Respiratroy System

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DONE BY

HISTICS Team

Bilal Marwa
Bedah AnNofal
AbdulAziz Joury
نبع الحياة

AbdulWahab Idrees
Yahya Aseery
Ibrahim AshSheheal

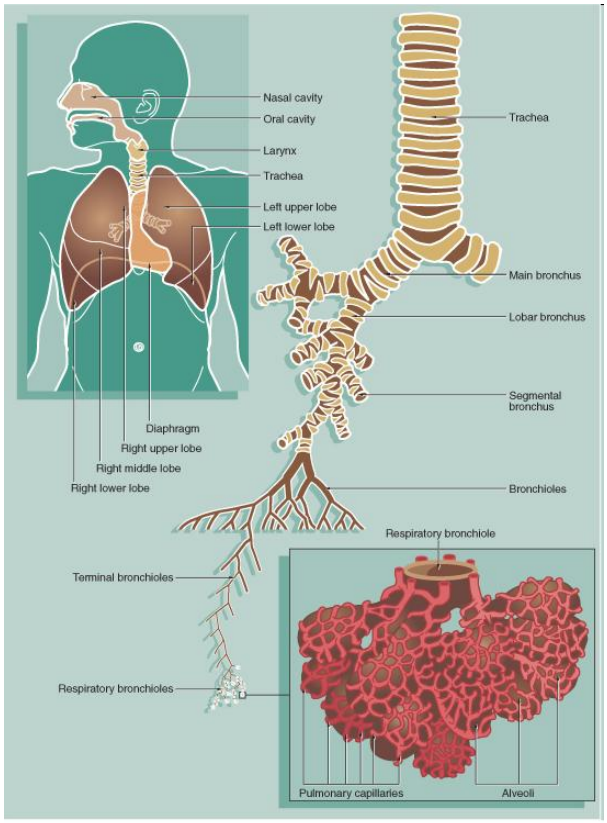
SPECIAL THANKS

Dr. Aly Mohammed, PhD

Dr. Maha Arafah, KSUFP

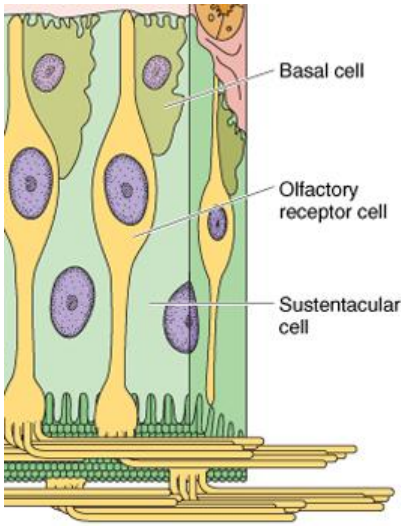
OVERVIEW

- Subdivided into:
  - Conducting Portion:
    - Transport, filter, moisten and warm inspired air.
    - Formed of:
      - Nasal cavity.
      - Nasopharynx.
      - Larynx.
      - Trachea.
      - Primary bronchi.
      - Secondary bronchi (lobar).
      - Tertiary bronchi (segmental).
      - Bronchioles.
      - Terminal bronchiole.
  - Respiratory Portion:
    - Sites of gas exchange.
    - Formed of:
      - Respiratory bronchioles.
      - Alveolar ducts.
      - Alveolar sacs.
      - Alveoli.



NASAL CAVITY

- Divided by nasal septum into two halves.
- Each half consists of:
  - Anterior portion (vestibule).
    - Lining:
      - Skin.
      - Dermis (house sweat & sebaceous glands).
      - Epidermis (keratinized stratified squamous epithelium).
    - Vibrissae: short, stiff hairs that prevent larger dust particles from entering the nasal cavity.
    - Wall (formed of cartilage).
  - Posterior portion (nasal fossae):
    - Contains 3 bony conchea (each fossa):
      - Superior, middle & inferior.
    - Olfactory portion:
      - Covers the superior aspect of the nasal septum and the superior concha.
      - Formed of olfactory mucosa.
      - Olfactory epithelium: Pseudostratified columnar epithileum
      - Three types of cells present:
        - → Sustentacular cells:
          - Columnar cells with:
            - Apical striated border (microvilli).
            - Oval Nucleus.
            - Apical cytoplasm has secretory granules with yellow pigments.
            - Junctional complexes with olfactory vesicles.



- Function:
  - Physical support, nourishment & electrical insulation for olfactory cells.
- Olfactory cells (olfactory nerve cells):
  - Bipolar neurons.
  - Dendrite has olfactory vesicle.
  - Olfactory vesicle has 6-8 olfactory cilia.
  - Olfactory cilia is nonmotile.
    - Microtubules of olfactory cilia: (9x2+2x1 then 9x1+2x1).
  - Cell body with spherical nucleus.
  - Axons are unmyelinated with Schwann cells.
  - Axons will collect to form the olfactory nerve.
  - Connected to supporting cells by junctional complexes.
- Basal cells.
  - Short basophilic pyramidal cells.
  - Function: replacement of sustentacular & olfactory cells.

- Lamina propria:
  - Contains:
    - Highly vascularized loose to dense C.T.
    - Bowman's glands (serous acini).
    - Axons of olfactory nerve cells + Schwann cells.
    - Numerous lymphoid elements.

- Respiratory portion:
  - Respiratroy epithelium:
    - Pseudo-stratified ciliated columnar epithelium with goblet cells.
    - Contains 6 types of cells (seen under E/M):
      - 3 of which can be concluded from the name (form 90%):
        - Ciliated columnar cells: 30%
        - Goblet cells: 30%
        - Basal cells: 30% (touch the basement membrane but doesn't reach the surface).
      - The remaining 3 cells (forming 10%) are only seen by E/M:
        - Brush cells (3%)
          - Small granule mucous cells.
          - Sensory receptors or degranulated goblet cells.
        - Diffuse neuroendocrine system (DNES) cells (small granule cells) (K cells) (3-4%)
        - Serous cells (3%).
  - Lamina propria (corium):
    - C.T.: richly (highly) vascularized.
    - 3 chonchea (superior, middle and inferior)
    - Large arterial plexuses & venous sinuses.
      - Highly vascular, especially in region of conchae & anterior part of nasal septum.
      - Many seromucous glands (acini).
      - Abundant lymphoid elements:
        - Including lymphoid nodules, plasma cells & mast cells.

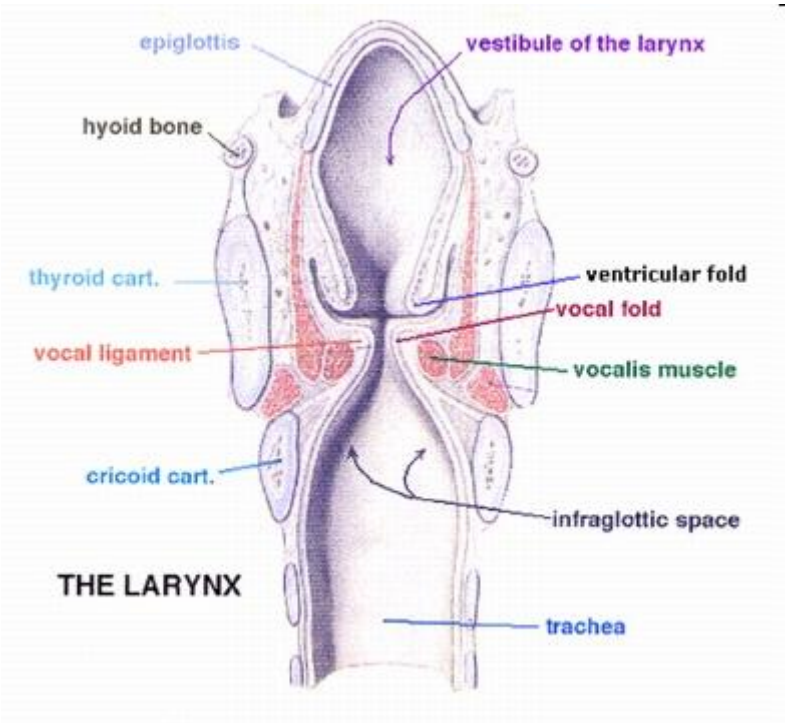
❖ Paranasal sinuses:
- Mucoperiosteum-lined spaces in sphenoid, frontal and maxilla bones.
- They communicate with the nasal cavity and have same lining.

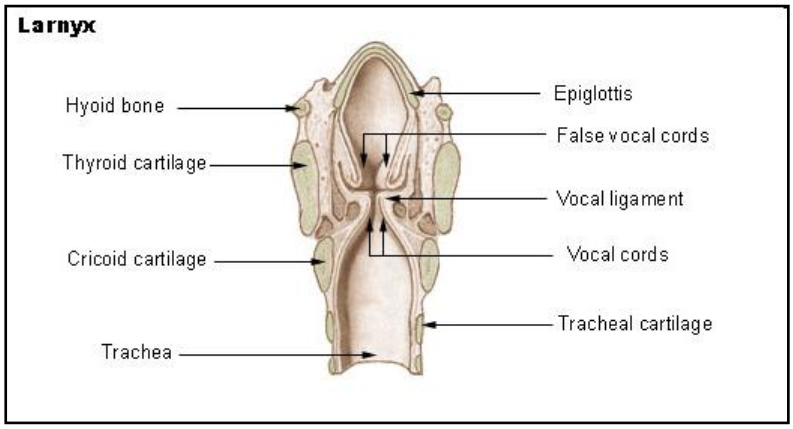
PHARYNX

- Subdivided into:
  - Nasopharynx (lined with respiratory mucosa and has pharyngeal tonsil).
  - Oral pharynx (lined with non-keratinized stratified squamous epthelium).
  - Laryngeal pharynx (lined with respiratory mucosa).

LARYNX

- Location: between pharynx and trachea.
- Size: 4 cm in length and 4 cm in diameter.
- Function: Responsible for phonation and prevent the entry of solids into the respiratory system during swallowing.
- The larynx contains:
  - Mucous membrane.
    - Lining of larynx (2 types):
      - Pseudostratified ciliated columnar epithelium (respiratory epithelium).
      - Nonkeratinized stratified squamous epithelium on the superior surfaces of the:
        - Epiglottis.
        - Vocal folds.
  - 2 pairs of mucosal folds within the mucous membrane.
    - 2 folds: vestibular and vocal.
    - Vestibular folds:
      - Immovable.
      - L/M:
        - Respiratory epithelium.
        - Lamina propria:
          - Loose C.T. with seromucous glands.
          - Lymphoid elements & adipose cells.
    - Vocal Folds (cords):
      - Vocal ligament: bundles of parallel elastic fibers (dense regular elastic C.T.).
      - Vocalis muscle: Skeletal muscle.
      - Nonkeratinized stratified squamous epithelium
  - Cartilages.
    - Hyaline cartilages:
      - Thyroid.
      - Cricoid.
      - Body of arytenoids.
    - Elastic cartilages:
      - Epiglottis.
      - Corniculate.
      - Cuneiform.
      - Tips of arytenoids.
    - Epiglottis:
      - Leaf-like structure.
      - Cover the upper end of larynx to prevent the entrance of food to respiratory passage.
      - Formed of elastic cartilage





- Surrounded with respiratory epithelium, except its superior (anterior) surface and the upper part of the (inferior) posterior surface which are covered by non-keratinized stratified squamous epithelium.

- Muscles.
- Ligaments.

TRACHEA

- Its wall is formed of:
  - Mucosa.
    - Mucosa is non-folded except posteriorly.
    - Made of: epithelium, lamina propria and elastic membrane
      - Respiratory epithelium.
      - Lamina propria:
        - Loose, fibroelastic C.T. containing:
          - Lymphoid elements, e.g. lymphoid nodules & lymphocytes.
          - Mucous & seromucous glands.
      - Elastic lamina:
        - Dense layer (thick bundle) of elastic fibers.
        - It separates lamina propria from submucosa.
  - Submucosa.
    - Dense irregular fibroelastic C.T.
    - Contain:
      - Numerous mucous and seromucous glands.
      - Lymphoid elements.
      - Rich blood and lymph supply.
  - Adventitia.
  - Fibroelastic C.T.
  - Contain:
    - C- shaped rings (12-16) of hyaline cartilages.
    - Trachealis muscle (bundles of smooth muscle, connecting the open ends of the C-shaped cartiages).
    - Perichondrium of cartilages are connected together by dense fibroelastic C.T.

PRIMARY BRONCHUS (EXTRAPULMONARY)

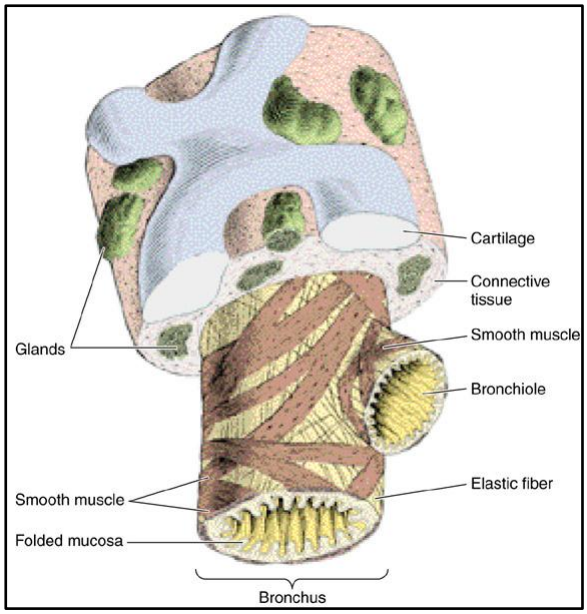
- Generally have the same histological appearance as the trachea.

GENERAL CHARACTERS OF BRONCHIAL TREE

- Progressive decrease in diameter.
- Decrease of amount of cartilage.
- Decrease in number of glands and goblet cells.
- Decrease the height of epithelial cells.
- Increase in smooth muscle.
- Increase of elastic tissue.

SECONDARY & TERTIARY BRONCHI (INTRAPULMONARY BRONCHI)

- Number:
- Secondary (lobar) bronchi:
  - 3 in the right lung.
  - 2 in the left lung.
- Tertiary (segmental) bronchi:



- 10 on both sides.
- Layers:
  - Mucosa:
    - Has longtidunal muscular folds.
    - Composed of an epithelium and a lamina propria (no elastic lamina)
      - Epithelium: Respiratory Epithelium
      - Lamina Propria:
        - Fibroelastic C.T. (loose C.T. rich in elastic fibers).
        - Contains:
          - Seromucous glands.
          - Lymphoid elements.
  - Muscle coat:
    - Two distinct layers of smooth muscle fibers.
    - Spirally arragned in different directions.
  - Submucosa:
    - Contain:
      - Lymphoid elements.
      - Seromucous glands.
  - Adventitia (has cartilages):
    - Loose C.T.
      - Containing radially arranged elastic fibers to connect with counterparts of neighbouring bronchial tree.
    - Irregular plate of hyaline cartilage forming a complete layer that contains:
      - Lymphoid nodules.
      - Seromucous glands.

BRONCHIOLES (OR PRETERMINAL OR PRIMARY)

- Diameter: 1 mm or less.
- Each bronciole supplies a pulmonary lobule.
- Layers:
- All layers contain no cartilage, no glands, no lymphoid elements.
  - Mucosa:
    - Mucosa has longitudinal folds.
    - Epithelium:
      - Simple columnar ciliated epithelium.
      - With occasional goblet cells
      - Later, becomes simple cuboidal partially ciliated, without goblet cells but with occasional clara cells (will be seen later)
    - Lamina propria:
      - Connective tissue rich in elastic fibers.
      - No glands.
      - No lymphoid elements.
  - Smooth muscle:
    - Hellically arranged smooth muscle layers.
  - Adventitia:
    - Loose fibroelastic C.T.
    - No cartilage.
    - Elastic fibers radiate out from here.

TERMINAL BRONCHIOLES (OR SECONDARY)

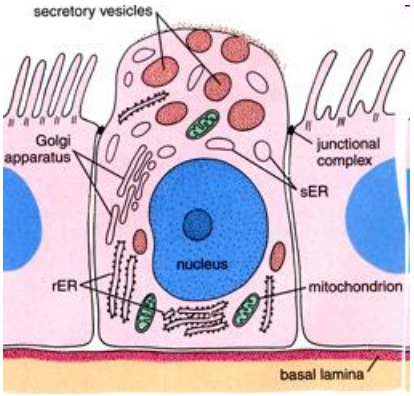
- Similar to preterminal bronchioles, but:
  - Epithelium:
    - Simple cuboidal epithelium.
    - Partially ciliated
    - With Clara cells.
  - Diameter: 0.5 mm or less.
  - Each terminal bronchiole supplies one lung acinus.

RESPIRATORY BRONCHIOLES (OR TERTIARY)

- Similar in structure to terminal bronchioles, except:
  - Their walls are interrupted by a few pulmonary alveoli.

CLARA CELLS

- Structure:
  - Columnar non-ciliated cells.
  - Dome-shaped apices with microvilli.
  - Numerous apical secretory granules (glycoproteins).
  - Abundant rER.
- Function:
  - Protect the bronchiolar epithelium by their secretions.
  - Degrade toxins in inhaled air by cytochrome P-450 enzymes (produced by sER).
  - Divide to regenerate the bronchiolar epithelium.
  - May produce surfactant-like material.

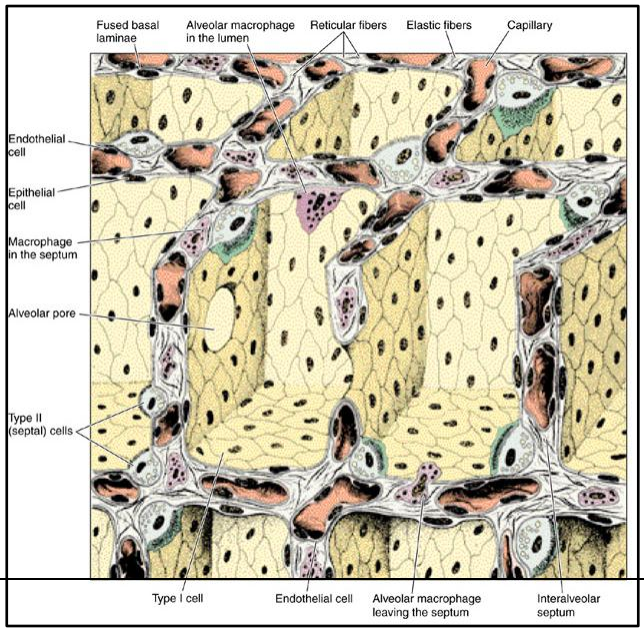


ALVEOLAR DUCTS

- Wall consists almost entirely of pulmonary alveoli.
- They end with two or more small clusters of alveoli (alveolar sac).
- Made up of:
  - Lining epithelium:
    - Squamous alveolar cells (type I pneumocytes).
  - Lamina propria
    - Elastic and reticular fibers.
    - Smooth muscle cells surround the opening of alveolus (small muscle knob).

ALVEOLI

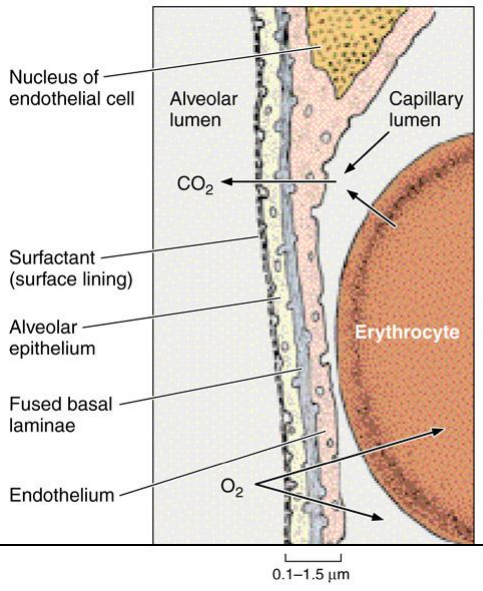
- The structural and functional unit of respiratory system.
- Small out pouchings of respiratory bronchioles, alveolar ducts & alveolar sacs.
- Have thin walls to permit exchange of CO_2 and O_2 between air in their lumina and blood in adjacent capillaries.
- Adjacent alveoli communicate through <u>alveolar pore</u> (pore of Kohn):
  - 8-60 µm in diameter.
  - Function: Equalize air pressure in the alveoli.
- Alveolar wall:
  - Alveolar Epithelium:
    - Made up of two types of cells:



- Type I pneumocytes (Squamous alveolar cells):
  - → 95 % of alveolar surface.
  - → Very thin simple squamous epithelium.
  - → Thin cytoplasm with small number of mitochondria, few RER and golgi apparatus.
  - → Form occluding junction with each other and with type II pneumocytes.
  - → Well-developed basal lamina.
  - → Luminal surface is lined by surfactant.
  - → Functions:
    - ➢ Gas exchange.
    - ➢ May play a role in surfactant turnover.
- Type II pneumocytes:
  - → More numerous than type I, but occupy less space (5% of alveolar surface).
  - → Cuboidal cells, with dome-shaped surface.
  - → Usually found in groups of 2-3 cells.
  - → Located in regions where adjacent alveoli are separated from each other by septum.
  - → Connected with type I cells by occluding junctions.
  - → Short apical microvilli.
  - → Abundant mitochondria, RER, well-developed Golgi apparatus.
  - → Membrane-bound Lamellar bodies
    - ➢ Contain concentric or parallel lamellae limited by a unit membrane.
    - ➢ Contain surfactant.
  - → Renewal of type II pneumocytes
    - ➢ By mitotic cell division
  - → Type II cells can divide to replace:
    - ➢ Their own population
    - ➢ Type I cells
  - → Function:
    - ➢ Synthesis and secretion of surfactant:
      - ▪ Composed of (phospholipids + GAGs + proteins).
      - ▪ Lower (↓) alveolar surface tension→ reduce effort to inflate pulmonary alveoli.
      - ▪ Phagocytosis of pulmonary surfactant.
      - ▪ Has bactericidal effect.
  - → Renewal of alveolar epithelial cells.
  - → Synthesis of surfactant by type II pneumocytes
    - ➢ Synthesis in RER.
    - ➢ Modification in Golgi apparatus,
    - ➢ Released into secretory vesicles (composite bodies) which are the immediate precurrsors of lamellar bodies.

❖ Interalveolar septum (interstitium):

- ➢ Occupied by:-
  - ▪ Extensive capillary bed of continuous capillaries.
  - ▪ Basal lamina.
  - ▪ C.T., elastic fiber and type III collagen (reticular fibers).
    - No muscle cells
  - ▪ Macrophages, fibroblasts, mast cells and lymphoid elements.
- ➢ Blood-Gas barrier:
  - ▪ It is the region of the interalveolar septum that is traversed by O2 and CO2.
- ➢ Between the lumen of the capillary & the lumen of the alveoli.
- ➢ Basal lamina of type I pneumocyte and capillary endothelium are fused.



- Components:
  - Thin layer of surfactant.
  - Type I pneumocyte.
  - Fused basal laminae.
  - Endothelial cells of the pulmonary capillary.

PLEURA

- Parietal pleura.
- Visceral pleura.
- L/M:
  - Simple squamous mesothelial cells.
  - Lamina propria:
    - Fine C.T. layer that contains collagen & elastic fibers.