THE RESPIRATORY SYSTEM I

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TOPIC

1. Respiratory Tract
2. Pulmonary Ventilation
3. Lung volumes and capacities
4. Gas Exchange
5. Transport of oxygen and carbon dioxide
6. Respiratory Control
7. Disorders on Respiratory System

1. Respiratory Tract

The Respiratory system consist of

I. Structurally

1. The upper respiratory system
   a. Nose
   b. Pharynx (throat)

2. The lower respiratory system
   a. Larynx
   b.Trachea
   c. Bronchi
   d. Lungs

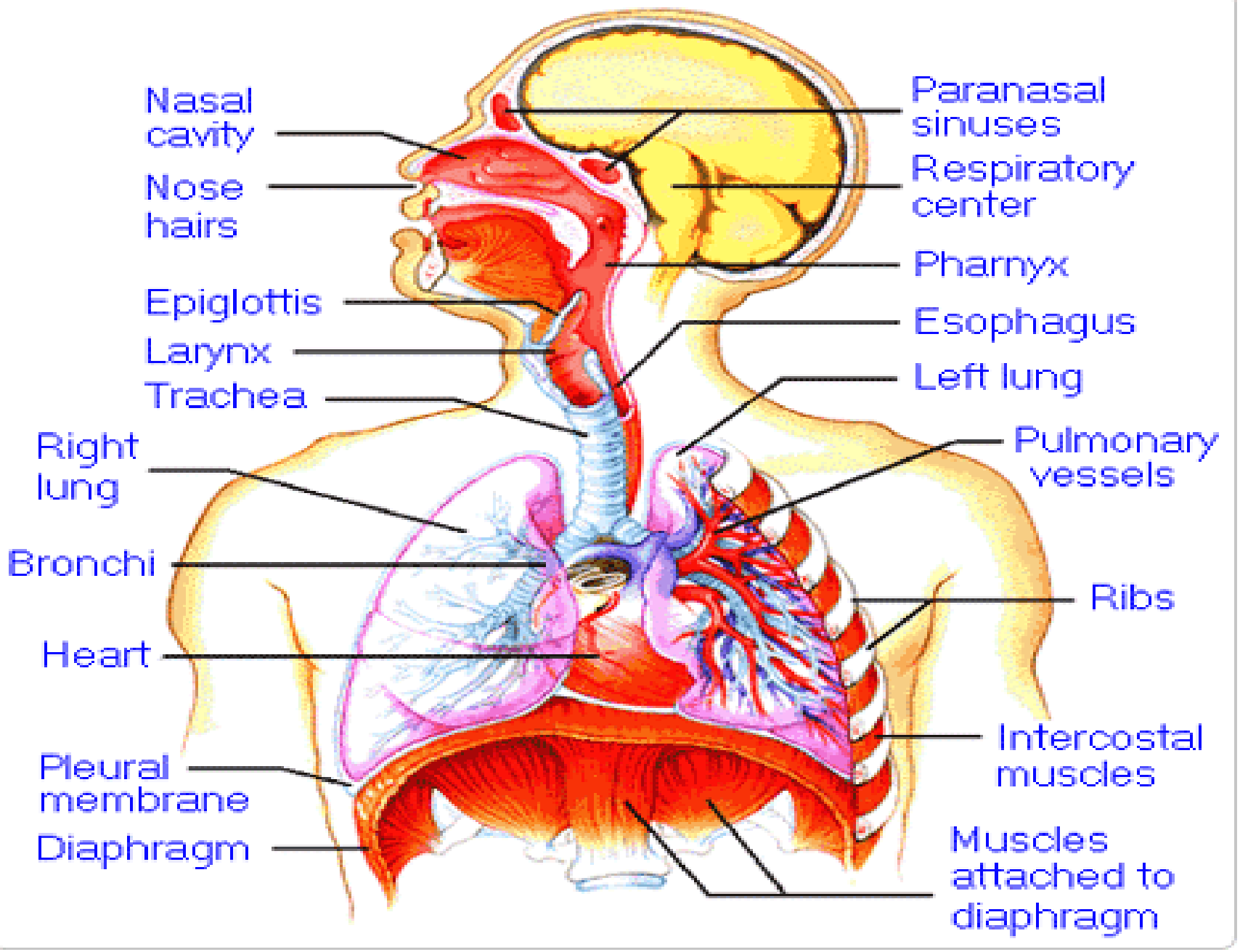
II. Functionally

1. The conducting zone
    - a . nose
    - b. pharynx (throat)
    - c. larynx
    - d. trachea
    - e. bronchi
    - f. bronchioles and terminal bronchioles

--→ filter, warm, moisten air and conduct it into the lungs

2. The respiratory zone
    a. respiratory bronchioles
    b. alveolar ducts
    c. alveoli

-→ gas exchange between air and blood


Nasal cavity
Nose hairs
Epiglottis
Larynx
Trachea
Right lung
Bronchi
Heart
Pleural membrane
Diaphragm
Paranasal sinuses
Respiratory center
Pharnyx
Esophagus
Left lung
Pulmonary vessels
Ribs
Intercostal muscles
Muscles attached to diaphragm

The function of Respiratory system :

- gas exchange
- participates in regulating blood pH
- contains receptor for the sense of smell
- filters inspired air
- produces sounds
- rides the body of some water and heat in exhaled air

NOSE

- The External nose :

  The bony framework

  - the frontal bone,
  - nasal bones
  - maxillae

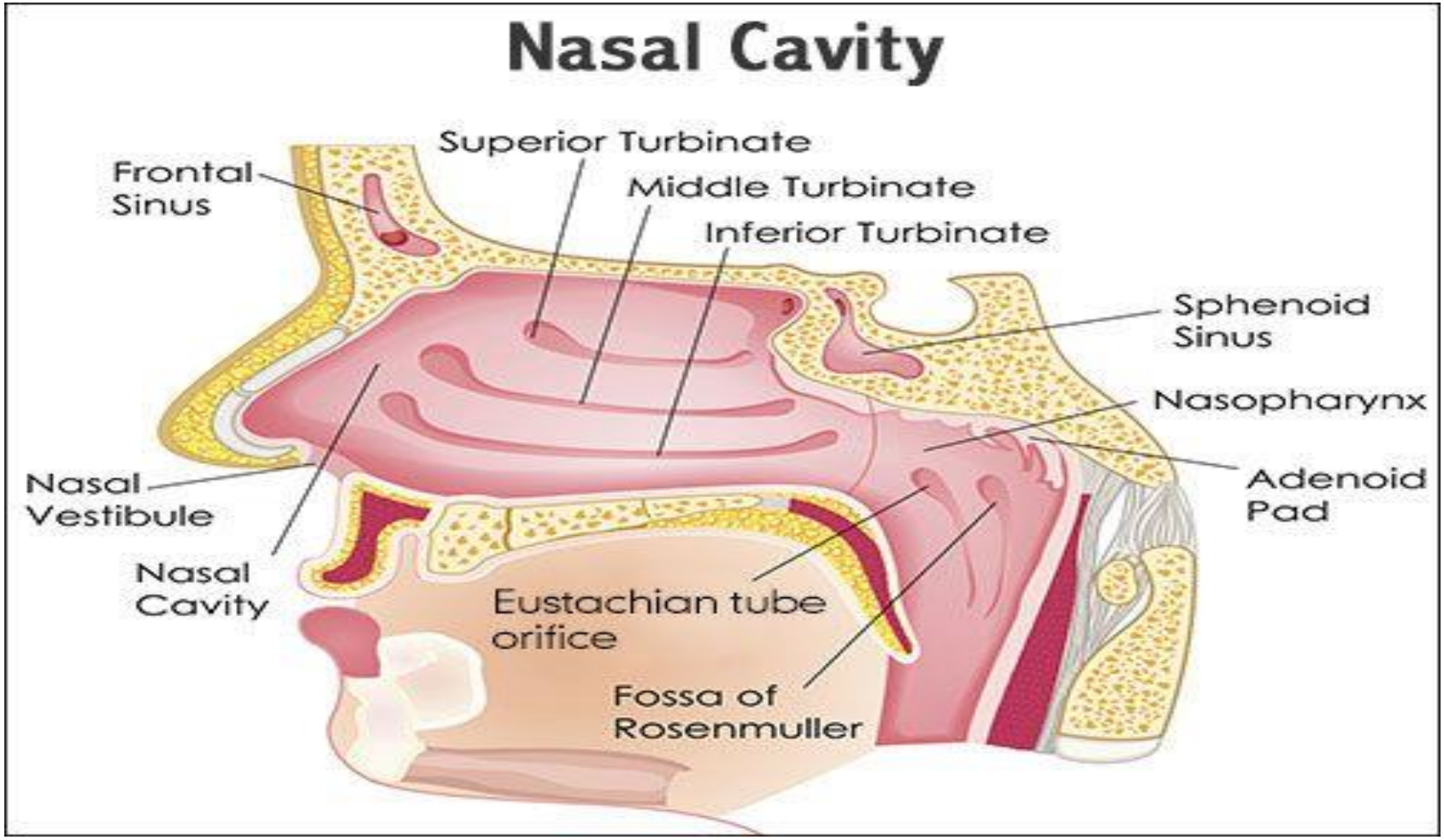
  The cartilaginous framework

  - the septal cartilage
  - the lateral nasal cartilages
  - the alar cartilages

The function of the interior structures of the external nose :

1. warming, moistening, and filtering incoming air
2. detecting olfactory stimuli
3. modifying speech vibrations

The **NASAL CAVITY** (nose) is the preferred entrance for outside air into the Respiratory System. The hairs that line the inside wall are part of the air-cleansing system.


Nasal Cavity
Superior Turbinate
Frontal Sinus
Middle Turbinate
Inferior Turbinate
Sphenoid Sinus
Nasopharynx
Adenoid Pad
Nasal Vestibule
Nasal Cavity
Eustachian tube orifice
Fossa of Rosenmuller

PHARYNX (throat)

The functions :

- A passageway for air and food.
- Provides a resonating chamber for speech sound
- House the tonsil, which participate in immuno logical reactions against foreign invaders.

- Collects incoming air from the nose and passes it downward to the trachea (windpipe).

The region of the pharynx

1. Nasopharynx : the superior portion
2. Oropharynx
3. Laryngopharynx

The muscles of the entire pharynx :

an outer circular layer

an inner longitudinal layer

Nasopharynx :

- the superior portion of the pharynx
- Lies posterior to the nasal cavity and extends to the soft palate
- Receives air from the nasal cavity
- There are 5 openings in its wall
    - 2 internal nares
    - 2 openings that lead into the auditory tubes
    - 1 opening into the oropharynx

Oropharynx

- the intermediate portion of the pharynx
- lies posterior to the oral cavity and extends from the soft palate inferiorly to the level of the hyoid bone
- has respiratory and digestive functions
- serving as a common passageway for air, food, and drink
- two pairs of tonsils, the palatine and lingual tonsils.

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Laryngopharynx /hypopharynx

- Inferior portion of the larynx
- A respiratory and a digestive pathway

- **LARYNX/VOICE BOX**

- a short passageway that connects the laryngopharynx with the trachea

-the wall of the larynx is composed of 9 pieces of cartilage:

  - 3 occur singly **(thyroid ,epiglottis and cricoid cartilage)**
  - 3 occurs in pairs **(arytenoid, cuneiform and corniculate cartilages)**

- contains the vocal cords. It is the place where moving air being breathed in and out creates voice sounds.

The extrinsic muscles of the larynx connect the cartilages to other structures in the throat.

The intrinsic muscles connect the cartilages to one another.

The thyroid cartilage (Adam's apple)

- present in males & females, but large in male due to the influence of male sex hormones on its growth during puberty

The epiglottis

- leaf shaped pieces of elastic cartilage that is covered with epithelium
- during swallowing, the pharynx and the larynx rise
- elevation of the pharynx widens it to receive food of drink
  - elevation of the larynx causes the epiglottis to move down and form a lid over the glottis, closing it off.

- the closing of the larynx in this way during swallowing route liquids and foods into the esophagus and keep them out of the larynx and airways

The **EPIGLOTTIS** is a flap of tissue that guards the entrance to the trachea, closing when anything is swallowed that should go into the esophagus and stomach.

When dust, smoke, food or liquids pass into the larynx----→ cough reflex occurs, usually expelling the material

The cricoid cartilages

- Is a ring of hyaline cartilage that forms the inferior wall of the larynx
- The thyroid cartilage is connected to the cricoid cartilage by the ***Cricothyroid ligament***

The paired arytenoid cartilage

- Attach to the vocal folds and intrinsic pharyngeal muscles.
- intrinsic pharyngeal muscles contract and move the vocal folds to produce sounds

The paired corniculate cartilage:

supporting structures for the epiglottis

The paired cuneiform cartilage :

support the vocal folds

The **ESOPHAGUS** is the passage leading from the mouth and throat to the stomach.

TRACHEA/WINDPIPE

: is the passage leading from the pharynx to the lungs

The layers of the tracheal wall are

a. mucosa

b. submucosa

c. hyaline cartilage :

d. adventitia : joins the trachea to surrounding tissues

- **BRONCHI**

The trachea divides into the two main **BRONCHI** (tubes), one for each lung. These, in turn, subdivide further into bronchioles

- the trachea divides into :

a. **a right primary bronchus**

----→ goes into the right lung

more vertical, shorter, and wider than the left

b. **a left primary bronchus**

----→ goes into the left lung

The primary bronchi divide to form smaller bronchi—*the secondary bronchi*, one for each lobe of the lung

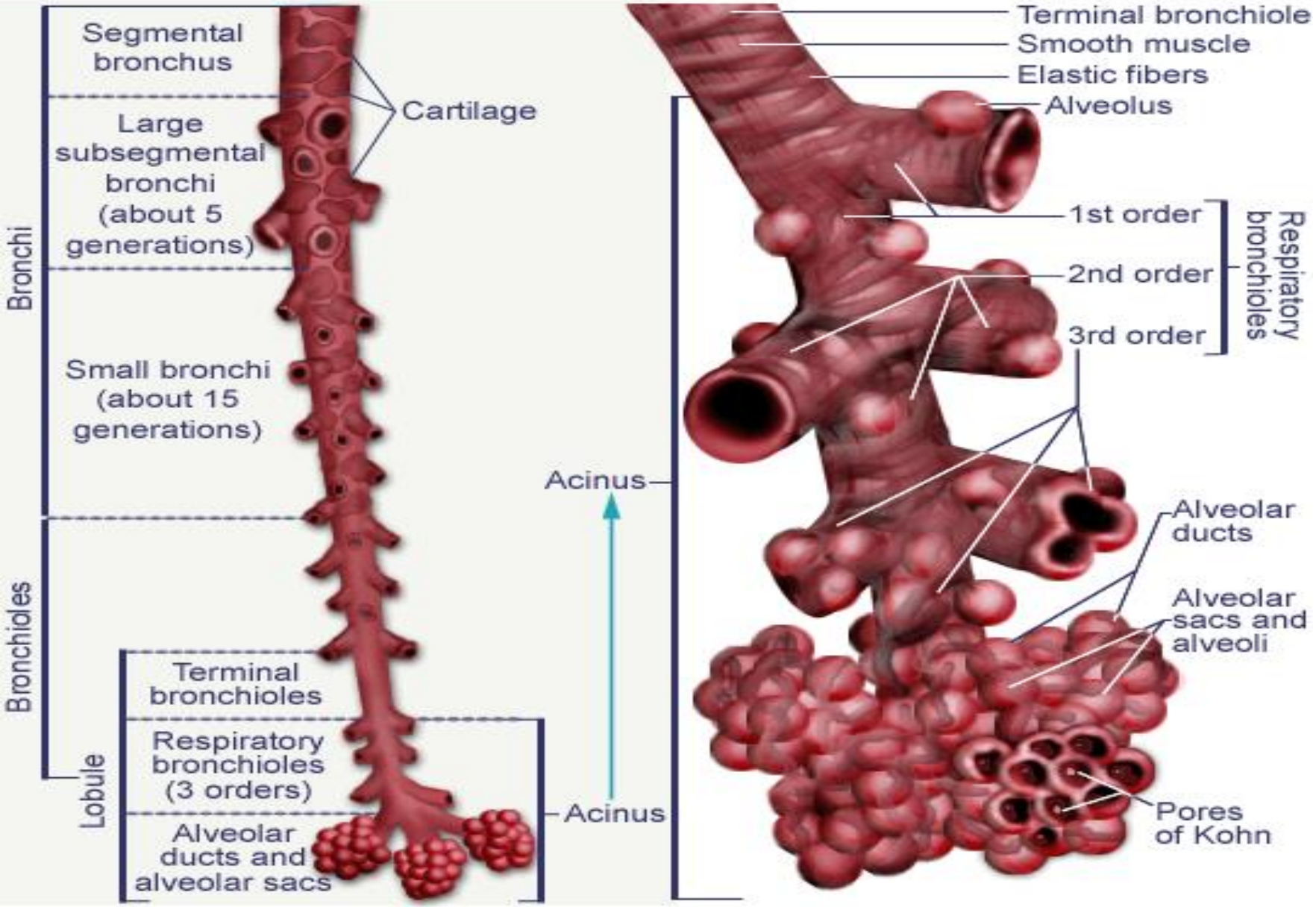
-→ the right lung has three lobes

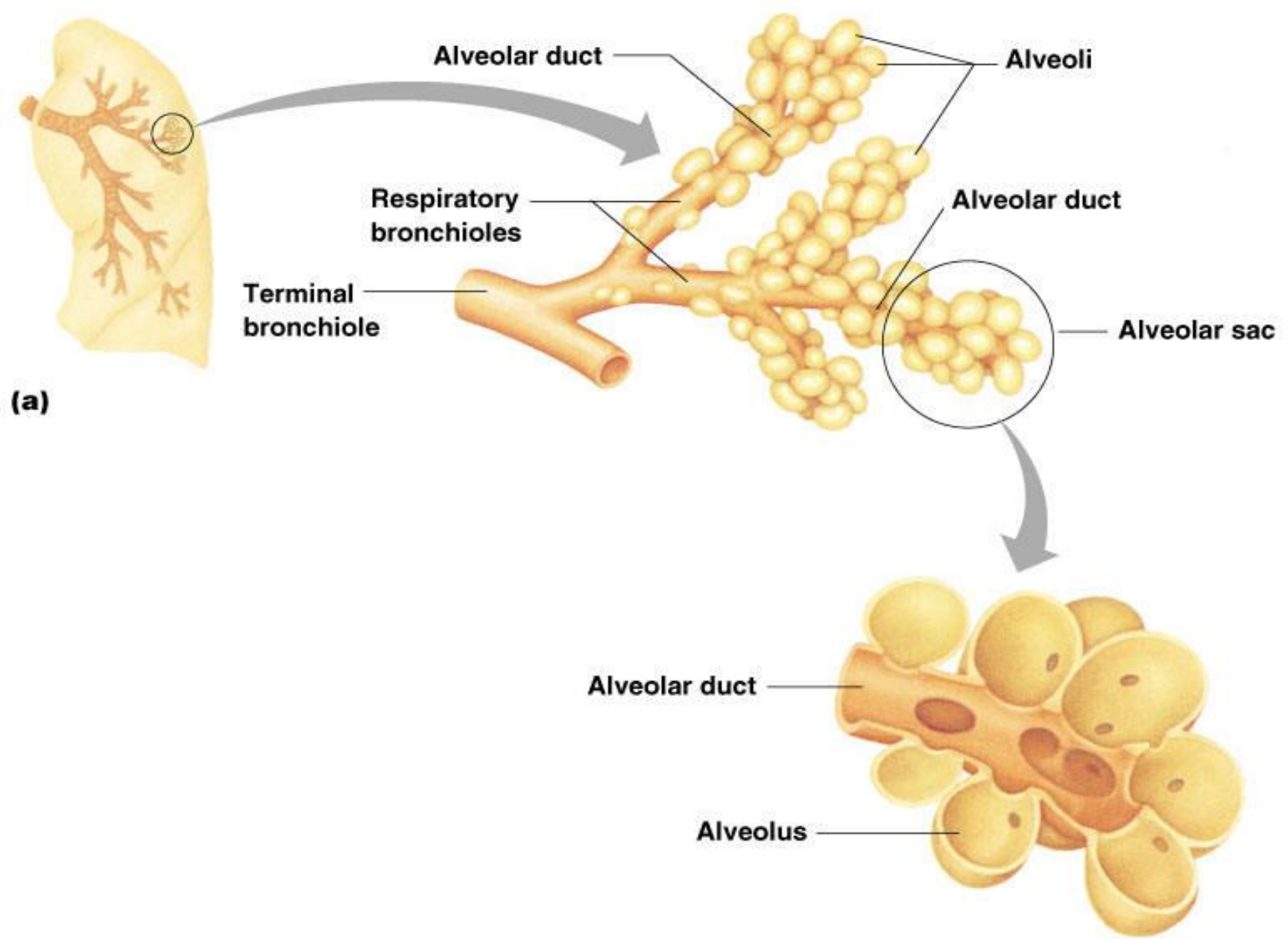
→ The left lung has two lobes

The secondary bronchi continue to branch, forming smaller bronchi ---→ tertiary bronchi -→ divide into bronchioles----→ terminal bronchioles --→bronchial tree

The smallest subdivisions of the bronchi are called **BRONCHIOLES**, at the end of which are the alveoli (plural of alveolus).

The Pulmonary Airway Tree





LUNGS

- a paired cone-shaped organs in the toracic cavity

  Pleural membrane : enclose and protect each lung

  Parietal pleura : the superficial layer

  Visceral pleura: covers the lungs themselves

  Pleural cavity : between the visceral and parietal pleurae contains a small amount of lubricating fluid secreted by the membranes -→ slide easily over one another during breathing.

Pleurisy/ pleuritis : inflammation of the pleural membrane

Pleural effusion : excess fluid accumulates in the pleural space

- The **DIAPHRAGM** is the strong wall of muscle that separates the chest cavity from the abdominal cavity. By moving downward, it creates suction to draw in air and expand the lungs.

ALVEOLI

: the exchange of O2 and CO2 between the air spaces in the lungs and the blood takes place by diffusion across the alveolar and capillary walls

The lungs contain 300 million alveoli, surface area 70 m^2

The walls of alveoli consist of two types of alveolar epithelial

1. Type I alveolar cells : the main sites of gas exchange
2. Type II alveolar cells : secrete alveolar fluid

(surfactant: lowers the surface tension of alveolar fluid , which reduces the tendency of alveoli to collapse)

The respiratory membrane consists of four layers

1. A layer of type I and type II alveolar cells and associated alveolar macrophages that constitutes the alveolar wall
2. An epithelial basement membrane underlying the alveolar wall
3. A capillary basement membrane that is often fused to the epithelial basement membrane
4. The capillary endothelium

The **ALVEOLI** are the very small air sacs that are the destination of air breathed in.

The **CAPILLARIES** are blood vessels that are imbedded in the walls of the alveoli. Blood passes through the capillaries, brought to them by the **PULMONARY ARTERY** and taken away by the **PULMONARY VEIN**.

Blood supply to the lungs

The lungs receive blood via :

- Pulmonary arteries and bronchial arteries

- Deoxygenated blood passes through the pulmonary trunk(left pulmonary artery -→ enter the left lung and right pulmonary artery -→ enter the right lung)

- Pulmonary arteries carry deoxygenated blood

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- Return of the oxygenated blood to the heart by way of the four pulmonary veins, which drain into the left atrium

- Bronchial arteries

  deliver oxygenated blood to the lungs

2. PULMONARY VENTILATION

Respiration : the process of gas exchange in the body

1. Pulmonary ventilation / breathing

   the inhalation and exhalation of air between the atmosphere and the alveoli of the lungs

2. External respiration : the exchange of gases between the alveoli and the blood in pulmonary capillaries across the respiratory membrane ---→pulmonary capillary blood gains O2 and loses CO2

3. Internal respiration

The exchange of gas between blood in systemic capillaries and tissue cell

--- the blood loses O2 and gains CO2

Factors Affecting Pulmonary Ventilation

* Air pressure differences during inhalation and exhalation
* Surface tensions of alveolar fluid
* Compliance of the lungs
* Airway resistance

Pressure Changes During Pulmonary Ventilation

Inhalation

Just before each inhalation,
the air pressure inside the lungs is equal to
the air pressure of the atm --→ + 760 mmHg
(1 atm)

For air to flow into the lungs--→ the pressure inside the alveoli must become lower than the atm pressure ----→ by increasing the volume of the lungs.

Boyle's law : inverse relationship between volume and pressure

The same number of molecules in half the volume produces twice the pressure

The main muscle of inhalation is

- **the diaphragm** (the most important muscle)
- **external intercostals**

contraction of the external intercostals is responsible for about 25 % of the air enters the lungs during normal quiet breathing.

During normal quiet breathing.

The diaphragm descends about 1 cm producing a pressure difference of 1-3 mm Hg and the inhalation about 500 ml of air

In strenuous breathing

Diaphragm descend 10 cm --→ produces a pressure difference of 100 mmHg and the inhalation Of 2-3 liters of air

Contraction of the diaphragm is responsible for about 75 % of the air that enters the lungs

Exhalation : breathing out: expiration

- The pressure in the lungs is greater than the pressure of the atmosphere
  Passive process because no muscular contractions.

- Starts when the inspiratory muscles relax

* Becomes active only during forceful breathing (exercise)--- muscle of exhalation – the abdominals and internal intercostals --→ contract---→
  Pressure in the abdominal region & thorax increases

Surface tension of Alveolar Fluid

Surface tension arises at all air-water interfaces because the polar water molecules are more strongly attracted to each other than they are to gas molecules in the air.

During breathing,

-- surface tension must be overcome to expand the lungs during each inhalation

During exhalation

---surface tension also accounts for two-thirds of lung elastic recoil, which decreases the size of alveoli

The surfactan

- a mixture of phospholipids and lipoproteins
- present in alveolar fluid reduces its surface tension below the surface tension of pure water
- deficiency of surfactant in premature infants causes *respiratory distress syndrome* the alveoli do not remain open due to a lack of surfactan

- Administered directly into the lungs oxygen

1. The surface tention of alveolar fluid is greatly increases-→ alveoli collapse
2. The condition is also more common in infants whose mother have DM, in male.

* Compliance of the lungs

Compliance refers to how much effort is required to stretch the lungs and chest wall

--- high compliance : the lungs and chest wall expand easily

---low compliance : resist expansion

Two principle factors :

- elasticity and
- surface tension

The lungs normally have high compliance and expand easily --→ because

- elastic fibers in lung tissue are easily stretched and
- surfactant in alveolar fluid reduces surface tension

Decreased compliance is a common feature in pulmonary conditions

1. scar lung tissue (TB)
2. cause lung tissue to become filled with fluid
3. produce a deficiency in surfactant
4. impede lung expansion in any way

Airway resistance

Depends of

- the pressure difference
- the resistance
- the degree of contraction or relaxation of smooth muscle in the wall of the airway

During inhalation the lungs expand, the bronchioles enlarge because their walls are pulled outward in all direction.

Larger diameter airways --- decreased resistance

During exhalation – airway resistance increase ---Diameter of bronchioles decreases.

3. Lung volumes and capacities

At rest a healthy adult averages 12 breaths /minute

Each inhalation and exhalation moving about 500 ml of air into and out of the lungs

Tidal Volume (V_T) : volume of one breath

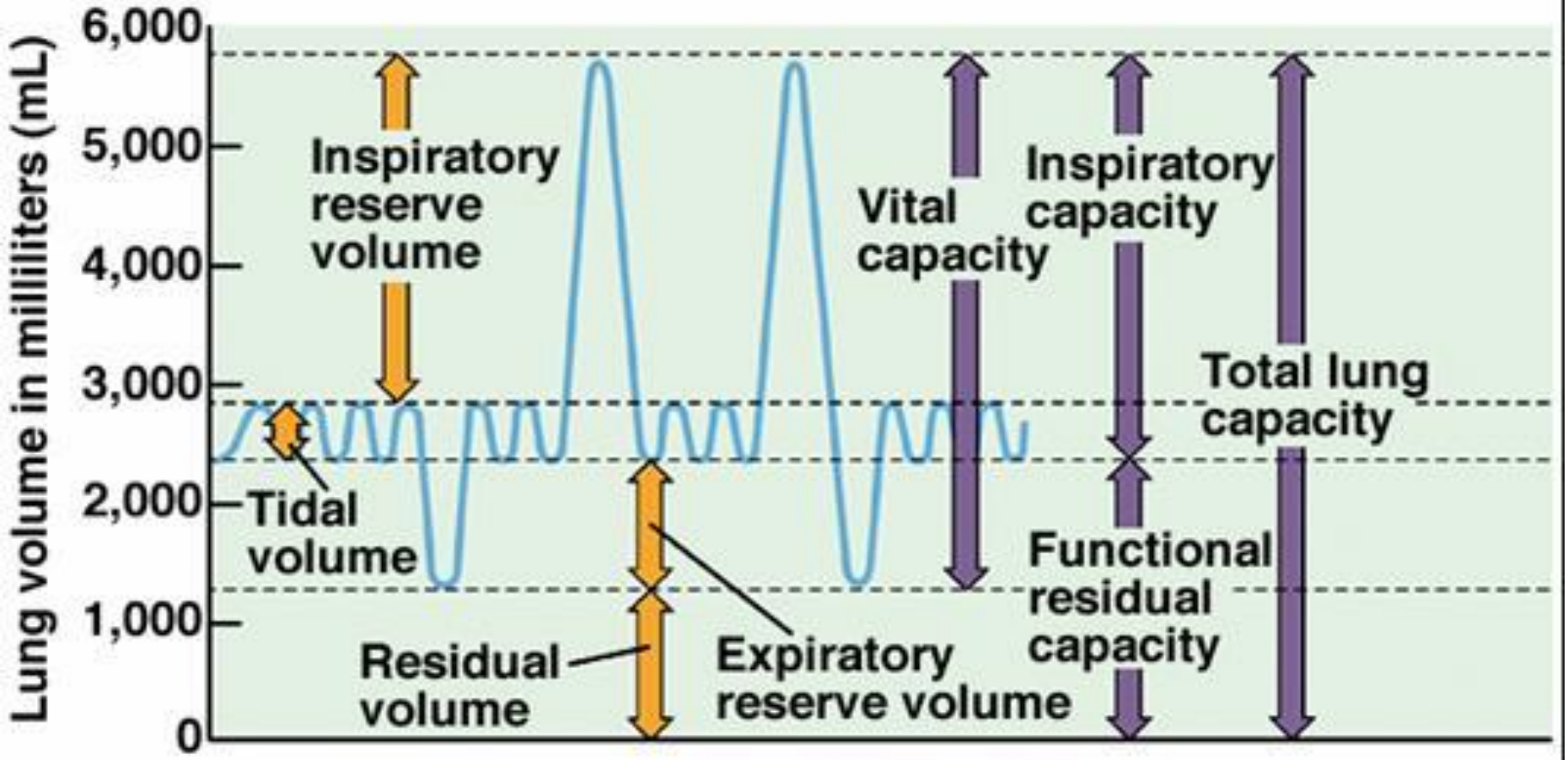
The minute ventilation (MV) :

The total volume of air inhaled and exhaled each minute

MV = 12 breath/min X 500 ml/breath

= 6 liters/min

Respiratory Volumes and Capacities



Tidal volume

In a typical adult :

70% of tidal volume (350 ml) actually reaches the respiratory zone of the respiratory system

30% (150 ml) remains in the conducting airways of the nose, pharynx, larynx,trachea, bronchi, bronchioles, and terminal bronchioles

Lung capacities:

Combinations of specific lung volumes

The sum **Inspiratory capacity**
of tidal volume and inspiratory reserve volume

In males : 500 ml + 3100 ml = 3600 ml

In females : 500 ml + 1900 ml = 2400 ml

Functional residual capacity

The sum of residual volume and expiratory reserve volume

In males : 1200 ml + 1200 ml = 2400 ml

In females : 1100 ml + 700 ml = 1800 ml

Vital capacity

The sum of inspiratory reserve volume, tidal volume, and expiratory reserve volume

In male : 4800 ml

In female : 3100 ml

Total lung capacity

The sum of vital capacity and residual volume

In male 4800 ml + 1200 ml – 6000 ml

In female 3100 + 1100 = 4200 ml