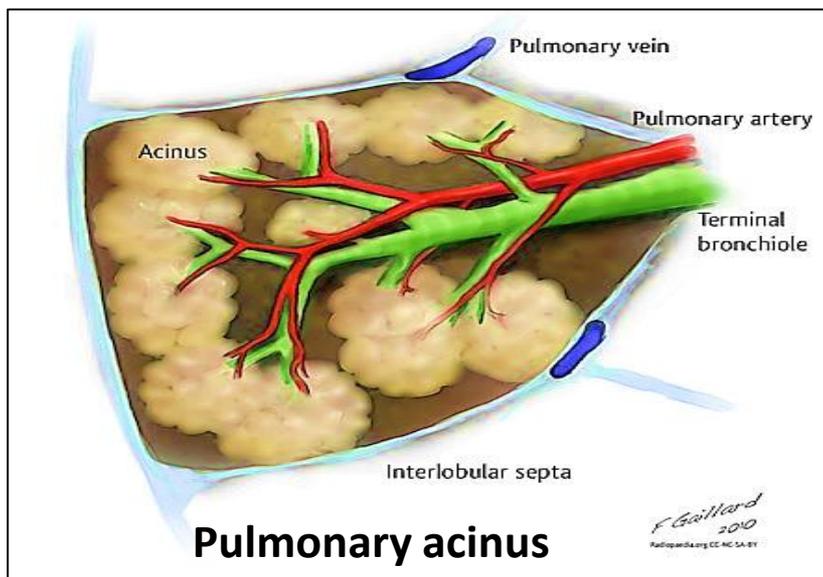
## ■ Terminal bronchioles:

تقسیم ترکیب  
بسی مختلف lining



- The smallest & last part of conducting portion
- Lining epithelium: <sup>انڈوسیلی و مقلی بدل سکتا ہے</sup> **Simple cubical ciliated e Clara cells**
- **Secondary pulmonary lobule:** is the lobule supplied by a terminal bronchiole that branches into respiratory bronchioles.

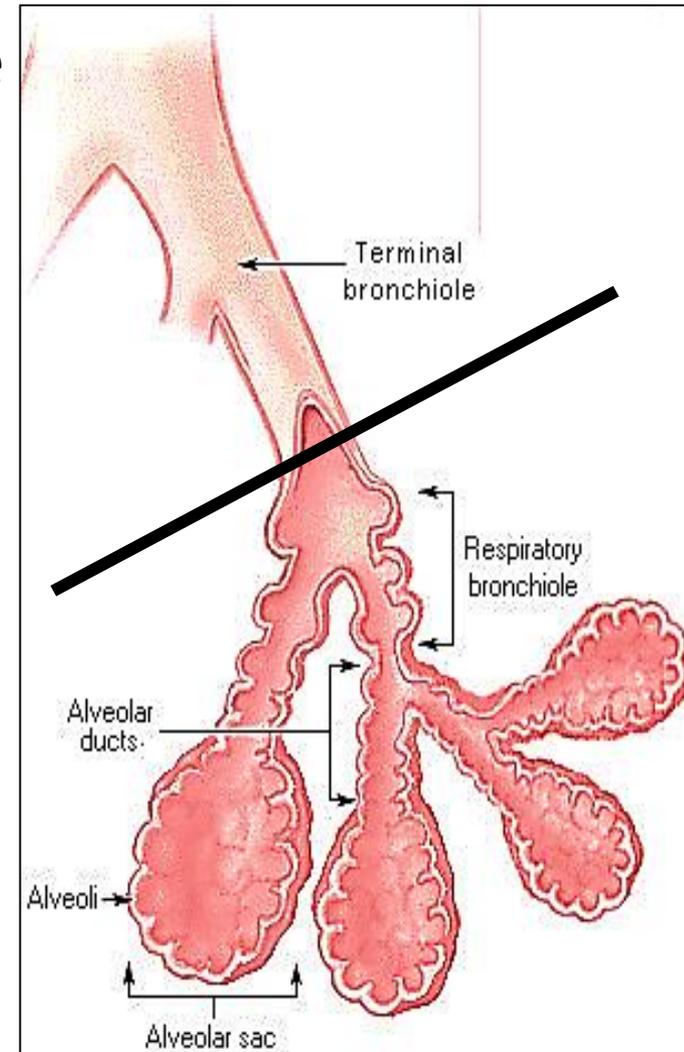
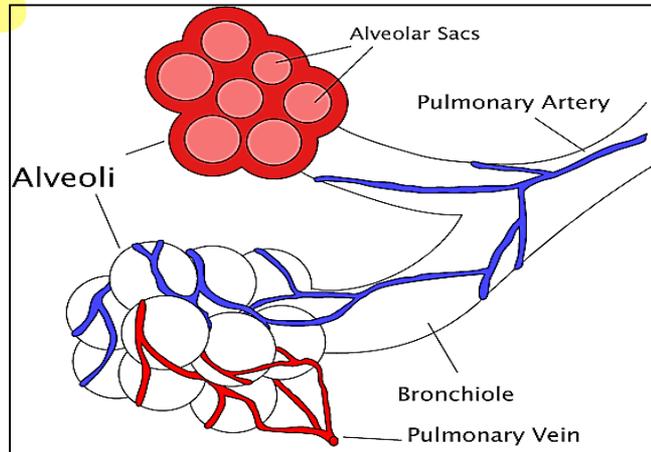




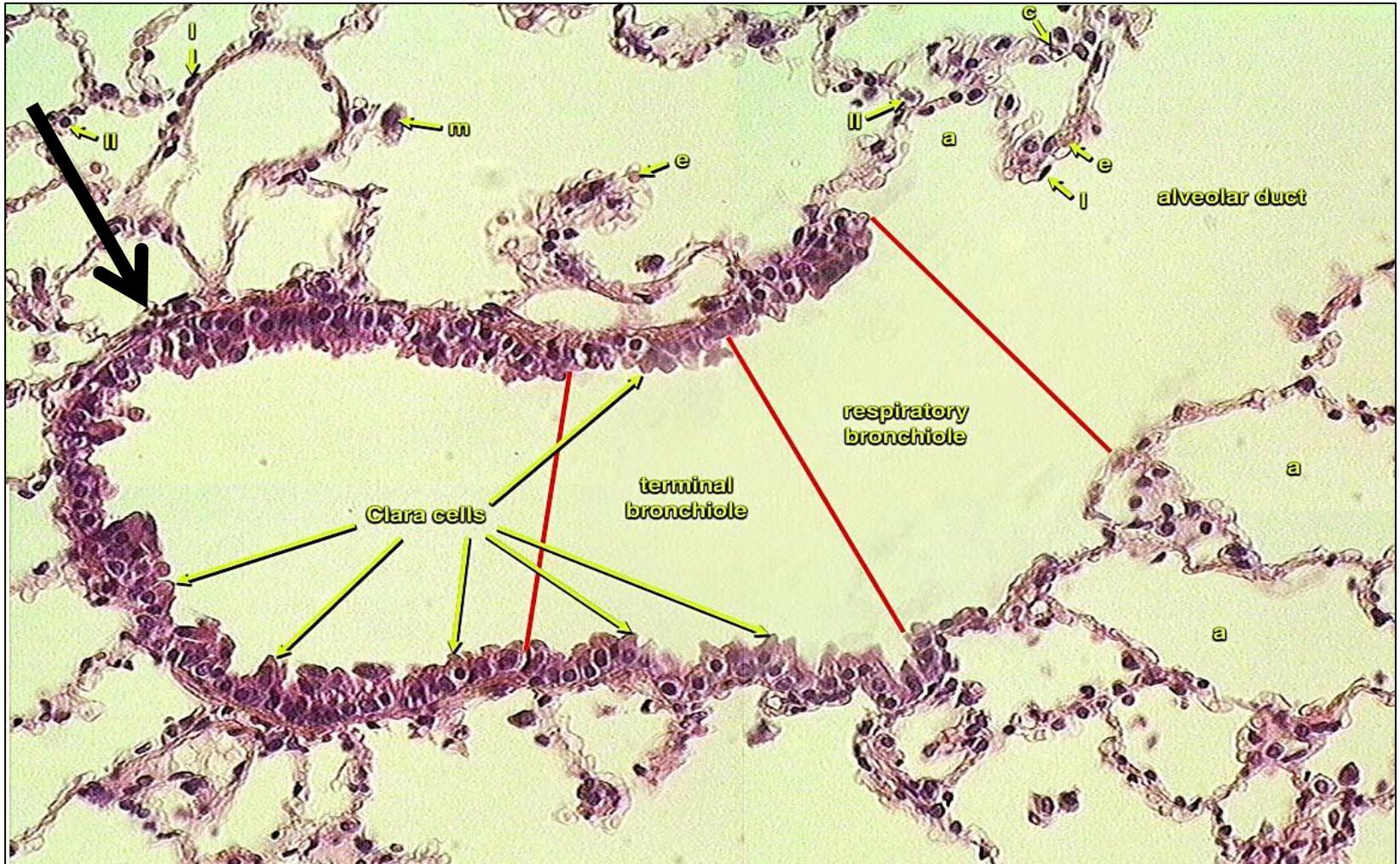
The secondary pulmonary lobule is a fundamental unit of lung structure, and it represents the lung in miniature. Airways, pulmonary arteries, veins, lymphatics, and the lung interstitium are all represented at the level of the secondary lobule. Several of these components of the secondary lobule are normally visible on **thin-section computed tomographic (CT) scans of the lung**. The recognition of lung abnormalities relative to the structures of the secondary lobule is fundamental to the interpretation of thin-section CT scans. **Pathologic alterations in secondary lobular anatomy visible on thin-section CT scans include interlobular septal thickening and diseases with peripheral lobular distribution, centrilobular abnormalities, and panlobular abnormalities.** The differential diagnosis of lobular abnormalities is based on comparisons between lobular anatomy and lung pathology.

## B- respiratory portion

- Is where gas exchange takes place
- Includes:
  1. Respiratory bronchioles
  2. Alveolar ducts
  3. Alveolar sacs
  4. Alveoli







Section is showing **terminal bronchiole** and parts of the respiratory portion

# Alveolar sacs (AS):

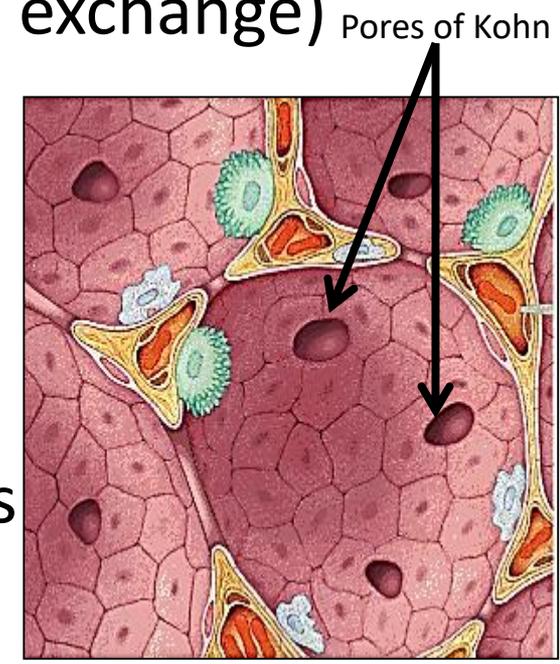
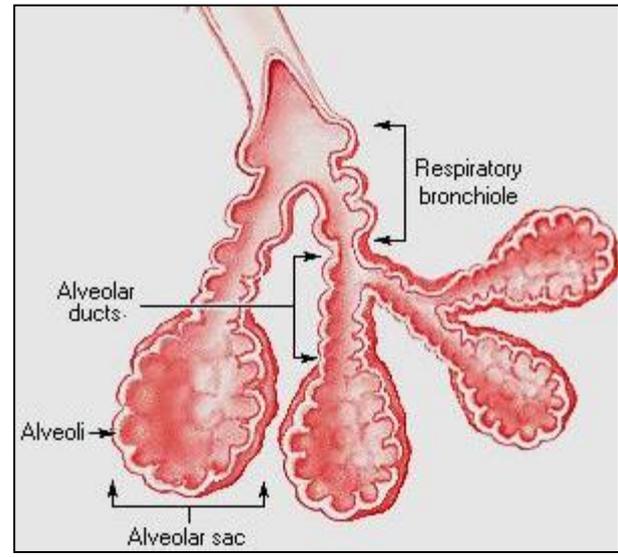
- Group of alveoli opens into common Central space
- Lined e **alveolar cells**

# Alveoli:

- Structural & functional units of lung (gas exchange)
- Alveoli found open into RB, AD, AS
- They separated by **inter-alveolar septa**

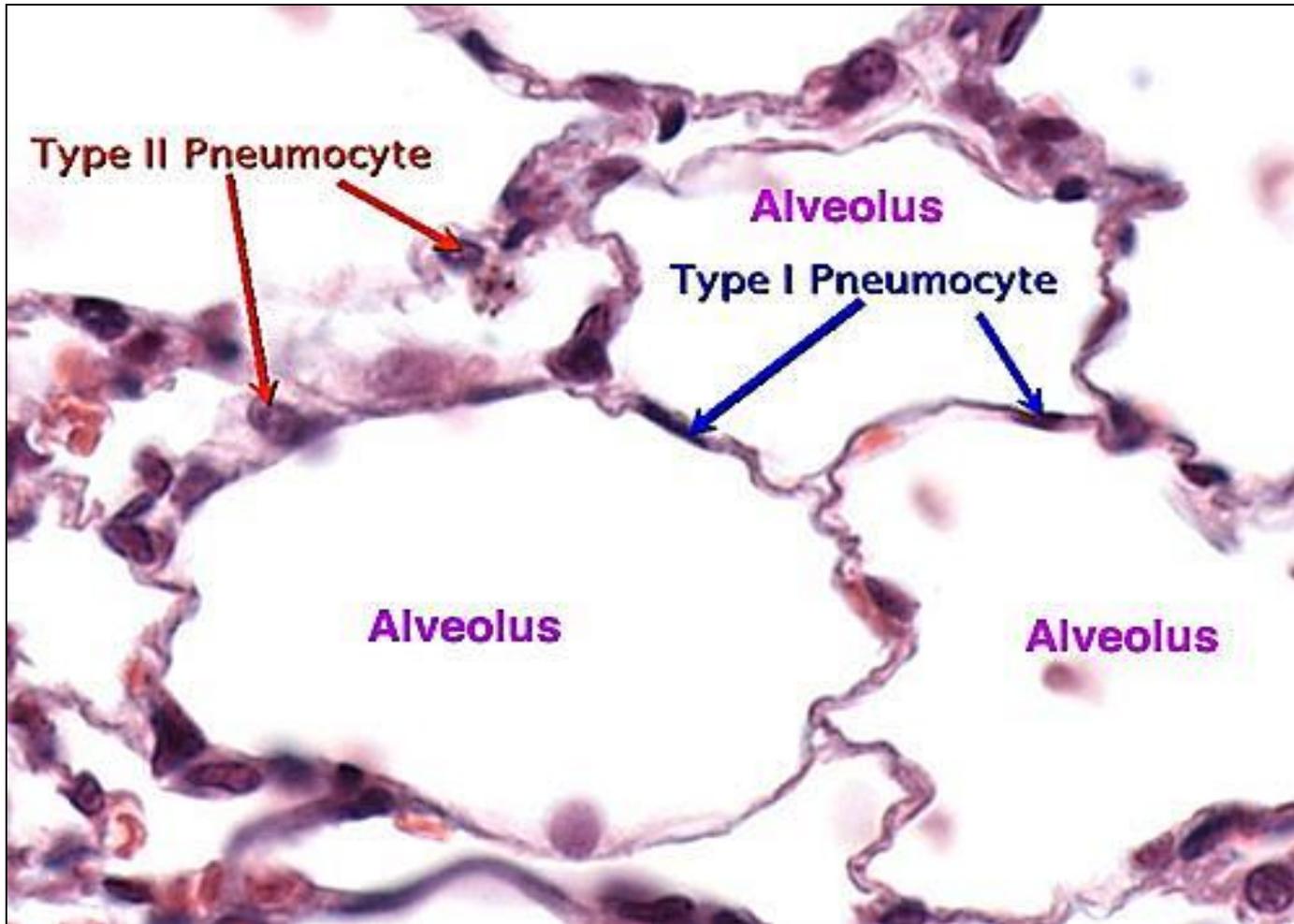
**Alveolar pores of Kohn** present in walls between alveoli (collateral ventilation ??)

- Lined e **alveolar epith.** formed of **2 types** of cells **type I & type II pneumocytes**



لنفس واحد يروح يتوزع بين الـ alveoli  
 في وقت واحد  
 في نفس الوقت  
 في نفس المكان  
 في نفس الوقت  
 في نفس المكان

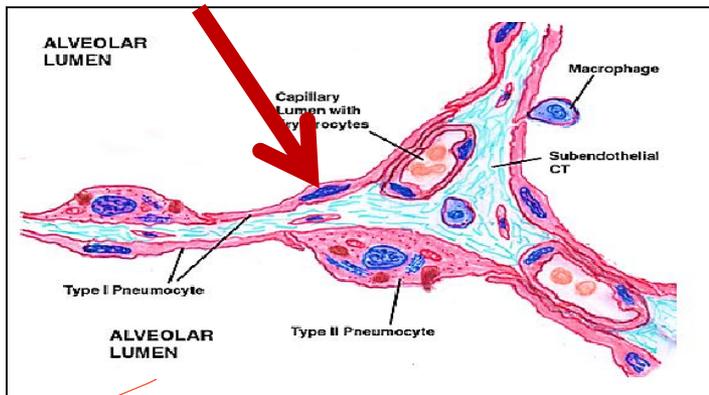
Gas exchange, or تبادل الغازات / تبادل  
 or wall  
 ← collateral ventilation or gas exchange  
 ←



**Type I and type II pneumocytes**

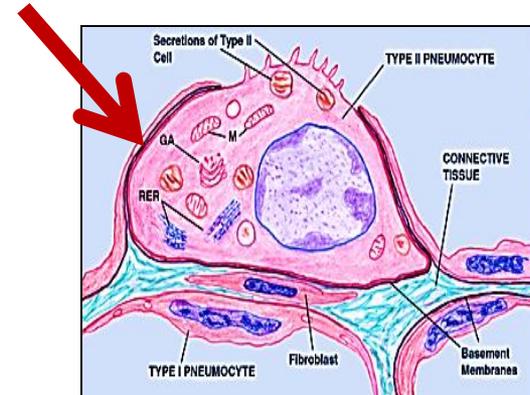
# Lining epithelium of alveoli

## Type I pneumocytes



- Cover **97%** of alveolar surface
- **Flat simple squamous cells** e flat nuclei
- cytoplasm has **few organelles**
- Cells joined together by **tight junctions**
- **Gas exchange** occurs through them

## Type II pneumocytes

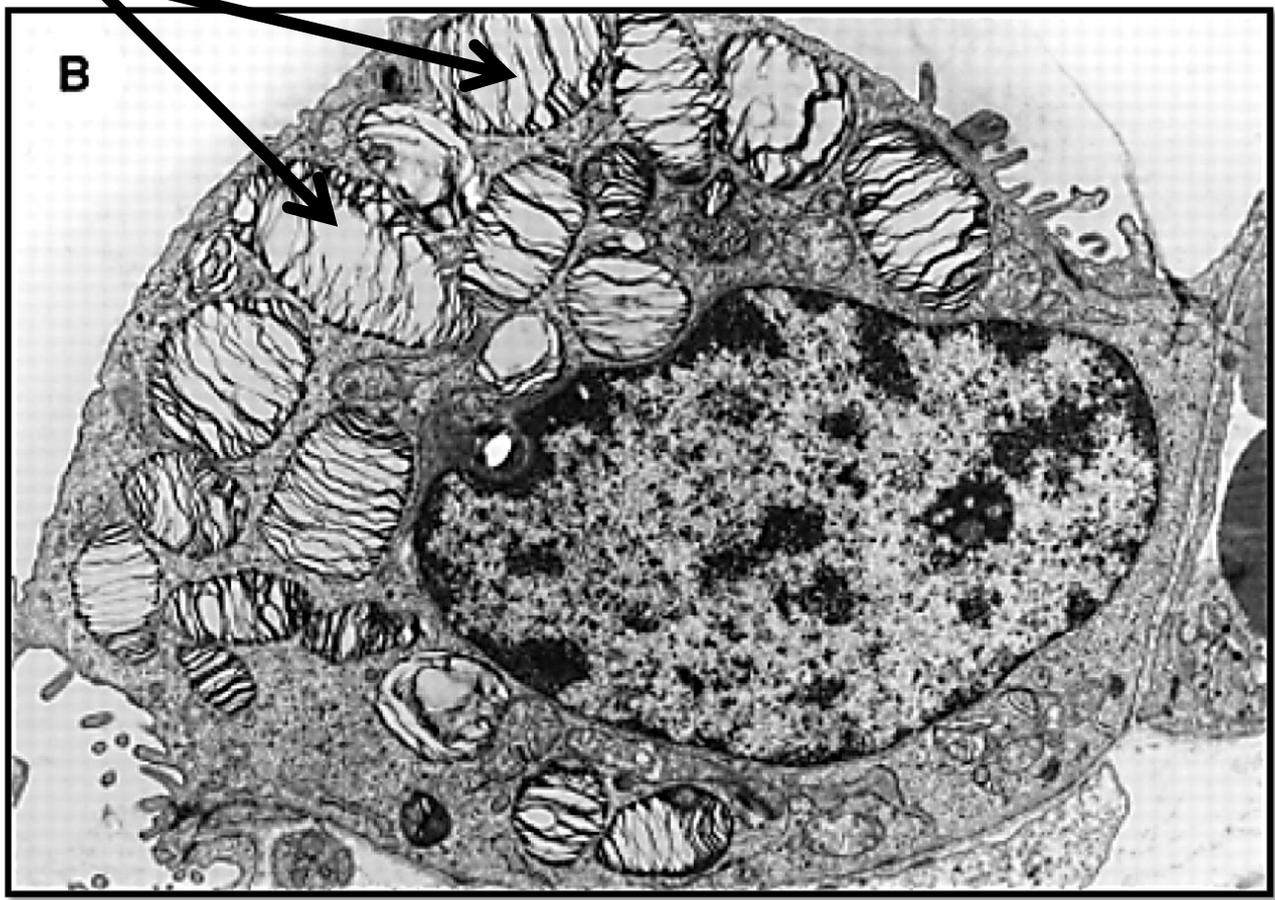


- Cover **3%**
- **Cuboidal cells** e central nuclei & foamy cytoplasm
- Free surface has **short microvilli**
- Cytoplasm **rich in organelles, multilamellar bodies**
- **Secrete surfactant** ( $\downarrow$  **tension** & **bactericidal**)
- Act as **stem cells**
- Have ACE2 receptors where Covid-19 spikes attack

• sustentacular cell } → Covid -1d  
pneumocyte type 2

## Multilamellar bodies

تخزين  
surfactant

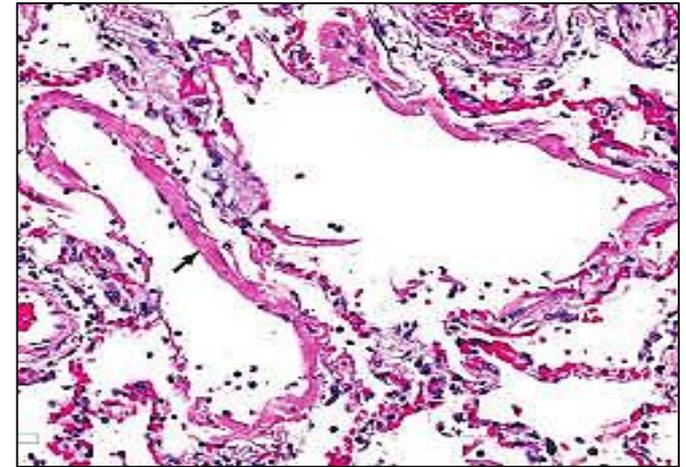


(E/M of type II pneumocyte)

**Respiratory Distress Syndrome (RDS):** occurs In premature babies because surfactant appears in last weeks of gestation

## Inter-alveolar septa:

- Delicate walls separate adjacent alveoli
- Have **richest capillary network** # أختار جسمي مليون Blood U
- **Where Gas exchange Take place**
- **Contains Blood –air barrier**
- **Rich in elastic & reticular fibers**  
تحتوي على  
Elastic + Collagen  
(support & prevent over expansion)
- **No smooth ms. cells**
- Contains extravasated leucocytes  
(**monocytes**), which will migrate through the **wall** →  
to the **lumen** and become **alveolar macrophages (A)**
- This septa are destructed in **emphysema & Covid - 19**



# Blood- air barrier ( respiratory membrane)

✓ Its where  $O_2$  &  $CO_2$  cross for exchange

✓ Composed of 4 layers: *exam*

■ Thin film of **surfactant** on the surface

■ Cytoplasm of type I **pneumocyte**

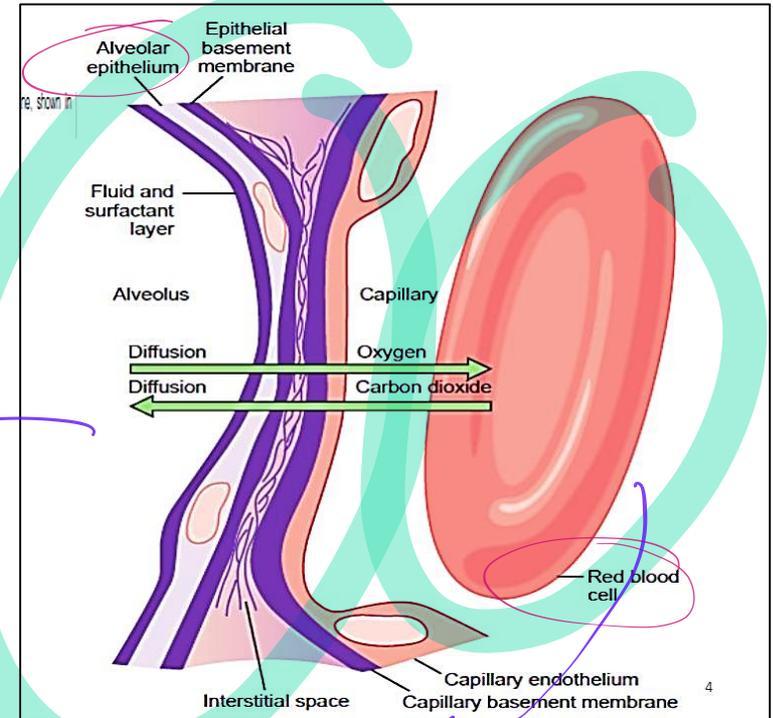
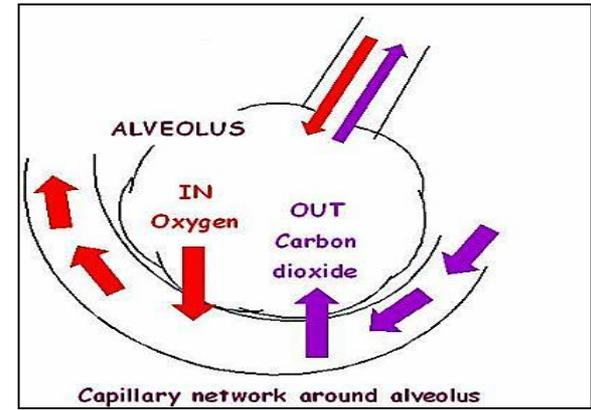
■ **Fused basal lamina** of type I pneumocytes + capillary

**endothelia cells**

*basement membrane of type I + endo...  
جميع بيوت*

*Alveoli*

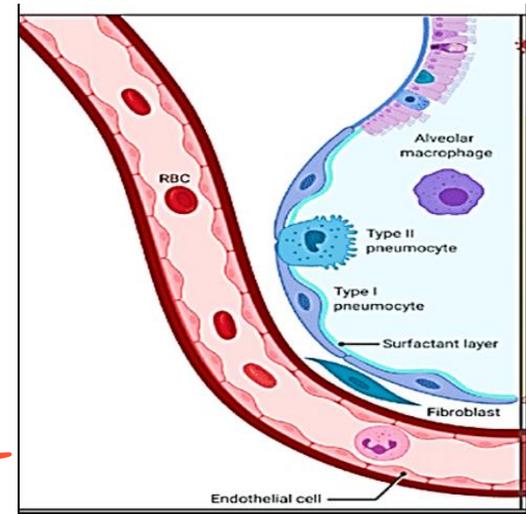
■ Cytoplasm of **endothelial cells**



*RBE (B.V)*

# Alveolar phagocytes

- Blood monocytes → CT in alveolar septa → lumen of alveoli → **macrophages**

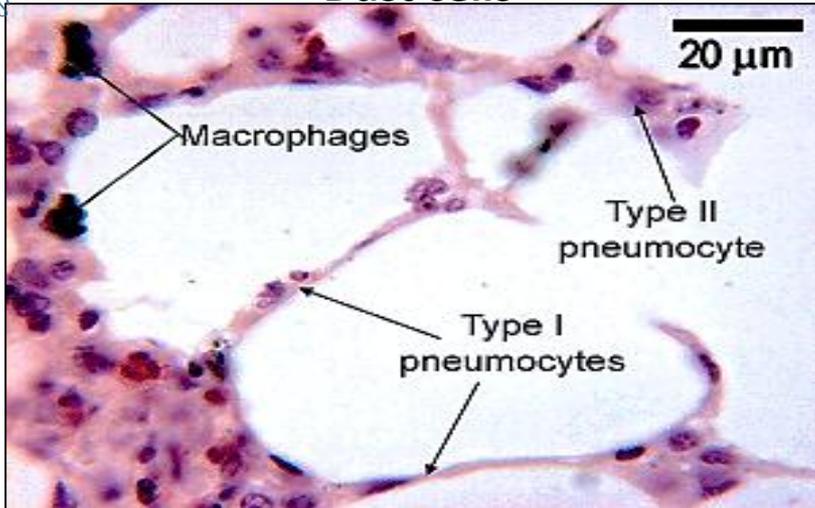


- **2 types** of alveolar macrophages: *مخاطبات*

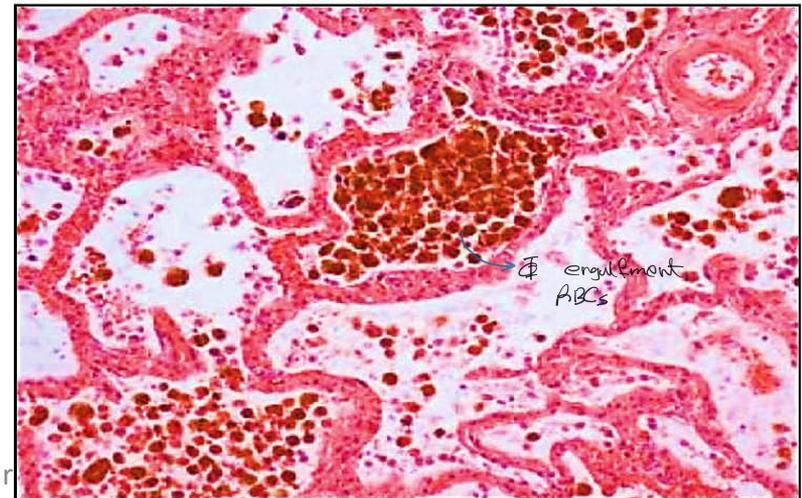
**Dust cells:** macrophages engulfing dust particles

**Heart failure cells:** macrophages engulfing erythrocytes (hemosiderin granules) found in congestive heart failure

Dust cells



Heart failure cells

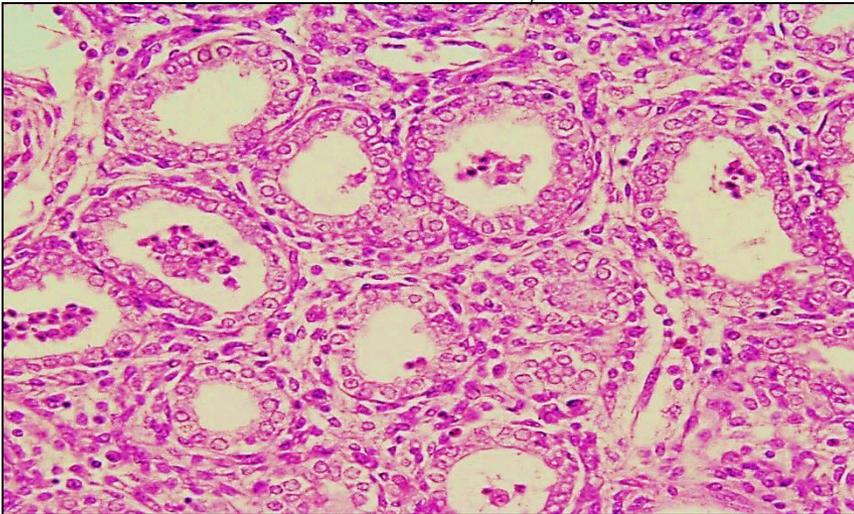


*خلايا  
مخاطبات  
مخاطبات  
مخاطبات  
congestive HF*

# Fetal Lung

- **Lobulation** is clear due to thick CT septa
- Fetal lung **similar to gland** in histological section
- **Alveoli collapsed** lined e simple cubical epith.
- **Pulmonary BV** are **congested**
- **Whole lung sinks in water**

Fetal lung # بيتي lung غدة في gland  
← Ring → ← Conbold ←



Normal lung

