PHYSIOLOGY

FACULTY OF PHARMACEUTICAL SCIENCES

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LECTURE 12: RESPIRATORY SYSTEM

Objectives

اللهمّ مهّد لي تمهيدًا ♡

تفريغ : مريم الشروف

1. Discuss **structures of the respiratory system.**
2. Describe **pulmonary ventilation**.
3. Explore **lung volumes and capacities.**
4. Discuss **exchange of oxygen and carbon dioxide as well as transport of both.**
5. Describe **control of breathing.**

(Pages 856- 876 of the reference)

لأ مش عادي ... هاد الفاينل اللي بدك تحوّضن فيه

😂😂😂

اعمل كاسة شاي وجيب صحنا بزر والحقني

رح يكون ؟سهل تشابتر وعد ...

بسم الله ♡

THE RESPIRATORY SYSTEM

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

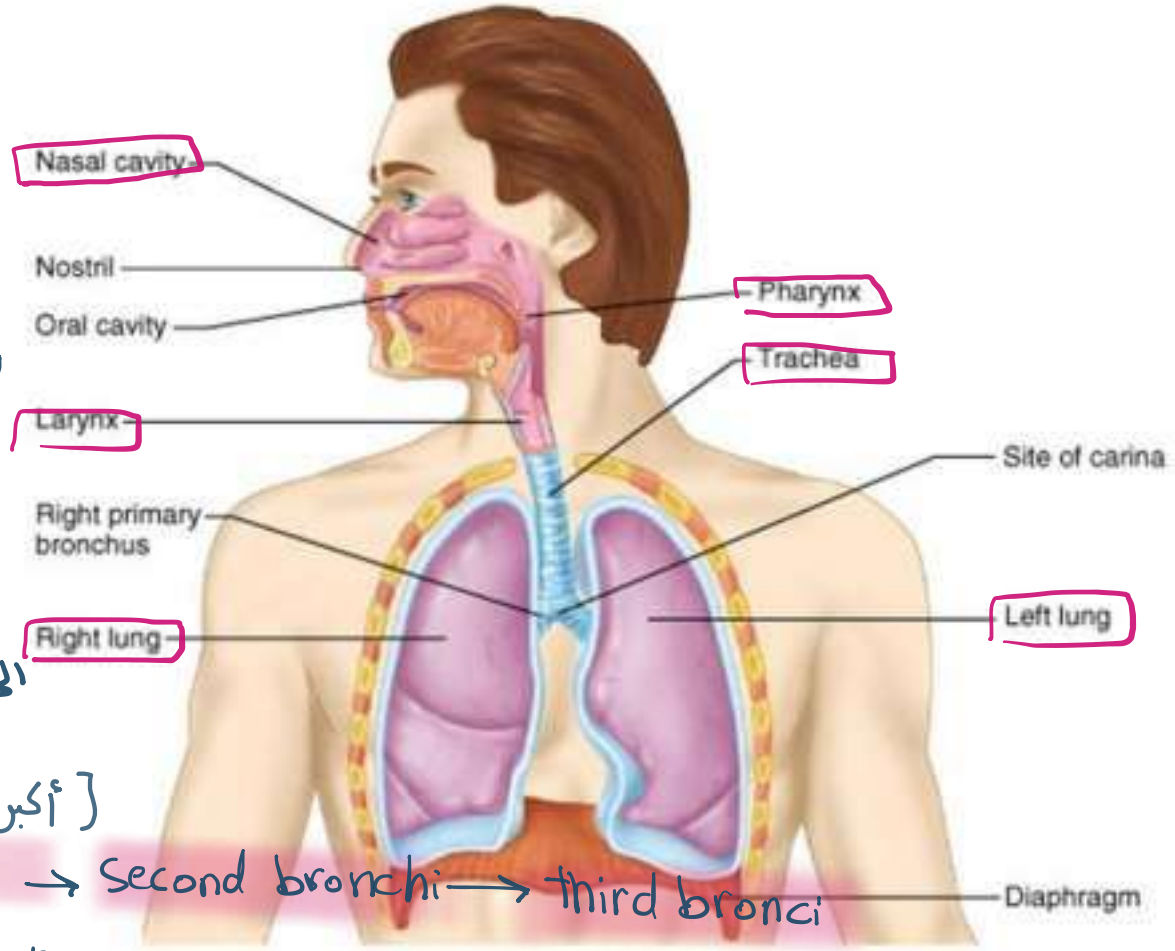
1- Providing for **gas exchange**: intake of O_2 for delivery to body cells and removal of CO_2 produced by body cells.

2- Helping in **regulating blood pH of body fluids**.

3- Contains **receptors for sense of smell**, **filters inspired air** produces vocal sounds (phonation), and **excretes small amounts of water and heat.**

STRUCTURES OF THE RESPIRATORY SYSTEM → upper ↳ lower

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

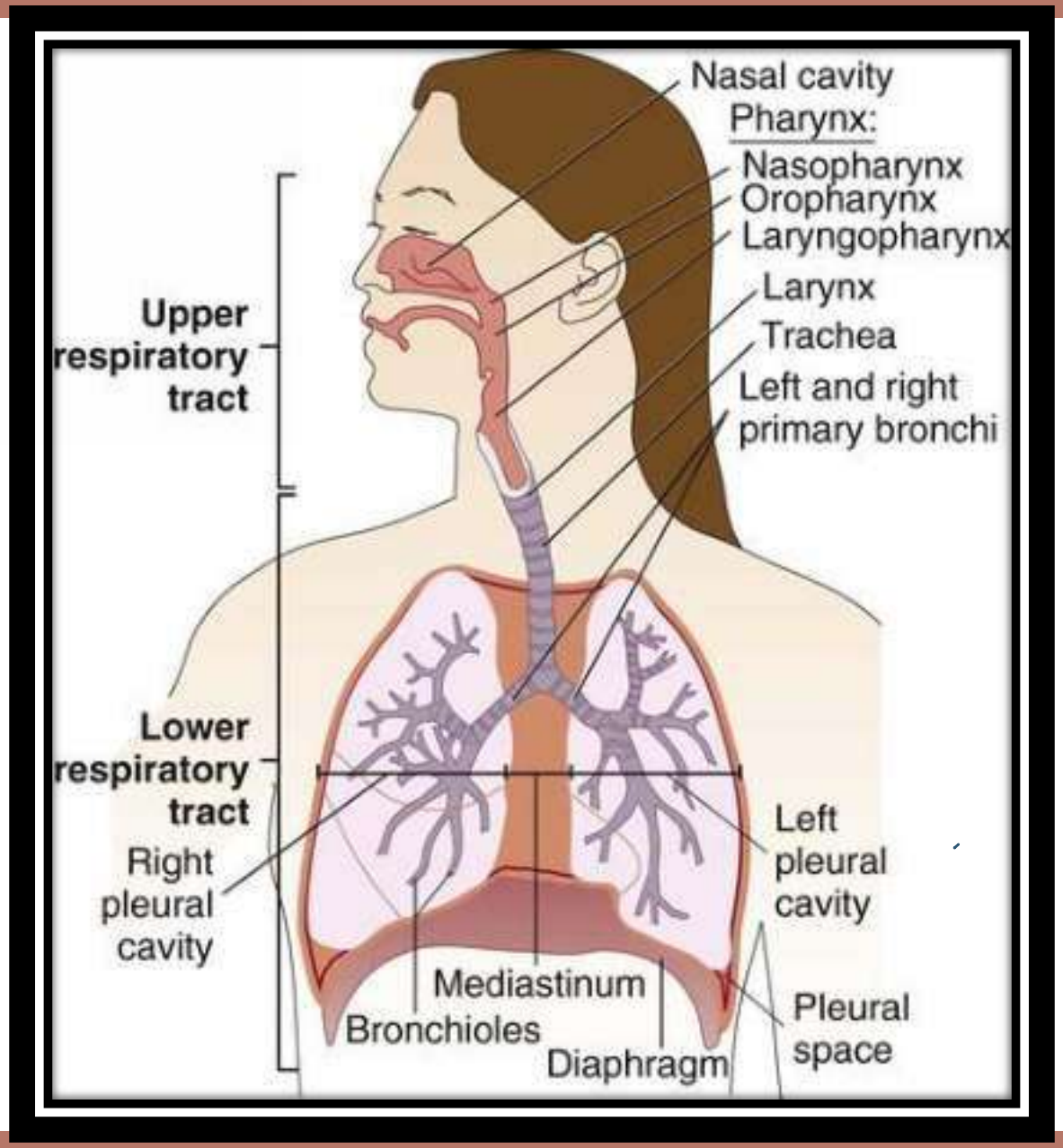


Branching: first bronchi → second bronchi → third bronci

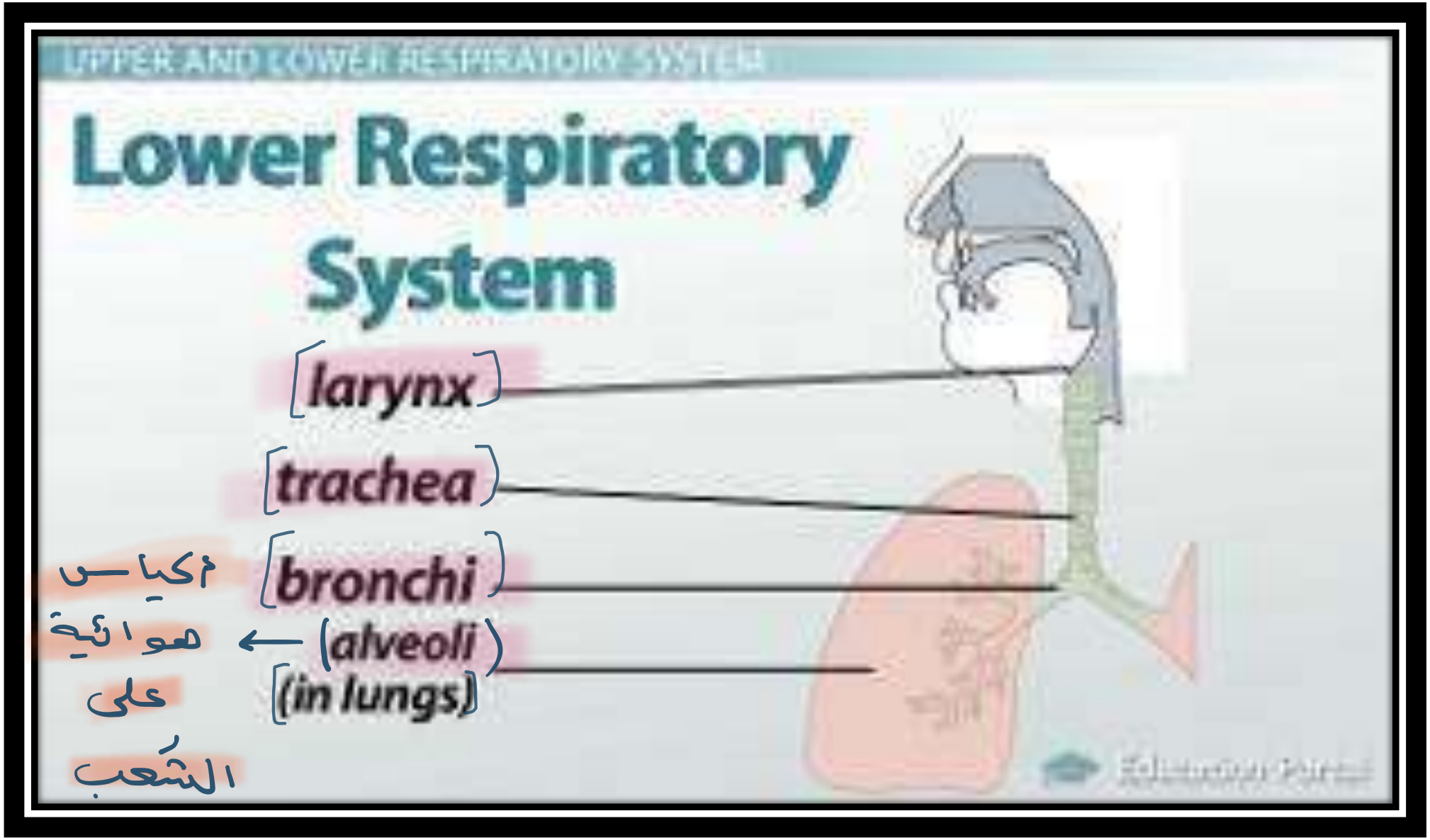
*Smallest branch: Bronchiols

هاي الرسمة
بتوضح الأجزاء
upper & lower

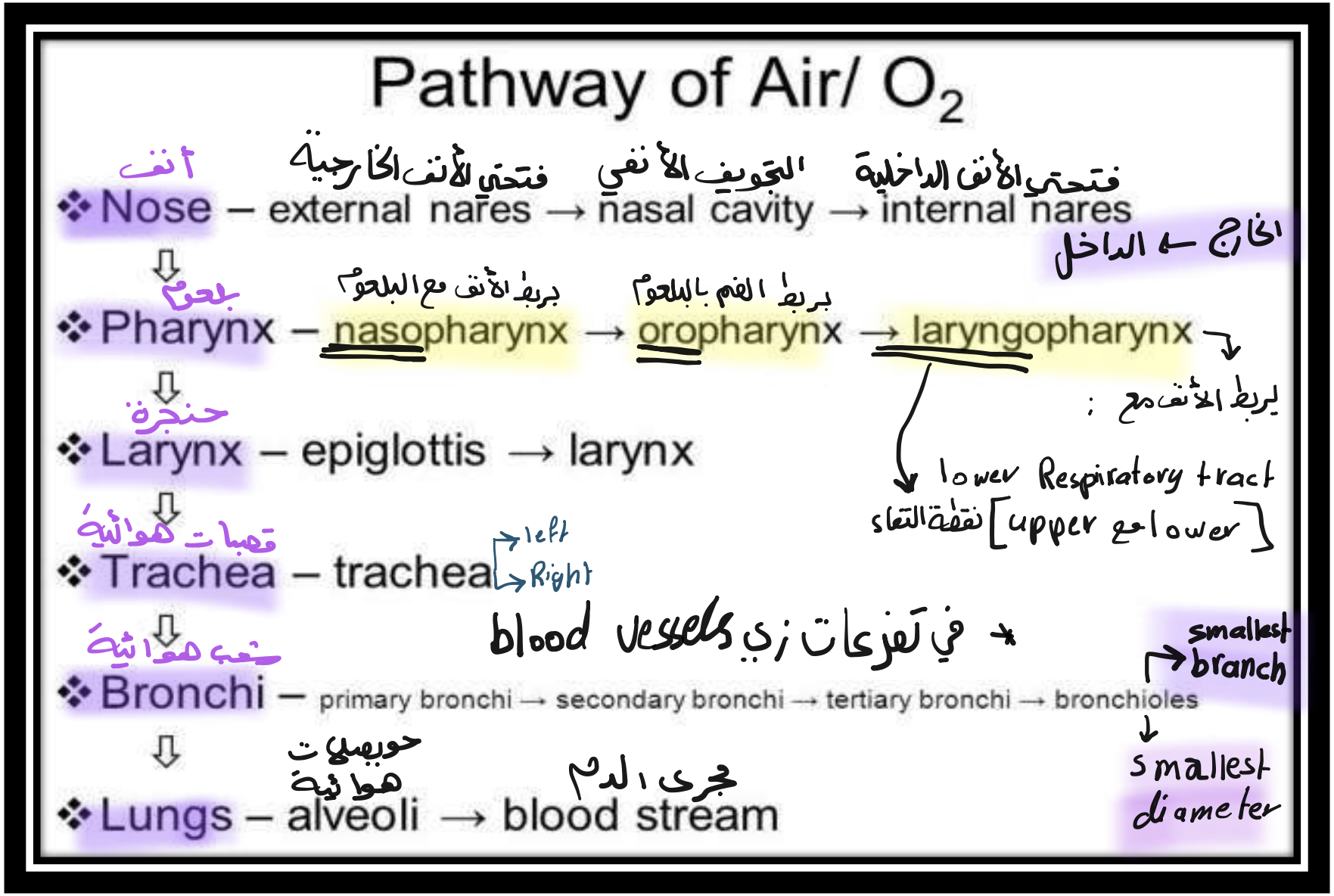
مطلوبة بالأناتومي أكثر



وحتى مطلوبة أحاكيهم


UPPER AND LOWER RESPIRATORY SYSTEM
Lower Respiratory System
larynx
trachea
bronchi
(alveoli)
(in lungs)
أكياس هوائية على الشُعب

Pathway of Air/ O_2



حسب فكي الدكتورة كنف خطط..

① Nose → ② Nasal Cavity → ③ pharynx → ④ larynx → ⑤ trachea → ⑥ left & Right (Bronchus) → ⑦ 1st bronchi → ⑧ 2nd bronchi → ⑨ 3rd bronchi → ⑩ Bronchioles → ⑪ alevedi

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.

باختصار :

عملية انتقال الغازات وتبادلها فايتكون بس بين الرئة والجسم تتكون بثلاث أماكن رئيسية :

1 palmonary ventilation (breathing) : enhalation & exhalation
هو عبارة عن (شهيق + زفير) يكون بين الجو والرئة (تحديداً بال alveoli)

---

2 External respiration : alveoli & palmonary capillaries
بهاي المرحلة الشعيرات الدموية بتوخد O_2 وتبعقد CO_2

---

3 internal respiration : يكون جوات الأنسجة والخلايا
between Systemic capillaries & tissues
بهاي المرحلة الدم بيعقد O_2 وبيوخد CO_2 عشان يرجع للقلب (systemi circulation)
وبدنا نعرف كمان إنه عمليات الأيض (البناء والهدم) بتستهلك الـ O_2 الموجود بالخلايا

وآخر آخر شغلة كل نفس بتكون عبارة عن (شهيق + زفير)

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.

* ينتقل الهواء من المنطقة ذات الضغط الأعلى ← الأقل

- **Inhalation:** شهيق outside → inside

  - 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**.

لكي يدخل الهواء من الجو ← داخل الرئة تتوسع ويزيد حجمها

  - **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**.

* كلما زاد حجم الوعاء ↑ يقل الضغط بداخله

أخدناه بكيمياء 107 صرتوا خاسيين

الأسماء مش حفظ بس نفهم الـ concept

لشرط يكونه الوعاء مختلف زي لما كنا نحكي عن blood vessels

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!!

لما نوخذ شهيق

لما نطلع زفير

- **For inhalation to occur, the lungs must expand, which increases lung volume and thus decreases the pressure in the lungs to below atmospheric pressure.**

تتوسع

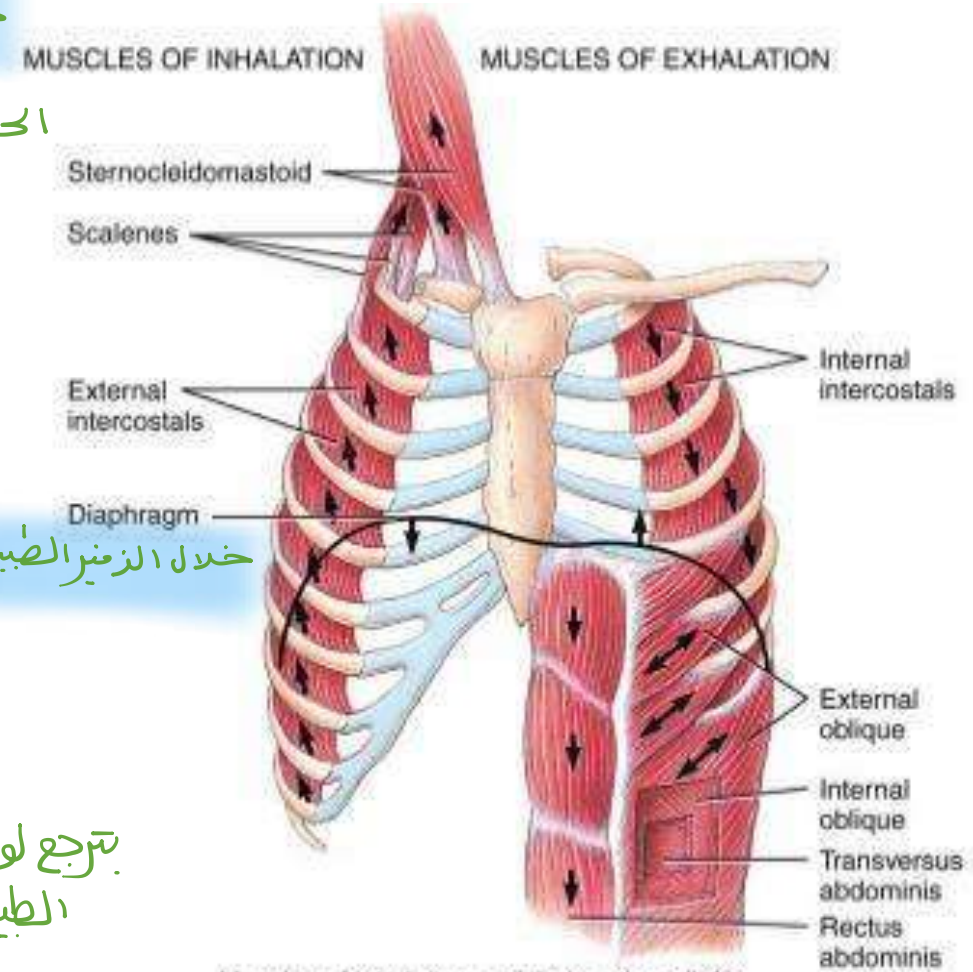
هون بكيلي إنه لما يصير عندي عملية الشهيق ، الرئة بتتوسع يعني بزداد حجمها

وبالتالي بقل الضغط جواتها مقارنة بالضغط الخارجي (ضغط الجو)

تتذكر إنه العلاقة عكسية بين الحجم والضغط حسب قانون بويل .

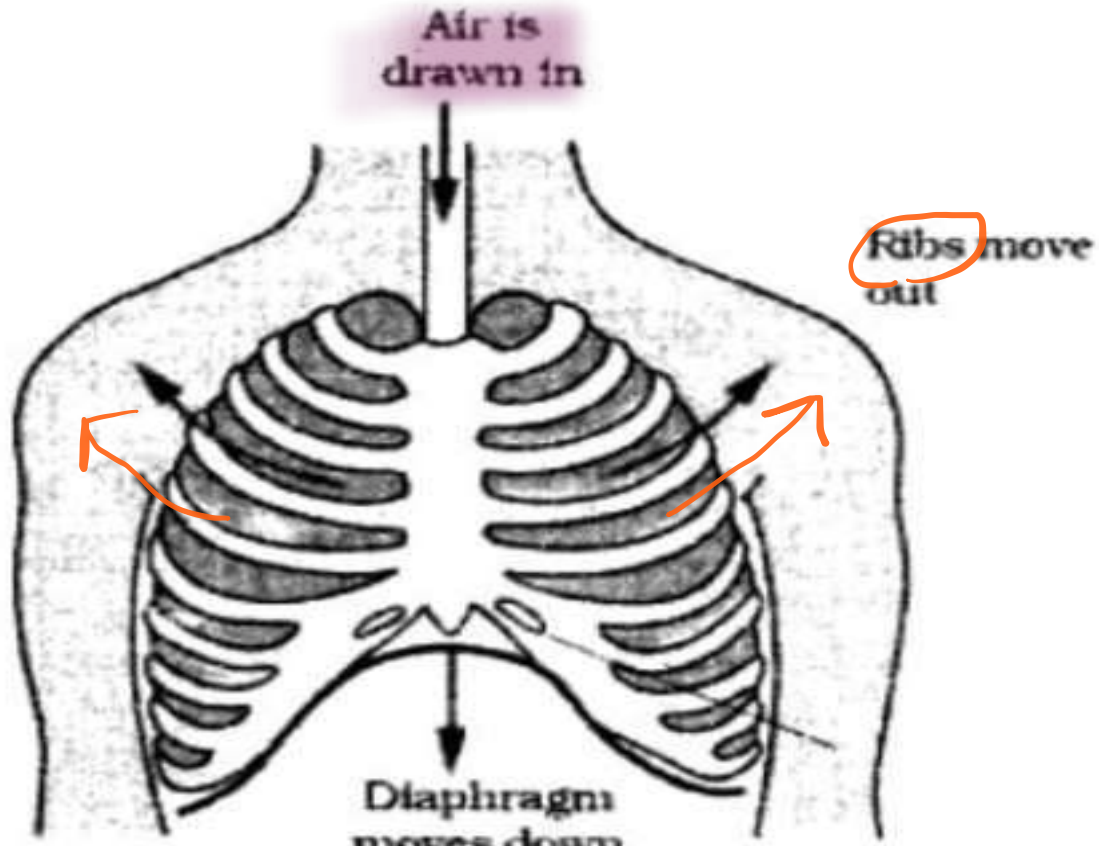
MUSCLES OF INHALATION AND EXHALATION

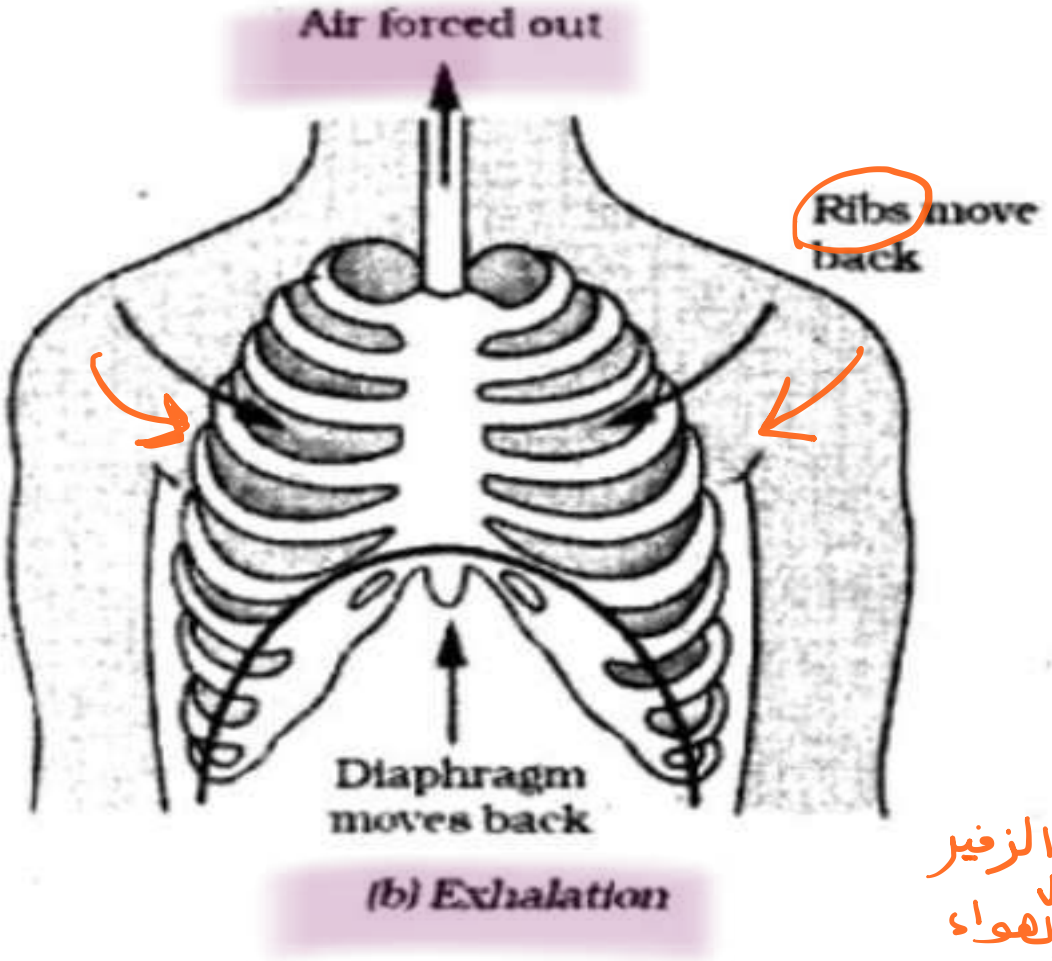
During normal, quiet inhalation, the diaphragm and external intercostals contract, the lungs expand, and air moves into the lungs; **during normal, quiet exhalation, the diaphragm and external intercostals relax** and the lungs recoil, forcing air out of the lungs.



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

Mechanism of breathing human beings





عملية الشهيق
توسع الرئة / يزداد حجمها
يدخل الهواء للداخل
يكون الضغط بداخل الرئة قليل

عملية الزفير
خروج الهواء
عودة الرئة لحجمها الطبيعي
استرخاء
الضغط داخل الرئة أكبر من ضغط الجو بالخارج

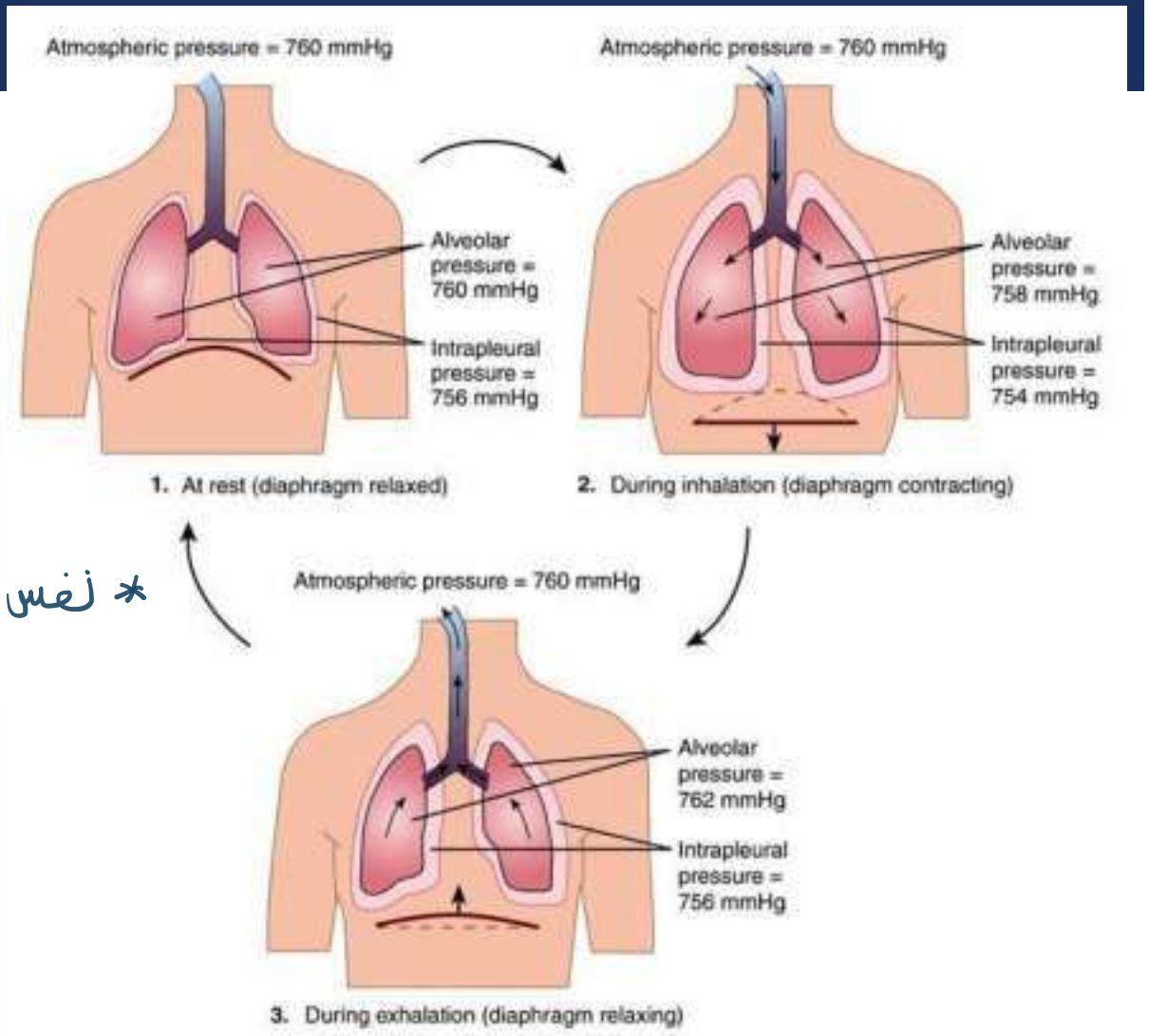
ترتخي الضلوع إلى أسفل

PRESSURE CHANGES IN PULMONARY VENTILATION

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

* نفس الحكي اللي فوق (بتطيقه ، زفير) وشو بصير

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.**

EXHALATION

inhalation → active
exhalation → passive

- **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. التمدد — مرونة

زي لما كنا نحكي عن skeletal muscles فيها خاصية المرونة
زي مبدأ [المطاطة] لما تتمدد بترجع لوضعها الطبيعي

- Exhalation **starts when the inspiratory muscles relax**. As the diaphragm relaxes, its dome moves superiorly owing to its elasticity.

* عضلة الحجاب الحاجز عند الزفير بترجع تتحرك للأعلى بعد ما تكون صارلها انقباض ونزلت لتحت "عندها مرونة"

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.

1
2 توتر السطح
3
4

قديش lungs بتقدر تعمل شهيقه زفير

SURFACE TENSION OF ALVEOLAR FLUID

- **A thin layer** (طبقة رقيقة) **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** (مادة زي الكريم المرطب) **(a mixture of phospholipids and lipoproteins) present in alveolar fluid reduces its surface tension.**
- **A deficiency** (النقص) **of surfactant in premature infants** (الأطفال اللي بتولد بكير) causes respiratory distress syndrome (مرض بالجهاز التنفسي), in which the surface tension of alveolar fluid is greatly increased, so that many alveoli collapse (الڤيصلات المنهارة) at the end of each exhalation. Great effort is then needed at the next inhalation to reopen the collapsed alveoli. (إعادة فتح)

شرح سلايد 18

آخر نقطة

في مادة اسمها (surfactant) مادة "مرطبة"
موجودة بالـ fluid حولين (alveoli) عشان تعمل
كنوع من الترطيب وما يلزقوا ببعض بعد عملية
الشهيق و بداية الزفير أو العكس.

اختلاك السطح
(surface tension) تمام كدهون !! وجودها في المادة يقلل من

اللي بصير إنه مرات في أطفال بنولدوا بالشهر السابع وما
بتكون هاي المادة المرطبة موجودة أو متكونة لسه فبتعمل مرض
اسمه (respiratory distress syndrome)

فلما يصير عملية (exhalation) بصير عندهم
(collapse) بـ (alveoli)

فلما يرجع يعمل (inhalation) يتطلب جهد كبير

هاي هي كل القصة ...

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).

آخر نقطة بسلايد 21 :

إنخفاض قدرة الرئة

* في عدّة أسباب بتسبّب low compliance منها :

1. scarlung tissue : موت الأنسجة داخل الرئة tuberculosis
2. palmonary edma : تجمع سوائل بالرئة
3. نقص في المادة المرطبة Surfactant بالتالي بزيد الـ Surface tension
4. paralysis of intercostal muscles : شلل في العضلات

AIRWAY RESISTANCE

↳ Sympathteic بزيدها → dilation

↳ Para Symphathteic بقلل → Constriction

- 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. مقسوم $airflow = \frac{P}{R}$

جدار الشعب الهوائية

- **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.

كلما زاد القطر
تقل المقاومة

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

عليه سؤالين

- ✓ **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.

12 نفس بالدقيقة
كل نفس عبارة عن :
[شهيق + زفير]

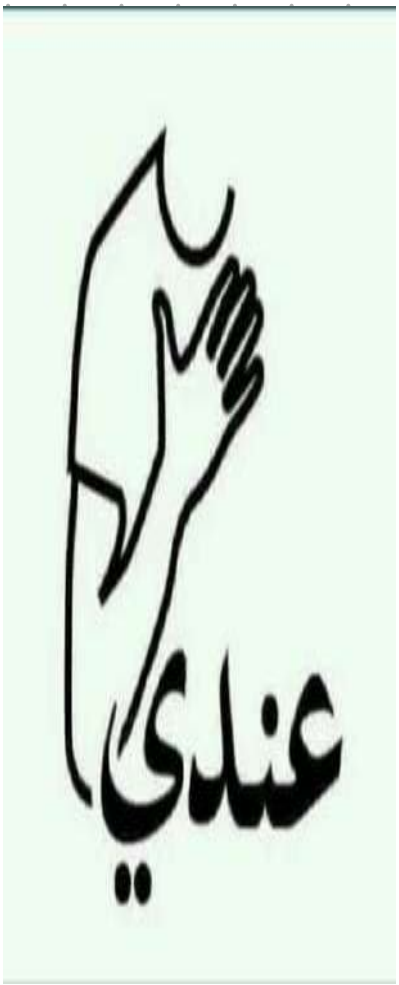
- ✓ The **volume of one breath is called the tidal volume (VT).**
- ✓ **The minute ventilation (MV)** — the total volume of air inhaled and exhaled each minute — is respiratory rate multiplied by tidal volume:

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

- ✓ **Lower-than-normal minute ventilation** usually is a sign of pulmonary malfunction.

إذا كان أقل من 12 ← عُطل

- ✓ 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**.



أبسطهالك !

[tidal volum] الـ volum للنَفَس الواحد هي
كمية الهواء اللي بتدخل خلال هاد الـ volum
تقريبًا 500 ml

عشان أعرف كم كمية الهواء بالدقيقة
بضرب عدد الأنفاس بالدقيقة X كم مل بكل نَفَس

Minute ventilation = 12 x 500 ml
= 6000 ml
= 6 liters/min

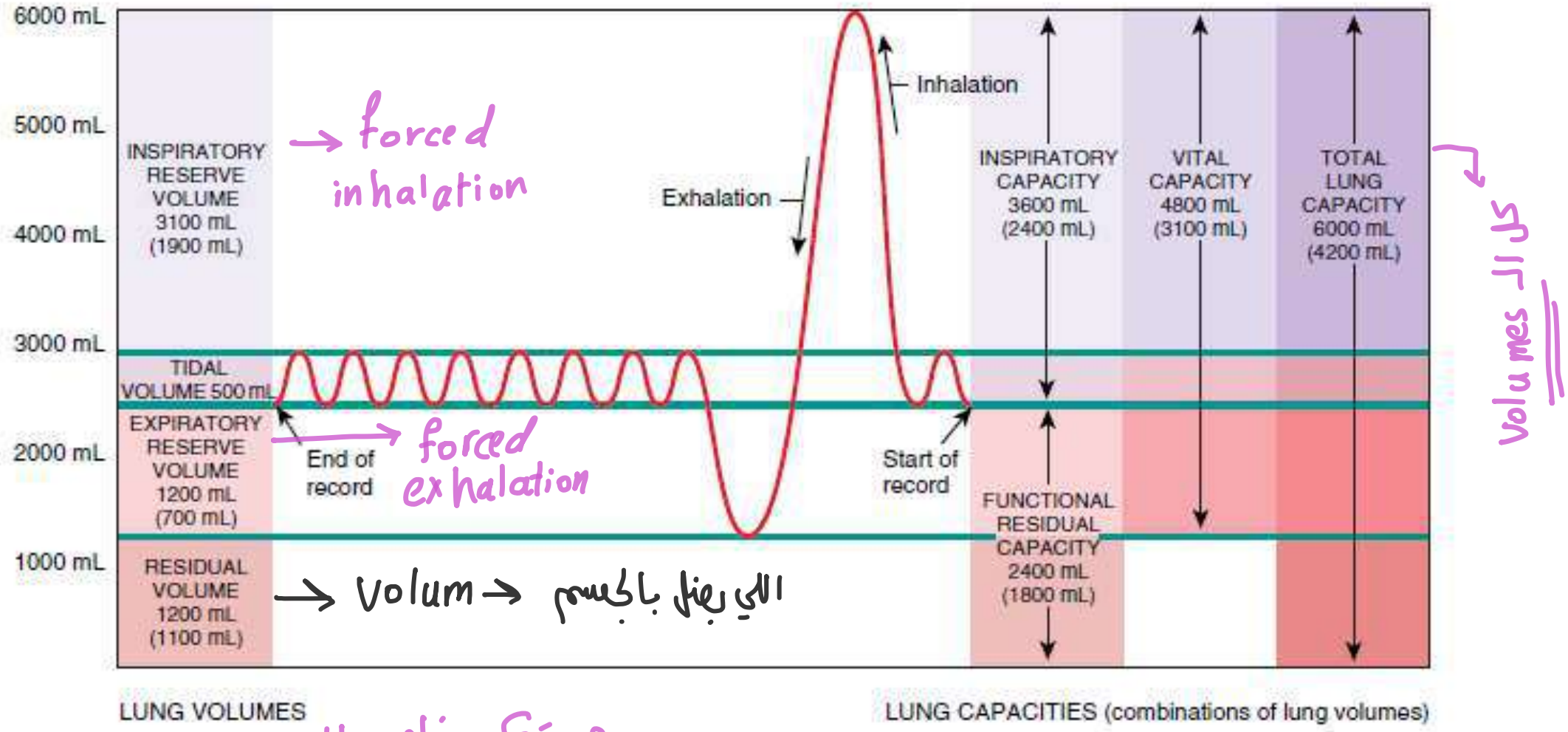
* spirogram: عبارة عن تمثيل بياني

inhalation: upward انحراف للأعلى
exhalation: downward انحراف للأسفل

السّعة

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.



→ forced inhalation

→ forced exhalation

→ Volum → اللي بيقل بالجسم

كل الـ Volumes

* وهم بتكون فاهم الرسمة

lung capacity = vital capacity + Residual volum

بدك تكون فاهم 4 مفاهيم : بس قبلهم اعرف إنه

1 inspiratory capacity = Tidal volum + inspiratory Reverse

2 vital capacity = Tidal volum + inspiratory Reverse + expiratory Reverse

3 functional Residual capacity = expiratory Reverse + Residual volum

4 Total lung capacity = all volumes كلّه يباشا

- لحد هون جاي ٦ أسئلة بالراحة

لا تعمل عنهم سكيب ... سكيب لا تعمل عنهم ... عنهم لا تعمل سكيب

LUNG VOLUMES AND CAPACITIES

- ✓ **Tidal volume varies considerably from one person to another and in the same person at different times.** — يختلف من شخص لآخر ومرات عدة نفس الشخص يختلف باختلاف الأوقات
- ✓ **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.**

اللي سمعتها شرحته

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.

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).

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).

EXCHANGE OF OXYGEN AND CARBON DIOXIDE

* أسماء العلماء مش حفظ

- **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.

[1] [2]

- **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.

هنري: كلما كانت ذائبية الغاز أكبر تكون نسبة الغاز أعلى

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). الضغط لغاز معين جوات خليط أو مزيج من الغازات اسمه
- ✓ **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.

الهواء بالجو مزيج / خليط

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.

إذا بدي أعرفكم الـ Partial pressure للغاز بدي أضرب نسبته x Total pressure

- **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**.

كلما كان فرق الضغط أكبر... يكون الانتشار أسرع وأفضل .

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.

ذائبية الـ CO_2 أكبر من ذائبية الـ O_2 بمقدار ٢٤ مرة

∴ إذن pressure gradient الـ CO_2 أسرع من O_2

* انتشار الغاز ← يعتمد على ضغطه
* ذائبية غاز N_2 قليلة

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.**

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.

سرعة الانتقال تبكون بطيئة عشان تنقل أكبر كمية من الدم للـ alveoli

- **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**.

لأنه صار أسرع فالوقت يصير أقصر

- **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.

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.

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.

تستخدم باستمرار

- 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.

والله منا عارف ... حتى أنا زهقت ... يلا هانت

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

- **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.**

إذا كان الفرق عالي ... تبادل الغاز يكون أسرع

- **Surface area available for gas exchange.** **The surface area of the alveoli is huge** (كبيرة). 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.

مساحة السطح

كلما زادت يزيد التوصيل بصير good inhalation

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

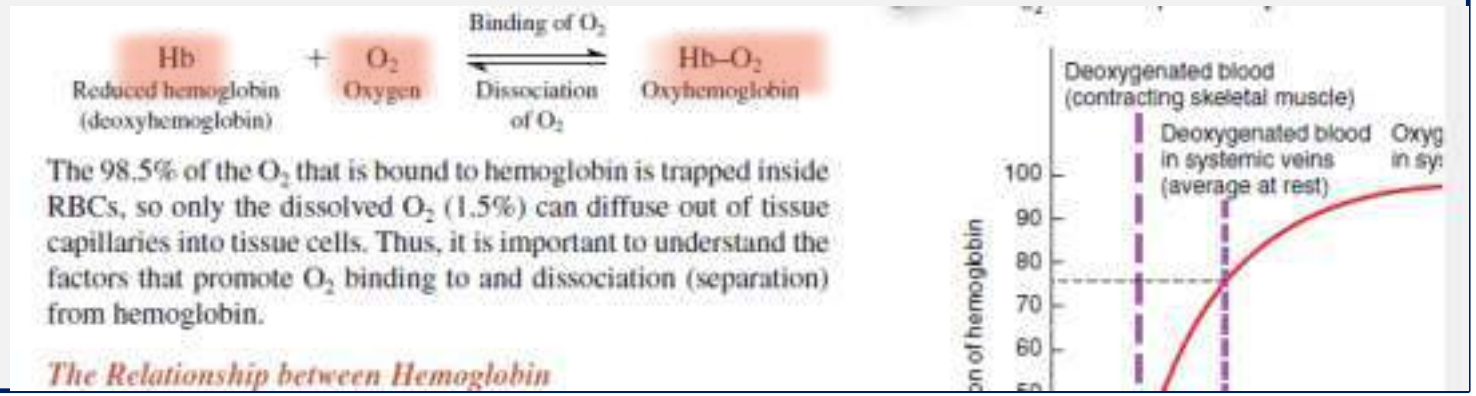
- **Diffusion distance.** The respiratory membrane is very thin, so diffusion occurs quickly. **Buildup of interstitial fluid between alveoli, as occurs in pulmonary edema, slows the rate of gas exchange because it increases diffusion distance.**

- **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

* كل جزيء هيموغلوبين (Hb) بإمكانه يرتبط مع ٤ جزيئات O_2

- **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.).



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.**

أهم عامل لارتباط O_2 مع Hb هو الضغط
لما يكون PO_2 عالي يكون ارتباطه مع Hb عالي

الخلاصة :
ارتباط الهيموغلوبين مع 4 O_2 ← fully saturated
ارتباط الهيموغلوبين مع 2 O_2 ← Partially saturated

- **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.

OTHER FACTORS AFFECTING THE AFFINITY OF HEMOGLOBIN FOR OXYGEN

في عوامل بتأثر على ارتباط الأكسجين مع الهيموغلوبين :

الحامضية

❖ **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).

$CO_2 + H_2O \rightarrow H_2CO_3 \xrightarrow{\text{تتفكك}} HCO_3^- + H^+$

↑ CO_2 بنسبة / O_2 بنسبة / acidity ↑ / H_2CO_3 لما يزيد ↓ ارتباط الأكسجين مع الهيموغلوبين يقل

OTHER FACTORS AFFECTING THE AFFINITY OF HEMOGLOBIN FOR OXYGEN

نفس الفكرة يلي فوق

❖ **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.**

لما بده يرتبط الـ CO_2 مع Hb بعتمد على ارتباط O_2 مع Hb

fully Partially

* ضيحة اكتب المعادلة قدك وقيس عليها

OTHER FACTORS AFFECTING THE AFFINITY OF HEMOGLOBIN FOR OXYGEN

الحرارة

❖ **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.

hyper therma: حرارة عالية
hypo therma: حرارة منخفضة

كلما زادت الحرارة ← عملية ارتباط O_2 مع Hb بتصير أقل
* انخفاض الحرارة: بيد من ارتباط الأكسجين مع الهيموغلوبين

بحمل Releasing أنه cells بحاجة ATP ليش؟؟ عشان تنتج طاقة ، مفهومين !! مو واضحين !! مو تل أبيب 😂

من O_2 أكيد فلما تزيد عملية استخدام O_2 يقل ارتباطه مع Hb ... بالتالي بيجي CO_2 برتبط مع Hb

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.

Slides 49 + 50

الـ CO_2 موجود بـ 3 forms :

1. 7% dissolved in plasma

2. 23% carboamino compounds مرتبط مع بروتينات مثل : ارتباطه مع الهيموغلوبين

3. 60-70% bicarbonate ions "أكبر نسبة"

CARBON DIOXIDE TRANSPORT

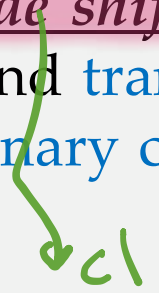
chains. Hemoglobin that has bound CO_2 is termed **carbamino-hemoglobin ($Hb–CO_2$):**

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

The formation of carbaminohemoglobin is greatly influenced by PCO_2. For example, in **tissue capillaries** PCO_2 is relatively high, which promotes formation of carbaminohemoglobin. But in **pulmonary capillaries**, PCO_2 is relatively low, and the CO_2 readily splits apart from globin and enters the alveoli by diffusion.

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.



HCO_3^- لما بدها تطلع من الخلية
وترتبط مع H^+ كيف بدنا نعوض السالب يلي طلع !!؟؟ بدخل Cl^-

CARBON DIOXIDE TRANSPORT

هكينا إنه ارتباط CO_2 مع Hb بتعمل ارتباط O_2 مع Hb والعكس صح

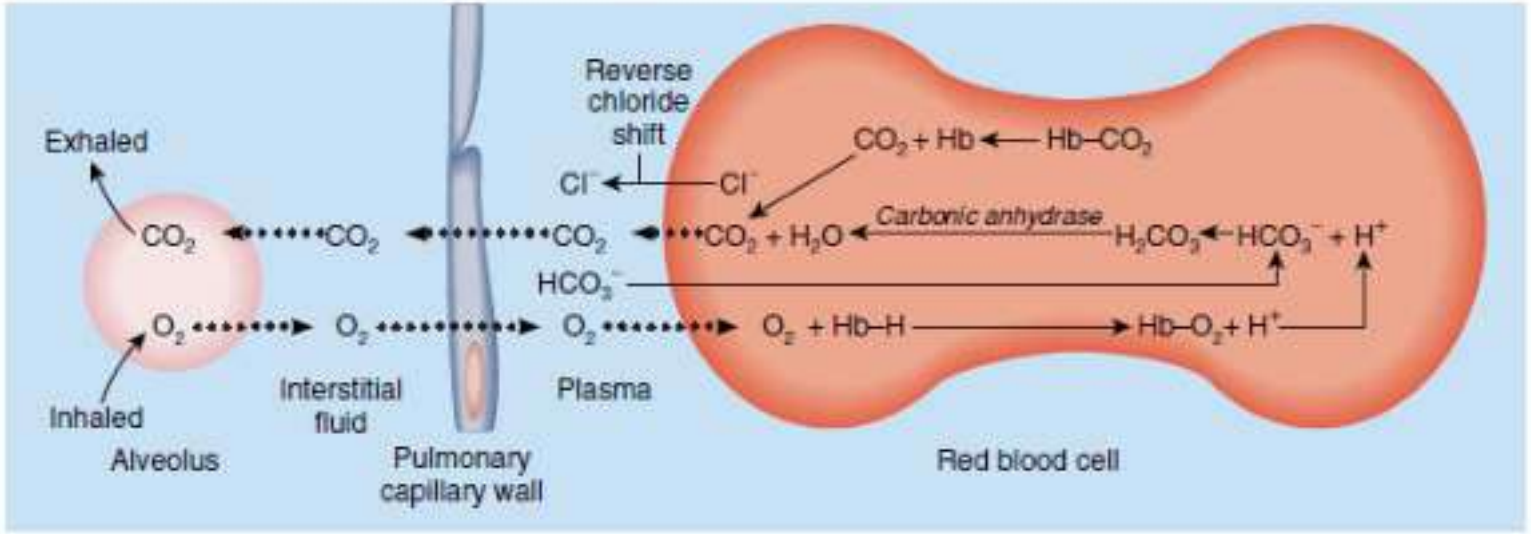
- The amount of CO2 that can be transported in the blood is influenced by the percent saturation of hemoglobin with oxygen. The lower the amount of oxyhemoglobin (Hb–O2), the higher the CO2-carrying capacity of the blood, **a relationship known as the Haldane effect.**

إذا قل ارتباط O_2 مع Hb

بده يزيد ارتباط CO_2 مع Hb

SUMMARY OF GAS EXCHANGE AND TRANSPORT IN LUNGS AND TISSUES

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

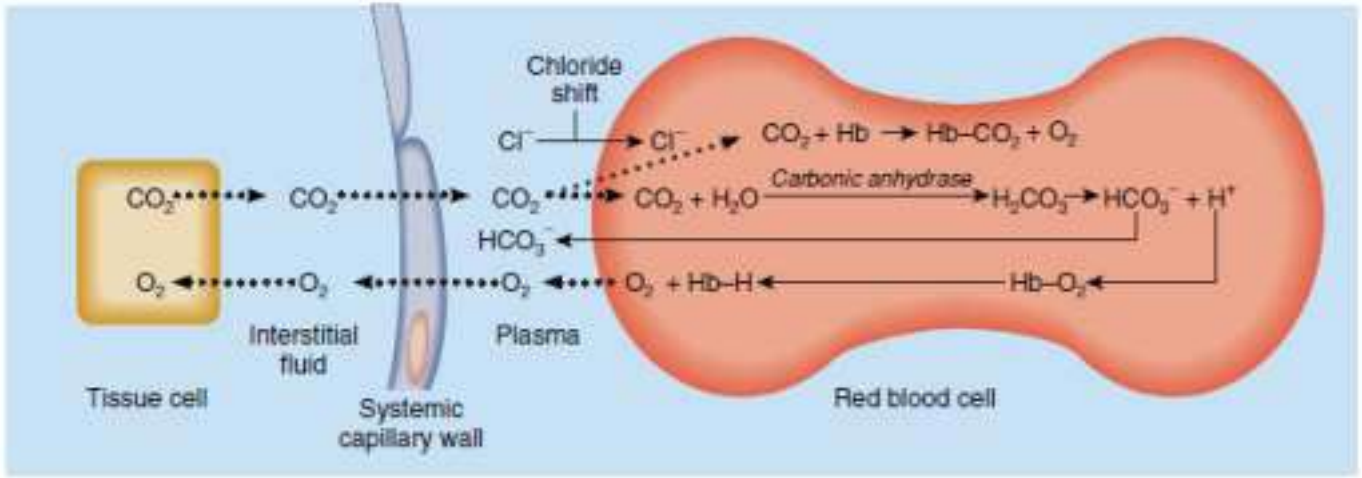


(a) Exchange of O_2 and CO_2 in pulmonary capillaries (external respiration)

نفس الحكي يلي حكيناه فوق افهم ... وفهم

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).

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.]

غيابي

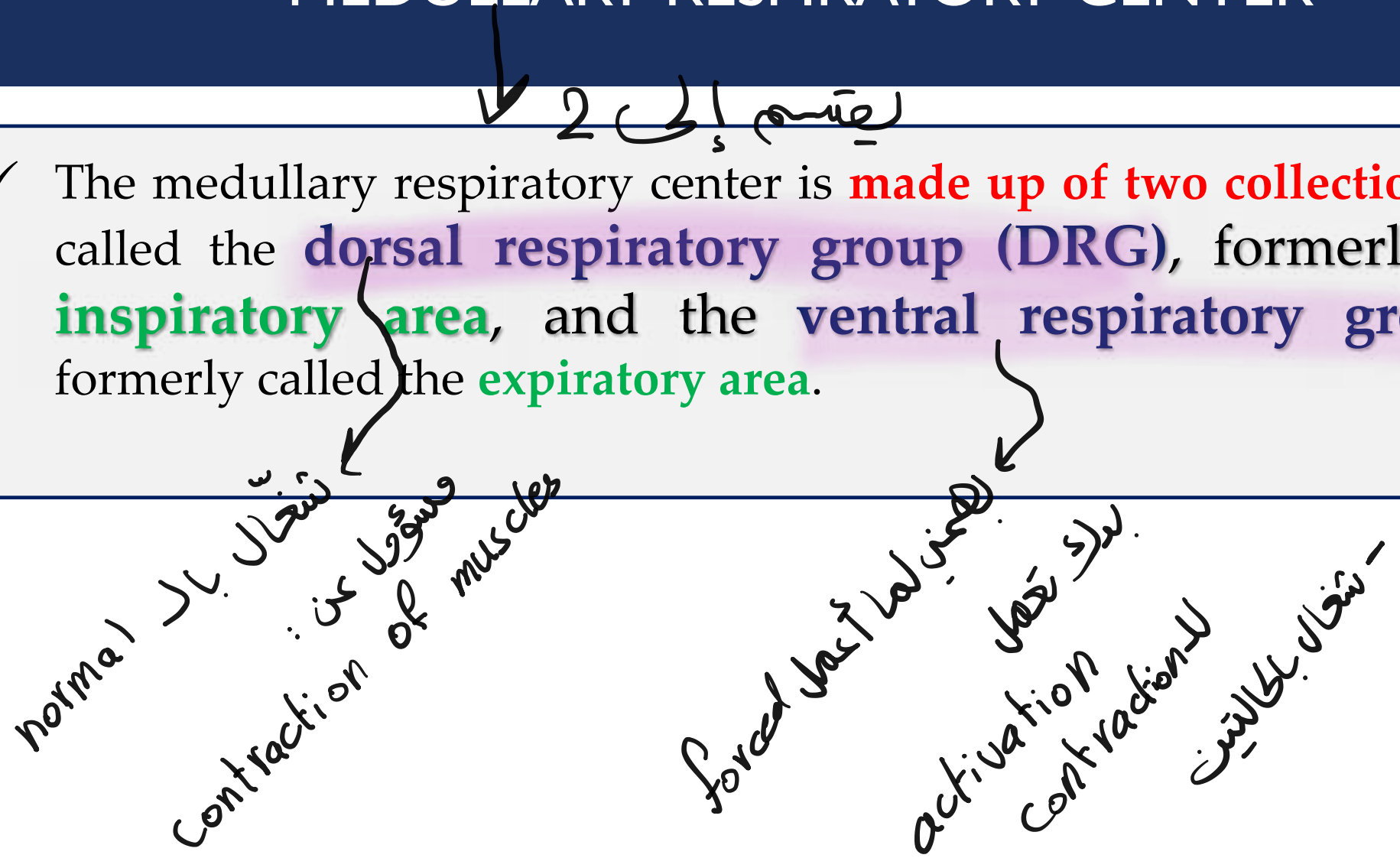
CONTROL OF BREATHING

✓ **Respiratory Center**: قسمين

- 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.

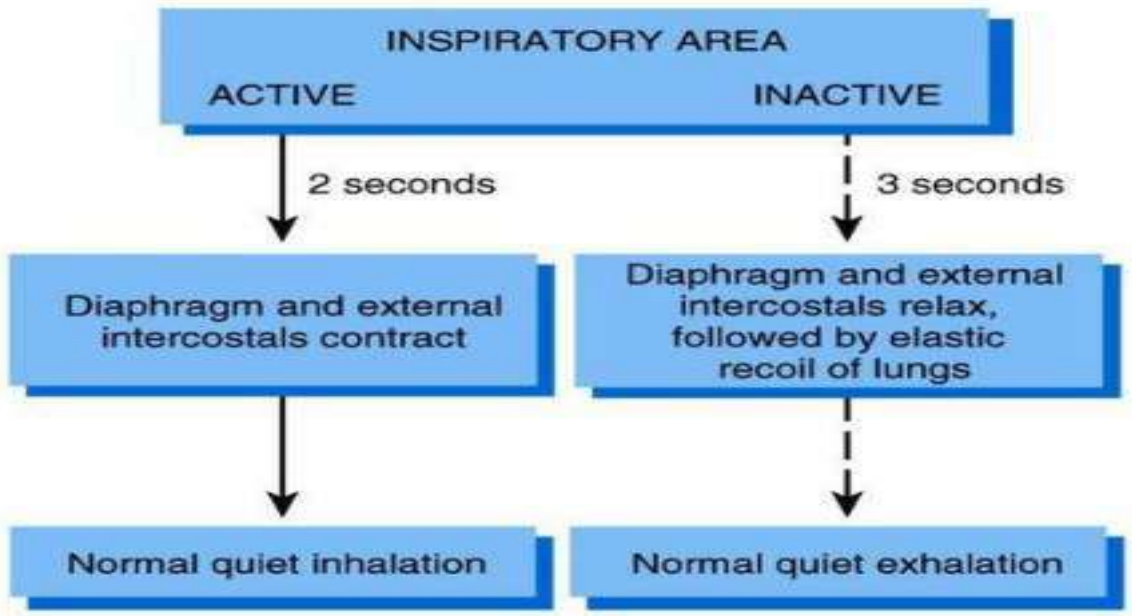
MEDULLARY RESPIRATORY CENTER

- ✓ 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**.

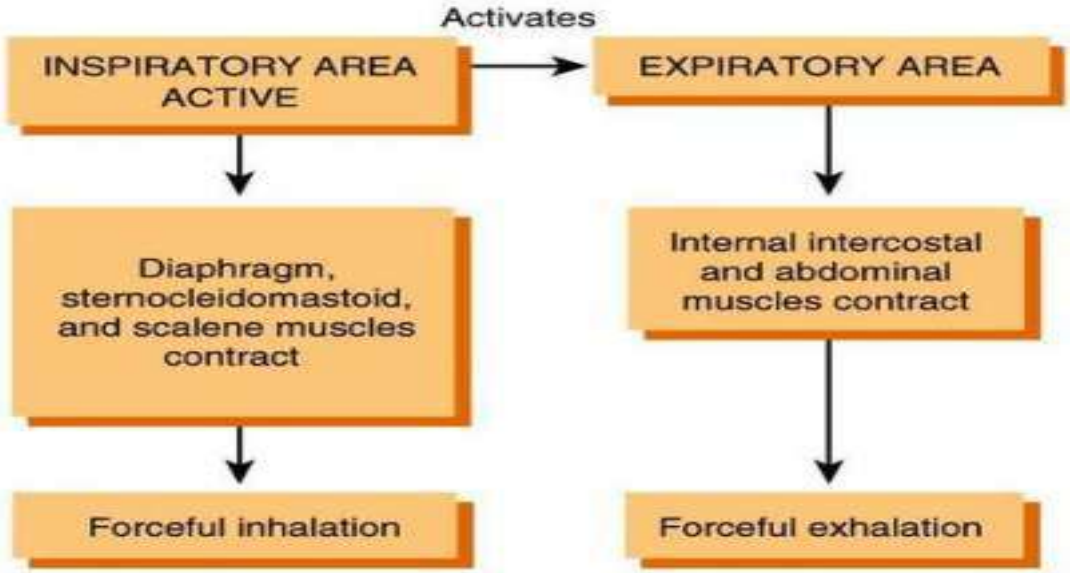


MEDULLARY RESPIRATORY CENTER

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



(a) During normal quiet breathing



(b) During forceful breathing

MEDULLARY RESPIRATORY CENTER

- ✓ The **VRG becomes activated when forceful breathing is required**, such as during exercise, when playing a wind instrument, or at high altitudes.

على ارتفاعات عالية

- ✓ **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).

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.

هو اللي بتحكم بشغل الـ medullary

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.

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.

في عنا chemoreceptors موجودين على الـ arch لـ carotid + aorta
بجانب Paroreceptors وهمة توعين بالسلايد يلي بعد

LOCATIONS OF PERIPHERAL CHEMORECEPTORS

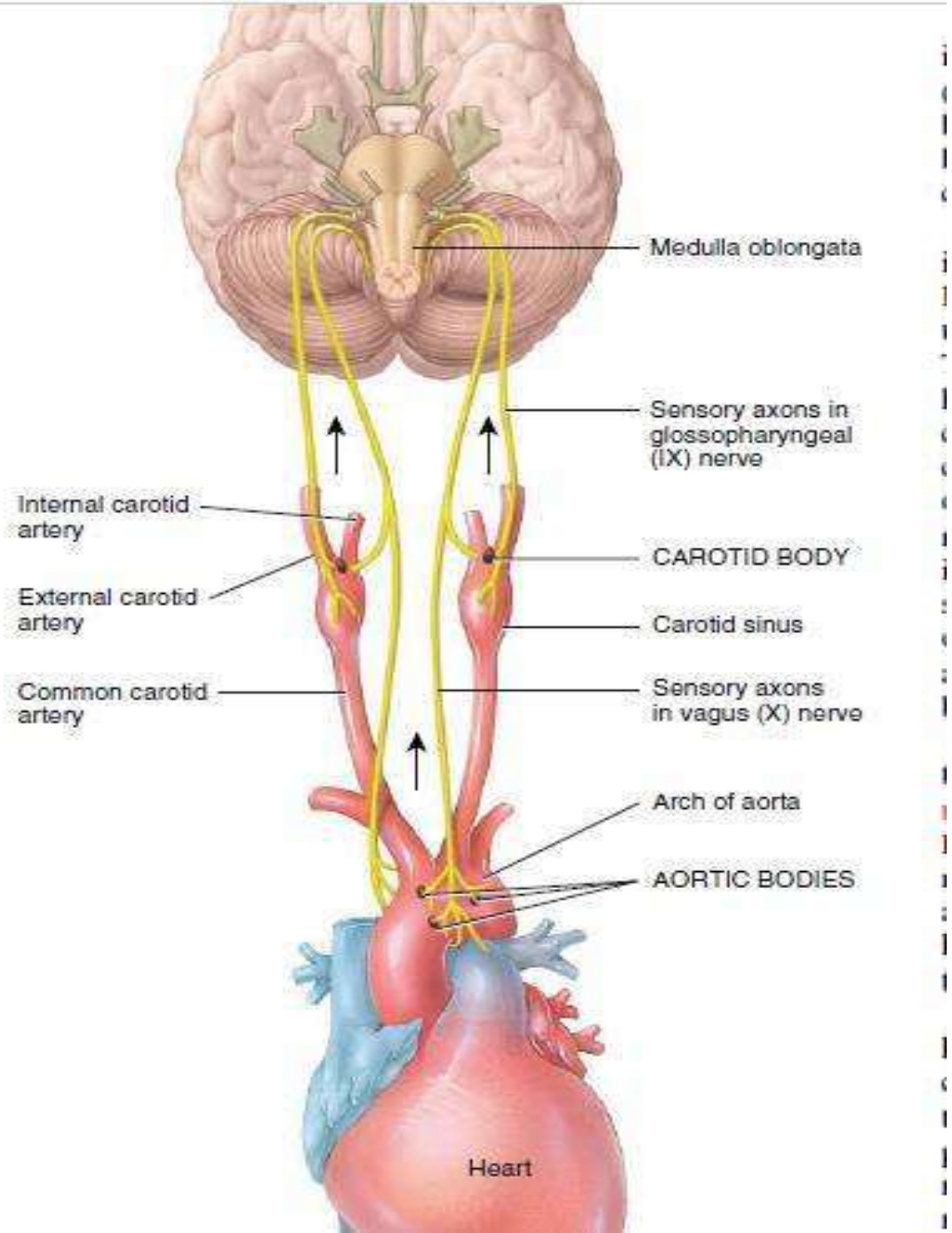
- ✓ **Chemoreceptors** are sensory neurons that respond to changes in the levels of certain chemicals in the body.

العزت بيحكم فيهم

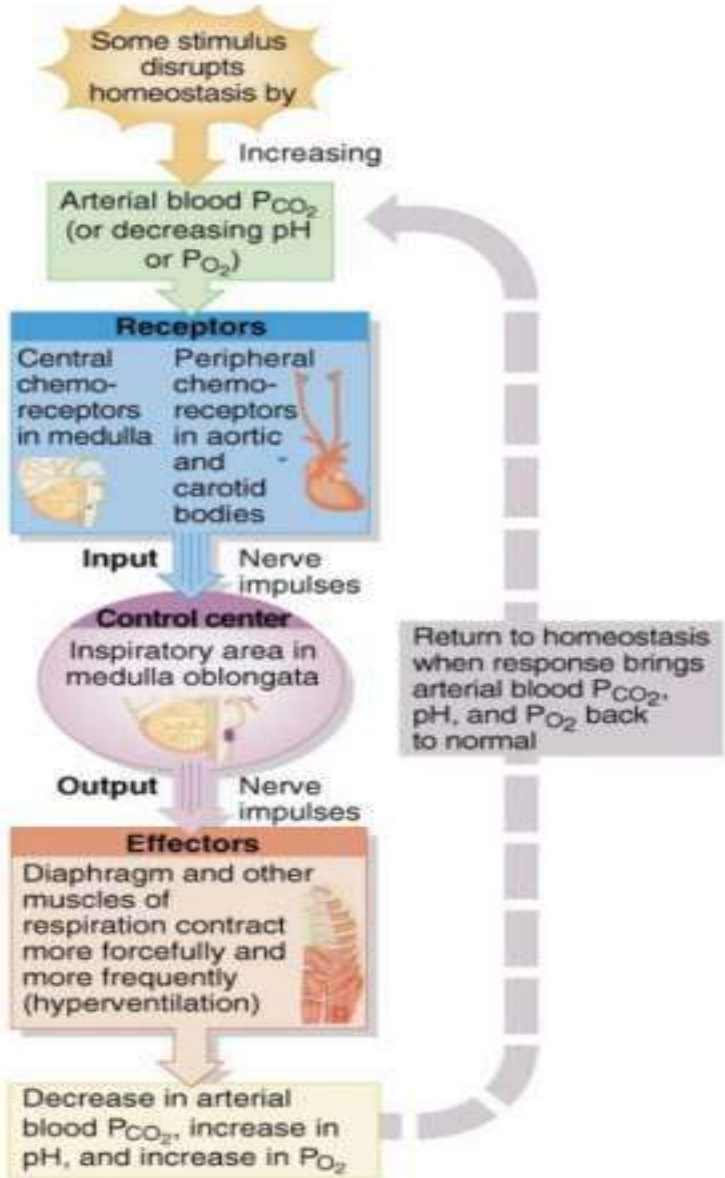
- ✓ **Central chemoreceptors are located in or near the medulla oblongata in the central nervous system. They are sensitive to changes in hydrogen ions in the CSF.**

- ✓ **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.**

$O_2/CO_2/pH$



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

* اقرأه قراءة * هاركزت عليه كيتر

- ✓ 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.

THE INFLATION REFLEX

يتضاءل حجمها

- ✓ **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.

- **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**

TABLE 23.3

Summary of Stimuli That Affect Breathing Rate and Depth

هاد الجدول أهم من جدول الضرب اللي لحد هسا بتخشه

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).

لاتحكي برجله ادرس هسا !!

* أهم النقاط بال chapter :

1. كل مايتعلّق بال O_2 / CO_2 وطرق انتقالهم
2. مع إيش برتبط كل واحد منهم
3. كيف بصير Normal Enhalition & Exhalation وكيف بصير الـ forced
4. شو أنواع الخلايا اللي بتشتغل بكل واحد .
5. العوامل وتأثيرها مهم جدًا
6. أسماء العلماء مش حفظ بس افهم شو كل واحد لحكي
7. علاقة الـ Para Symp & Symp

- & تنسوا أختكم مريم من دعواتكم .

" وَأَنْ لَيْسَ لِلْإِنْسَانِ إِلَّا مَا سَعَىٰ "

" وَأَنَّ سَعْيَهُ سَوْفَ يُرَىٰ "