Respiratory revision

Dr. Amr Medhat Abbas

Professor of Medical Physiology

Functional divisions of respiratory system and mechanics of breathing

Dr. Amr Medhat Abbas

Professor of Medical Physiology

(I) Air passages and lung

- **divided into two functional zones:**

A) Air conducting zone:

- **Include:** nose, nasopharynx, larynx, trachea, 2 main bronchi and the smaller bronchioles till the respiratory bronchioles.
- **Walls:** thick & **do not allow gas exchange** (dead space).

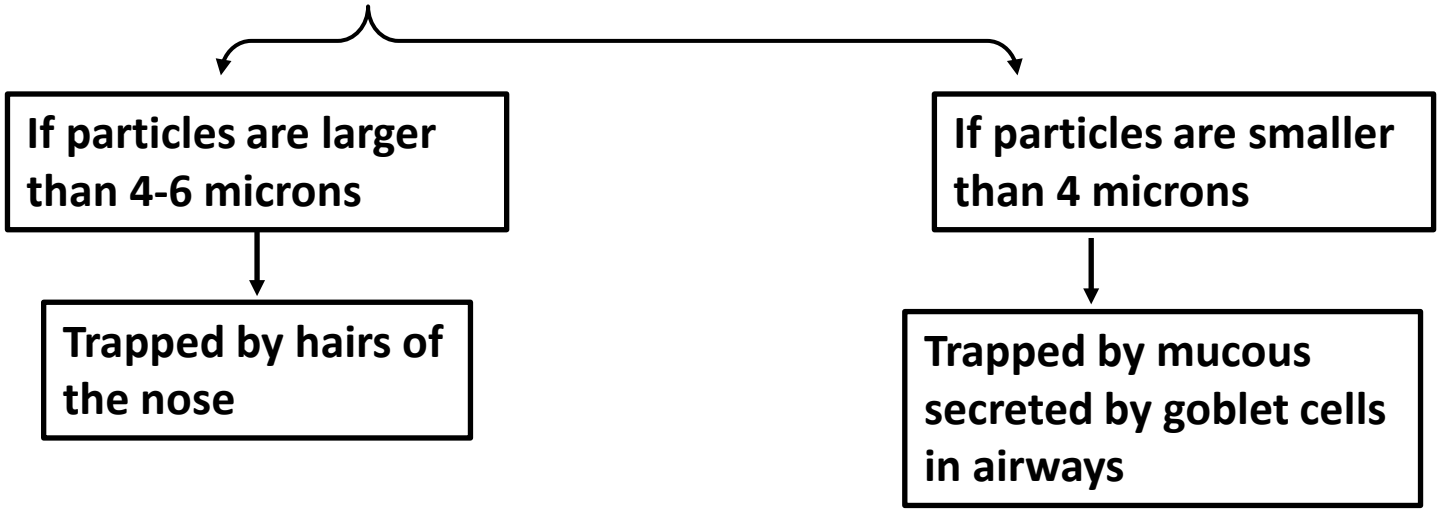
➢ Functions:

1. **Conduction of air:** into the respiratory zone.
2. **Air conditioning:** Mucosa of mouth, nose & pharynx has a **large surface area** and **rich blood supply** → **add heat** to cold air or **remove heat** from hot air → inspired air reach the respiratory zone at a temperature of **37°C** → maintain **constant internal body temperature**.

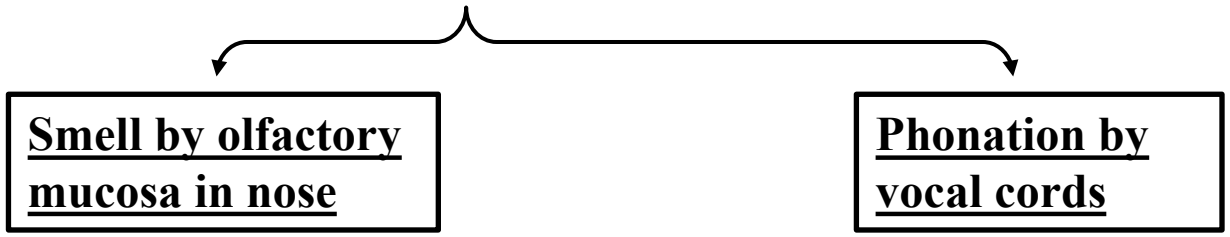
3. **Humidification of air:**

- Air is saturated with **water vapor** to protect delicate lung tissue from dryness.
- Occurs by transcapillary fluid in the mucous membrane.

4. **Filtration:**



5. **Protective reflexes:** cough reflex and sneezing reflex.
6. **Non respiratory functions:**



PULMONARY VENTILATION

- **Def:** It is **renewal of air** in the lung alveoli from the atmospheric air by movement of air in **(inspiration)** followed by its movement out **(expiration).**
- This occurs in cycles called ***"respiratory cycles"***.

- **Respiratory cycle:**

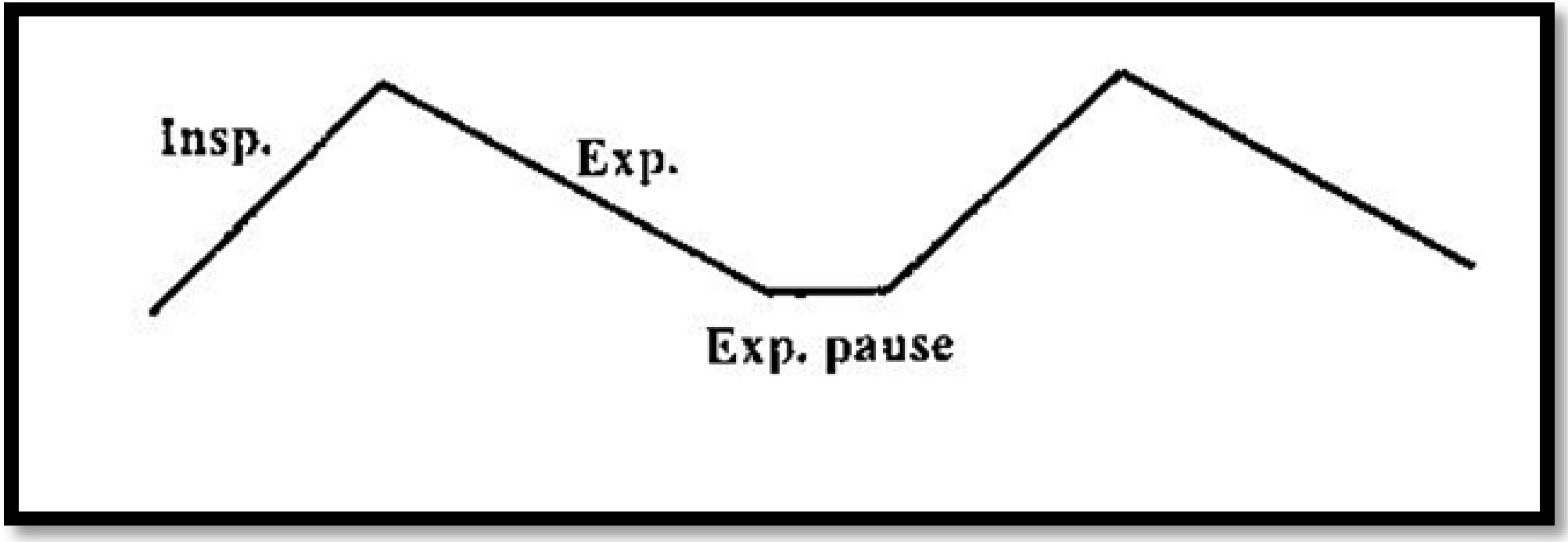
	1- Inspiration	2- Expiration
-**Duration**	1.3 sec.	1.7 sec.
-**Process**	Active.	Passive.
-**Thoracic cavity**	Increase.	Decrease.
-**Lung**	Distend.	Recoil.
-**Air**	Rushes into the lung.	Rushes out of lung.

*** Duration of respiratory cycle: 1.3 + 1.7 + 0.7 = 3.7 seconds.**

*** Respiratory rate = 60/3.7 = 16/min. In children = 25/min.**

3- Expiratory pause:

- ***A period of rest*** sometimes present after expiration.
  - ***Duration:*** 0.7 second.
  - ***Absent in rapid resp***. e.g. muscular exercise



Respiratory cycle

- **Mechanics of respiration:**

(I) Normal respiration (eupnea):

A-Normal inspiration:

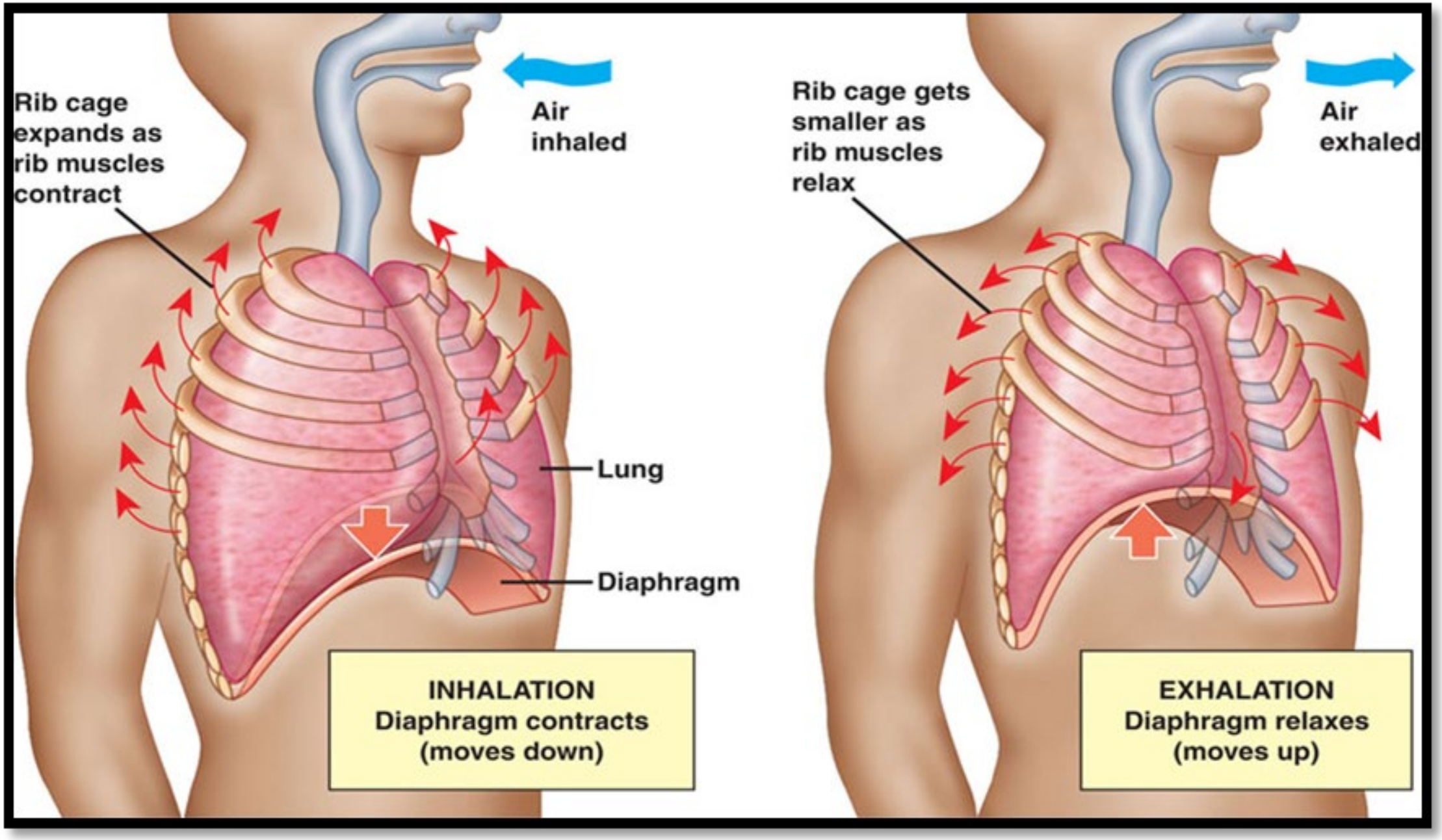
- It is an **active process** that occurs as a result of contraction of the **diaphragm** and **external intercostal muscles**

- ***<u>Contraction of the diaphragm & external intercostals muscles</u>*** ➔ ↑ all chest dimensions ➔ lung follows the chest passively (it is attached to it by pleura) ➔ ↑ its volume ➔ ↓ intrapulmonary pressure to **-2mmHg** ➔ rush of air (**500ml = tidal volume**) into the lungs.

B-Normal expiration:

- **Passive** process.

- ***Relaxation of the diaphragm & external intercostals muscles*** ➔ ↓ all chest dimensions ➔ ↓ lung volume (aided by lung elastic recoil) ➔ ↑ intrapulmonary pressure to **+2mmHg** ➔ rush of air (500ml = **tidal volume**) outside the lungs.



Normal inspiration and normal expiration

MCQ

What occurs during external respiration?

a) Blood transports O_2 from lungs to tissues

b) Oxidation of nutrients to produce energy

c) Exchange of gases between air and blood in the lungs

d) Blood transports CO_2 from tissues to lungs

e) Regulation of body temperature

Answer: c

Control of pulmonary ventilation

Dr. Amr Medhat Abbas

Professor of Medical Physiology

Control of pulmonary ventilation

(I) Resistance of air passages:

-The **resistance to airflow** depends on the **diameter of the respiratory passages.**

- ↓ **diameter** of airways ➔ ↑ **resistance** & vice versa

- Diameter of the air passages is affected by:

A)**Bronchial muscle tone (bronchomotor tone).**

B)**Bronchial mucosa.**

A) Bronchial muscle tone (bronchomotor tone):

* **Def:** It is a state of **contraction of the smooth muscle** in the bronchial walls that regulates the **diameter** of the airways.

* **Contraction** of bronchial smooth muscle ➔ ↓ airway diameter **(bronchoconstriction)** ➔ ↑ airway resistance.

* ***Bronchial muscle tone is affected by:***

1- Autonomic nervous system.

2- Inflammatory mediators.

3- Reflex bronchoconstriction.

1- Autonomic nervous system:

- **Sympathetic** → bronchoconstriction (**α_1 adrenergic receptors**), or bronchodilatation (**β_2 adrenergic receptors**).
- **Parasympathetic** → bronchoconstriction (**M_3 receptors**).

2- Inflammatory mediators:

- **Histamine, serotonin & platelet activating factor (PAF) → bronchoconstriction**
- **Prostaglandins → bronchodilatation**

3- Reflex bronchoconstriction:

Irritants (**e.g**. cold air, cigarette smoke, inhaled dust) ➔ stimulate irritant receptors in the trachea and large bronchi ➔ **reflex bronchoconstriction**.

B) Bronchial mucosa:

↑ thickness (mucosal edema) or **↑ secretion (mucous)** ➔ **↑ resistance** as in **bronchial asthma**.

(II) Pressure relationship in thoracic cavity:

A) Intrapulmonary pressure:

- **Def:** It is the pressure inside the lung alveoli.
- **It is connected with the atmosphere**.
- **Before the start of inspiration**, it equals zero (i.e atmospheric pressure).
- **Values:**

	1- During inspiration	2- During expiration
Intra pulmonary Pressure	decrease to -2 mmHg	increase to +2 mmHg
Cause	Contraction of diaphragm & external intercostals muscles ➔ ↑ chest cavity ➔ lung expansion.	Relaxation of diaphragm & external intercostals muscles ➔ ↓ chest cavity ➔ lung recoil.
Air	rush into the lung ➔ pressure becomes atmospheric at the end of inspiration	rush out of the lung ➔ (aided by lung elasticity)➔ pressure becomes atmospheric at the end of expiration

B) Intrapleural pressure (IPP):

❑Intrapleural pressure (IPP):

❖**Def:** it is the pressure inside the pleural cavity.

❖**Usually – ve.**

	Value
At the end of normal expiration	- 3 mmHg
At the end of normal inspiration	- 6 mmHg

❖Causes:

1. ***Lack of air*** in the pleural cavity.

2. ***Continuous tendency of the lung to recoil*** against **tendency of chest wall to expand** ➔ continuously pulls the **visceral pleura** (attached to the lung) away from the **parietal pleura** (attached to the chest wall) ➔ creating a continuous -ve pressure

❖Significance of negativity of IPP:

1) Help **expansion of the lung during inspiration**.

2) **Prevent collapse** of the lung and keep them inflated.

3) Help **venous return** to heart (**respiratory pump**) by **suction** of blood from extrathoracic veins

4) Help **lymph drainage** through thoracic lymph ducts.

5) **↑ blood flow** through pulmonary vessels.

MCQ

What is the value of intrapulmonary pressure during normal inspiration?

a) -20 mmHg.

b) +20 mmHg.

c) -2 mmHg.

d) +2 mmHg.

e) -30 mmHg.

Answer: c

(III) Surfactant:

- **Def:** It is a substance secreted in the alveoli by type II alveolar cells. It is a surface active agent that **decreases surface tension of the fluid lining the alveoli**.

- **Structure:** complex mixture of:

1. **Phospholipids** ➔ mainly dipalmitoyl phosphatidyl-choline (DPPC).
2. **Surfactant proteins (SP)** as: **SP-A**, **SP-B** and **SP-C**.
3. **Ca^{++} ions**.

- **Stimulus for its release:** Direct **mechanical** effect & **distortion** of type II alveolar cells by tidal volume.

- **Functions:**

1.Lowers the surface tension of fluid lining alveoli by:

a)Spreading over the fluid preventing air-fluid interface.

b)Scattering among the fluid molecules ➔ ↓ attraction between them.

❖**This decreased surface tension is necessary because it:**

a)Helps lung expansion during inspiration.

b)Prevents lung collapse during expiration.

2.Activate macrophages.

3.Has a bacteriolytic effect, rendering the bacteria susceptible to alveolar macrophages.

4. ***Phospholipids*** of surfactant may act directly on T-lymphocytes membrane ➔ ***prevent excess immune response***.

5. ***Assist ciliary movement*** in upper respiratory tract

- **Factors that stimulate surfactant formation:**

Thyroid and **glucocorticoid** hormones

• Causes of decreased surfactant:

1)Respiratory distress syndrome (RDS):

- **Premature babies** are born with lungs that lack sufficient surfactant → collapse of their alveoli.
- **Cause:** surfactant starts to be formed at **8th month** of pregnancy.
- **Fatal condition**.

2) Cigarette smoking: ➔ destruction of type II alveolar cells ➔ ↓ surfactant.

3) Open cardiac surgery.

4) Elective cesarian section.

5) Long-term inhalation of 100% O_2.

(IV) Compliance:

- **Def:** It is a measure for the distensibility (expansibility) of the lung and chest wall

❑ Factors affecting compliance:

1. Factors in the lung:

-It is **affected by:**

a) Elastic elements of the lung

b) Surface tension of the fluid lining the alveoli.

- **Lung compliance is:**

- ***decreased in*** pulmonary congestion, pulmonary fibrosis and pulmonary edema
- ***increased in*** emphysema.

2. Factors in the chest wall:

- It is affected by the ***elastic properties of the thorax*** caused by elasticity of the muscles, tendons and connective tissues in the chest wall.

- ***Chest wall compliance is decreased in:***

1-Deformities of spine.

2-Arthritis of vertebra.

3-Obesity.

4-Skeletal muscle disease **e.g.** poliomyelitis & myasthenia gravis.

MCQ

What is the source of surfactant?

a) Type II alveolar cells

b) Goblet cells

c) Type I alveolar cells

d) Macrophages

e) Bronchial cells

Answer: a

Gas exchange

Dr. Amr Medhat Abbas

Professor of Medical Physiology

Factors affecting gas exchange:

(I) Respiratory membrane:

- **Def:** Air in alveoli is separated from blood in capillaries by respiratory membrane.
- **Structure of respiratory membrane:**

1. Layer of fluid lining the alveoli and containing surfactant.
2. Single layer of thin alveolar epithelial cells.
3. An epithelial basement membrane.

4. A very thin interstitial space between the alveolar epithelium and the capillary membrane.
5. Capillary basement membrane.
6. Capillary endothelial cells.

• Properties of respiratory membrane:

1- Thickness	2- Surface area
- **0.6 micron**	- **50 – 100 m^2**
- Rate of gas diffusion is inversely proportional with thickness of the membrane (**i.e.** ↑ thickness **e.g.** fibrosis➔ ↓ rate of gas diffusion).	**- Rate of gas diffusion is directly proportional** with surface area of membrane (**i.e.** ↑ SA ➔ ↑ rate of gas diffusion & ↓ SA **e.g.** removal of one lung or emphysema ➔ ↓ rate of gas diffusion)

(II) Respiratory gases:

The rate of diffusion of respiratory gases is affected by:

A) Pressure gradient:

According to pressure gradient ➔

- **O2** diffuses from **alveoli** (PO2 **100** mmHg) to **capillaries** (PO2 in venous blood **40** mmHg).
- **CO2** diffuses from **capillaries** (PCO2 in venous blood 46 mmHg) to **alveoli** (PCO2 40 mmHg)

B) Lipid solubility and molecular weight of gases:

1- lipid solubility of gases	2- Molecular weight of gases
• **Rate of gas diffusion is:** **Directly proportional** with lipid solubility of gases	• **Rate of gas diffusion is:** **Inversely proportional** with molecular weight of gases.
• CO_2 diffuses **faster than** O_2 due to its high lipid solubility.	• CO_2 diffuse **slower than** O_2 due to its high MW (CO_2 44, O_2 32)
• **Net result:** CO_2 diffuse **20 times** faster than O_2	

C) Diffusion capacity:

- **Def:** the volume of gas that diffuses through the respiratory membrane each minute for a pressure difference of 1 mmHg.
- **At rest:** the diffusion capacity:
  - **For O2 = 20 ml/min./mmHg.**
  - **For CO2 = 400 ml/min./mmHg.**

(III) Ventilation/perfusion ratio:

- **Def:** This is the ratio between effective alveolar ventilation and pulmonary blood flow per minute.
- **Value:**
  - **Effective alveolar ventilation** = 4L/min.
  - **Pulmonary blood Flow (=cardiac output "C.O.P")** = 5L/min.
  - **V/P ratio** = 4/5 = 0.8

MCQ

What is the respiratory membrane thickness?

a) 0.1 micron

b) 0.6 micron

c) 5 microns

d) 10 microns

e) 2 microns

Answer: b

Carriage of O2 and CO2 by the blood

Dr. Amr Medhat Abbas

Professor of Medical Physiology

Carriage of O2 by the blood

Forms of O2 in the blood

O2 is present in the blood in the following 2 forms:

I) In Physical solution (dissolved in plasma and RBCs) (2%):

- **This is normally a very small amount.**
- **Value:**
  - **Arterial blood: 0.3** ml/100ml blood.
  - **Venous blood: 0.13** ml/100 ml blood.
- **Importance:**

(1) It determines O_2 tension in the blood:

- At O_2 tension 100 mmHg (Art. bl) ➔ amount of O_2 dissolved = 0.3ml.
- At O_2 tension 40 mmHg (Ven. bl) ➔ amount of O_2 dissolved =0.13ml.

(2) It determines the rate and direction of O2 flow (from high to low pressure).

II) In chemical combination with Hb (98 %):

- **98% of O_2** is bound to HB of RBCs.

- The reaction of Hb with O2 is:

1- **Rapid** and **reversible**.

2- **Oxygenation**, **not oxidation** (when Fe^{++} combine with O_2, it **remain in ferrus** state).

3- Occurs gradually in **4 steps (each step facilitate the next):**

- $HB + O_2 \rightarrow HBO_2$ (25%)
- $HBO_2 + O_2 \rightarrow HBO_4$ (50%)
- $HBO_4 + O_2 \rightarrow HBO_6$ (75%)
- $HBO_6 + O_2 \rightarrow HBO_8$ (100%)

Definitions

	1- O2 content	2- O2 capacity
Def:	It is the volume of O_2 (in ml) present in chemical combination with Hb in 100 ml blood.	It is the maximal volume of O2 (in ml) that can be carried in chemical combination with Hb in 100 ml blood (**i.e.** when Hb is completely saturated with O2).
Value	Arterial blood: 19.5 ml O_2/100ml blood. Venous blood: 14.5 ml O_2/100 ml blood.	• HB content 15 gm%. • When fully saturated, each gm of Hb can combine with 1.34 ml O_2. • O_2 capacity = 15 × 1.34 = 20 ml O_2 / 100 ml arterial blood.
Depends on:	• HB content. • O_2 tension.	• HB content only.

3- % saturation of Hb with O_2:

- **Def:** This is the % saturation of Hb with O2.
- **Calculation:** **% saturation of Hb with O2 =** $\frac{O2\ content\ X\ 100}{O2\ capacity}$
- **Arterial blood** ➔ only **97%** saturation with O_2 due to presence of **physiological shunt** (some venous blood from **bronchial and coronary veins** is added to the arterial side).
- **Venous blood** ➔ **70%** saturation with O_2

4- Coefficient of O2 utilization :

- **Def:** This is the % of O2 in the arterial blood that is taken by tissues
- **Calculation:**

➢ **Coefficient of O2 utilization =** $\frac{arterial\ O2\ content - venous\ O2\ content \quad X\ 100}{arterial\ O2\ content}$

➢ **At rest =** $\frac{19.5 - 14.5 \quad X\ 100}{19.5}$ **= 25 %.**

➢ **During exercise,** this coefficient ↑ to **75%.**

- **Factors affecting it:**

1) Degree of tissue activity.

2) Rate of blood flow to tissues.

3) Affinity of Hb to O_2.

Carriage of CO_2 by the blood

CO_2 in the arterial blood

Each 100ml arterial blood carries 48-52ml CO_2 which are present in the following forms:

1) In physical solution (dissolved in plasma and RBCs) (5%):

Importance: determine the arterial PCO_2 (normally about 40 mmHg).

2) In chemical combination (95%): present in **2 forms:**

a-Carbamino compound (6%):

- **Formed by** combination of **CO_2** to the **amino** group of the amino acids in the plasma proteins **(2%)** and in the Hb (globin) **(4%)**.

b- Bicarbonate (89%):

Present as **$KHCO_3$** in the **RBCs** and **$NaHCO_3$** in the **plasma.**

Importance of high arterial CO_2 content:

CO_2 forms an important **buffer system** (HCO_3^-/H_2CO_3) that antagonizes changes in the **blood pH.**

Tidal CO2

- **Def:** it is the volume of CO2 added (by tissues) to each 100 ml of arterial blood during its flow through the tissues.
- **Value:** **5 ml** CO2/100 ml blood
- **Transported by blood** to pulmonary capillaries where it diffuse into the alveoli to be expired from the body (PCO_2 in **pulmonary capillaries** = **46 mmHg** and in **alveoli 40 mmHg** ➔ **pressure gradient 6 mmHg** during which CO_2 cross the alveolar membrane).

MCQ

What is the value of physically dissolved O2 in the arterial blood?

a) 0.1 ml/100 ml blood
b) 0.13 ml/100 ml blood
c) 0.5 ml/100 ml blood
d) 0.3 ml/100 ml blood
e) 0.7 ml/100 ml blood

Answer: d

Regulation of respiration

Dr. Amr Medhat Abbas

Professor of Medical Physiology

Respiratory centers

- **Def:** Collection of neurons located **bilaterally** in the **brain stem**. They **regulate** the process of **respiration automatically**.
- **Types (Classification):**

(I) Medullary centers:

	1- Dorsal respiratory group (DRG or inspiratory center)	2- Ventral respiratory group (VRG or expiratory center)
Site:	Located in the **dorsal** region of **medulla**	Located in the **ventral** region of **medulla**
Character:	Have the property of **intrinsic periodic firing** (active for 2 sec then inactive for 3 sec).	**Inactive** during **normal expiration** as it is a **passive** process.
Responsible for:	**Basic rhythm of ventilation**.	Forced expiration (as it is **active process**).

(II) Pontine centers:

	1- Apneustic center	2- Pneumotaxic center
Site	**lower 1/3** of **pons**	**upper 1/3** of **pons**
Action:	Continuously send **excitatory impulses** to DRG. **(=pacemaker of respiration).**	Send **inhibitory impulses** to insp. center & apneustic center.
Its stimulation produces:	**Prolongation** of inspiration	**Shortening** of respiration

Generation of rhythmic respiration

- During **eupnea** **(=normal resting breathing)**, the breathing rhythm (i.e. the alternation of inspiratory and expiratory phases) occurs **as follows:**

➢ **Apneustic center** has an inherent **tonic (=continuous)** activity (**pace maker of respiration**). It discharges continuous stimulatory signals to **DRG** in medulla oblongata.

- **Such discharge is rendered rhythmic (=inhibited)** by the **pneumotaxic center** discharge inhibitory signals to the apneustic center.

- **Mechanism of inspiration:**

Apneustic center ➔ continuously send excitatory impulses to **DRG** ➔ **descending respiratory tract** to the motor neurons of the **diaphragm** (C3,4,5) and of **intercostal muscles** (T1-10) of the spinal cord ➔ **phrenic & intercostal nerves** ➔ contraction of **diaphragm & external intercostal muscles** respectively➔ ↑ all diameters of thoracic cavity ➔expansion of lung➔ intrapulmonary pressure ↓ to -2 mmHg ➔ air rushes in.

- **Mechanism of expiration:**

➢ **Inhibitory impulses from the pneumotaxic center** inhibit the **apneustic center and the DRG** ➔ inspiration is terminated & expiration starts passively.

➢ **Suppressed inspiratory center (DRG)** stops to stimulate spinal motor neurons of respiratory muscles causing their relaxation➔↓ all diameters of thoracic cavity & lung recoils➔ intrapulmonary pressure ↑ to +2 mmHg and air rushes out.

Regulation of respiration

(I) Nervous regulation of respiration:

(A) Afferent impulses from higher centers of the brain:

1- From cerebral cortex:

- **Cerebral cortex** sends impulses to **inspiratory center** ➔ **limited voluntary** control of breathing. ***e.g.***

a) **Voluntary hyperventilation**.

b) **Voluntary apnea:**

✓ **Def:** temporary voluntary stoppage of breathing (1-3 minutes).

2- From hypothalamus:

a) *Pain:*

- **Mild to moderate** ➔ ↑ respiratory rate.
- **Severe** ➔ ↓ respiratory rate.

b) *Emotions:*

- **Mild to moderate** (fear, anger, anxiety)➔ ↑ respiratory rate.
- **Severe** (sudden shocky news) ➔ ↓ respiratory rate.

c) ***Temperature:***

- **↑ body temperature (as in fever) or ↑ environmental temperature** ➔ ↑ resp. rate ➔ get rid of some of excess body heat through evaporation of water from lungs and respiratory passages during expiration.

(B) Afferent impulses from the respiratory system:

a) From lung stretch receptors:

Stimulation of these receptors by lung distension ➔

Hering Breuer reflexes.

b) From irritant receptors:

i- In the nose (sneezing reflex).

ii- In the larynx, trachea and bronchi (cough reflex).

b) From irritant receptors:

i- In the nose (sneezing reflex):

- **Stimulus** → chemical & mechanical irritants as foreign body.
- **Receptor** → **irritant receptors** in the nose
- **Afferent** → **trigeminal** nerve (**5th** cranial nerve).
- **Center** → stimulation of RC.
- **Effect** → **deep inspiration** followed by **forced expiration**.
- **Significance** → removal of foreign body from nose.

ii- In the larynx, trachea and bronchi (cough reflex):

- **Stimulus** ➔ chemical & mechanical irritants as foreign body or food.
- **Receptor** ➔ **irritant receptors** in the larynx, trachea & bronchi
- **Afferent** ➔ **vagus** nerve (**10th** cranial nerve).
- **Center** ➔ stimulation of RC.
- **Effect** ➔ **deep insp.** followed by **forced expiration** against a **closed glottis** ➔ ↑ intra pulmonary pressure to **100 mmHg** ➔ then glottis is **suddenly opened** ➔ forcible outflow of air.
- **Significance** ➔ removal of foreign body from larynx, trachea and bronchi.

MCQ

Where is the dorsal respiratory group located?

a) Upper third of pons

b) Cerebellum

c) Lower third of pons

d) Medulla oblongata

e) Midbrain

Answer: d

(II) Chemical regulation of respiration:

- This is the **main breathing regulatory mechanism**.

1- Central chemoreceptors:

- **Site:** These are located at the ventral surface of medulla oblongata.
- **The only blood gas that can stimulate these receptors:** is **CO_2**, so they are stimulated **only** in cases of **hypercapnia**.

2- Peripheral chemoreceptors:

- **Site:** Located in:
  - **Carotid bodies**: at the bifurcation of **common carotid arteries (most important).**
  - **Aortic bodies**: above and below **aortic arch**.
- **Stimulus:** ↓ O_2 **(mainly)**, ↑ H^+ & ↑ CO_2
- **Afferent:** **impulses are carried to RC by:**
  - ***From carotid body:*** sinus nerve **(branch of glossopharyngeal nerve)**
  - ***From aortic body:*** aortic nerve **(branch of vagus nerve).**

MCQ

Where are central chemoreceptors located?

a) At ventral surface of medulla oblongata

b) In the aortic bodies

c) In the carotid bodies

d) At dorsal surface of medulla oblongata

e) In the upper pons

Answer: a

Hypoxia

Dr. Amr Medhat Abbas

Professor of Medical Physiology

Hypoxia

- **Def:** **O_2 deficiency** at the **tissue level** resulting from disturbances in the respiratory process.
- **Types:** depending on the cause, hypoxia is classified into **4 main types:**

1) **Hypoxic hypoxia:** ***due to disturbance in external resp.***

2) **Anemic hypoxia:**

3) **Stagnant hypoxia:**

} ***due to disturbance in respiratory function of blood.***

4) **Histotoxic hypoxia:** ***due to disturbance in internal resp.***

(I) Hypoxic hypoxia

- **Def:** This type of hypoxia occurs secondary to hypoxemia (O_2 deficiency in the blood).
- **Causes**:

1. ↓ PO_2 in the atmospheric air: e.g. High altitudes.

2. <u>Ventilation defects:</u> e.g.

a) **Obstructive** disease as bronchial asthma.

b) **Restrictive** disease as obesity.

c) **Disease of respiratory muscles** as poliomyelitis.

d) **Disease of lung** as: ↓ surfactant ➔ alveolar collapse.

e) **Central causes:** depression of respiratory center as in morphine poising.

3. **<u>Defective Gas exchange:</u> e.g.**

- **↑ thickness of respiratory membrane** as in pulmonary fibrosis.

(II) Anaemic hypoxia

- **Def:** This type of hypoxia occurs as a result of deficiency of of Hb capable of carrying O_2.
- **Causes:**

1) All types of **anaemia**.
2) **↑ abnormal (non functioning) Hb** (= **↓** functional Hb): transformation of Hb by certain toxins and drugs into compounds that are unable to carry O2 e.g. metHb and sulph-Hb.
3) **Carbon monoxide (CO) poisoning**.

(III) Stagnant hypoxia:

- **Def:** This type of hypoxia occurs due to blood stagnation (slow blood flow) in the tissues.
- **Causes:**

1) **General:**

   a. Congestive **heart failure**.

   b. Shock.

   c. Polycythemia.

2) Local:

a. ***Obstruction of blood vessels*** either:

- ***From inside***: by thrombus or embolus.
- ***From outside***: tumour.
- ***In the wall itself***: atherosclerosis.

b. ***Sympathetic over activity***.

c. ***Peripheral vascular spasm***; **e.g. Raynaud's disease** that is characterized by sever arterial vasoconstriction in the fingers and toes particularly on exposure to cold.

(IV) Histotoxic hypoxia:

- **Def:** This type of hypoxia occurs due to blockage of enzymes involved in tissue (internal) resp.
- **Causes:**
  1. **Alcohol poisoning:** blocks ***dehydrogenase enzyme***.
  2. **Cyanide poisoning: (commonest cause of histotoxic hypoxia)** inactivates **cytochrome oxidase system.**

Cyanosis

- **Def:** **Bluish** coloration of **skin and mucous membrane** due to presence of increased amount of **reduced Hb** in the blood of **superficial capillaries.**
- **Threshold of cyanosis:**
  - **Def:** the minimal concentration of reduced Hb in the capillary blood that leads to appearance of cyanosis.
  - **Equals: 5 gm% reduced Hb** in the **capillary blood**.

- **Causes of cyanosis:**

  ***1-Hypoxic hypoxia*.**

  2-*Stagnant hypoxia*.

- **Cyanosis does not occur in:**

  ***1.Histotoxic hypoxia*.**

  2.Anemic hypoxia ➔ due to ↓ Hb content.

  3.CO poisoning ➔ As carboxy Hb is cherry red in colour.

MCQ

What is the definition of hypoxia?

a) Low oxygen in the blood
b) Low oxygen at the tissues
c) Decreased carbon dioxide in tissues
d) High oxygen at the tissue level
e) Normal oxygen levels but impaired blood flow
Answer: b