THE RESPIRATORY SYSTEM

The respiratory system **contributes to homeostasis** by:

- Providing for gas exchange: intake of O_2 for delivery to body cells and removal of CO_2 produced by body cells.
- Helping in regulating blood pH of body fluids.
- Contains receptors for sense of smell, filters inspired air produces vocal sounds (phonation), and excretes small amounts of water and heat.

- نبلش ب Introduction about the respiratory system
هو بساهم في عملية الاتزان (زي لما حكينا كل systems بتحاول تشتغل مع بعض على انها تحافظ على حالة الاتزان)

- كيف بساهم في عملية الاتزان:
١. Providing for gas exchange (هو مكان تصنيع الأكسجين فهو بينقل الاكسجين لأجزاء الجسم او أعضاء الجسم او خلايا الجسم و هو يستقبل CO2 من خلايا الجسم)
٢. Helping in regulating blood ph in body fluids (هو بحافظ على blood ph ورح نوخد كيف بحافظ عليه)
٣. بحتوي receptors (يعني كمان بحافظ على حالة الاتزان بإنه بخلص الجسم من اي amount بتكون قليلة و زائدة عن الحاجة من water و heat وايضا هو بحتوي receptors اللي هي بتساعد الجسم انه يشم او يحس بمثلا في رائحة خطأ وأيضا بخلص الجسم من أشياء ما بحتاجها مش بس CO2 ايضا body can excrete small amounts of water and heat)

STRUCTURES OF THE RESPIRATORY SYSTEM

ينقسم إلى lower and upper respiratory system

The [1] **upper respiratory system** includes the nose, nasal cavity, pharynx, and associated structures; [2] **the lower respiratory system** includes the larynx, trachea, bronchi, and lungs.

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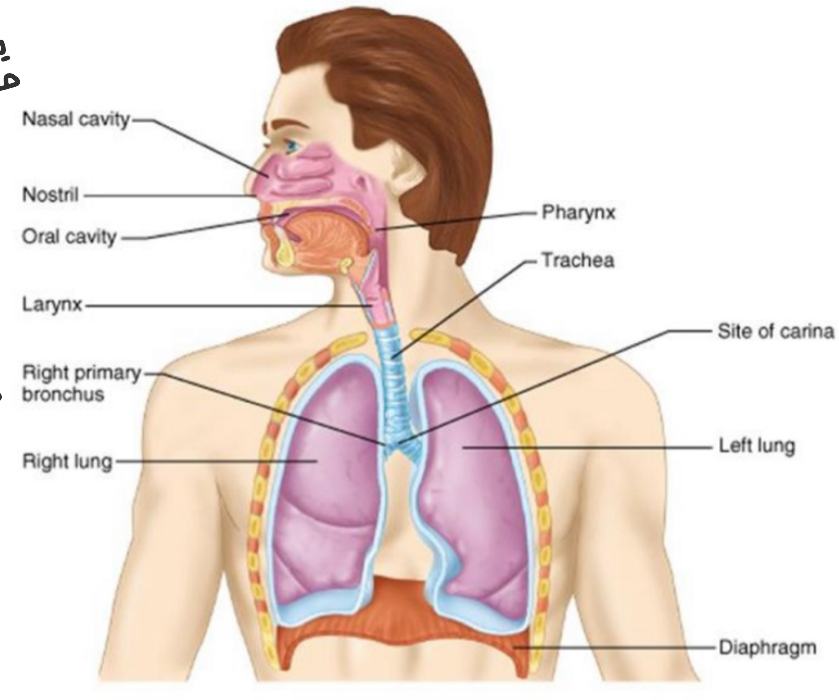
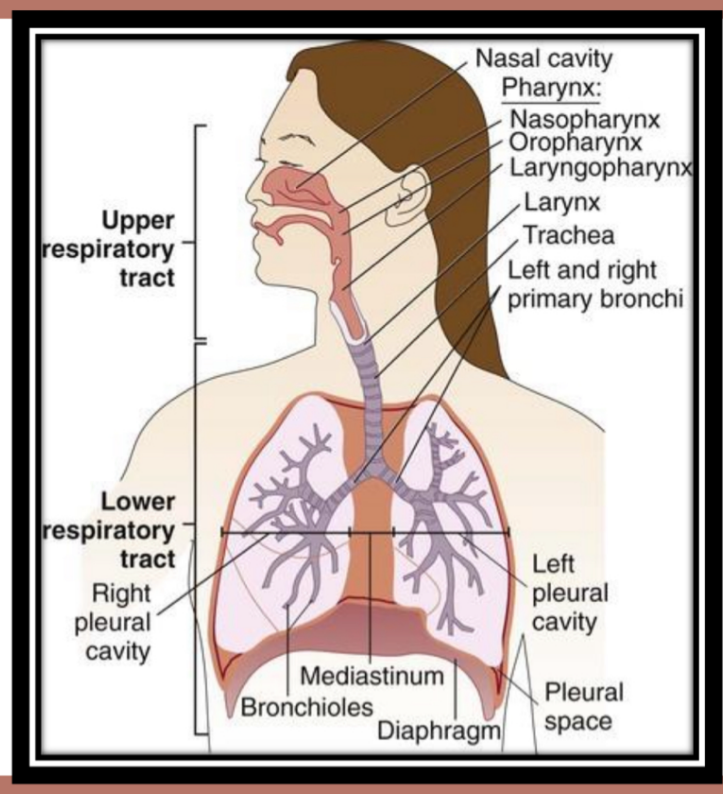
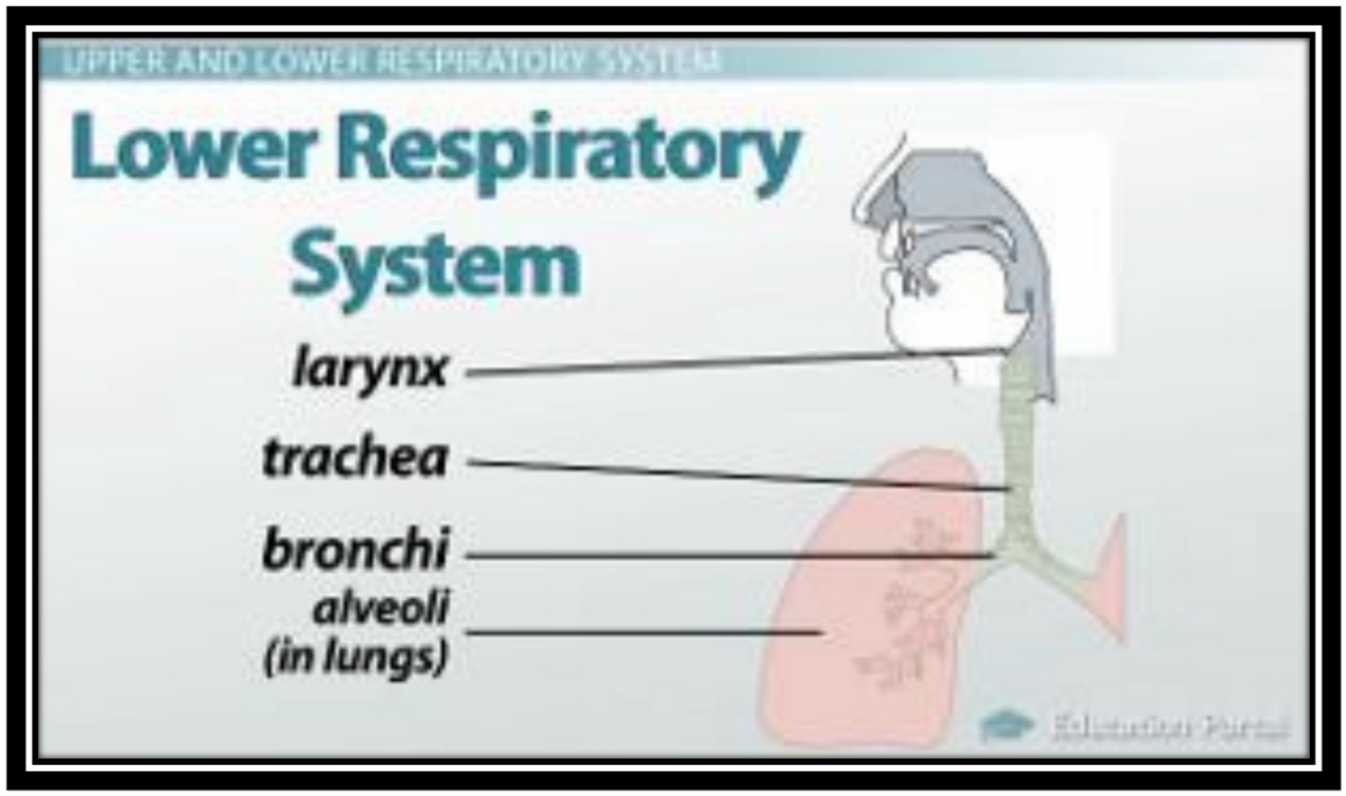






Pathway of Air/ O_2

- Nose – external nares → nasal cavity → internal nares
  ⇩
- Pharynx – nasopharynx → oropharynx → laryngopharynx
  ⇩
- Larynx – epiglottis → larynx
  ⇩
- Trachea – trachea
  ⇩
- Bronchi – primary bronchi → secondary bronchi → tertiary bronchi → bronchioles
  ⇩
- Lungs – alveoli → blood stream

PULMONARY VENTILATION

The **process of gas exchange** in the body, called **respiration**, has **three basic steps**:

1. **Pulmonary ventilation or breathing**, **is the inhalation (inflow) and exhalation (outflow)** of air and involves the exchange of air between the atmosphere and the alveoli of the lungs.
2. **External (pulmonary) respiration**, is **the exchange of gases between the alveoli of the lungs and the blood in pulmonary capillaries** across the respiratory membrane. In this process, pulmonary capillary blood gains O_2 and loses CO_2.
3. **Internal (tissue) respiration**, is the **exchange of gases between blood in systemic capillaries and tissue cells.** In this step the blood loses O_2 and gains CO_2. Within cells, the metabolic reactions that consume O_2 and give off CO_2 during the production of ATP are termed cellular respiration.

حكينا اول شغله حتى يساهم respiratory system بعملية الhomeostasis انه بشارك بgas exchange ف

بالpulmonary ventilation الprocess of gas exchange منسميها respiration, في عنا 3 steps لهاد الاشي

1- اول شي pulmonary ventilation or breathing هي عملية inhalation (inflow of air) وعملية exhalation (outflow of air) اللي بتصير بين الجو المحيط والرئتين

2- اما external pulmonary respiration هي عملية exchange of gases بين lungs و blood الlungs اللي بده يمشي بال pulmonary capillaries فهون ال pulmonary capillaries بوخد O_2 الموجود بال lungs و بيعطي lungs ال CO_2

3- رقم ٣ ال internal ومن اسمها internal tissues respiration هي عملية exchange of gases ما بين الblood الموجود في systematic capillaries وما بين tissue cells، يعني دخل الجسم عن طريق pulmonary capillaries وصلنا systematic capillaries بعدها صار exchange للgases اللي هي محملة بpulmonary capillaries (بحتوي O_2) بهاي الخطوة blood بيخسر O_2 وبيكسب CO_2, ليش؟ لانه هون بده يعطي O_2 للtissue cells وبده يوخد CO_2 من tissue cells في الcells لانه metabolic reactions بتعمل consuming of O_2 وبالتالي بتتخلص من CO_2 خلال production of ATP بعملية اسمها cellular respiration

PRESSURE CHANGES DURING PULMONARY VENTILATION

- **Air moves into the lungs** when the air pressure inside the lungs is less than the air pressure in the atmosphere. **Air moves out of the lungs** when the air pressure inside the lungs is greater than the air pressure in the atmosphere.
- **Inhalation:**
  - Breathing in is called inhalation (**inspiration**).
  - For air to flow into the lungs, the pressure inside the alveoli must become lower than the atmospheric pressure. This condition is achieved by **increasing the size of the lungs**.
  - **The pressure of a gas in a closed container is inversely proportional to the volume of the container**. This inverse relationship between volume and pressure, called **Boyle's law**.

- رح نحكي اول شي عن gas change during pulmonary ventilation, عملية انتقال الهواء من atmosphere الى داخل lungs بعتمد على اختلاف الalternating pressure نتيجة الdifference وال contraction لل relaxation pulmonary muscles

- هلا الهواء بدخل من الatmosphere لل lungs لما يكون air pressure inside the lungs هو اقل من pressure بال atmosphere بمعنى اخر انه الpressure بينتقل من الhigher level الى low level ، ولكن air moves out of the lungs لما يكون الair pressure بال lungs اكبر من air pressure بال atmosphere وهاد هو pressure change اللي بنتج عنه pulmonary ventilation او airflow بين atmosphere and lungs

- نبلش بال inhalation ، عملية التنفس breathing in منسميها inhalation والها اسم تاني inspiration, حكينا air حتى يدخل لل lungs لازم pressure جوا lungs يكون اقل من pressure الموجود بال atmosphere ، في هاي الحالة عشان تصير رح يصير عن طريق زيادة size of the lungs ، مثال pressure of gas in closed container is inversely proportional to the volume of the container يعني اذا كان عنا الvolume تبع container كبير رح يكون pressure تبع الgas قليل وكل ما كان volume of container اقل كل ما كان pressure of gas اكبر لانه بتكون الvolume تاع container قليلة وgas بده يكون كتير فال pressure تاع بكون اكبر ولكن لما يكون volume of container كبير شو ما كان فيه gas وبدنا pressure وكمية gas عاليه حتى يصير الpressure عالي ، فبالتالي حتى احنا نزيد size of the lungs هاد بده يعتمد على نفس الconcept

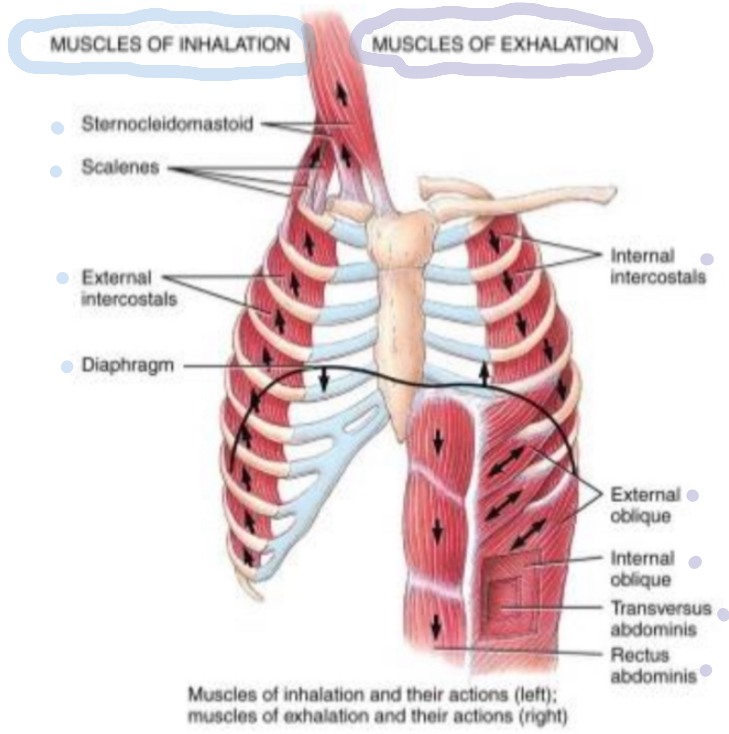
- وبالتالي الdifferences in pressure اللي بصير عن طريق change in lungs volume هو اللي بتحكم انه هل الهواء بده يدخل الى lungs بالتالي بتكون inhalation ولا الهواء بده يخرج خارج lungs حتى يصيرله exhalation فحتى inhalation يصير لازم pressure in lungs لازم يصير اقل من pressure in atmosphere يعني لازم يصير expanding واللي هو انه يزيد lung volume وبالتالي pressure اللي فيه يقل حتى يصير اقل من atmospheric pressure فينتقل الهواء من atmosphere الى داخل الlungs

PRESSURE CHANGES DURING PULMONARY VENTILATION

- **Differences in pressure caused by changes in lung volume** force air into our lungs when we inhale and out when we exhale.
- **For inhalation to occur, the lungs must expand, which increases lung volume and thus decreases the pressure in the lungs to below atmospheric pressure.**

MUSCLES OF INHALATION AND EXHALATION

During normal, quiet inhalation, the diaphragm and external intercostals contract, the lungs expand, and air moves into the lungs; **during normal, quiet exhalation, the diaphragm and external intercostals relax** and the lungs recoil, forcing air out of the lungs.

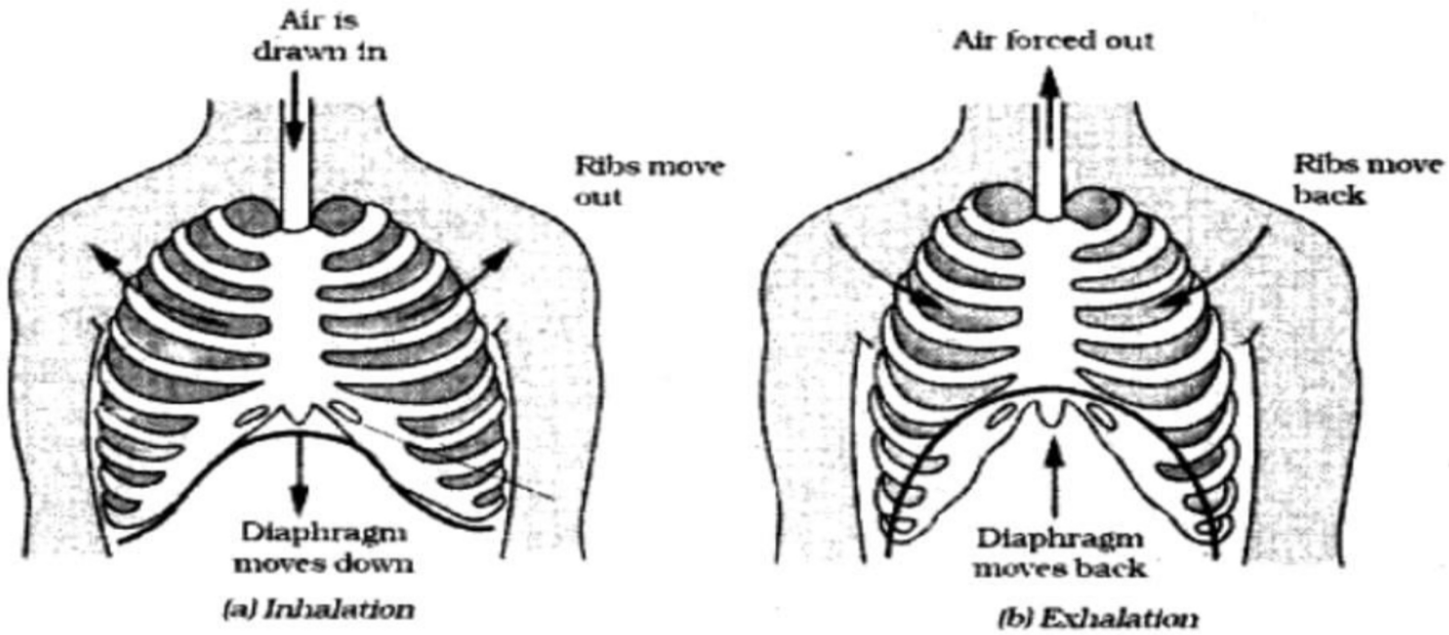


Muscles of inhalation and their actions (left); muscles of exhalation and their actions (right)

- هلا شو بصير خلال عملية inhalation كيف بتصير عنا عملية الexpanding خلال inhalation الvolume of lungs بده يزيد عشان pressure يقل ، لكن خلال عملية exhalation الvolume of lungs بده يقل عشان pressure يزيد

- بالرسسمة خلال normal inhalation حتى يزيد volume of lungs الdiaphragm وexternal intercostals هدول المسؤولين عن normal inhalation فبصيرلهم concentrations بالتالي lungs بصيرلها expanding فالهواء بدخل من atmosphere الى lungs

- لكن خلال عملية exhalation بدنا volume of lungs يقل حتى pressure يزيد بهاي الحالة الdiaphragm وexternal intercostals بده يصيرلهم relaxation وlungs يصيرلها recoiling وبالتالي forcing air out the lungs



Mechanism of breathing human beings

- خلال عملية inhalation الdiaphragm بصيرله contraction فالchest رح يصيرله expanding فلما يصير expanding الvolume of lungs بزيد فالpressure الموجود بالlungs رح يقل فال lungs are pulled outwards وبالتالي الintrapulmonaric pressure رح يقل اللي هو الpressure الموجود داخل الpulmonary او داخل الlungs فبصير pressure بالatmosphere اعلى فبدخل من atmosphere الى lungs

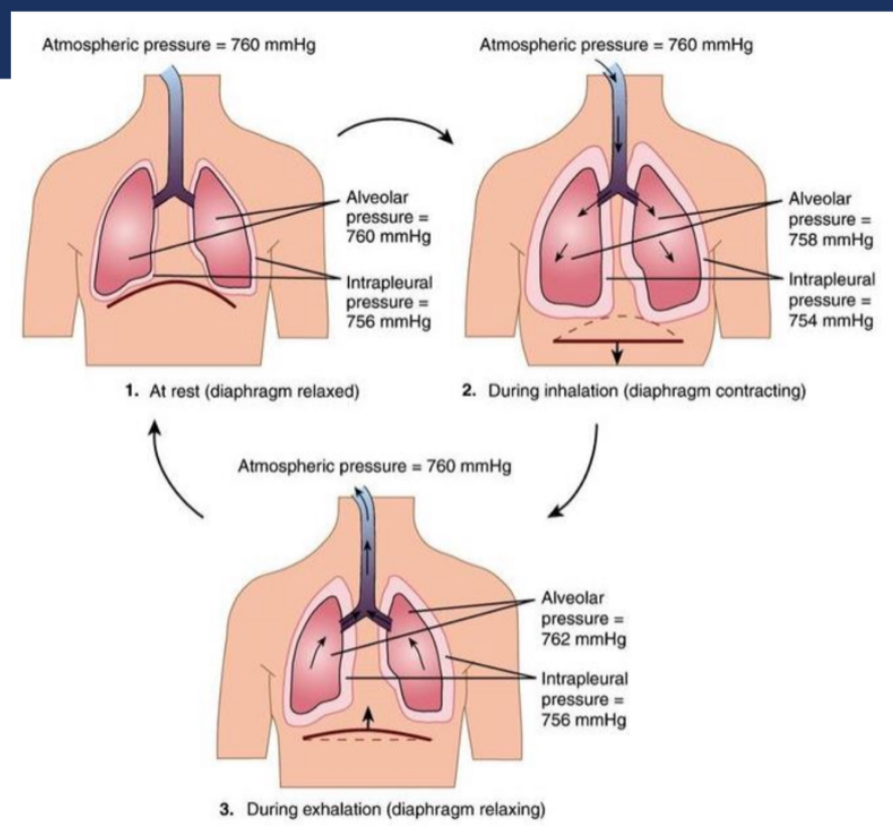
- خلال عملية exhalation الdiaphragm بصيرله relaxation يعني lungs بصيرلها recoiling inward يعني زي تنقبض على بعض فالvolume بقل و pressure بزيد فبنتقل الهواء من داخل lungs للخارج

- هالرسمات بتوضح كيف بصير بpressure atmospheric وكيف بصير pressure in lungs خلال at rest لما ما يكون عنا اشي وخلال inhalation بصير contraction of diaphragm وخلال exhalation بصير relaxation of lungs, وكيف الضغط بتغير نتيجة تغير size of lungs

PRESSURE CHANGES IN PULMONARY VENTILATION

During inhalation, the diaphragm contracts, the chest expands, **the lungs are pulled outward, and alveolar (intrapulmonic) pressure decreases.**

During exhalation, the diaphragm relaxes, **the lungs recoil inward, and alveolar pressure increases, forcing air out of the lungs.**



MUSCLES OF INHALATION AND EXHALATION

- **Because air always flows from a region of higher pressure to a region of lower pressure, inhalation takes place**. Air continues to flow into the lungs as long as a pressure difference exists.
- During deep, forceful inhalations, accessory muscles of inspiration also participate in increasing the size of the thoracic cavity.
- The muscles are so named because they make little, if any, contribution during normal quiet inhalation, but **during exercise or forced ventilation they may contract vigorously. The accessory muscles of inhalation include the sternocleidomastoid muscles.**
- **Because both normal quiet inhalation and inhalation during exercise or forced ventilation involve muscular contraction, the process of inhalation is said to be active**.

- زي ما حكينا air بتنتقل من region اللي بكون فيه high pressure لل region اللي بكون في low pressure فكل ما كان pressure difference موجود كل ما كان inhalation and exhalation موجودين
- خلال عملية deep او forceful inhalation اذا الواحد عمل inhalation جدا قوي بهاي الحالة مش بس رح يشتغلو muscles of inhalation or exhalation في عندي accessory muscles of inspiration ايضا هي participate بتغيير size of thoracic cavity بتزيده هون
وهي doesn't contribute that much بعملية inspiration هي فقط بتساهم بعملية inspiration لما يكون عنا deep and forceful inhalation يعني خلال عملية الexercise مثلا او خلال forced ventilation بصير عنا contraction بشكل جدا كبير عشان هيك بهالحالة بتساهم الaccessory muscles
ولازم نعرف شو همه accessory muscles
- خلال forceful inhalation او normal inhalation هاي الprocess منسميها active , لانه عنا عضلات شغاله سواء muscles of inhalation بعدم وجود accessory muscles طبعا بعتمد اذا هل هو normal or forceful and deep inhalation اللي بحتاج muscular contraction of accessory muscles

EXHALATION

- **Breathing out, called exhalation (expiration),** is also due to a pressure gradient, but in this case the gradient is in the opposite direction: The pressure in the lungs is greater than the pressure of the atmosphere. Normal exhalation during quiet breathing, unlike inhalation, is a passive process because no muscular contractions are involved.
- Instead, exhalation results from **elastic recoil of the chest wall and lungs**, both of which have a natural tendency to spring back after they have been stretched.
- Exhalation **starts when the inspiratory muscles relax**. As the diaphragm relaxes, its dome moves superiorly owing to its elasticity.

- منسميه exhalation او expiration هاي العملية برضو بتشتغل نتيجة وجود pressure gradient ب opposite direction يعني pressure داخل lungs بكون اعلى من atmosphere وبالتالي خلال normal exhalation بطلع من lungs الى atmosphere

- بعملية exhalation ما في عنا muscular contractions زي ما حكينا هون diaphragm وexternal intercostals بصيرلهم relaxation عشان هيك exhalation هي passive process
  فهون بتتحرك lungs inward عشان هيك بصير عنا خروج air من داخل للlungs atmosphere ولما يصير relaxation of muscles and diaphragm بصير elasticity او stretching للlungs

OTHER FACTORS AFFECTING PULMONARY VENTILATION

As you have just learned, air pressure differences drive airflow during inhalation and exhalation. However, three other factors affect the rate of airflow and the ease of pulmonary ventilation: surface tension of the alveolar fluid, compliance of the lungs, and airway resistance.

- اذًا air pressure differences هو اللي بحرك الairflow خلال عملية الinhalation و exhalation
- في عندي 3 main factors بتتحكم بالrate of airflow and ease of pulmonary ventilation
  - مثل surface tension of alveolar fluid
  - Compliance of the lungs
  - Airway resistance

SURFACE TENSION OF ALVEOLAR FLUID

- **A thin layer of alveolar fluid coats the luminal surface of alveoli** and exerts a force known as **surface tension**.
- **During breathing**, surface tension must be overcome to expand the lungs during each inhalation. **Surface tension also accounts for two-thirds of lung elastic recoil, which decreases the size of alveoli during exhalation**.
- **The surfactant (a mixture of phospholipids and lipoproteins)** present in alveolar fluid reduces its surface tension.
- **A deficiency of surfactant in premature infants** causes respiratory distress syndrome, in which the surface tension of alveolar fluid is greatly increased, so that many alveoli collapse at the end of each exhalation. Great effort is then needed at the next inhalation to reopen the collapsed alveoli.

- اول اشي surface tension of alveolar fluid هلا الsurface تبع الlungs في حوليه زي fluid واللي هو عبارة عن thin layer of alveolar fluid وهو بحيط بlungs بعمل زي coating وهاد الthin layer هو اللي بيعمل force منسميها surface tension ، خلال عملية الbreathing بده surface tensionال يتغير يعني خلال عملية inhalation بده يتغير عن surface tension اللي بكون ناتج من عملية الexhalation, فالsurface tension هو account تقريبا ثلثين من lung elastic recoil which decreases size of alveoli during exhalation فالsurface tension هو الي بسبّب elasticity او stretching properties تبعت الlungs وبالتالي هو اللي بده يقلل size of lungs خلال عملية exhalation، فال surface tension must be overcome to expand the lungs خلال عملية inhalation, لانه حكينا خلال inhalation بده يزيد volume of lungs ولكن خلال exhalation size of lungs بده يقل فالsurface tension تأثيره اكبر خلال عملية exhalation فالثلثين تبعت lung elastic recoiling بتكون ناتجة من surface tension لانه هو اللي بده يقلل من size of lungs خلال exhalation, وبالتالي surface tension must be overcome حتى يصير expanding of lungs خلال عملية inhalation

- كيف بده يقل surface tension حتى يصير عنا contraction للdiaphragm وexternal intercostals وبالتالي يصير عنا expanding of lungs ويزيد volume of lungs حتى يقل pressure الموجود in lungs ويحدث inhalation, الاشياء الي بتقلل surface tension هي عبارة عن surfactant اللي هي mixtures of phospholipids and lipoproteins هاي بتكون موجودة بالfluid وبتقلل منsurface tension فبتساعد على حدوث inhalation,

- عشان هيك deficiency بالsurfactant بpremature infant الرضع اللي بولدو قبل بوقت بصير عندهم Respiratory distress syndrome لانه surfactant عندهم قليلة فالsurface tension تبع fluid بكون عندهم جدا عالي فبصير collapsing خلال عملية exhalation وبالتالي هدول بدهم great effort حتى يبلشو بnext inhalation مرة اخرى لانه الsurface tension بصير عالي فعملية inhalation عملية expanding of lungs بتصير صعبة لانه عندي deficiency of surfactant و الsurface tension عالي فصار عندهم respiratory distress syndrome

COMPLIANCE OF THE LUNGS

- ✓ **Compliance** refers to **how much effort is required to stretch the lungs and chest wall.**
- ✓ **High compliance** means that **the lungs and chest wall expand easily.**
- ✓ **Low compliance** means that **they resist expansion.**
- ✓ **In the lungs, compliance is related to two principal 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** that (1) scarlung tissue (for example, tuberculosis), (2) cause lung tissue to become filled with fluid (pulmonary edema), (3) produce a deficiency in surfactant, or (4) impede lung expansion in any way (for example, paralysis of the intercostal muscles).

- تاني شغله بتتحكم بـairflow من والىlungs اللي هي compliance of the lungs, معناها how much effort is required to stretch the lungs and chest wall ، اذا حكينا lungs and chest walls can be expanded معناها high compliance عندها lungs very easily ، ولكن لو حكينا lungs عندها low compliance بتكون lungs في هاي الحالة resist of expansion

- الcompliance بعتمد على 2 factors اللي همه elasticity and surface tension فإذا كانت elasticity جدا عالية الlungs and chest wall can be expanded very easily فـlungs اللي عندها high compliance حكينا it can expand very easily ليش؟ لانه elastic fibers الموجودة بالlung tissue can be easily stretched و surfactant الموجودة بالfluid بدها تقلل من surfaces tension وبالتالي الcompliance of lungs بده يعتمد عالelasticity كل ما كان elasticity اعلى كل ما كان compliance اعلى كل ما كان lungs and chest walls الها مقدرة اعلى انها تعمل expanding اكبر
وكل ما كان surface tension اقل نتيجة وجود surfactant كل ما كانت lungsعندها high compliance فعندها القدرة تعمل expanding easily

- في عنا some pulmonary conditions بصير فيهم decrease in compliance بالتالي هي بتكون resist لعملية expansion اللي هي مثل وجود tuberculosis, pulmonary edema, deficiency in surfactant, paralysis of intercostal muscles

AIRWAY RESISTANCE

- Like the flow of blood through blood vessels, the rate of airflow through the airways depends on both the pressure difference and the resistance.
- Airflow equals the pressure difference between the alveoli and the atmosphere divided by the resistance.
- **The walls of the airways, especially the bronchioles, offer some resistance to the normal flow of air into and out of the lungs.**
- As the lungs expand during inhalation, the bronchioles enlarge because their walls are pulled outward in all directions.
- **Larger-diameter airways** have decreased resistance.

- تالت عامل هو airway resistance مثل ما حكينا عن blood اللي بمشي خلال blood vessels ايضا rate تبع airflow خلال airways بعتمد مش بس على pressure difference ايضا بعتمد على resistance
- هلا airflow equals pressure difference بين lungs و atmosphere على resistance ،بمعنى airflow مش بس بعتمد على pressure difference between lungs and atmosphere لا..هذا الاشي مقسوم على airway resistance فهي الها دور مهم بـairflow
- خلال عملية inhalation بده يصير expanding لانه الwalls تبع bronchioles صارلها pulling outward in all directions فالvolume of lungs زاد فالpressure صار بداخل lungs اقل من pressure بالatmosphere
- طبعا كل ما كانت airways عندها large diameter بدها تكون resistance اقل وكل ما كان diameter of airways اقل بتكون resistance اعلى
- بالتالي الairway resistance بتزيد خلال عملية exhalation فهي وبتقل خلال inhalation ليش؟ لانه diameter of airways خلال عملية inhalation بكون كبير فـresistance بتكون اقل ، لكن خلال exhalation بكون diameter قليل ف resistance بتزيد
- الsmooth muscles الموجودة تبع الairways اذا صارلها contraction او صار relaxation ايضا بتتحكم بالairway diameter بالتالي رح تفرق عنا airway resistance
- اذا اجت signals مثلا من sympathetic division of autonomic system الsmooth muscles فيwalls of airways رح يصيرلها relaxation بصير عنا bronchodilation واللي نتيجته بصير عنا decreased resistance
- اي condition بعمل narrowing او obstruction للairway بده يزيد الresistance ، مثال عليه في حالة asthma او حالة chronic obstructive pulmonary disease COPD فهدول بكون فيهم resistance جدا عاليه فبالتالي بده يتأثر airflow

AIRWAY RESISTANCE

- **Airway resistance then increases during exhalation as the diameter of bronchioles decreases.** Airway diameter is also regulated by the degree of contraction or relaxation of smooth muscle in the walls of the airways.
- **Signals from the sympathetic division of the autonomic nervous system** cause relaxation of this smooth muscle, which results in **bronchodilation and decreased resistance.**
- **Any condition that narrows or obstructs the airways increases resistance,** so that more pressure is required to maintain the same airflow (i.e. asthma or chronic obstructive pulmonary disease (COPD)).

LUNG VOLUMES AND CAPACITIES

- ✓ **While at rest**, a healthy adult averages 12 breaths a minute, with each inhalation and exhalation moving about 500 mL of air into and out of the lungs.
- ✓ The **volume of one breath is called the tidal volume (VT).**
- ✓ **The minute ventilation (MV)**—the total volume of air inhaled and exhaled each minute—is respiratory rate multiplied by tidal volume:

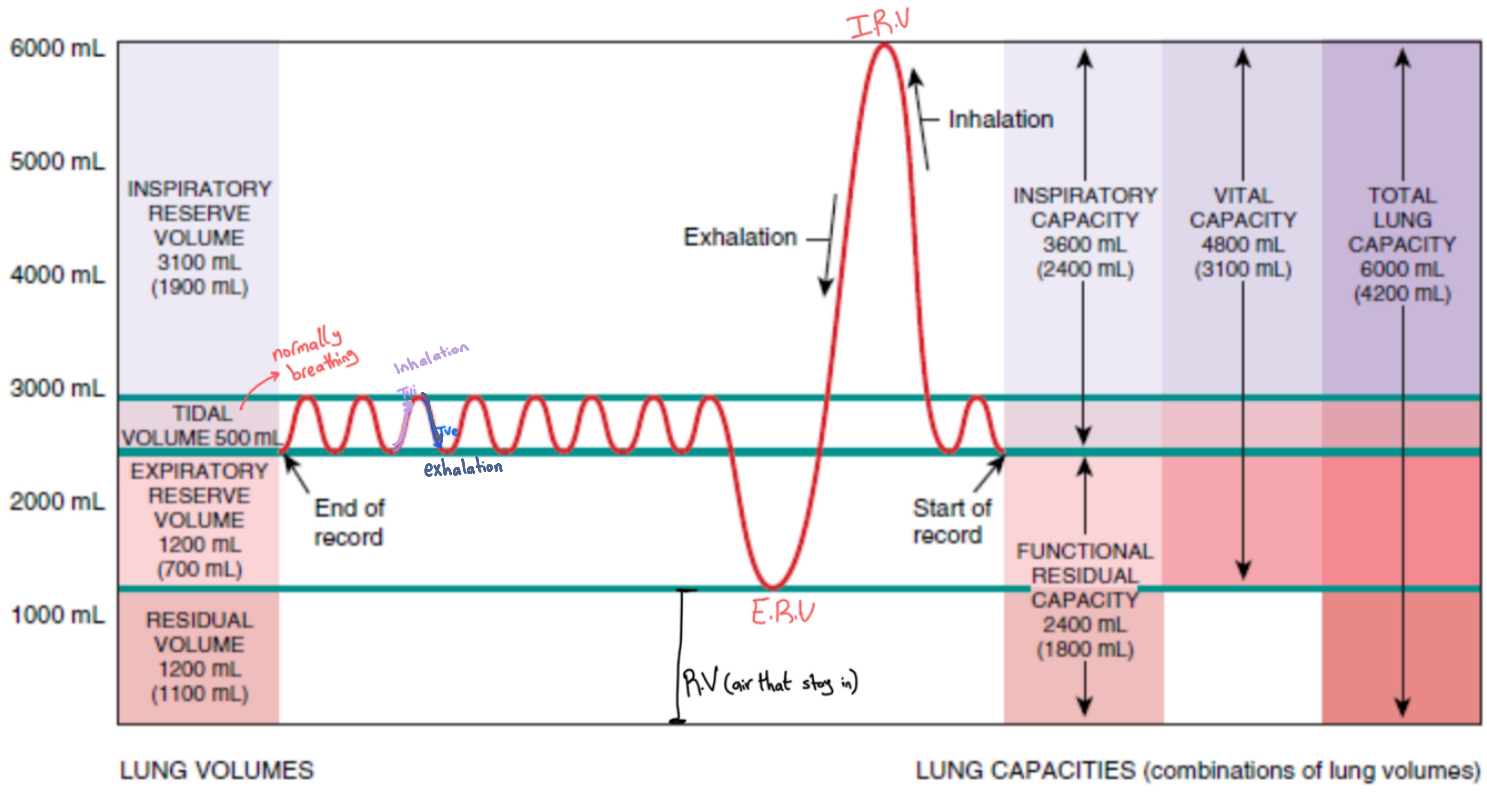
$$MV = 12 \text{ breaths/min} \times 500 \text{ mL/breath}$$
$$= 6 \text{ liters/min}$$

- ✓ **Lower-than-normal minute ventilation** usually is a **sign of pulmonary malfunction**.
- ✓ The **apparatus commonly used to measure the volume of air exchanged during breathing and the respiratory rate** is **a spirometer or respirometer**.
- ✓ **The record is called** a **spirogram**. **Inhalation** is recorded as an **upward deflection**, and **exhalation** is recorded as a **downward deflection**.

- في حالة rest الhealthy adults تقريبا بوخد breaths عبارة عن 12 breaths per minute مع كل inhalation و exhalation تقريبا بنتقل 500ml of air داخل وخارج الlungs
- الvolume of one breath اسمه tidal volume VT اللي هو 500ml
- عنا مصطلح منسميه minute ventilation MV وهو الtotal volume of air inhaled and exhaled each minute يعني اذا احنا منتنفس خلال الminute 12breaths وكمية الهواء اللي بتدخل وبتخرج خلال inhalation هي عبارة عن 500ml لما نضربها ب12 بعطينا minute ventilation اذا كان MV اقل من الطبيعي بعطينا sign انه عنا pulmonary malfunction في عنا مشكلة بالpulmonary functionality
- في عنا جهاز بستخدموه ليعملوا measuring of volume of air اللي صارله exchange خلال عملية breathing وrespiratory rate ، إسم الجهاز respirometer او spirometer
الrecord اللي بنتج يعني الصورة اللي منشوفها نتيجة استخدام spirometer اسمها spirogram بالspirogram بشوفو upward deflection بعبر عن inhalation او downward deflection اللي هو بعبر عن exhalation

Figure 23.15 **Spirogram of lung volumes and capacities.** The average values for a healthy adult male and female are indicated, with the values for a female in parentheses. Note that the spirogram is read from right (start of record) to left (end of record).

Lung capacities are combinations of various lung volumes.



- لما نحكي عن lung capacities بدنا نحكي عن combinations لكل lung volumes اللي رح نشرحهم هلا

LUNG VOLUMES AND CAPACITIES

- ✓ **Tidal volume varies considerably from one person to another and in the same person at different times.**
- ✓ **The alveolar ventilation rate is the volume of air per minute that actually reaches the respiratory zone.**
- ✓ **Several other lung volumes are defined relative to forceful breathing**. In general, these volumes are larger in males, taller individuals, and younger adults, and smaller in females, shorter individuals, and the elderly. Various disorders also may be diagnosed by comparison of actual and predicted normal values for a patient's gender, height, and age.
- ✓ **Lung capacities are combinations of various lung volumes.**

- الtidal volume بختلف من شخص لآخر وبختلف لنفس الشخص بـdifferent times يعني اللي بلعب رياضة مثلا غير عن اللي at rest (هاي لنفس الشخص) وحتى من شخص لشخص بختلف لكن قبل شوي احنا اخدنا average
- في عنا مصطلح alveolar ventilation rate (هو نوع من انواع الvolume)وهو كمية الهواء او حجم الهواء بكل دقيقة اللي فعليا وصل respiratory zone
- في عنا other lung volumes are defined relative to forceful breathing يعني الvolumes مثلا بكون اكبر بالmales مقارنة بـfemales مثلا بكون larger in males , in taller individuals, in younger adults وبكون مثلا smaller in females, in shorter individuals,in elderly عشان هيك كيف ما حكينا نفسه tidal volume بختلف من شخص لشخص اخر

LUNG VOLUMES AND CAPACITIES

- By taking a very deep breath, you can inhale a good deal more than 500 mL. This **additional inhaled air**, called the **inspiratory reserve volume**, is about 3100 mL in an average adult male and 1900 mL in an average adult female.
- Even more air can be inhaled if inhalation follows forced exhalation. **If you inhale normally and then exhale as forcibly as possible, you should be able to push out considerably more air in addition to the 500 mL of tidal volume**. The extra 1200 mL in males and 700 mL in females is called the **expiratory reserve volume**.
- **The forced expiratory volume in 1 second, (FEV1.0) is the volume of air that can be exhaled from the lungs in 1 second with maximal effort following a maximal inhalation.** Typically, chronic obstructive pulmonary disease (COPD) greatly reduces FEV1.0 because COPD increases airway resistance.

- في عنا نوعين رئيسين من انواع الvolume
اول نوع inspiratory reserve volume ، والنوع التاني expiratory reserve volume
- اول نوع هو عبارة عن additional inhalation air وهاد النوع انه احنا الطبيعي نستنشق 500ml اذا تم استنشاق اكتر من 500ml بينتج عنا additional inhalation يعني منكون استنشقنا من الهواء كمية اكبر من اللي لازم نستنشقها
- النوع التاني انه اذا اتنفسنا بشكل طبيعي ولكن عملنا exhalation بشكل قوي جدا بالتالي هون عملنا exhalation اكبر من يعني مثلا عملنا inhalation لتقريبا 500ml per breath لكن exhalation كان اكثر من 500ml per breath فهاد منسميه expiratory reserve volume وبكون عبارة عن additional exhalation air
- هلا ال FEV1.0 forced expiratory volume in 1 second هو يعني اذا شخص استخدم قوته الكبيرة يعني عمل maximum exhalation in 1 second ورجع بعديها with maximum effort وعمل maximum inhalation هاد الvolume of air اللي وصل من lungs in 1 second منسميه forced expiratory volume ومنحسبه in 1 second فهو الvolume of air that can be exhaled from lungs in1 second with maximum effort following a maximum inhalation
- بالchronic obstructive pulmonary disease بقلل force expiratory volume بقلله كتير لانه بزيد الairway resistance, حتى انه صعب الشخص يقدر انه ياخد maximum exhalation and inhalation بهاي الحالة

LUNG VOLUMES AND CAPACITIES

- Even after the expiratory reserve volume is exhaled, considerable air remains in the lungs, is called the **residual volume** and amounts to about 1200 mL in males and 1100 mL in females.
- **Inspiratory capacity** is the sum of tidal volume and inspiratory reserve volume (500 mL + 3100 mL = 3600 mL in males and 500 mL + 1900 mL = 2400 mL in females).
- **Functional residual capacity** is the sum of residual volume and expiratory reserve volume (1200 mL + 1200 mL = 2400 mL in males and 1100 mL + 700 mL = 1800 mL in females).

- هلا في عنا volume اسمه residual volume, يعني مثلا واحد عمل normal inhalation ولكن بعديها عمل exhalation بشكل جدا كبير فلما عمل exhalation جدا كبير الadditional air اللي صارله exhalation منسميه expiratory reserve volume ولكن هون بحكي انه بعض expiratory reserve volume ما بصيرله exhalation بضل بالlungs واللي هو منسميه residual volume

- طبعا لازم ننتبه انه كل volumes اللي منحكي عنهم بتفرق من males عن females وكل lung volumes بعبروا عن lung capacity

- في عنا مصطلح اسمه capacity, فمثلا اذا حكينا عن inspiratory capacity فهو عبارة عن مجموع
tidal volume +inspiratory reserve volume

مصطلح functional residual capacity هو مجموع residual volume +expiratory reserve volume

وزي ما حكينا كونه volume بختلف من male لfemale بالتالي الرقم اللي رح يطلع عنا من الجمع رح يخلف من male لfemale

LUNG VOLUMES AND CAPACITIES

- **Vital capacity** is the sum of inspiratory reserve volume, tidal volume, and expiratory reserve volume (4800 mL in males and 3100 mL in females).
- Finally, **total lung capacity** is the sum of vital capacity and residual volume (4800 mL + 1200 mL = 6000 mL in males and 3100 mL + 1100 mL = 4200 mL in females).

وعنا vital capacity وهو مجموع
Inspiratory reserve volume +tidal volume +expiratory reserve volume

وtotal lung capacity هو عبارة عن مجموع vital capacity + residual volume

- لازم نعرف القوانين ممكن تجيب حل

EXCHANGE OF OXYGEN AND CARBON DIOXIDE

- **The exchange of oxygen and carbon dioxide between alveolar air and pulmonary blood occurs via passive diffusion**, which is governed by the behavior of gases by two gas laws, Dalton's law and Henry's law.
- **Dalton's law** is important for understanding how gases move down their pressure gradients by diffusion, and **Henry's law** helps explain how the solubility of a gas relates to its diffusion.

- عملية الbreathing الinhalation and exhalation بتصير بإنه بصير بالlungs تبديل بين O2 وCO2 مثل ما شرحنا قبل بإنه بصير exchange between atmosphere and lungs و بعدين بين lungs and capillaries و الcapillaries معtissues ، فبصير عنا عبارة عن exchange بين O2 و CO2 , فالlungs بتبدل CO2 بالO2 وبتعطي الO2 body tissues ,

- هلا الexchange of oxygen and carbon dioxide بين alveolar air وبين pulmonary blood اللي بده يوصل الoxygen للsystematic circulation و systematic circulation بدها توصل لblood لtissues فهاد بحدث عن طريق passive diffusion والpassive diffusion بتعتمد على 2 gas laws اللي همه dalton and henry وهدول التنين بعتمدو على exchange of oxygen and carbon dioxide بين alveolar air and pulmonary blood عن طريق passive diffusion

- هلا الdalton's law هو مهم بإنه بعطينا معلومات انه كيف oxygen and carbon dioxide بدها تنتقل حسب pressure gradient باستخدام passive diffusion ، يعني انتقال oxygen بده يصير من المنطقة اللي تركيز الoxygen فيها عالي لمنطقة تركيز الoxygen فيها قليل ، ونفس الطريقة للCO2 لانها عن طريق passive diffusion

- لكن بhenry's law هو بعطينا عن شو علاقة solubility يعني gas ما بهمني بس هو وين concentration تبعه اقل ووين اعلى .. لا بهمني كمان قديش هاد الgas بقدر يدوب بهاي الmedia related to it's diffusion

GAS LAWS: DALTON'S LAW AND HENRY'S LAW

- ✓ According to **Dalton's law**, each gas in a mixture of gases exerts its own pressure as if no other gases were present.
- ✓ **The pressure of a specific gas in a mixture** is called its **partial pressure** (Px).
- ✓ **The total pressure of the mixture** is calculated simply by **adding all of the partial pressures**.
- ✓ **Atmospheric air is a mixture of gases**—nitrogen (N_2), oxygen (O_2), argon (Ar), carbon dioxide (CO_2), variable amounts of water vapor (H_2O), plus other gases present in small quantities.

According to dalton's law

- هلا كل gas اله pressure مختلف عن pressure of other gases
- اذا منحكي عن pressure of O2 منسميه partial pressure
- لكن pressure لكل الmixture of gasesمنعمل عبارة عن addition لكل الpartial pressure
- يعني الatmospheric air بحتوي عالnitrogen,oxygen,carbon dioxide و غير هيك فكل واحد منهم اله partial pressure و الtotal pressure لكلmixture منجمع مثلا partial pressure of nitrogen +partial pressure of oxygen + partial pressure of CO2..... وهيك

GAS LAWS: DALTON'S LAW AND HENRY'S LAW

- We can determine the **partial pressure exerted by each component in the mixture** by multiplying the percentage of the gas in the mixture by the total pressure of the mixture. Atmospheric air is 78.6% nitrogen, 20.9% oxygen, 0.093% argon, 0.04% carbon dioxide, and 0.06% other gases; a variable amount of water vapor is also present.

- **These partial pressures determine the movement of O_2 and CO_2 between the atmosphere and lungs, between the lungs and blood, and between the blood and body cells**. Each gas diffuses across a permeable membrane from the area where its partial pressure is greater to the area where its partial pressure is less. **The greater the difference in partial pressure, the faster the rate of diffusion**.

هلا في عنا طريقة احسب partial pressure for each gas وهو يساوي percentage of gas in mixture ضرب total pressure of mixture

وكل ما كانت difference in partial pressure اكبر بكون rate of diffusion اسرع
فالpartial pressure هو بحدد ال movement of O2 and CO2 بين atmosphere and lungs وبين lungs and blood و بين blood and body cells

GAS LAWS: DALTON'S LAW AND HENRY'S LAW

- Compared with inhaled air, **alveolar air has less O_2 and more CO_2 while exhaled air contains more O_2 than alveolar air and less CO_2**.

- **Henry's law states that the quantity of a gas that will dissolve in a liquid is proportional to the partial pressure of the gas and its solubility. In body fluids, the ability of a gas to stay in solution is greater when its partial pressure is higher and when it has a high solubility in water.** The higher the partial pressure of a gas over a liquid and the higher the solubility, the more gas will stay in solution. In comparison to oxygen, much more CO_2 is dissolved in blood plasma because the solubility of CO_2 is 24 times greater than that of O_2. Even though the air we breathe contains **mostly N_2, this gas has no known effect on bodily functions**, and at sea level pressure very little of it dissolves in blood plasma because its solubility is very low.

هلا بالinhaled air الalveolar air بكون فيه less O2 وmore CO2 ، لكن بالexhaled air بكون فيه more O2 و less CO2

لكن بالنسبة لhenry's law هو ما بتعامل مع pressure gradient ..هو بتعامل عن كمية الغاز اللي بتكون ذائبة بالliquid بالاعتماد على partial pressure of the gasوعلى ذائبيته ، يعني قديش percentage تبع partial pressure of gas بهاد الliquid وكم هو soluble هو اللي بعطينا quantity of a gas the dissolve in a liquid

الgases كيف بتسبح بجسمنا... بfluid فكل ما كان solubility الها بالwater اعلى والpartial pressure الها اعلى فأكيد قدرة gas انه يضل بالsolution اكبر

مثلا nitrogen ما اله اي known effect على body functions لانه solubility للنيتروجين بأجسامنا جدا قليلة وبالتالي ability of nitrogen انه يضلّ بأجسامنا قليلة بالتالي functionality تبعه بتكون جدا قليلة او معدومة داخل جسم الانسان

EXTERNAL AND INTERNAL RESPIRATION

- **Pulmonary gas exchange** is the diffusion of O_2 from air in the alveoli of the lungs to blood in pulmonary capillaries and the diffusion of CO_2 in the opposite direction.
- Respiration in the lungs **converts deoxygenated blood (depleted of some O2) coming from the right side of the heart into oxygenated blood (saturated with O2) that returns to the left side of the heart.**

- ال pulmonary gas exchange هو diffusion of O2 من air in lungs لل blood in pulmonary و diffusion of CO2 ب opposite direction ليش ؟ لانه O2 بتيجي ال pulmonary بتطلع O2 حتى توصله لل body tissues لكن ال blood اللي بدع يطلع من body tissues وبده يرجع لل lungs بده يكون محمل بال CO2 فال O2 direction of diffusion حيكون عكس direction of diffusion of CO2
- بالتالي respiration in lungs بحول deoxygenated blood اللي ما بحتوي كتير O2 بحتوي كتير CO2 جاي من right side of the heart الى oxygenated blood حتى يرجع لل left side of heart

EXTERNAL AND INTERNAL RESPIRATION

- **The number of capillaries near alveoli in the lungs is very large**, and blood flows slowly enough through these capillaries that it picks up a maximal amount of O_2.
- **During vigorous exercise**, when cardiac output is increased, blood flows more rapidly through both the systemic and pulmonary circulations. As a result, **blood's transit time in the pulmonary capillaries is shorter**.
- **In diseases that decrease the rate of gas diffusion**, however, the blood may not come into full equilibrium with alveolar air, especially during exercise. When this happens, the PO_2 declines and PCO_2 rises in systemic arterial blood.

- هلا number of capillaries الموجودة في lungs هي جدا كبيرة very large واعدادها كبيرة لانه blood flow بحتاج انه يمرّ من خلال هاي ال capillaries حتى يعمل pickup ل maximum amount of O2 يعني يحصل على كمية اكبر من ال O2 فكل ال capillaries الموجودة حولين lungs هي very large in number لانه هي بدها توخد O2 من عملية exchange of O2 and CO2 حتى تنقل O2 لاجزاء الجسم فهي اعدادها جدا كبيرة
- خلال vigorous exercise لما الواحد يعمل تمرينات عنيفة ال cardiac output بزيد ال blood flow بزيد بصير بشكل سريع خلال systematic و pulmonary circulations وبالتالي blood transit time in pulmonary capillaries بكون shorter ، يعني احنا حكينا blood flows خلال هاي ال capillaries بالحالات الطبيعية بكون كتير slow فبياخد maximum amount of O2 لكن الانسان ليش بتعب الي بعمل هاد ال exercise..لانه ال blood هون بتحرك بشكل سريع فبقاء ال blood بال pulmonary capillaries بكون كتير shorter وما بوصل O2 لجميع انحاء الجسم فالواحد بتعب
- ال diseases اللي بتقلل من rate of gas diffusion تركيز ال pressure of O2 بقل وتركيز CO2 بزيد بال systematic arterial blood

EXTERNAL AND INTERNAL RESPIRATION

- The left ventricle pumps oxygenated blood into the aorta and through the systemic arteries to systemic capillaries. **The exchange of O_2 and CO_2 between systemic capillaries and tissue cells** is called internal respiration or systemic gas exchange.
- As O_2 leaves the bloodstream, oxygenated blood is converted into deoxygenated blood.
- **Unlike external respiration,** which occurs only in the lungs, internal respiration occurs in tissues throughout the body.

- الleft ventricle بعمل pumping لل oxygenated blood بال aorta بنتقل لل systematic arteries فبنتقل لل systematic capillaries
  لانه الpulmonary حولت deoxygenated لل oxygenated وال oxygenated وصل لل left ventricle فبعمله pumping لل aorta
  وبعدين من خلال systematic arteries بوصلها ل systematic capillaries
  الexchange بين O2 and CO2 بين systemic capillaries and tissue cells مثل ما شرحناها قبل منسميه internal respiration or systematic gas exchange

- فالO2 لما بده يغادر bloodstream الblood oxygenated بتحول لل deoxygenated لانه هو بعطي tissues O2 وبياخد CO2

- الexternal respiration بصير داخل الlungs بين alveolar and pulmonary capillaries ولكن الinternal respiration هو بحدث بال tissues اللي بتكون حولين الbody

- وبالتالي زي ما شرحنا الO2 diffuse from systemic capillaries ل tissue cells الCO2 بده يتحرك بالاتجاه المعاكس لانه tissue cells بتعمل على انتاج CO2 فبالتالي CO2 بتحرك من tissue cells لجهة الpulmonary capillaries
  فال deoxygenated blood is then returned to the heart and pumped to the lungs for another cycle of external respiration فأول شي بصير عنا external respiration بعدين internal respiration

EXTERNAL AND INTERNAL RESPIRATION

- The PO_2 of blood pumped into systemic capillaries is higher (100 mmHg) than the PO_2 in tissue cells (40 mmHg at rest) because the cells constantly use O_2 to produce ATP.
- While O_2 diffuses from the systemic capillaries into tissue cells, **CO_2 diffuses in the opposite direction**. Because tissue cells are constantly producing CO_2, the PCO_2 of cells (45 mmHg at rest) is higher than that of systemic capillary blood (40 mmHg).
- The **deoxygenated blood then returns to the heart** and is pumped to the lungs for another cycle of external respiration.

THE RATE OF PULMONARY AND SYSTEMIC GAS EXCHANGE DEPENDS ON SEVERAL FACTORS:

- **Partial pressure difference of the gases.** Alveolar PO_2 must be higher than blood PO_2 for oxygen to diffuse from alveolar air into the blood. **The differences between PO_2 and PCO_2 in alveolar air versus pulmonary blood increase during exercise.**

- **Surface area available for gas exchange. The surface area of the alveoli is huge**. In addition, many capillaries surround each alveolus, so many that as much as 900 mL of blood is able to participate in gas exchange at any instant.

- زي ما حكينا الpartial pressure difference of gases هو اللي بحرك gases من one side to another وبالتالي لما يكون تركيز الoxygen الموجود في lungs اعلى من تركيز oxygen في blood فهون بده ينتقل من lungs لل blood ، و difference بين الضغط لoxygen وضغط CO2 الموجود بـ lungs مقارنة مع pulmonary blood بزيد خلال exercise (مثال على drug بعمل slow ventilation هو morphine لانها بتقلل كمية O2 and CO2 اللي ممكن يصيرلها exchange between lungs and blood يعني مش بس حالات exercise or rest بينهم difference..لا كمان حتى لو كان في حالة rest معينة وبوخد certain drugs حيصير عندي اختلاف)
- اذًا اول factor بعتمد عليه الrate of pulmonary and systemic gas exchange حكينا عليه انه يكون عنا فرق في الpartial pressure of gases فحكينا gases بنتقل من high to low pressure

- تاني عامل هو surface area available for gas exchange الsurface area الموجودة في lungs is very huge

- تالت عامل هو diffusion distance كل ما زادت الdiffusion distance كل ما كان rate of gas exchange اقل ، يعني كل ما كانت المسافة اللي بده يمشي فيها O2 and CO2 اللي بده يصيرله exchange اكبر فالrate بده يقل ، مثل حالة pulmonary edema بكون فيها gas exchange اصعب مقارنة بالأوضاع الطبيعية

- رابع عامل بعتمد على molecular weight and solubility of gases حكينا كل غاز معين اله solubility معينة وكل ما كان solubility اكتر كل ما كان تواجده بالfluid اكتر وبالتالي الeffect تبعه حيكون اكبر ، حتى الmolecular weight تبع gases اله دور.. كيف ؟ الO2 اله molecular weight اقل من CO2 معناته منتوقع diffusion of O2 يكون اسرع من CO2 ، كل ما كان حجم الاشي اقل بكون حركته و exchange اسرع ، ولكن solubility of CO2 in fluid portions of respiratory membrane is 24 times greater than O2 يعني مقدار ذائبية CO2 بالrespiratory membrane اكبر من O2 بمقدار 24 مرة مع انه molecular weight لل O2 هو اقل من CO2, وبالتالي net outward CO2 diffusion بصير 20مرة اسرع من net inward O2 diffusion

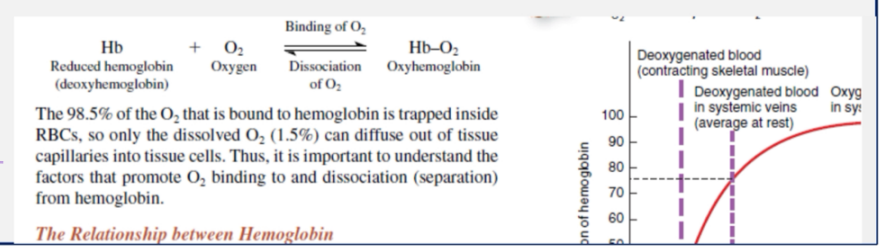
THE RATE OF PULMONARY AND SYSTEMIC GAS EXCHANGE DEPENDS ON SEVERAL FACTORS:

- **Diffusion distance.** The respiratory membrane is very thin, so diffusion occurs quickly. **Buildup of interstitial fluid between alveoli, as occurs in pulmonary edema, slows the rate of gas exchange because it increases diffusion distance.**

- **Molecular weight and solubility of the gases.** Because **O_2 has a lower molecular weight than CO_2**, it could be expected to diffuse across the respiratory membrane about 1.2 times faster. However, **the solubility of CO_2 in the fluid portions of the respiratory membrane is about 24 times greater than that of O_2**. Taking both of these factors into account, net outward CO_2 diffusion occurs 20 times more rapidly than net inward O_2 diffusion.

TRANSPORT OF OXYGEN AND CARBON DIOXIDE: OXYGEN TRANSPORT

- **Oxygen does not dissolve easily in water**, so only about 1.5% of inhaled O2 is dissolved in blood plasma.
- **About 98.5% of blood O_2 is bound to hemoglobin in red blood cells** (the amount dissolved in the plasma is 0.3 mL and the amount bound to hemoglobin is 19.7 mL.).



- رح نبلش بـoxygen transport
زي ما حكينا solubility of CO2 هي اكبر من solubility of O2 فـit doesn't dissolve easily

- الرسمة : في عنا hemoglobin واللي هو ما معاه oxygen فلما يدخل oxygen على red blood cells بصير عنا binding بين O2 and hemoglobin بعمل oxyhemoglobin واللي هو ممكن يصيرله dissociation ويرجع يتقسم الى O2 و hemoglobin

THE RELATIONSHIP BETWEEN HEMOGLOBIN AND OXYGEN PARTIAL PRESSURE

- The most important factor that determines how much O_2 binds to hemoglobin is the PO_2; **the higher the PO_2, the more O_2 combines with Hb**.
- **When reduced hemoglobin (Hb) is completely converted to oxyhemoglobin ($Hb–O_2$), the hemoglobin is said to be fully saturated; when hemoglobin consists of a mixture of Hb and $Hb–O_2$, it is partially saturated.** The percent saturation of hemoglobin expresses the average saturation of hemoglobin with oxygen. For instance, if each hemoglobin molecule has bound two O_2 molecules, then the hemoglobin is 50% saturated because each Hb can bind a maximum of four O_2.

كل ما كان الpartial pressure of O2 اعلى كل ما كانت عدد جزيات O2 اللي بدها ترتبط مع hemoglobin اكبر

لازم نعرف متى hemoglobin بكون fully saturated ومتى partially saturated, حسب الpressure of O2 لما يكون pressure of O2 اعلى بكون عدد جزيئات O2 اللي بدها ترتبط مع hemoglobin اكبر
بالتالي لما reduced hemoglobin يرتبط مع O2 ويتحول لoxyhemoglobin بصير اسمه Hb-O2 وهاد منسميه fully saturated
ولكن لما hemoglobin لما يصير يتكون من mixture of Hb and Hb-O2 بصير اسمه partially saturated لانه جزء من O2 مرتبط مع hemoglobin وجزء مش مرتبط ، لانه ممكن عدد جزيئات الاكسجين مش كبيرة فمو موجود يرتبط مع hemoglobin

OTHER FACTORS AFFECTING THE AFFINITY OF HEMOGLOBIN FOR OXYGEN

❖ **1. Acidity (pH):** As acidity increases (pH decreases), the affinity of hemoglobin for O_2 decreases, and O_2 dissociates more readily from hemoglobin. **The Bohr effect** works both ways: An increase in hydrogen ion in blood causes O2 to unload from hemoglobin, and the binding of O_2 to hemoglobin causes unloading of hydrogen ion from hemoglobin (hemoglobin can act as a buffer for hydrogen ions).

لما acidity تزيد الph بتقل فالaffinity لارتباط hemoglobin مع O2 بتقل ، يعني ph لازم تكون عالية حتى يرتبطو بشكل اكبر ويعطيني fully saturated or partially saturated hemoglobin

هاد منسميه bohr effect لما يزيد H+ in blood معناته acidity زادت معناته O2 can be easily dissociated from hemoglobin

OTHER FACTORS AFFECTING THE AFFINITY OF HEMOGLOBIN FOR OXYGEN

❖ **2. Partial pressure of carbon dioxide:** PCO2 and pH are related factors because low blood pH (acidity) results from high PCO2. As CO_2 enters the blood, much of it is temporarily converted to carbonic acid (H_2CO_3). The carbonic acid thus formed in red blood cells dissociates into hydrogen ions and bicarbonate ions. **As the hydrogen ions concentration increases, pH decreases. Thus, an increased PCO_2 produces a more acidic environment, which helps release O_2 from hemoglobin.**

حكينا PO2 بأثر على أرتباط الأكسجين مع hemoglobin ، فأيضًا PCO2 بأثر على affinity of hemoglobin بارتباطه مع oxygen

ف PCO2 وPh همه related factors يعني بأثر زيه ، فلما يقل ph وينتج acidity فهو ناتج من high PCO2 ، في معادلة اخدناها انه برتبط CO2 مع H2O يعطينا H2CO3 واللي هو بتحلل ل HCO3- و +H فبرتفع +H فكل ما كان عنا CO2 اكتر نسبة +H حتكون اعلى فبقل ph فالacidity بتكون عالية

OTHER FACTORS AFFECTING THE AFFINITY OF HEMOGLOBIN FOR OXYGEN

لما تزيد temperature

❖ **3. Temperature:** Within limits, as temperature increases, so does the amount of O2 released from hemoglobin. During hypothermia (lowered body temperature) cellular metabolism slows, the need for O_2 is reduced, and more O_2 remains bound to hemoglobin.

Body temperature بكون قليل

لما تكون درجة الحرارة عالية بتكون affinity بينهم قليلة بينما لو حرارة قليلة فحاجة الجسم لO2 رح تقل لانه O2 بهاي الحالة غالبا بضل مرتبط مع hemoglobin

CARBON DIOXIDE TRANSPORT

Under normal resting conditions, each 100 mL of deoxygenated blood contains the equivalent of 53 mL of **gaseous CO2, which is transported in the blood in three main forms:**

1. **Dissolved CO_2.** The smallest percentage—about 7%—is dissolved in blood plasma. On reaching the lungs, it diffuses into alveolar air and is exhaled.

2. **Carbamino compounds**. somewhat higher percentage, about 23%, combines with the amino groups of amino acids and proteins in blood to form carbamino compounds. **Because the most prevalent protein in blood is hemoglobin** (inside red blood cells), most of the CO2 transported in this manner is bound to hemoglobin.

- اول شي بدنا نعرف انه CO2 بيتواجد بالجسم بعدة أشكال
- على شكل dissolved CO2 بكون ذائب فبشكل small percentage تقريبا 7% بكون ذائب بـblood plasma فلما يعمل reaching لـlungs بصيرله diffusion لـalveolar air بعدين exhalation

CARBON DIOXIDE TRANSPORT

chains. Hemoglobin that has bound CO_2 is termed **carbamino-hemoglobin ($Hb–CO_2$):**

$$\underset{\text{Hemoglobin}}{Hb} + \underset{\text{Carbon dioxide}}{CO_2} \rightleftharpoons \underset{\text{Carbaminohemoglobin}}{Hb–CO_2}$$

ممكن يصيرله dissociation فيرجع يعطيني CO2 and hemoglobin

The formation of carbaminohemoglobin is greatly influenced by PCO2. For example, in **tissue capillaries** PCO2 is relatively high, which promotes formation of carbaminohemoglobin. But in **pulmonary capillaries**, PCO2 is relatively low, and the CO2 readily splits apart from globin and enters the alveoli by diffusion.

- ممكن يتواجد على شكل carbamino compounds وهاد الشكل بتواجد بنسبة 23% ومنلاقيه مرتبط مع amino groups بالـamino acids و proteins وايضًا برتبط مع hemoglobin (برتبط مع amino groups اللي بالـhemoglobin)

- بالـtissue capillaries الـPCO2 بكون عالي لانه هي بتستخدم اصلا O2 لانتاج CO2 فبالتالي هاد الاشي بكون عندي caraminohemoglobin
- ولكن بالـpulmonary capillaries الـCO2 بكون قليل وبالتالي ما بكون مرتبط مع hemoglobin فممكن يكون داخل بعملية diffusion وممكن جزء dissolved

CARBON DIOXIDE TRANSPORT

3. Bicarbonate ions. The greatest percentage of CO_2—about 70%—is transported in blood plasma as bicarbonate ions. Thus, as blood picks up CO_2, bicarbonate ion accumulates inside RBCs. Some bicarbonate ion moves out into the blood plasma, down its concentration gradient. In exchange, chloride ions move from plasma into the RBCs. *This exchange of negative ions, which maintains the electrical balance between blood plasma and RBC cytosol, is known as* ***the chloride shift.*** The **net effect** of these reactions is that CO_2 is removed from tissue cells and transported in blood plasma as bicarbonate ion. As blood passes through pulmonary capillaries in the lungs, all of these reactions reverse and CO_2 is exhaled.

- ممكن يتواجد ايضًا على شكل bicarbonate ions مثل ما شرحناها بالمعادلة , وهاي منعتبرها the greatest percentage 70%

- اذا HCO3- بده ينتقل للblood plasma بده يصير عنا shift يعني تغيير بالشحنات ، حتى ترجع الشحنات لوضعها الطبيعي كونه طلع HCO3 بهاي الحالة بصير عنا exchange انه Cl- chloride ions بتتحرك من plasma للRBC حتى تعوض HCO3 اللي طلع من RBC للblood plasma،فبعادل الشحنة وهاي العملية اسمها chloride shift

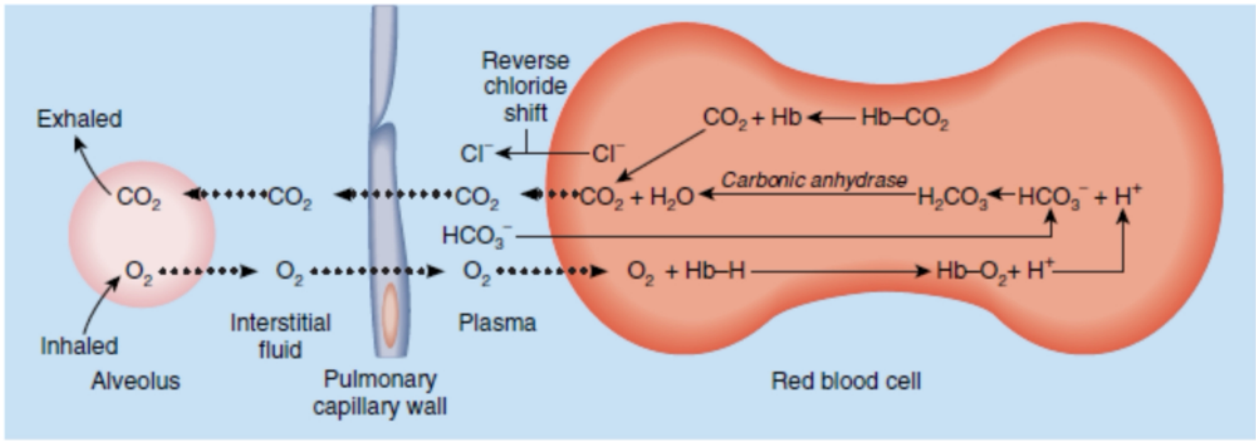
CARBON DIOXIDE TRANSPORT

- The amount of CO2 that can be transported in the blood is influenced by the percent saturation of hemoglobin with oxygen. The lower the amount of oxyhemoglobin ($Hb–O_2$), the higher the CO_2-carrying capacity of the blood, **a relationship known as the Haldane effect.**

- اذا كانت الamount كمية الoxyhemoglobin قليلة بالتالي كمية CO2 اللي بدها ترتبط معها عالية، لانه hemoglobin بده يرتبط مع الاكسجين فإذا كان ارتباطه مع الاكسجين كبير اذًا ارتباطه مع CO2 بده يكون اقل وهاد الrelationship منسميه haldane effect واللي هو ارتباط CO2 او affinity of CO2 انه يرتبط مع hemoglobin بعتمد على percent saturation of hemoglobin with oxygen

SUMMARY OF GAS EXCHANGE AND TRANSPORT IN LUNGS AND TISSUES

Hemoglobin inside red blood cells transports O_2, CO_2, and H^+.

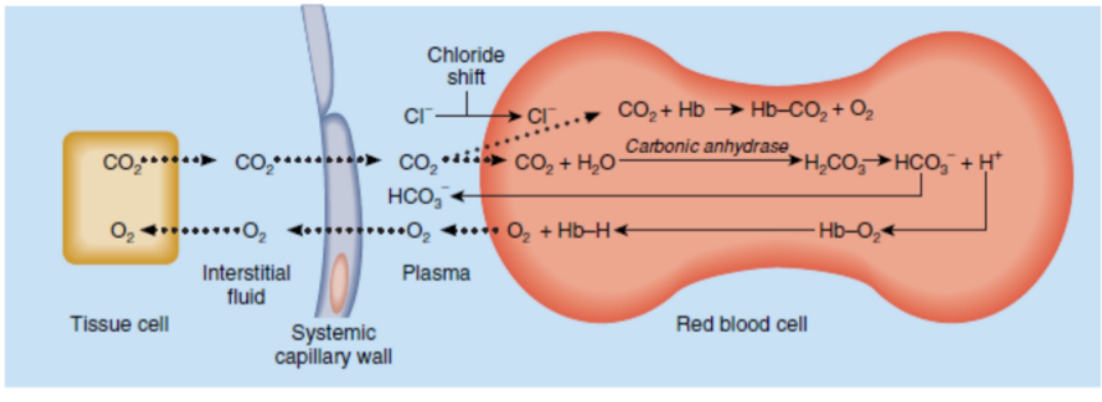


(a) Exchange of O_2 and CO_2 in pulmonary capillaries (external respiration)

Summary of chemical reactions that occur during gas exchange. (a) As carbon dioxide (CO_2) is exhaled, hemoglobin (Hb) inside red blood cells in pulmonary capillaries unloads CO_2 and picks up O_2 from alveolar air. Binding of O_2 to Hb–H releases hydrogen ions (H^+). Bicarbonate ions (HCO_3^-) pass into the RBC and bind to released H^+, forming carbonic acid (H_2CO_3). The H_2CO_3 dissociates into water (H_2O) and CO_2, and the CO_2 diffuses from blood into alveolar air. To maintain electrical balance, a chloride ion (Cl^-) exits the RBC for each HCO_3^- that enters (reverse chloride shift). (b) CO_2 diffuses out of tissue cells that produce it and enters red blood cells, where some of it binds to hemoglobin, forming carbaminohemoglobin (Hb–CO_2). This reaction causes O_2 to dissociate from oxyhemoglobin (Hb–O_2). Other molecules of CO_2 combine with water to produce bicarbonate ions (HCO_3^-) and hydrogen ions (H^+). As Hb buffers H^+, the Hb releases O_2 (Bohr effect). To maintain electrical balance, a chloride ion (Cl^-) enters the RBC for each HCO_3^- that exits (chloride shift).

شرحناهم فوق

SUMMARY OF GAS EXCHANGE AND TRANSPORT IN LUNGS AND TISSUES



(b) Exchange of O_2 and CO_2 in systemic capillaries (internal respiration)

Summary of chemical reactions that occur during gas exchange. (a) As carbon dioxide (CO_2) is exhaled, hemoglobin (Hb) inside red blood cells in pulmonary capillaries unloads CO_2 and picks up O_2 from alveolar air. Binding of O_2 to Hb–H releases hydrogen ions (H^+). Bicarbonate ions (HCO_3^-) pass into the RBC and bind to released H^+, forming carbonic acid (H_2CO_3). The H_2CO_3 dissociates into water (H_2O) and CO_2, and the CO_2 diffuses from blood into alveolar air. To maintain electrical balance, a chloride ion (Cl^-) exits the RBC for each HCO_3^- that enters (reverse chloride shift). (b) CO_2 diffuses out of tissue cells that produce it and enters red blood cells, where some of it binds to hemoglobin, forming carbaminohemoglobin (Hb–CO_2). This reaction causes O_2 to dissociate from oxyhemoglobin (Hb–O_2). Other molecules of CO_2 combine with water to produce bicarbonate ions (HCO_3^-) and hydrogen ions (H^+). As Hb buffers H^+, the Hb releases O_2 (Bohr effect). To maintain electrical balance, a chloride ion (Cl^-) enters the RBC for each HCO_3^- that exits (chloride shift).

CONTROL OF BREATHING

❖ **At rest**, about 200 mL of O_2 is used each minute by body cells. **During strenuous exercise**, however, O_2 use typically increases 15- to 20-fold in normal healthy adults.

✓ Respiratory Center:

- **The size of the thorax is altered by the action of the breathing muscles**, which contract as a result of nerve impulses transmitted from centers in the brain and relax in the absence of nerve impulses.

- ال control of breathing اول شي بده يعتمد على انه وين بدها تحدث control of breathing
اول شي على respiratory center اول center بعمل control of breathing طبعا ال size of thorax رح يتغير
حسب ال action of breathing muscles يعني breathing muscles اذا صارلها contraction بتعمل على ارسال
nerve impulses بتنتقل من centers بال brain فبصير contraction , وبعدم وجود impulses بصير relaxation

CONTROL OF BREATHING

بتنقسم حسب location and function

✓ Respiratory Center:

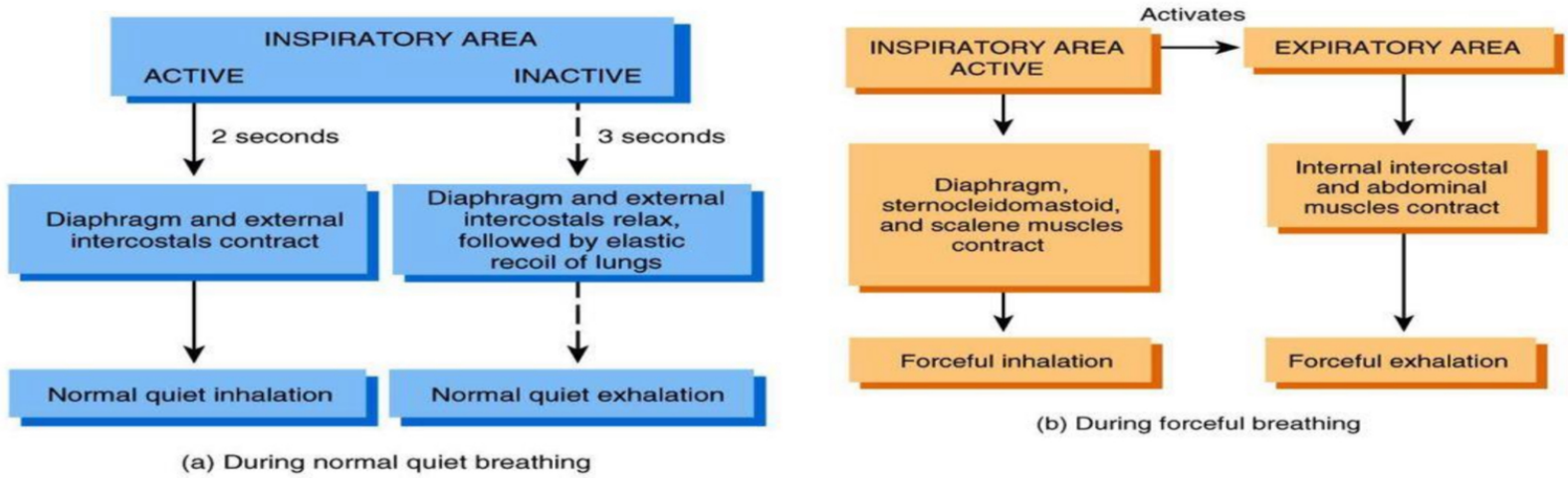
- These nerve impulses are sent from clusters of neurons located bilaterally in the brain stem. This widely dispersed group of neurons, collectively called the respiratory center, can be divided into two principal areas on the basis of location and function: (1) the medullary respiratory center in the medulla oblongata and (2) the pontine respiratory group in the pons.

MEDULLARY RESPIRATORY CENTER

✓ The medullary respiratory center is **made up of two collections of neurons** called the **dorsal respiratory group (DRG)**, formerly called the **inspiratory area**, and the **ventral respiratory group (VRG)**, formerly called the **expiratory area**.

MEDULLARY RESPIRATORY CENTER

Figure 23.25 Role of the medullary rhythmicity area during normal quiet breathing



- هون بحكيلي متى بده يصير عنا contractionومتى بده يصير relaxation ، كيف بده يصير normal quite breathing وكيف بصير forceful breathing , كيف nerve impulses بدها تنتقل من medullary respiratory centers عن طريق neurons حكيناهم اللي همه اما اللي موجودين بالinspiratory area او اللي موجودين بال expiratory area فإما بتشجع يصير contraction of breathing muscles بإنها بترسل nerve impulses او relaxation في حالات rest فما بتنتج nerve impulses

MEDULLARY RESPIRATORY CENTER

- ✓ The **VRG becomes activated when forceful breathing is requir**ed, such as during exercise, when playing a wind instrument, or at high altitudes.
- ✓ **During forceful inhalation**, nerve impulses from the DRG not only stimulate the diaphragm and external intercostal muscles to contract, they also activate neurons of the VRG involved in forceful inhalation to send impulses to the accessory muscles (i.e. sternocleidomastoid) of inhalation.
- ✓ **During forceful exhalation**, the DRG is inactive along with the neurons of the VRG that result in forceful inhalation, but neurons of the VRG involved in forceful exhalation send nerve impulses to the accessory muscles of exhalation (i.e. internal intercostals).

- هلا الVRG هي expiratory area لكن DRG هي inspiratory area فالVRG becomes activated لما يكون عنا forceful breathing فهون بوضحلنا متى بصير activation لكل وحدة
- خلال عملية forceful inhalation الnerve impulses اللي بتنتقل من DRG هي مش بس بتعنل لل stimulation لل diaphragm و external costal muscles حتى يصيرلها contraction..لا هي ايضًا بتعمل لل activation لل neurons الموجودة بالVRG اللي هي الها علاقة بالforceful inhalation حتى تعمل ارسال لل impulses لل accessory muscles of inhalation
- لكن خلال forceful exhalation الDRG او inspiratory neurons بتكون inactivate ، المتضمن بهاي العملية هو بس VRG اللي برسل nerve impulses لل accessory muscles زي internal intercostals
- بدنا نركز هون انه متى بشتغل neurons of DRG and VRG بشتغلو together خلال عملية forceful inhalation
ولكن forceful exhalation بس بشتغل VRG مااا بشتغل DRG

PONTINE RESPIRATORY GROUP

- ✓ **The pontine respiratory group (PRG)**, formerly called the pneumotaxic area, is a collection of neurons in the pons.
- ✓ The neurons in the PRG are active during inhalation and exhalation.
- ✓ The PRG transmits nerve impulses to the DRG in the medulla.
- ✓ The PRG may play a role in both inhalation and exhalation by modifying the basic rhythm of breathing generated by the VRG, as when exercising, speaking, or sleeping.

- هاد بكون موجود بالpons , ال neurons of PRG هي active خلال عملية inhalation و exhalation
ال PRG بعمل على ارسال nerve impulses لل DRG اللي بكون موجود بالmedulla ، ايش بعمل ال PRG بعمل...

بالتالي PRG ممكن يأثر على DRG و بأثر على VRG

REGULATION OF THE RESPIRATORY CENTER

- ✓ **Activity of the respiratory center can be modified in response to receptors in the peripheral nervous system**, and other factors in order to maintain the homeostasis of breathing.

- يعني مش بس regulation بصير عن طريق medullary و pontine respiratory... ممكن ايضا ال activity of respiratory center تتأثر ب other brain regions ,receptors and other factors

CHEMORECEPTOR REGULATION OF BREATHING

- ✓ **Certain chemical stimuli modulate how quickly and how deeply we breathe.** The respiratory system functions to maintain proper levels of CO_2 and O_2 and is very responsive to changes in the levels of these gases in body fluids.
- ✓ We introduced sensory neurons that are responsive to chemicals, called chemoreceptors.

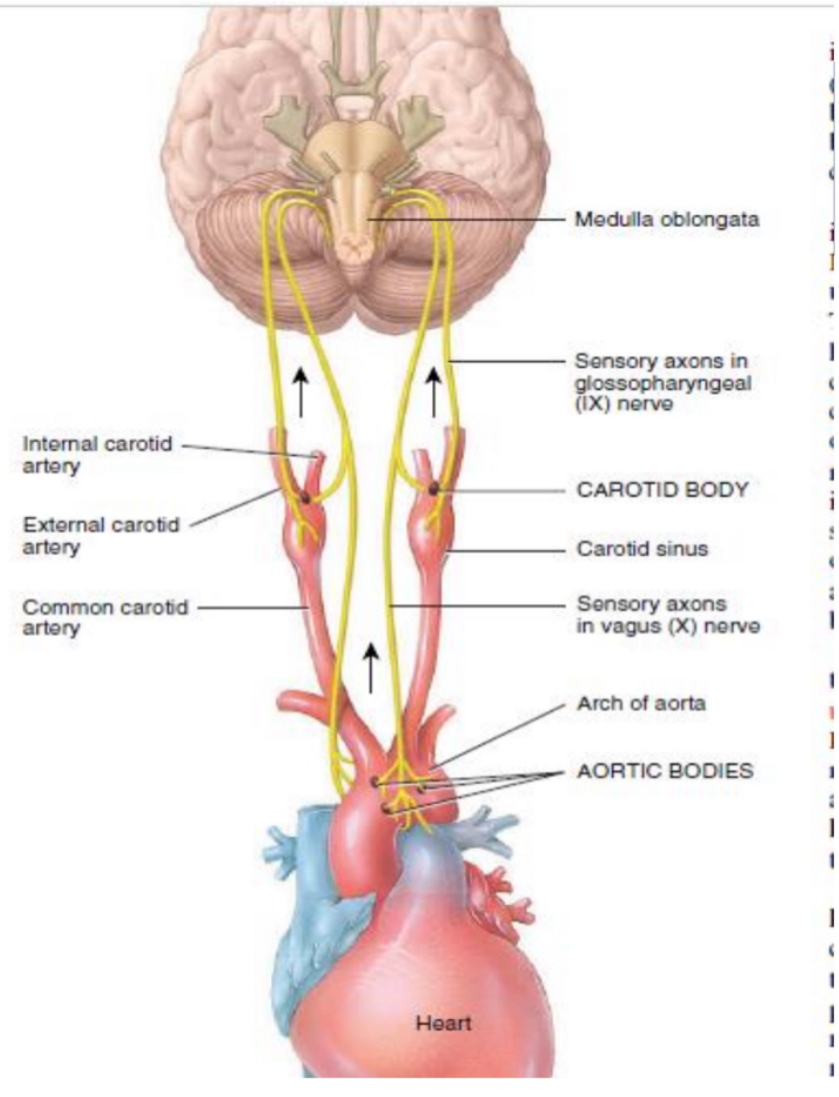
- هون بحكي respiratory system عم بحاول يعمل maintaining لlevel مناسب من CO2 and O2 وبالتالي اي تغيير ب CO2and O2 عن طريق chemical stimuli ممكن يأثر على proper levels of CO2 and O2 داخل lungs , فعشان هيك chemical stimuli ممكن تأثر عن طريق انه كيف بصير عنا change بال level of O2 and CO2 لهاي ال gases بال body fluids هي بتأثر عليهم

- ال sensory neurons لل chemicals منسميهم chemoreceptors واللي ممكن يعمل detect لأي chemical stimuli

- عندي هون انواع chemoreceptors :

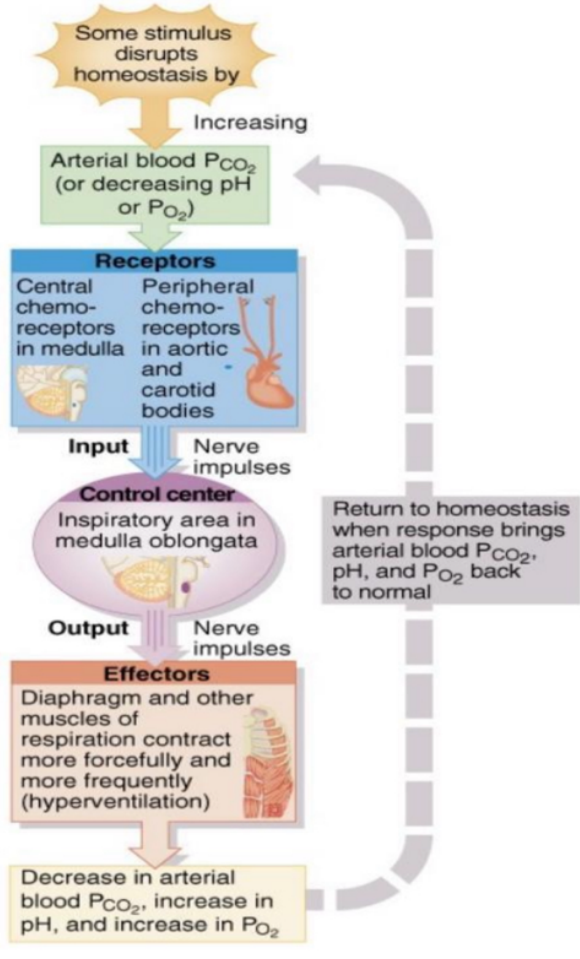
LOCATIONS OF PERIPHERAL CHEMORECEPTORS

- ✓ **Chemoreceptors** are sensory neurons that respond to changes in the levels of certain chemicals in the body.
- ✓ **Central chemoreceptors are located in or near the medulla oblongata in the central nervous system. They are sensitive to changes in hydrogen ions in the CSF.**
- ✓ **Peripheral chemoreceptors are located in the aortic bodies. They are clusters of chemoreceptors located in the wall of the arch of the aorta, and in the carotid bodies. They are sensitive to changes in PO2, hydrogen ions, and PCO2 in the blood.**



- هاد نفس الشرح اللي حكيناه قبل شوي انه كيف بدي يصير regulation اذا صار activation لل chemoreceptors برجع يصير activation لـ respiratory centers اا بصير activation لل inspiratory او expiratory اللي موجوين بـ respiratory center

Negative Feedback Regulation of Breathing



- Negative feedback control of breathing
- Increase in arterial pCO2
- Stimulates receptors
- Inspiratory center
- Muscles of respiration contract more frequently & forcefully
- pCO2 Decreases

THE INFLATION REFLEX

- ✓ Similar to those in the blood vessels, **stretch-sensitive receptors called baroreceptors or stretch receptors** are located in the walls of bronchi and bronchioles.
- ✓ **When these receptors become stretched during overinflation of the lungs**, nerve impulses are sent along the vagus (X) nerves to the dorsal respiratory group (DRG) in the medullary respiratory center. In response, the DRG is inhibited and the diaphragm and external intercostals relax. As a result, further inhalation is stopped and exhalation begins.

- هون بحكي انه مش بس chemoreceptors بتعمل controling of breathing عنا ايضا baroreceptors اللي منسميهم strech receptors و هدول ال receptors اخدناهم بلل sensory receptors
- هاي الreceptors لما يصيرلها stretching خلال عملية overinflation of the lungs الnerve impulses يتم ارسالها عن طريق vagus nerve اللي هي مسؤولة عن parasympathetic regulation يتم انتاج الnerve impulses لdorsal respiratory group الموجود بmedullary respiratory center بالتالي dorsal respiratory group لانه صار عنا stretching فمش محتاجين يصير contraction فبصير inhibition لDRG المسؤولة عن contraction وبصير relaxation of diaphragm and external intercostal muscles وبالتالي further inhalation is stopped وببلش exhalation

THE INFLATION REFLEX

- ✓ **As air leaves the lungs during exhalation**, the lungs deflate and the stretch receptors are no longer stimulated. Thus, the DRG is no longer inhibited, and a new inhalation begins. This reflex is referred to as the inflation reflex.

OTHER INFLUENCES ON BREATHING

- **Limbic system stimulation:** Anticipation of activity or emotional anxiety may stimulate the limbic system, which then sends excitatory input to the DRG, increasing the rate and depth of breathing.

ال DRG هون بده يسبب زيادة ل rate and depth of breathing
في حالة limbic system اللي هي emotional anxiety

- **Temperature**
- **Pain**
- **Stretching the anal sphincter muscle**
- **Irritation of airways:** Physical or chemical irritation of the pharynx or larynx brings about an immediate cessation of breathing followed by coughing or sneezing.
- **Blood pressure**

- هاي summary لل stimuli اللي بتعمل affecting لل breathing rate and depth

TABLE 23.3

Summary of Stimuli That Affect Breathing Rate and Depth

STIMULI THAT INCREASE BREATHING RATE AND DEPTH	STIMULI THAT DECREASE BREATHING RATE AND DEPTH
Voluntary hyperventilation controlled by cerebral cortex and anticipation of activity by stimulation of limbic system.	Voluntary hypoventilation controlled by cerebral cortex.
Increase in arterial blood P_{CO_2} above 40 mmHg (causes an increase in H^+) detected by peripheral and central chemoreceptors.	Decrease in arterial blood P_{CO_2} below 40 mmHg (causes a decrease in H^+) detected by peripheral and central chemoreceptors.
Decrease in arterial blood P_{O_2} from 105 mmHg to 50 mmHg.	Decrease in arterial blood P_{O_2} below 50 mmHg.
Increased activity of proprioceptors.	Decreased activity of proprioceptors.
Increase in body temperature.	Decrease in body temperature (decreases respiration rate), sudden cold stimulus (causes apnea).
Prolonged pain.	Severe pain (causes apnea).
Decrease in blood pressure.	Increase in blood pressure.
Stretching of anal sphincter.	Irritation of pharynx or larynx by touch or chemicals (causes brief apnea followed by coughing or sneezing).

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