

The logo of Galgotias University is a circular emblem with a stylized, multi-colored swirl in shades of blue, yellow, and red. Below the swirl, the text "GALGOTIAS UNIVERSITY" is written in a light grey, serif font.

Pulmonary Physiology

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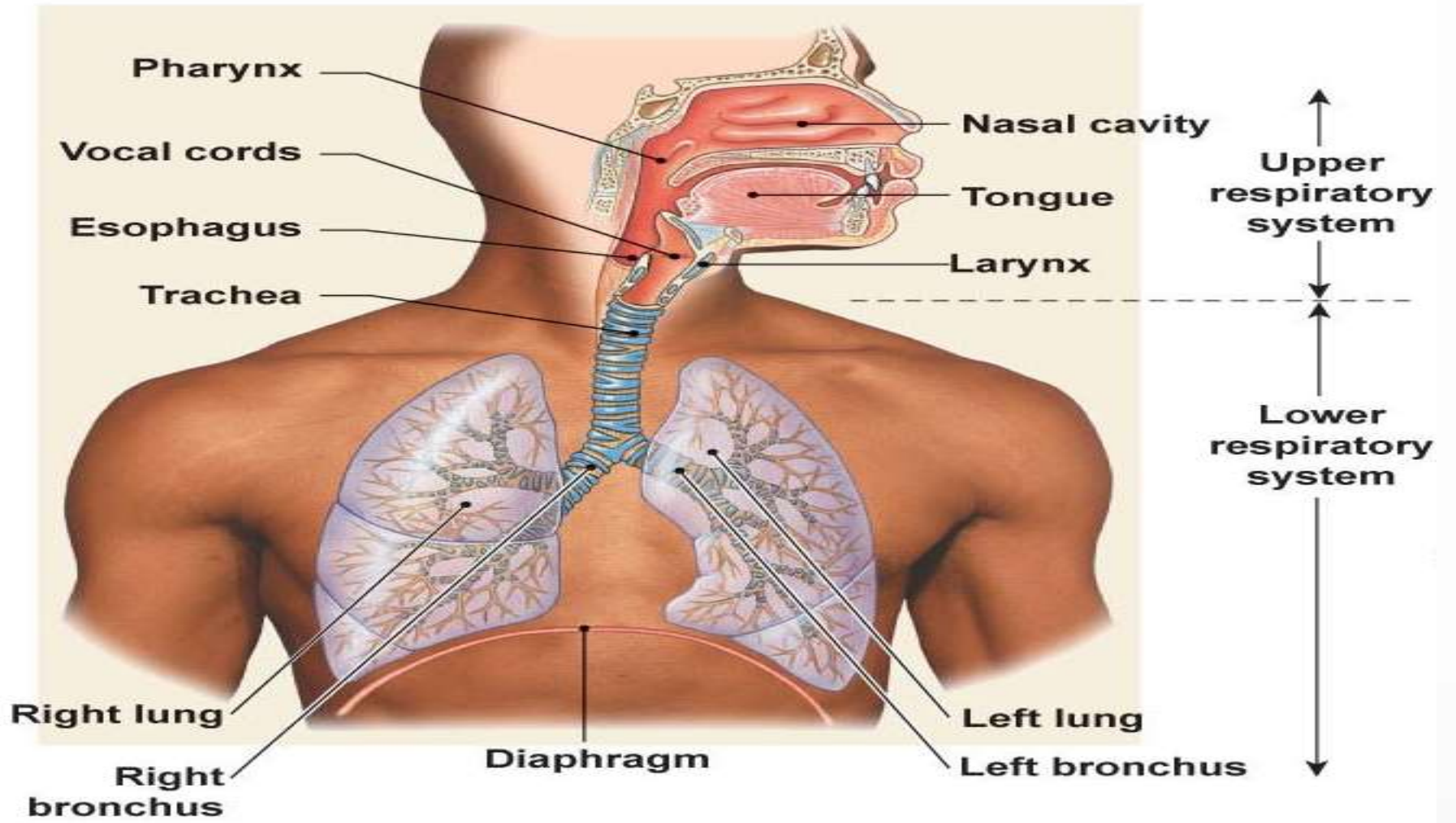
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This content is only for educational and teaching purposes.

The logo of Galgotias University is a circular emblem with a stylized 'G' shape in the center. The 'G' is composed of three curved segments in shades of yellow, blue, and red. The entire logo is rendered in a light, semi-transparent grey.

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FUNCTIONAL ANATOMY



Respiration

Respiration = the series of exchanges that leads to the uptake of oxygen by the cells, and the release of carbon dioxide to the lungs

Step 1 = ventilation

- Inspiration & expiration

Step 2 = exchange between alveoli (lungs) and pulmonary capillaries
(blood)

- Referred to as External Respiration

Step 3 = transport of gases in blood

Step 4 = exchange between blood and cells

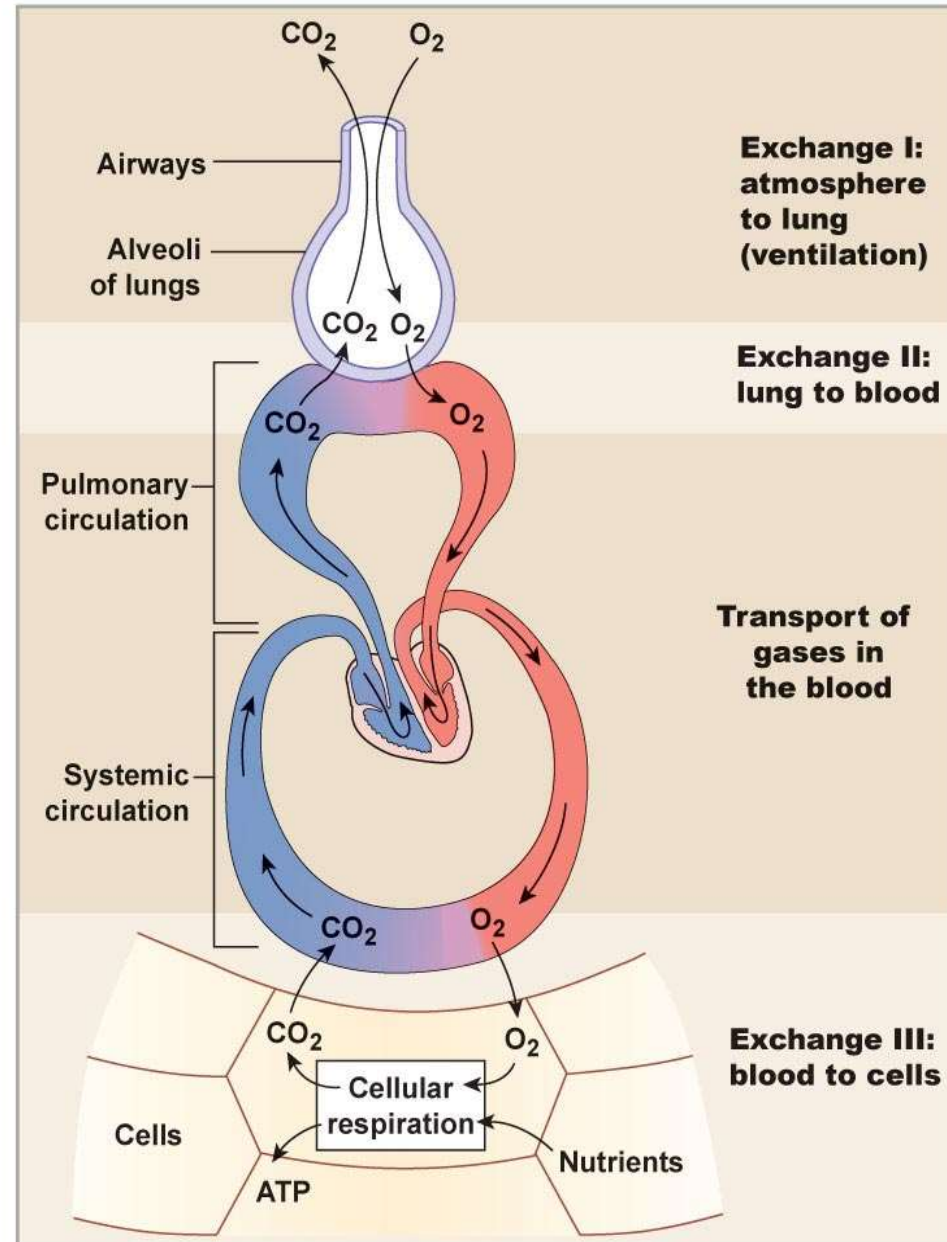
- Referred to as Internal Respiration

Respiration

- Goals of respiration- to provide oxygen to the tissues and to remove carbon dioxide
- 4 major functional events-
 - i. Pulmonary ventilation- Inspiration & expiration
 - ii. Diffusion of oxygen and carbon dioxide between alveoli and blood- *External Respiration*
 - iii. Transport of oxygen and carbon dioxide in blood and body fluids to and from the cells- *Internal Respiration*
 - iv. Regulation of ventilation


- EXTERNAL RESPIRATION

- INTERNAL RESPIRATION



Respiratory Tree

- The Respiratory Tree
 - Upper respiratory tract a single large conductive tube
 - The lower respiratory tract starts after the larynx and divides again and again...and again to eventually get to the smallest regions which form the exchange membranes
 - Trachea
 - Primary bronchi
 - Secondary bronchi
 - Tertiary bronchi

- 
- Bronchioles
 - Terminal bronchioles
 - Respiratory bronchioles with start of alveoli outpouches
 - Alveolar ducts with outpouchings.

Trachea to terminal bronchiole- conducting zone

Last two's- exchange portion



WEIBEL'S LUNG MODE

- E.R Weibel(1963)- tracheobronchial tree
- The main, lobar and segmental – first four
- Subsegmental bronchi -5th to 7th they extend upto 11th generation and are known as bronchioles
- Terminal bronchioles- 12-16th generation
- Respiratory bronchioles- 17-19th generation
- Alveolar ducts- 20-22nd generation
- Alveolar sacs- 23rd generation

Upto 16th gen- no exchange of gases-dead space. Total capacity- approx 150ml-
conducting zone

From 17th onwards- gaseous exchange take place. Volume – approx 4 litres-
respiratory zone

Histology

- Wall of tracheobronchial tree made up of fibers, cartilages, smooth muscles and epithelial lining containing glands and **cilia**(escalator action).
- Alveolar lining epithelium:- thin and simple squamous type. Consist of 2 types of cells
 1. Type 1 cells:- flat and primary lining cells
 2. Type II cells (granular pneumocytes):- granular and secrete **surfactant**

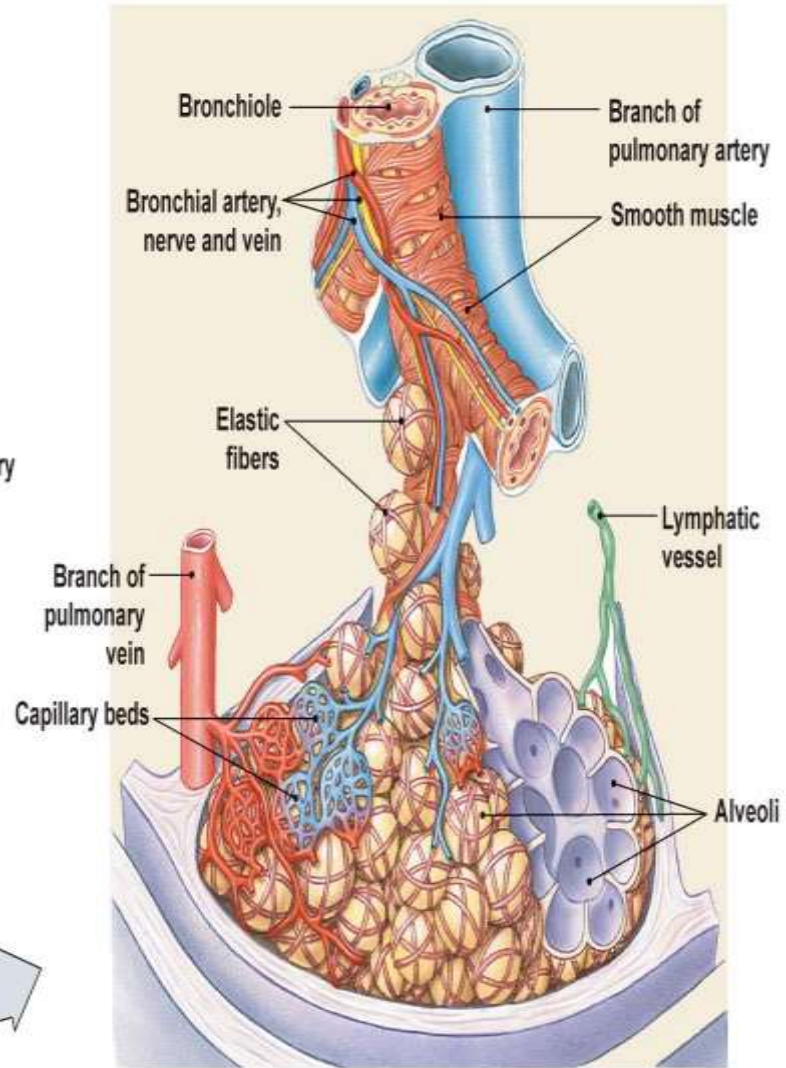
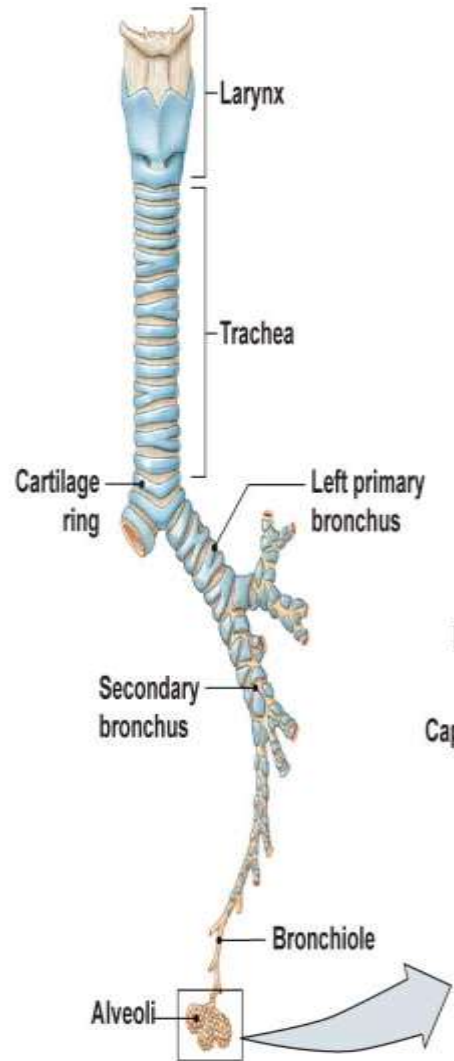
Alveoli also contain

- PAM- pulmonary alveolar macrophages- phagocytic cells
- Lymphocytes
- Plasma cells- form and secrete immunoglobulins
- APUD cells- amine precursor uptake and decarboxylation cells- store and secrete peptides. E.g's- VIP(vaso active peptide), substance P etc
- Mast cells containing heparin, histamine etc.

Pores of kohn:- small pores, alveoli communicating channels

Innervation

- Two branches of autonomic nervous system (ANS)
 1. Parasympathetic nerve-stimulation by irritants, chemical, cool air or exercise-cholinergic discharge-bronchoconstriction and increased bronchial secretions via muscarinic receptors
 2. Sympathetic nerve- stimulation via adrenergic receptors causes bronchodilation and inc secretions.
- Non-cholinergic Non-adrenergic nerve- its stimulation causes bronchodilation due to release of mediator VIP. – deficient in bronchial asthma



BRONCHOPULMONARY SEGMENTS

Upper lobe

- 1 Apical bronchus
- 2 Posterior bronchus
- 3 Anterior bronchus

Middle lobe

- 4 Lateral bronchus
- 5 Medial bronchus

Lower lobe

- 6 Apical bronchus
- 7 Medial basal (cardiac) bronchus
- 8 Anterior basal bronchus
- 9 Lateral basal bronchus
- 10 Posterior basal bronchus

Upper lobe

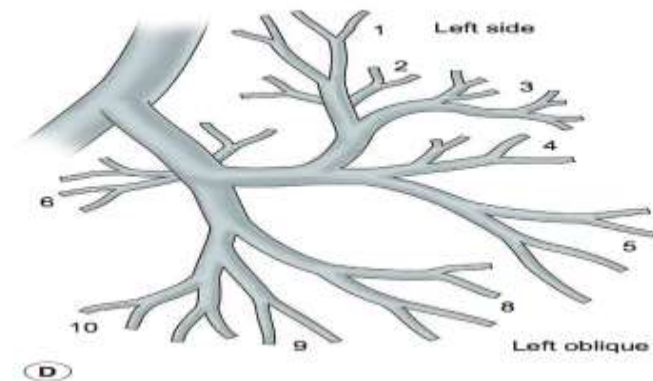
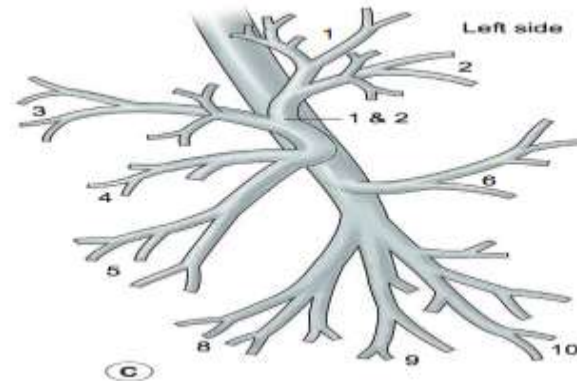
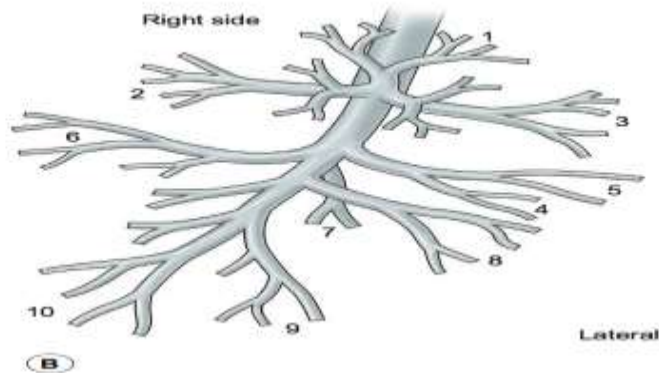
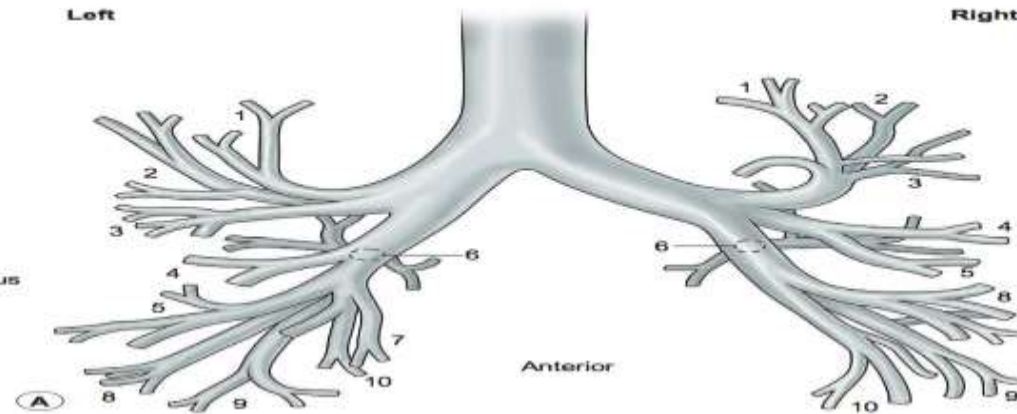
- 1 Apical bronchus
- 2 Posterior bronchus
- 3 Anterior bronchus

Ligula

- 4 Superior bronchus
- 5 Inferior bronchus

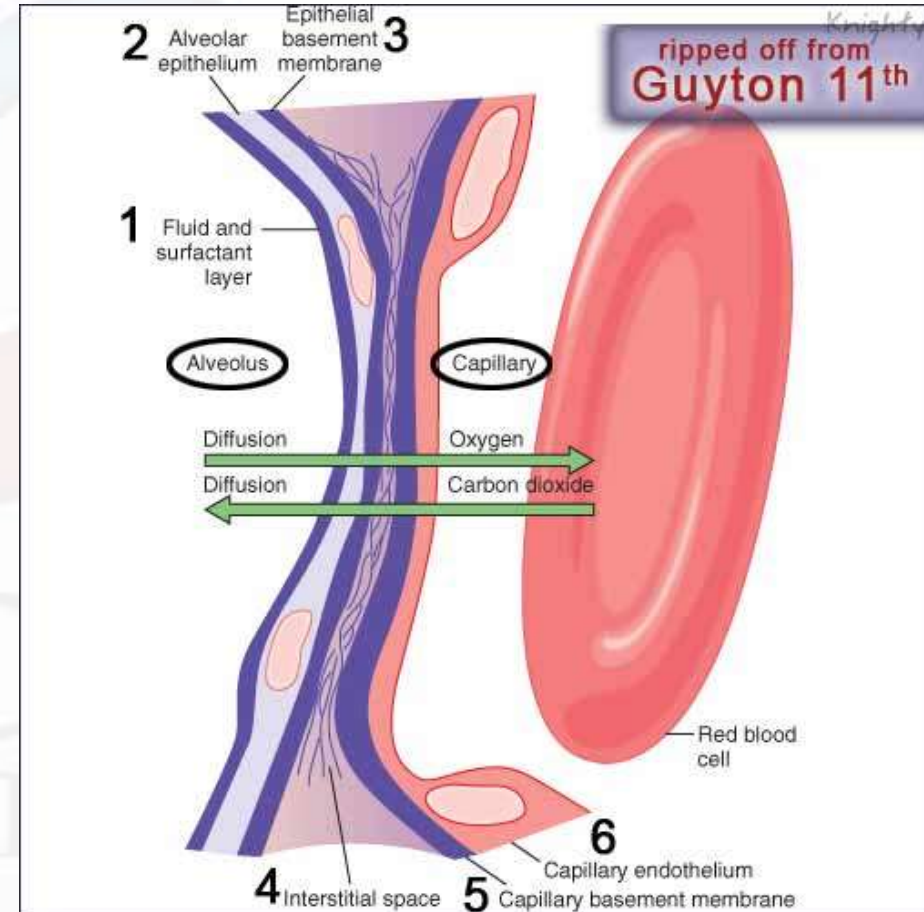
Lower lobe

- 6 Apical bronchus
- 8 Anterior basal bronchus
- 9 Lateral basal bronchus
- 10 Posterior basal bronchus



Respiratory Membrane

- Also known as alveolar-capillary membrane.- thickness 0.3-1micrometer.
- Made up of alveolar wall and capillary wall.



The factors that determine how rapidly a gas will pass through the membrane are:

- The thickness of the membrane,
- The surface area of the membrane,
- The diffusion coefficient of the gas in the substance of the membrane, and
- The partial pressure difference of the gas between the two sides of the membrane.

Pleura

- Outer covering of lungs
- Two layers:- parietal pleura and visceral pleura
- Pleural cavity:- space between two layers
- **Pleural fluid**:- approx 2ml, serous lubricating fluid.
 - Adhesive and non-expansile keeps two layer together i.e, hydraulic traction therefore when one moves other follows.
 - Lung slide easily on the chest wall but resist when pulled away.

Partial Pressure

- Pressure exerted by any one gas in a mixture of gases is called its partial pressure
- $P = nRT/V$, P= pressure, n= number of moles, R= gas constant, T=temperature, V=volume
- Calculation of partial pressure of gases
- $P_{\text{gas}} = \frac{\% \text{ of gas} \times \text{total atm pressure}}{100}$
- Composition of dry air-
- O₂-20.98%, CO₂- 0.03%, N₂- 78.06%

	ATMOSPHERIC AIR(mmHg)	HUMIDIFIED AIR	ALVEOLAR AIR	EXPIRED AIR
N ₂	597.0	563.4	569.0	566.0
O ₂	159.0	149.3	104.0	120.0
CO ₂	0.3	0.3	40.0	27.0

FUNCTIONS OF RESPIRATORY TRACTS

- Upper respiratory tract
 - Warm
 - Humidify
 - Filter
- Lower respiratory tract
 1. Exchange of gases Due to
 - Huge surface area
 - Associated network of pulmonary capillaries
 2. Protection
 - Free pulmonary alveolar macrophages (PAMS dust cells)
 - Surfactant produced by type II alveolar cells (septal cells)

Non Respiratory Functions

- Lung defence mechanism-humidify, cool, warm air,
Bronchial secretions contain Ig A and nitric oxide- helps in resist infection
Prevent foreign bodies from reaching alveoli
 - Particles > 10micrometer- strained out by nostrils hair
 - Particles 2-10 micrometer- fall on walls of bronchi- initiate bronchoconstriction and coughing-moved out by ciliary escalator action
 - Particles <2 micrometer- reaches alveoli- ingested by macrophages
- Functions of pulmonary circulation
 - Reservoir of left ventricle-if LV output>>systemic venous return-maintained for few stroke by drawing out blood stored in pul circulation
 - Pul circulation as filter- blood clots, fat cells etc
- Metabolic and endocrine functions.

Basic Mechanics

- Eupnoea- rhythmic breathing at rest. Consist of inspiration and expiration.
- Inspiration – active process

Thorax is enlarged by

- A. Rib movements- outwards and upwards
- B. Diaphragmatic movement - Descent of diaphragm

Rib movement:- pump handle movement by 2nd to 6th ribs due to contraction of external intercostal muscles(T1,2) leads to increase in A-P diameter of chest.

Bucket handle movement by 7th to 10th ribs leads to increase in transverse diameter of chest.

Diaphragmatic movement:- muscle fibers arise from

- Xiphisternum
- Inner surface of lower ribs
- Lumbar vertebrae

- Supplied by phrenic neurons(C3,4,5), draws central tendon downwards.

- Inspiratory muscles-

- increase thoracic cage volume

Diaphragm, External Intercostals

Accessory muscles:- SCM, Ant & Post. Sup. Serratus, Scalene, intrinsic muscles of larynx- abductor muscles of vocal cords: post cricoarytenoid.

EXPIRATION:- passive process

Abdominals, Internal Intercostals,

Accessory muscles:- Post Inf. Serratus, Transverse Thoracis, adductor muscles of vocal cords.

PRESSURE CHANGES DURING VENTILATION

- Intra-pulmonary pressure or intra alveolar pressure
- Intra- pleural or intra thoracic pressure: -2mmHg
- Trans-pulmonary pressure
 - difference between alveolar P & pleural P
 - Pressure difference between that in the alveoli and that on the outer surfaces of the lungs
 - measure of the elastic recoil tendency of the lung
 - peaks at the end of inspiration

LUNG VOLUMES AND CAPACITIES

2 major headings

1. Static lung volumes and capacities- time factor is not involved , ml or L
2. Dynamic lung volumes and capacities- time dependent, ml/min or L/min

Static lung volumes

- Tidal Volume (500ml)
amount of air moved in or out of lungs during quiet respiration.
- Inspiratory Reserve Volume (2000-3200ml)
Maximal vol. of air which can be inspired after completing normal tidal inspiration.

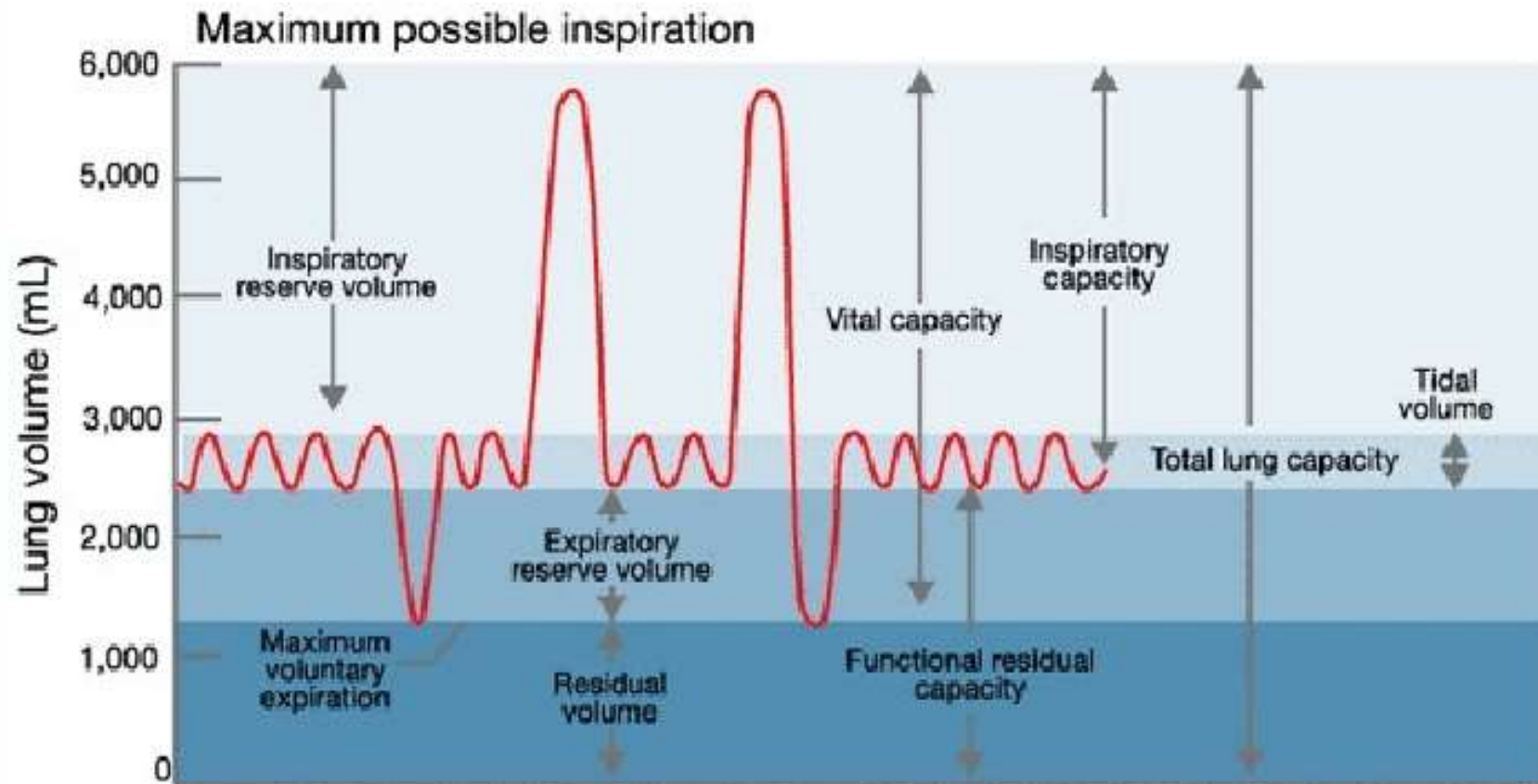
- Expiratory Reserve Volume (750-1000ml)
maximal vol. of air which can be expired after a normal tidal inspiration.
- Residual Volume (1200 ml)
volume of air left in the lungs after maximal expiration.

STATIC LUNG CAPACITIES

- Functional residual capacity (RV+ERV) (about 2.5 liters). vol. of air left in the lungs at end expiratory position.
- Inspiratory capacity (TV+IRV) about 2500-3700 ml. max. vol. of air that can be inspired after completing tidal expiration

- Expiratory capacity (TV+ERV) about 1250-1500ml.max vol of air which can be expired after completing tidal inspiration.
- Vital capacity (IRV+TV+ERV) (about 4.8 L in males and 3.2 L in female).
 - max. amount of gas that can be expelled from the lungs by forceful effort following a maximal inspiration.
- Total lung capacity (IRV+TV+ERV+RV or VC+RV) about 5800 ml. the vol of air contained in the lungs after a maximal inspiration.

Lung Volumes and Capacities



Dynamic lung capacities

- Timed vital capacity(TVC) or forced vital capacity(FVC) - maxi volume of air which can be breathed out as forcefully and rapidly as possible following a maximum inspiration.

Components of FVC:-

1. FEV1 (forced expiratory volume in 1 sec)- vol of FVC expired in 1st sec of exhalation. 80% of FVC
 2. FEV2. - 95% of FVC
 3. FEV3 – 98-100% of FVC
- Minute ventilation or pulmonary ventilation- vol of air expired or inspired by the lungs in 1 minute. 6L/min
 - Maximum breathing capacity(MBC)- largest vol of air that can be moved into and out of the lungs in 1 minute by maximum voluntary effort. 90-170 L/min

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Thank you.

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