physiology

LEC.1

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Lec: 1

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فسلجة

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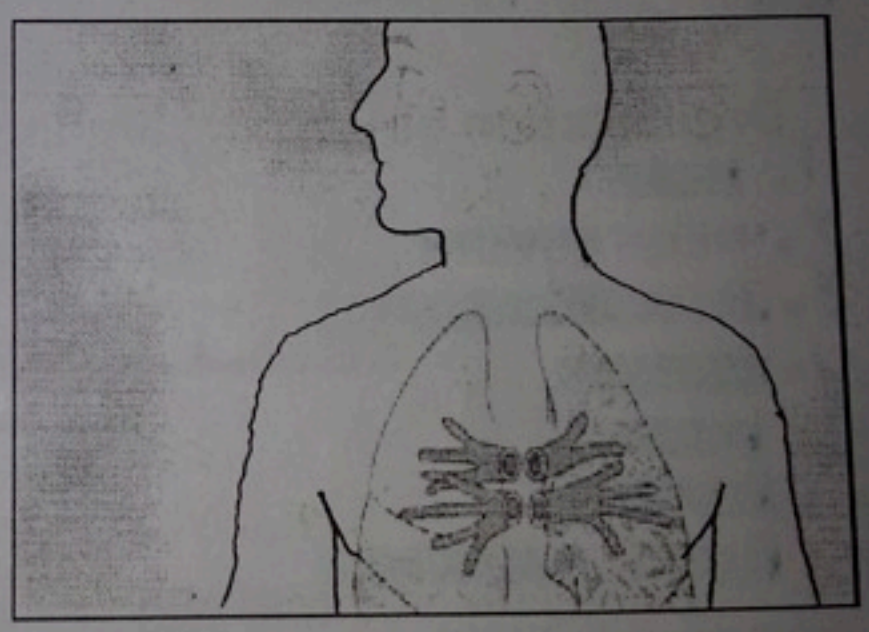
RESPIRATORY SYSTEM: EXCHANGE OF GASES

Objectives

- Functions of the Respiratory System
- Physiological anatomy
- Organization of the Respiratory System

- Respiratory Physiology
  - Pulmonary ventilation
  - Gas exchange
  - Gas transport

- The Control of Respiration
  - Local control
  - Respiratory centers of the brain
  - Reflex control of respiration
  - Control by higher centers



- The goals of respiration are
- *to provide oxygen to the tissues

* to remove carbon dioxide

Respiration can be divided into

- pulmonary ventilation
- diffusion
- transport of oxygen and carbon dioxide in the blood and body fluids to and from the body's tissue cells; and
- regulation of ventilation and other facets of respiration.

To achieve these goals

We should have :

1- efficient respiratory pump
2-efficient heart and circulatory system
3- efficient respiratory control

Functions of the Respiratory System

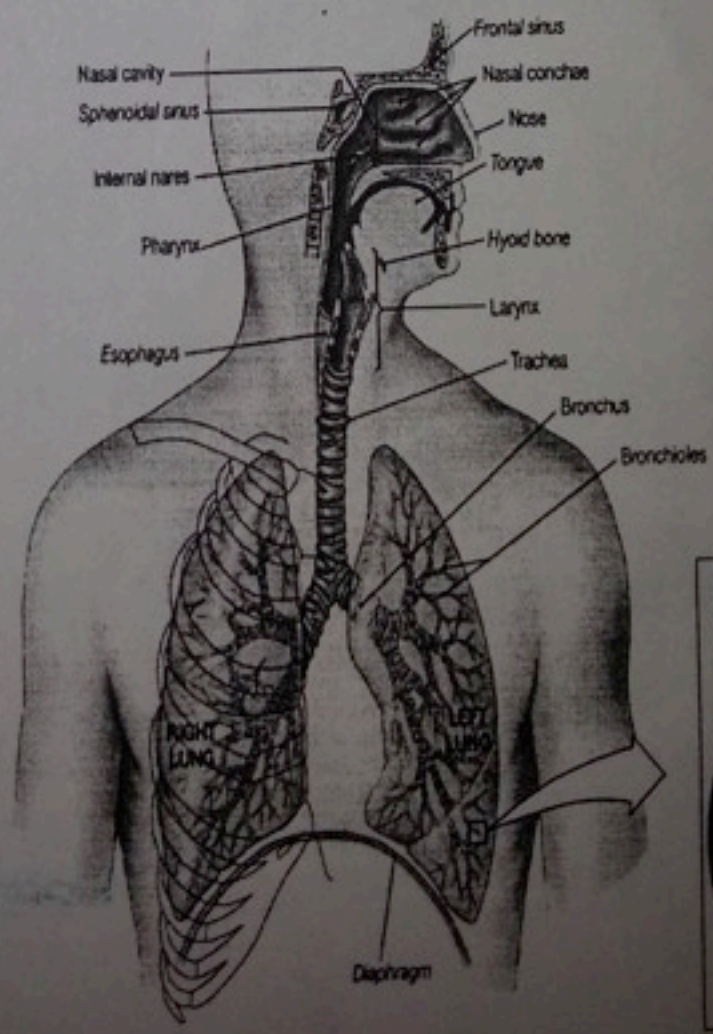
- Provides large area for gas exchange between air and circulating blood
- Moves air to and from the gas-exchange surfaces of lungs
- Protects:
  - Respiratory surfaces from dehydration and temp changes
  - Provides nonspecific defenses against invading pathogens
- Produces sounds permitting speech, singing, and nonverbal communication
- Provides olfactory sensations to the CNS for sense of smell

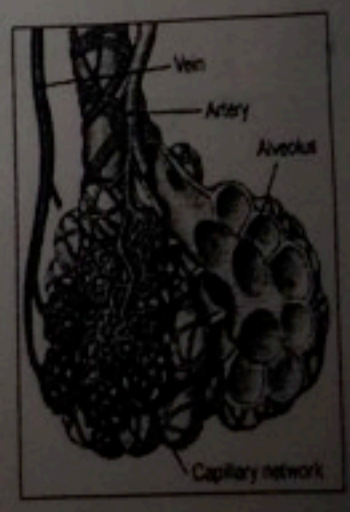
Organization of Respiratory System

- Nose
- Nasal cavities
- Paranasal sinuses
- Pharynx
- Larynx
- Trachea
- Bronchi and lungs
  - Bronchioles
  - Alveoli

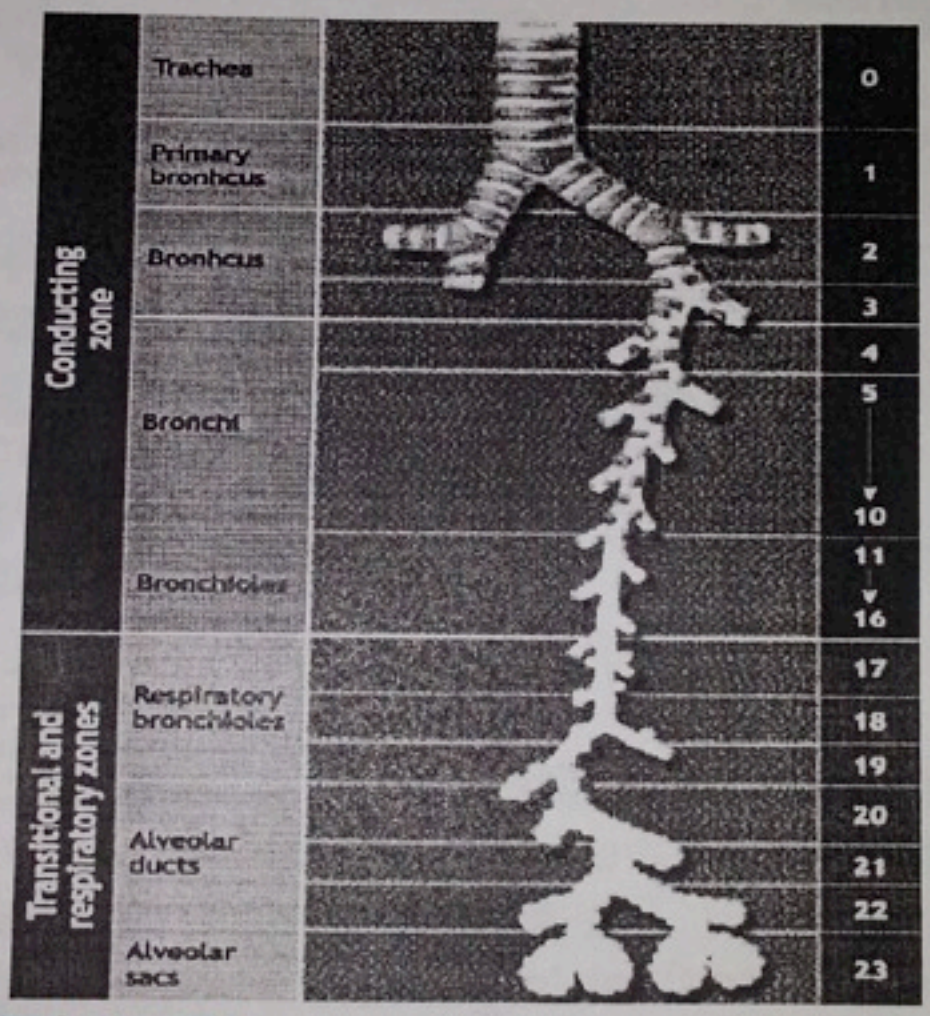
Airways in lung

- 23 generations of branching
  - Trachea (2 cm^2)
  - Bronchi





- first 11 generations of branching
- Bronchioles (lack cartilage)
  - Next 5 generations of branching
- Respiratory bronchioles
  - Last 4 generations of branching
- Alveolar ducts give rise to alveolar sacs which give rise to alveoli
  - 300 million with surface area 50-100 M^2



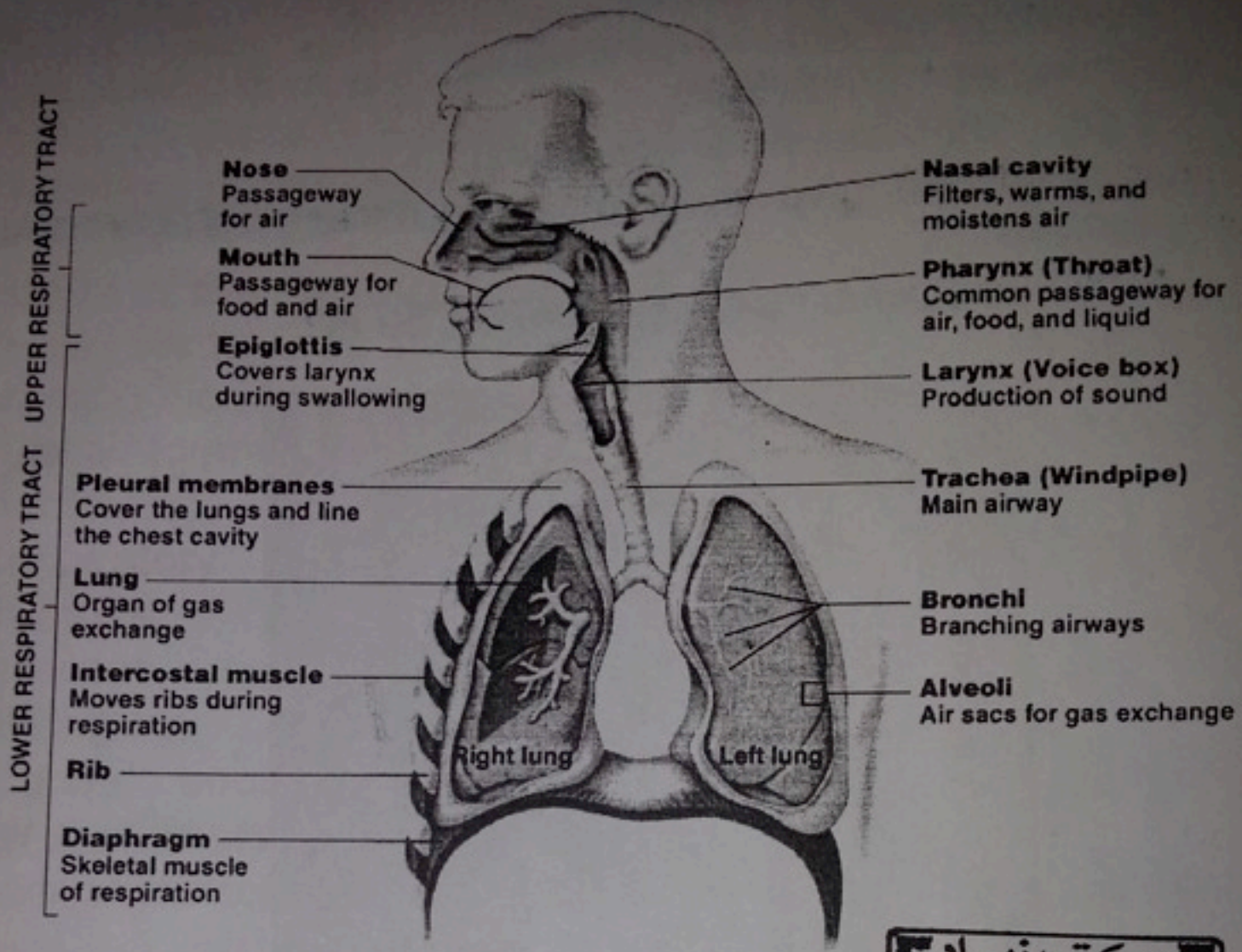
Respiratory airways

Anatomical classification:

*Nose ,pharynx, (upper resp. tract)

*Larynx, trachea, bronchi, bronchioles terminal bronchiols, respiratory bronchiols, alveolar duct ,sacs and alveoli (lower resp. tract)

Human Respiratory System

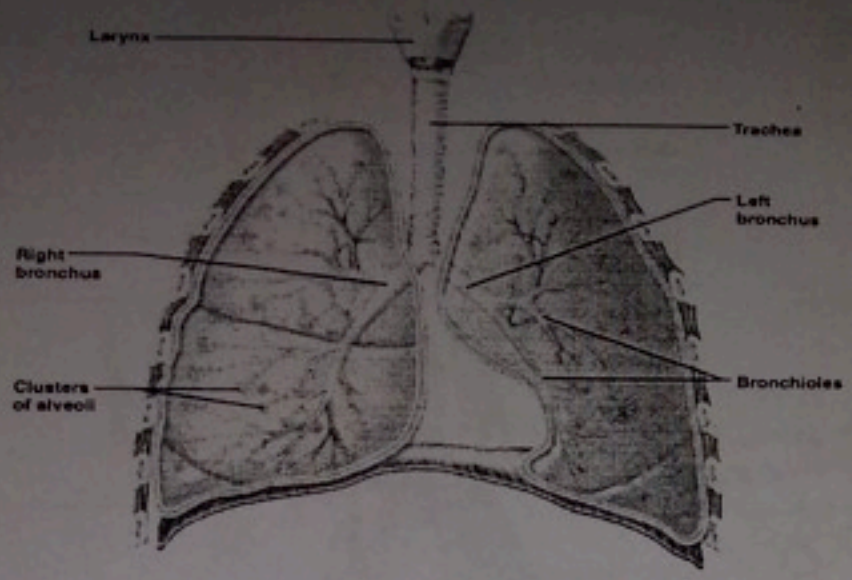


Upper Respiratory Tract Functions

- Passageway for respiration
- Receptors for smell
- Filters incoming air to filter larger foreign material
- Moistens and warms incoming air
- Resonating chambers for voice

(When a person breathes air through a tube directly into the trachea (as through a tracheostomy), the cooling and especially the drying effect in the lower lung can lead to serious lung crusting and infection).

Components of the Lower Respiratory Tract



Lower Respiratory Tract

- Functions:
- Larynx: maintains an open airway, routes food and air appropriately, assists in sound production
- Trachea: transports air to and from lungs
- Bronchi: branch into lungs
- Lungs: transport air to alveoli for gas exchange

Respiratory airways

Physiological classification

-Nose ,pharynx, Larynx, trachea, bronchi, bronchioles terminal bronchiols (conducting zone)(16 times).

-Respiratory bronchiols, alveolar duct ,sacs and alveoli (respiratory zone)(7 times)

These 23 division greatly increase the total cross sectional area.

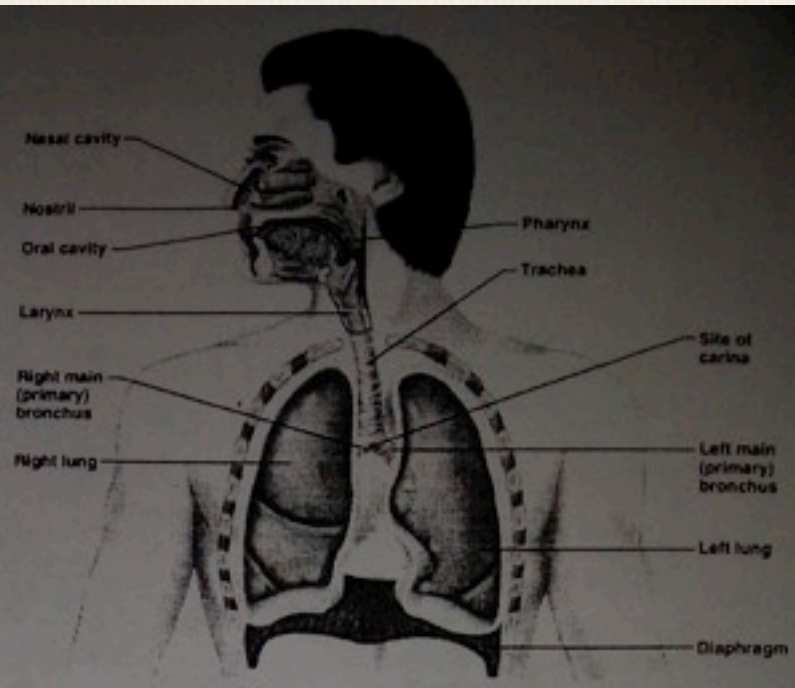
The Respiratory Organs

Conducting zone

- Respiratory passages that carry air to the site of gas exchange
- Filters, humidifies and warms air

Respiratory zone

- Site of gas exchange
- Composed of
  - Respiratory bronchioles
  - Alveolar ducts
  - Alveolar sacs



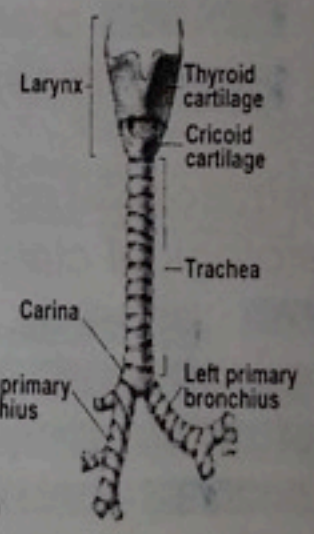
Conducting zone labeled

Conducting Zone

Includes all the structures that air passes through before reaching the respiratory zone.

Mouth, nose, pharynx, glottis, larynx, trachea, bronchi.

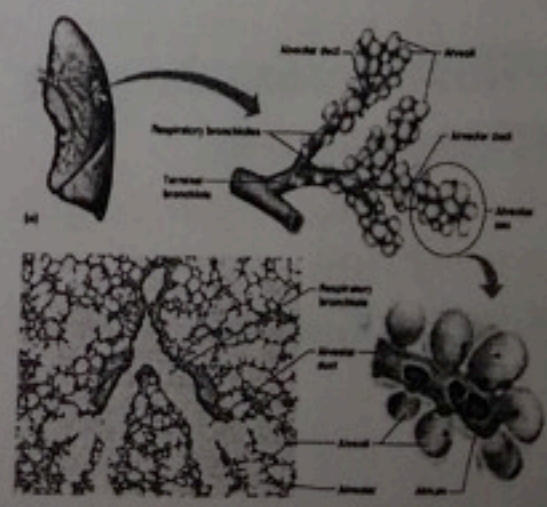
- Warms and humidifies until inspired air becomes:
  - 37 degrees
  - Saturated with water vapor
- Filters and cleans:
  - Mucus secreted to trap particles
  - Mucus/particles moved by cilia to be expectorated.



Respiratory Zone

Respiratory zone End-point of respiratory tree and Region of gas exchange between air and blood

- Respiratory bronchioles lead into alveolar ducts

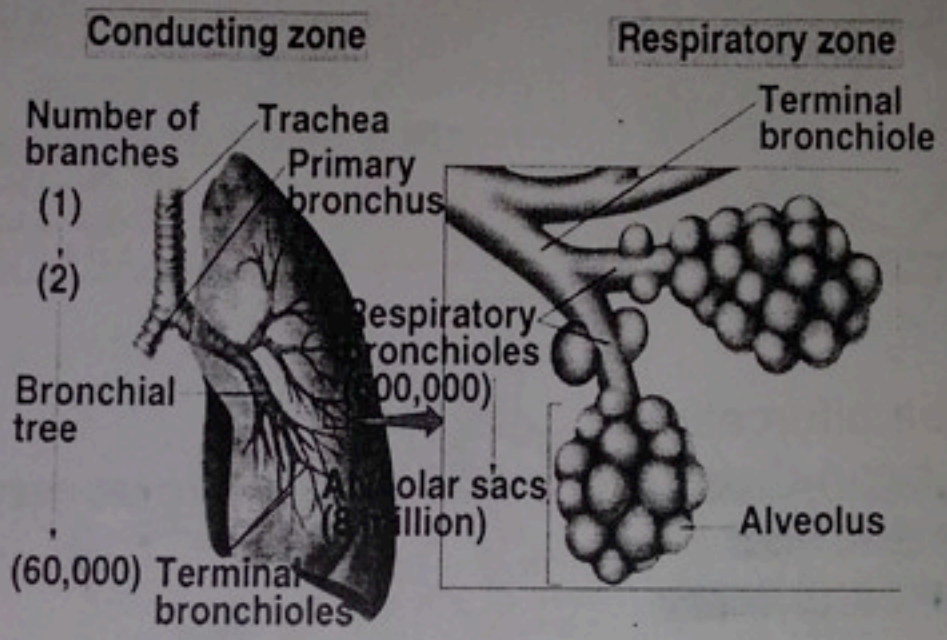


- Ducts lead into terminal clusters called alveolar sacs – and
- Alveoli (microscopic chambers)

There are 3 million alveoli

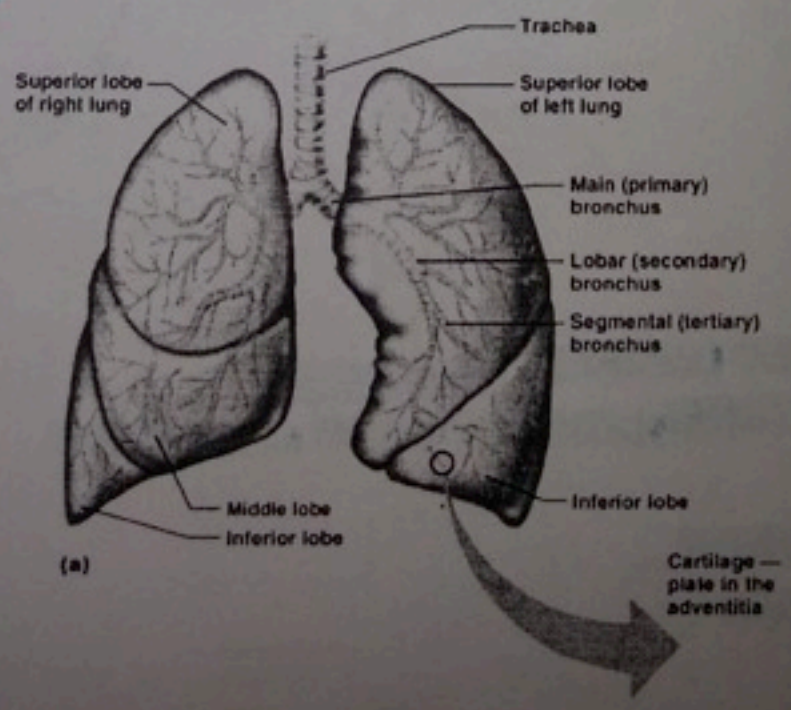
or 300 ??

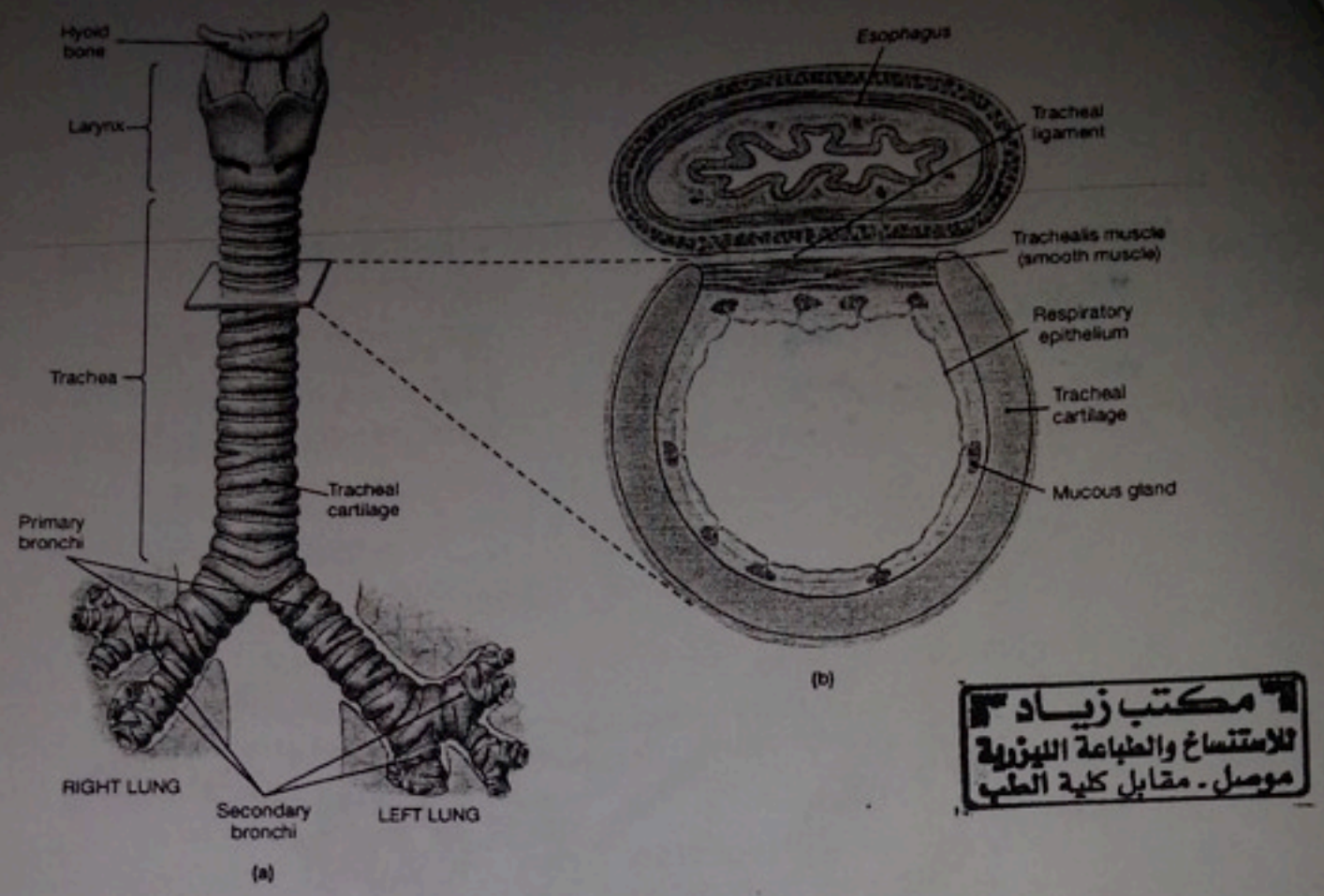
Respiratory Zone



Trachea (the windpipe)

- Descends: larynx through neck into mediastinum
- Divides in thorax into two main (primary) bronchi
- 16-20 **C**-shaped rings of hyaline cartilage joined by fibroelastic connective tissue
- Flexible for bending but stays open despite pressure changes during breathing



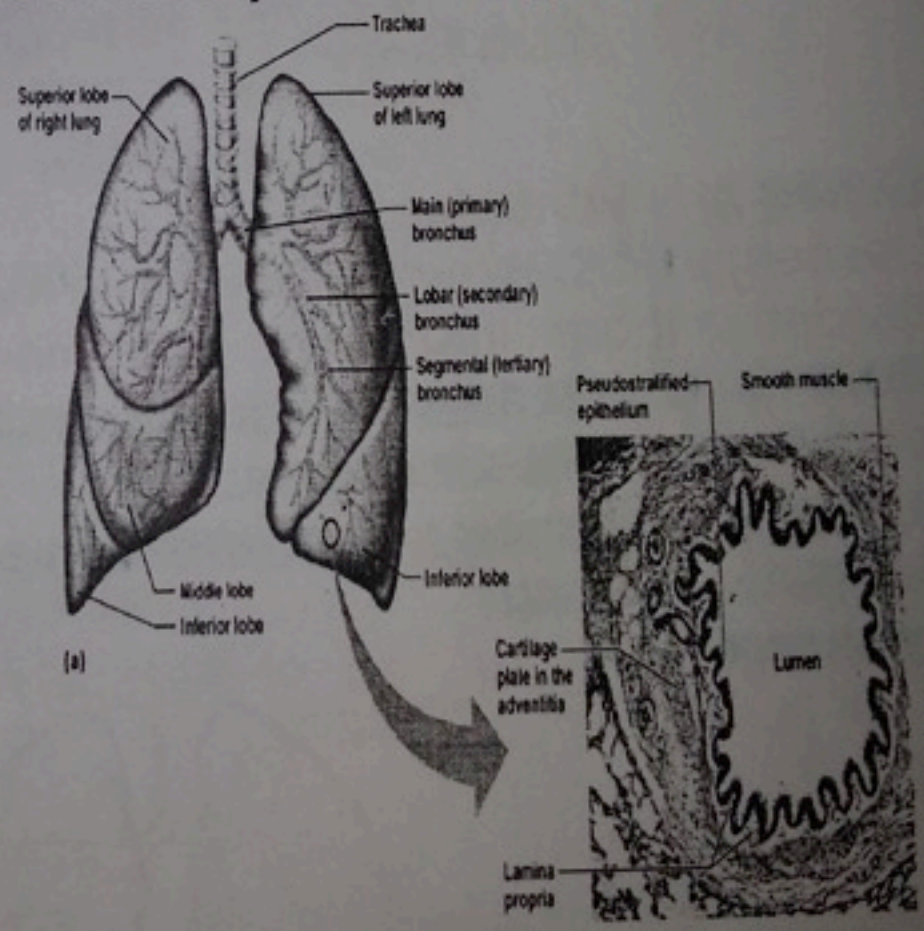


Bronchial tree bifurcation

Right main bronchus ***(more susceptible to aspiration)***

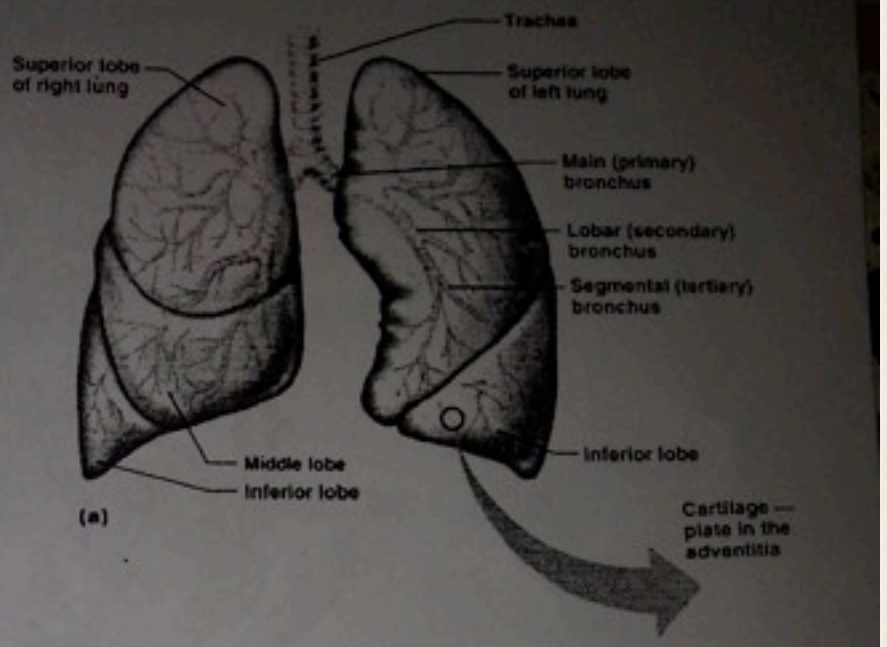
Left main bronchus

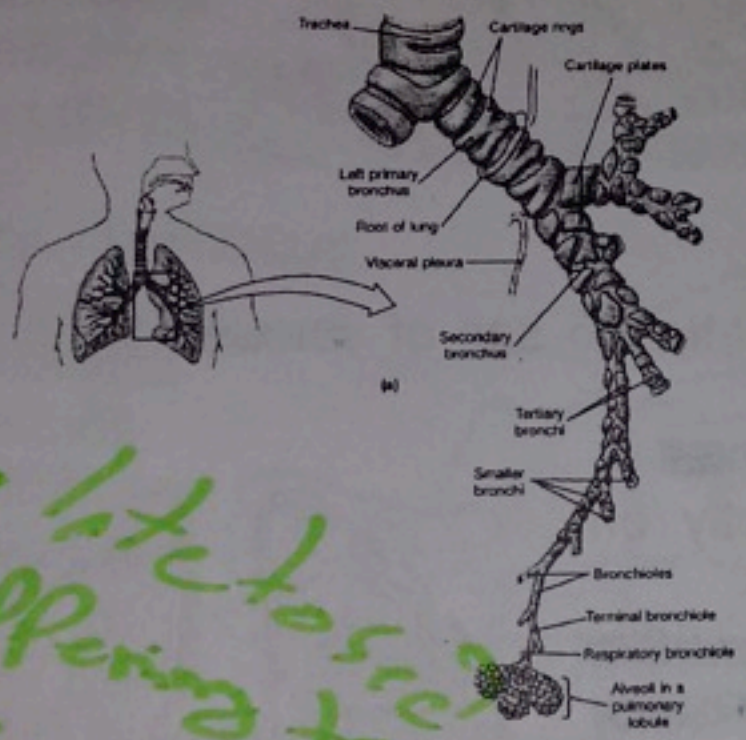
- Each main or primary bronchus runs into hilus of lung posterior to pulmonary vessels



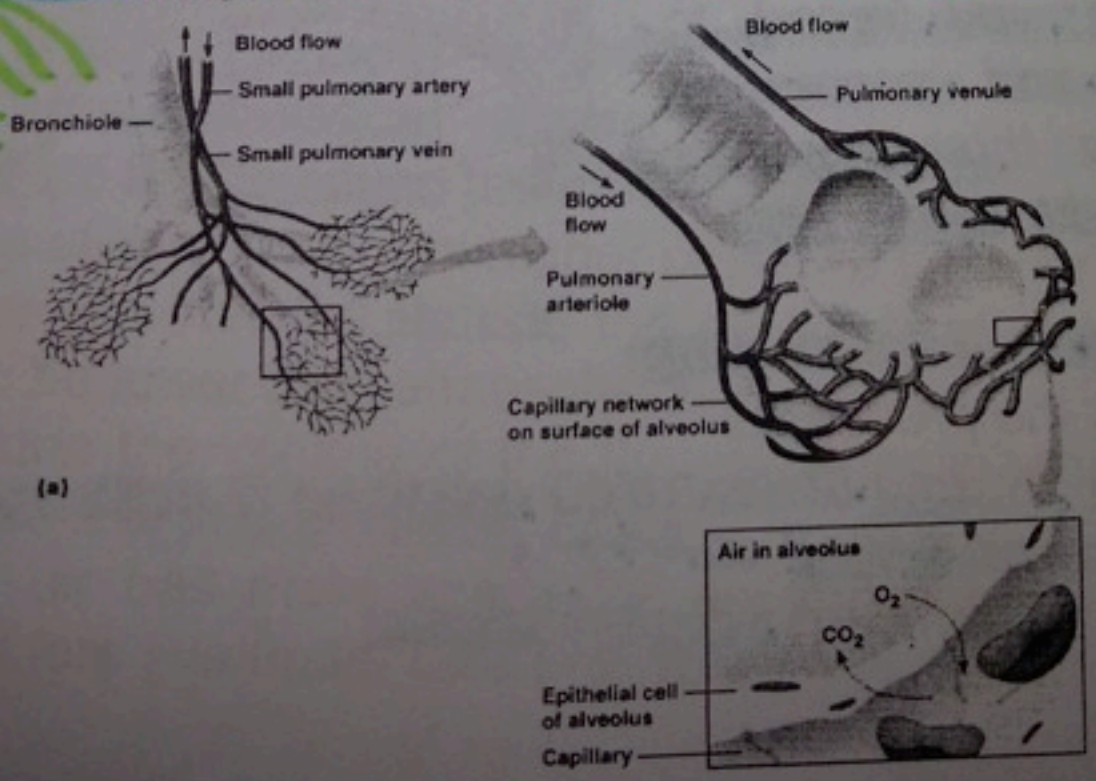
- Main=primary bronchi divide into secondary=lobar bronchi, each supplies one lobe
  - **3 on the right**
  - **2 on the left**

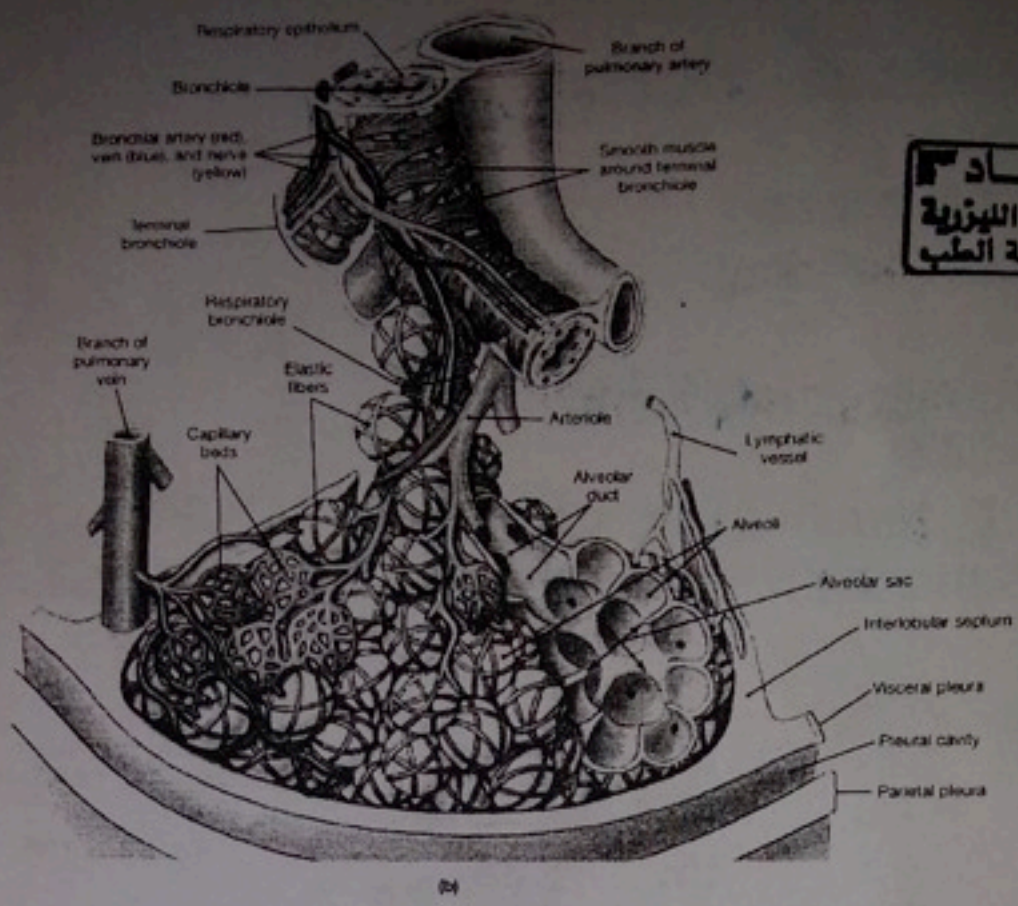
- Lobar bronchi branch into tertiary = segmental bronchi
- Continues dividing: about 23 times
- Tubes smaller than 1 mm called bronchioles
- Smallest, terminal bronchioles, are less the 0.5 mm diameter





Gas Exchange Between the Blood and Alveoli





(b)

Lungs and Pleura

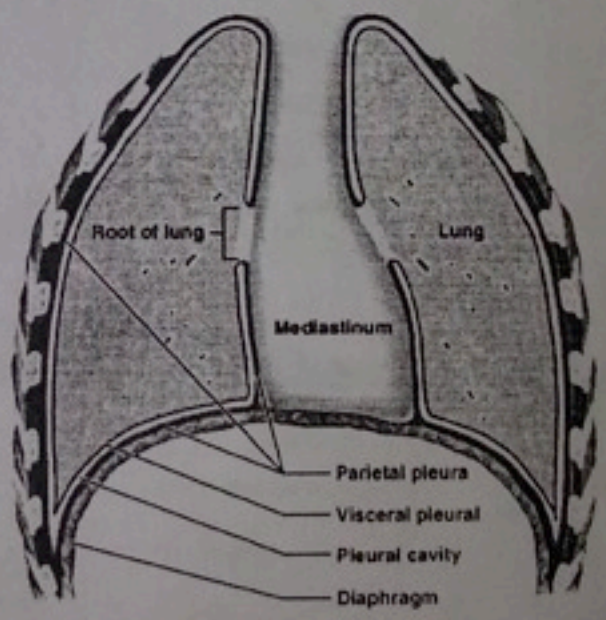
Around each lung is a flattened sac of serous membrane called ***pleura***

Parietal pleura – outer layer

Visceral pleura – directly on lung

Pleural cavity – *slit-like potential space filled with pleural fluid*

- *Lungs cling to thoracic wall and are forced to expand and recoil as volume of thoracic cavity changes during breathing*



Pneumothorax (collapsed lung)

- Think about the processes
  1. Trauma causing the thoracic wall to be pierced so air gets into the pleural cavity
  2. Broken rib can cause pneumothorax

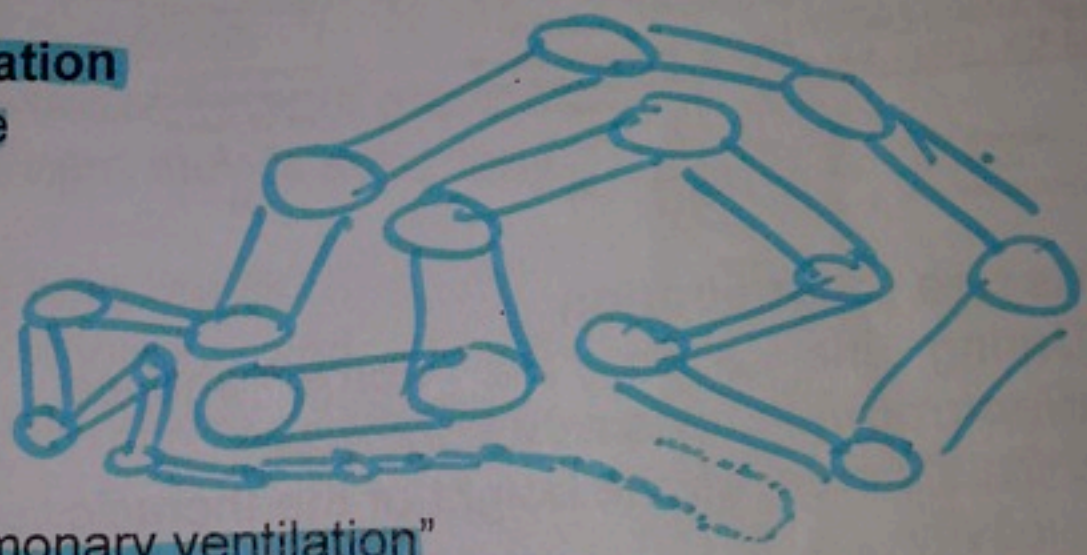
(always do a CXR if there's a broken rib)

Respiratory Physiology

- 3 steps
  - Pulmonary ventilation
    - Breathing; involves physical movement of air into and out of lungs
  - Gas exchange
    - Gas diffusion across respiratory membrane and capillary and other cells
  - Gas transport
    - Transport of oxygen and carbon dioxide between alveolar capillaries and capillary beds in other tissues

Pulmonary Ventilation

- Respiratory cycle
  - Single breath
  - Consists of:
    - Inspiration
    - Expiration



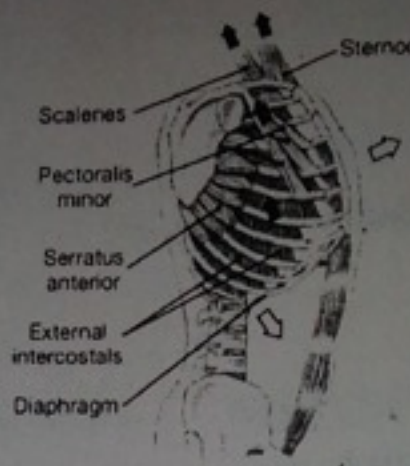
Ventilation

- Breathing = "pulmonary ventilation"
  - Pulmonary means related to the lungs
- Two phases
  - Inspiration (inhalation) – air in
  - Expiration (exhalation) – air out
- Mechanical forces cause the movement of air
  - Gases always flow from higher pressure to lower
  - For air to enter the thorax, the pressure of the air in it has to be lower than atmospheric pressure
    - Making the volume of the thorax larger means the air inside it is under less pressure
      (the air has more space for as many gas particles, therefore it is under less pressure)

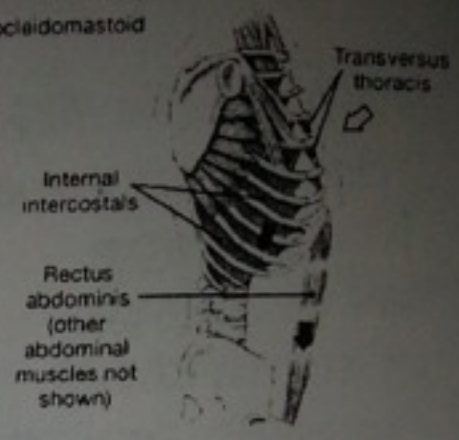
. The diaphragm and intercostal muscles accomplish this

(a)

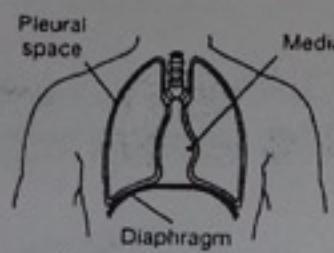

At rest



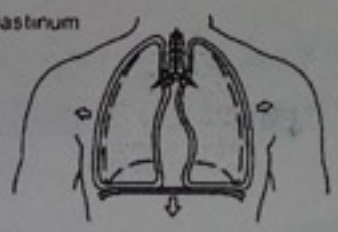
Inhalation



Exhalation



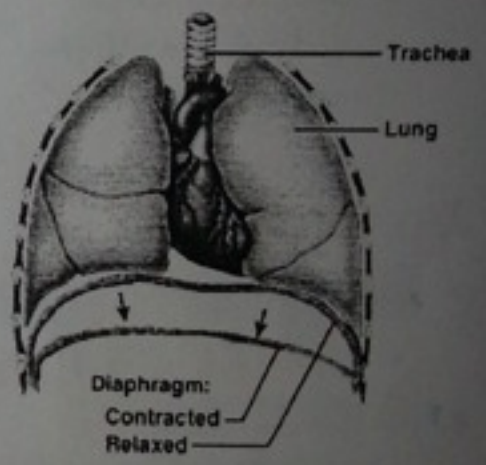
Pressure outside and inside are equal, so no movement occurs
$P_o = P_i$
(b)


Volume increases
Pressure inside falls, and air flows in
$P_o > P_i$
(c)


Volume decreases
Pressure inside rises, so air flows out
$P_o < P_i$
(d)

Muscles of Inspiration

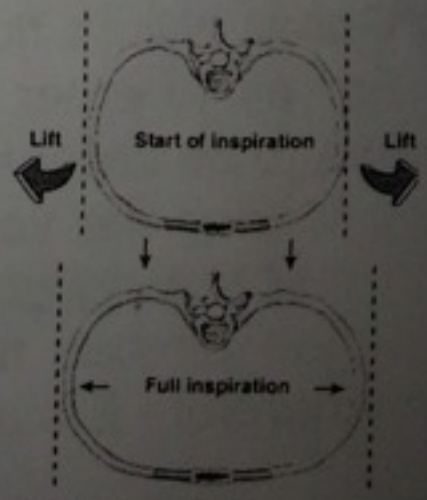
- During inspiration, the dome shaped ***diaphragm*** flattens as it contracts
  - This increases the height of the thoracic cavity



(a) Superoinferior expansion

(d) Inspiration

- The ***external intercostal muscles*** contract to raise the ribs
  - This increases the circumference of the thoracic cavity



(b) Lateral expansion

Intercostals keep the thorax stiff so sides don't collapse in with change of diaphragm

During deep or forced inspiration, additional muscles are recruited:

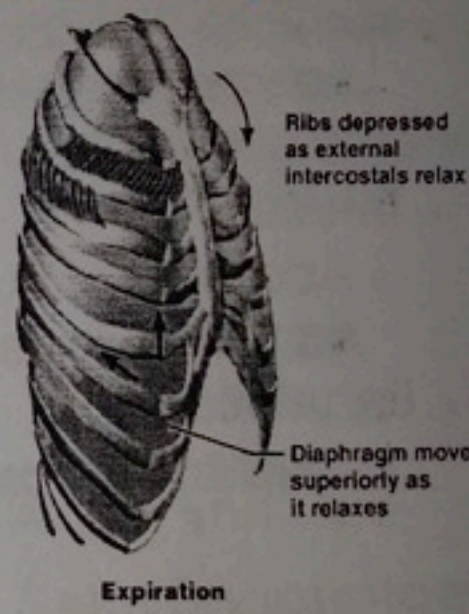
- (1) sternocleidomastoid muscles, which lift upward on the sternum
- (2) anterior serrati, which lift many of the ribs
- and (3) scaleni, which lift the first two ribs.

(some of these "accessory muscles" of ventilation are visible to an observer; it usually tells you that there is respiratory distress – working hard to breathe)

Expiration

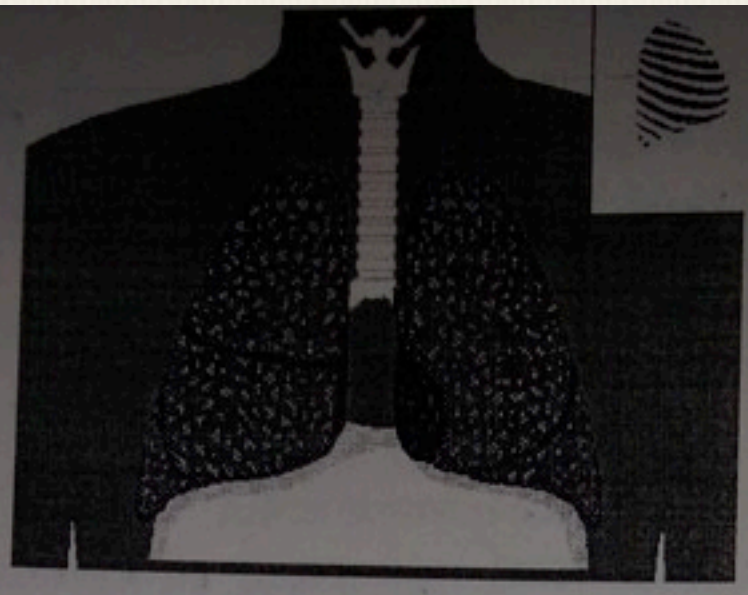
No muscle action ??

- Quiet expiration in healthy people is chiefly passive
  - Inspiratory muscles relax
  - Rib cage drops under force of gravity
  - Relaxing diaphragm moves superiorly (up)
  - Elastic fibers in lung recoil
  - Volumes of thorax and lungs decrease simultaneously, increasing the pressure
  - Air is forced out



Expiration

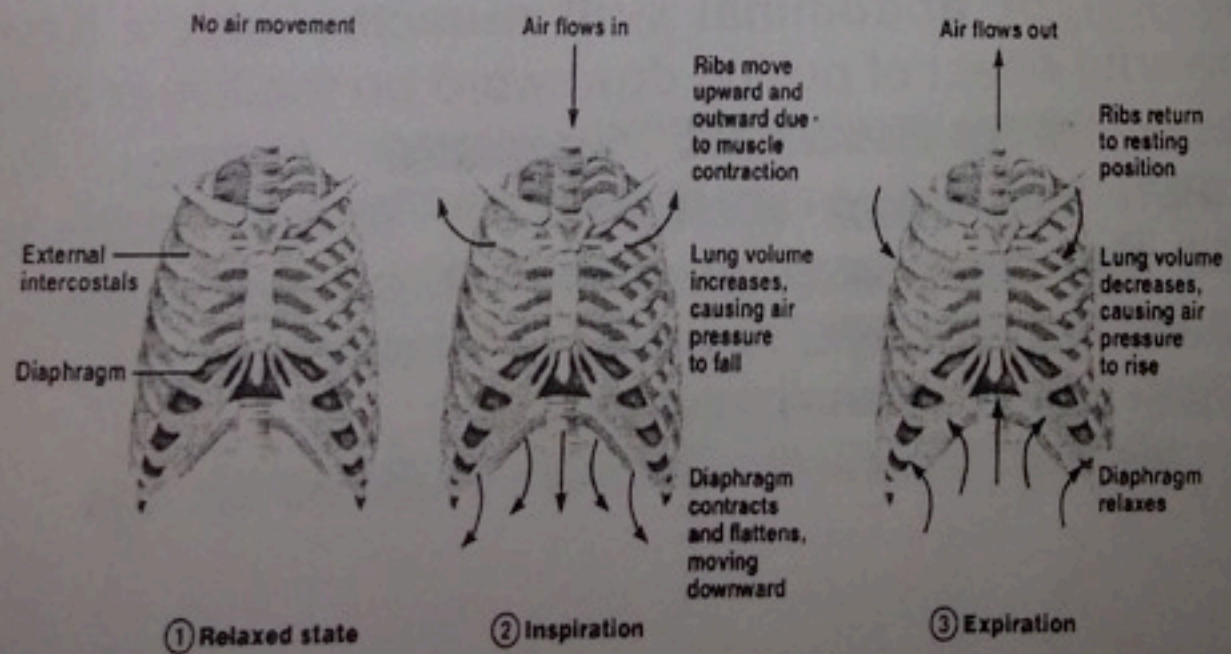
- Forced expiration is active
  - ***Contraction of abdominal wall muscles** which have the powerful effect of pulling downward on the lower ribs increases intra-abdominal pressure forcing the diaphragm superiorly at the same time abdominal muscles also compress the abdominal contents upward depressing the rib cage, decreases thoracic volume
  - ***Some help from internal intercostals**
- (try this on yourself to feel the different muscles acting)



Modes of Breathing

- Quiet Breathing
  - Inhalation requires muscles
    - Contraction of diaphragm (75%), external intercostals (25%)
  - Exhalation passive
    - Lungs recoil due to elasticity
- Forced Breathing
  - Inhalation
    - Accessory muscles include sternocleidomastoid and scalenes (muscles of the neck)
  - Exhalation
    - Internal intercostals, abdominal muscles

Respiratory Cycle



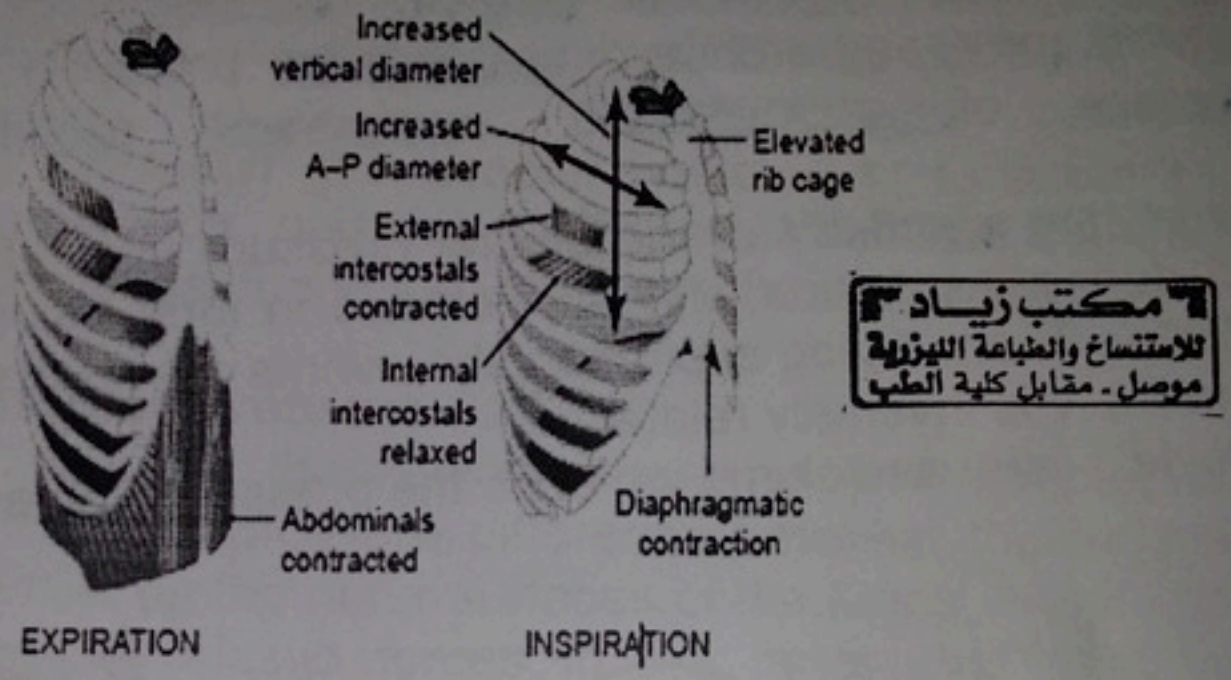
Mechanics of Pulmonary Ventilation

Muscles that cause lung expansion & contraction

The lungs can be expanded and contracted in two ways:

(1) by downward and upward movement of the diaphragm to lengthen or shorten the chest cavity

(2) by elevation and depression of the ribs to increase and decrease the anteroposterior diameter of the chest cavity



Movement of Air In and Out of the Lungs and the Pressures That Cause the Movement

*The lung is an elastic structure that collapses (like a balloon) and expels all its air through the trachea whenever there is no force to keep it inflated.

* there are no attachments between the lung and the walls of the chest cage, except at its hilum from the mediastinum.

The lung "floats" in the thoracic cavity, surrounded by a thin layer of pleural fluid that lubricates movement of the lungs within the cavity.

Continual suction of excess fluid into lymphatic channels maintains a slight suction between the visceral and the parietal pleural surface of the thoracic cavity.

Pleural pressure and its changes during respiration

Pleural pressure is the pressure of the fluid in the thin space between the lung pleura and the chest wall pleura. (slightly negative pressure).

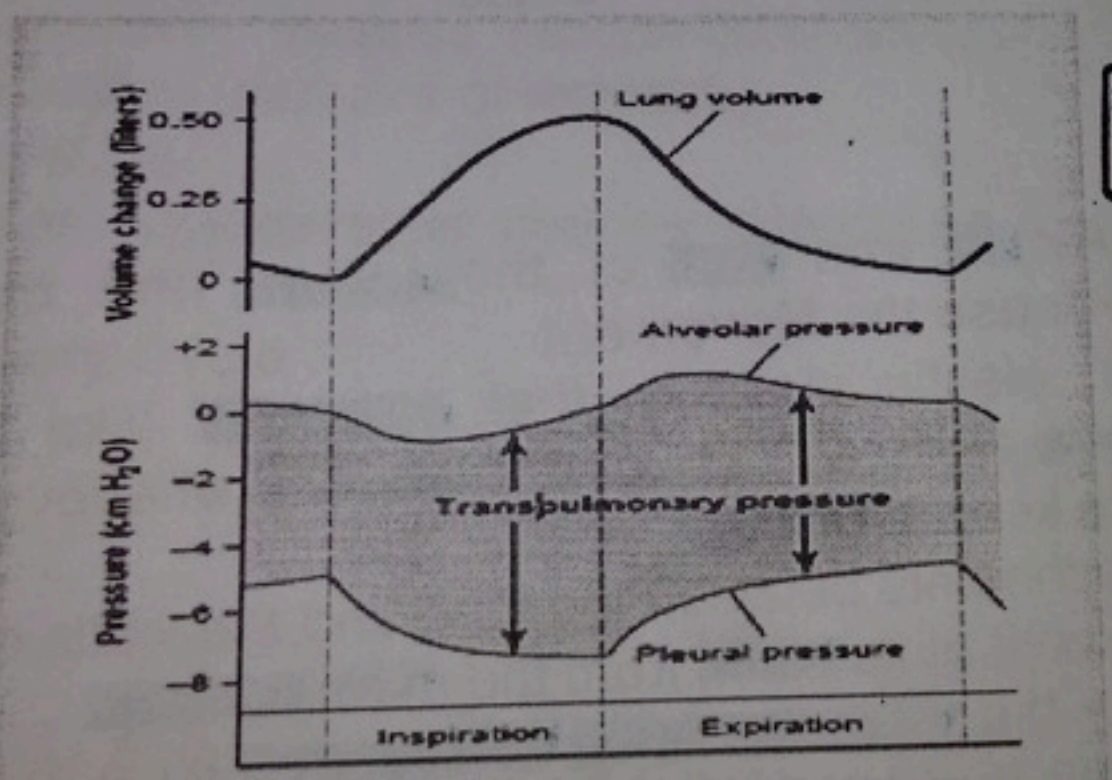
The normal pleural pressure at the beginning of inspiration is about –5 centimeters of water.

Then, during normal inspiration, expansion of the chest cage pulls outward on the lungs with greater force and creates more negative pressure, to an average of about –7.5 centimeters of water.

Increasing negativity of the pleural pressure from –5 to –7.5 during inspiration with an increase in lung volume of 0.5 liter. Then, during expiration, the events are reversed.

The P& V is inversely related

(Boyle's law) as volume increase the pressure decreases.



Changes in lung volume alveolar pressure pleural pressure and transpulmonary pressure during normal breathing

Alveolar Pressure

Alveolar pressure is the pressure of the air inside the lung alveoli. When the glottis is open and no air is flowing into or out of the lungs, the pressures in all parts of the respiratory tree, all the way to the alveoli, are equal to atmospheric pressure.
(0 centimeters water pressure).
During normal inspiration, alveolar pressure ↓↓ to about –1 centimeter of water.
This slight negative pressure is enough to pull 0.5 liter of air into the lungs in the 2 seconds required for normal quiet inspiration.

During expiration, the alveolar pressure ↑↑ to about +1 centimeter of water, and this forces the 0.5 liter of inspired air out of the lungs during the 2 to 3 seconds of expiration.

Transpulmonary Pressure.

Difference between the alveolar pressure and the pleural pressure. It is the pressure difference between that in the alveoli and that on the outer surfaces of the lungs, and it is a measure of the elastic forces in the lungs that tend to collapse the lungs at each instant of respiration, called the recoil pressure.