Control Of breathing

- Color index:

Red: important
Green: doctor's notes
Grey: extra information
Pink: found only in female's slides
Blue: found only in male's slides
Yellow: numbers

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Physiology 437 team work

Editing file

objectives:

By the end of the lecture you will be able to:

- Understand the role of the medulla oblongata in determining the basic pattern of respiratory activity.
- List some factors that can modify the basic breathing pattern e.g.
  a. The Hering-Breuer reflexes
  b. The proprioceptor reflexes
  c. The protective reflexes, like the irritant, and the J-receptors.
- Understand the respiratory consequences of changing PO2 , PCO2 , and PH.
- Describe the locations and roles of the peripheral and central chemoreceptors.
- Compare and contrast metabolic and respiratory acidosis and metabolic and respiratory alkalosis

Controls of rate and depth of respiration

Rate: Normal 8-12 breaths per min

Depth of breathing two types : normal"superficial and deep

- Arterial PO2 (oxygen pressure) " Normal arterial PO2=100"

When PO2 is VERY low (Hypoxia), ventilation increases. "Less sensitive , major changes in PO2 will cause increase ventilation"

- Arterial PCO2 (Carbon dioxide pressure) " Normal arterial PCO2=40"

The most important regulator of ventilation is PCO2, small increases in PCO2, greatly increases ventilation. يعني ان زيادة بسيطه في تركيز ثاني اكسيد الكربون تعطي زيادة كبيرة في معدل التهوية "most sensitive , any minor changes in PCO2 , ventilation will greatly increase"

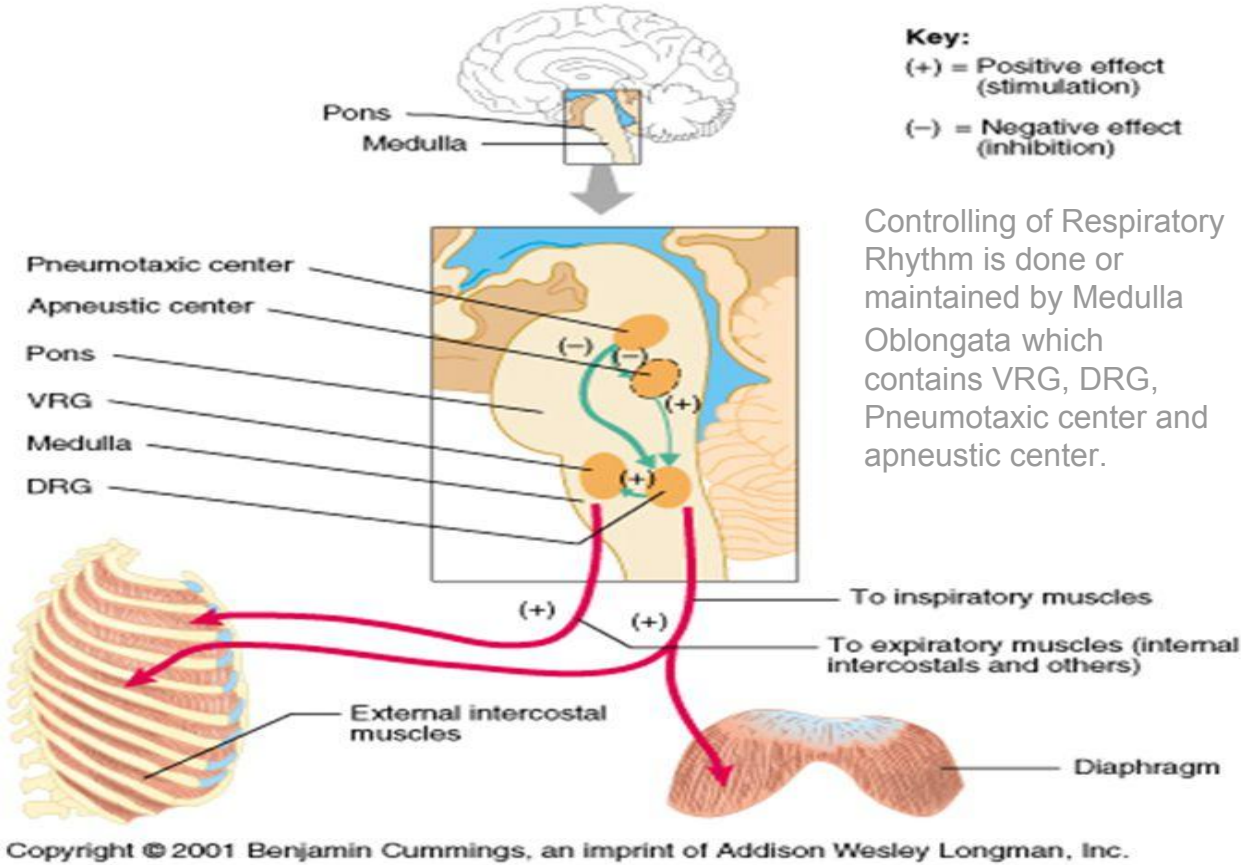
- Arterial pH " Normal pH=7.4"

As hydrogen ions increase (acidosis)(الحمضية), alveolar ventilation increases. بعض الرياضيين يزيدون الحموضة في دمهم عشان يفكون ارتباط الاكسجين فيغذي العضلات

Control of Respiratory Rhythm

الصورة مهمه ارجع لها بعد ما تنتهي من الدرس

عملية التنفس عملية ارادية الى درجة معينة فتتحول وتصبح غير ارادية" لا يمكن لشخص كتمان نفسه حتى الموت " وكذلك يوجد عوامل كثيرة تؤثر على عملية التنفس ومنها تركيز الاكسجين وثاني اكيد الكربون.



Controlling of Respiratory Rhythm is done or maintained by Medulla Oblongata which contains VRG, DRG, Pneumotaxic center and apneustic center.

Medullary Respiratory centers

The first system that controls respiration is CNS

- Inspiratory area (Dorsal Respiratory Group) DRG

-Determines basic rhythm of breathing. Damage of this area lead to breathing arrhythmia

-Causes contraction of diaphragm and external intercostals. "inspiration"

- Expiratory area (Ventral Respiratory Group) VRG

-Although it contains both inspiratory and expiratory neurons. It is inactive during normal quiet breathing. As you know normal expiration is a passive process no need for muscles

-Activated by inspiratory area during forceful breathing.

-Causes contraction of the internal intercostals and abdominal muscles.

- The medullary respiratory center stimulates basic inspiration for about 2 seconds and then basic expiration for about 3 seconds (5breaths/sec = 12breaths/min).

Inspiration last for 2 seconds which is shorter than expiratory that last for 3 seconds !!! why? Because inspiration is an active process that involves muscles while expiration is an inactive process depend upon lung recoiling and inspiratory muscles relaxation.

The respiratory center is composed of several groups of neurons located bilaterally in the medulla oblongata and pons of the brainstem, It is divided into three major collections of neurons:

(1) a dorsal respiratory group, located in the dorsal portion of the medulla, which mainly causes inspiration; (2) a ventral respiratory group, located in the ventrolateral part of the medulla, which mainly causes expiration; and (3)The pneumotaxic center, located dorsally in the superior portion of the pons,which mainly controls rate and depth of breathing.

Pontine Respiratory centers

Transition"التبديل" between inhalation and exhalation is controlled by:

These two areas contribute in switching off of inhalation or exhalation to prevent continuous inhalation or exhalation

1- Pneumotaxic area

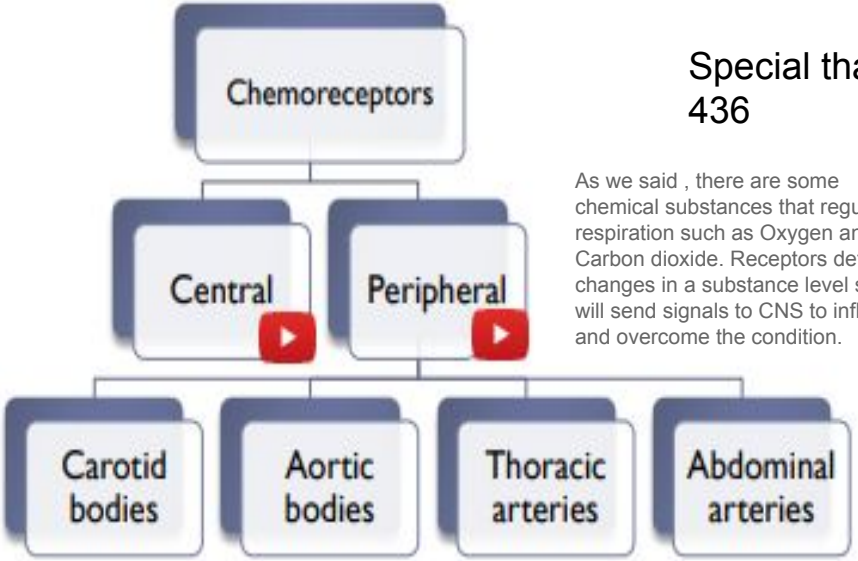
Inhibits inspiratory area of medulla to stop inhalation. Therefore, breathing is more rapid when pneumotaxic area is active.

2- Apneustic area

Stimulates inspiratory area of medulla to prolong inhalation. Therefore slow respiration and prolonged respiratory cycles will result if it is stimulated.

A Pneumotaxic Center Limits the Duration of Inspiration and Increases the Respiratory Rate A pneumotaxic center, located dorsally in the nucleus parabrachialis of the upper pons, transmits signals to the inspiratory area. The primary effect of this center is to control the "switch-off" point of the inspiratory ramp, thus controlling the duration of the filling phase of the lung cycle. When the pneumotaxic signal is strong, inspiration might last for as little as 0.5 second,thus filling the lungs only slightly; when the pneumotaxic signal is weak, inspiration might continue for 5 or more seconds, thus filling the lungs with a great excess of air.The function of the pneumotaxic center is primarily to limit inspiration.This has a secondary effect of increasing the rate of breathing because limitation of inspiration also shortens expiration and the entire period of each respiration. A strong pneumotaxic signal can increase the rate of breathing to 30 to 40 breaths per minute, whereas a weak pneumotaxic signal may reduce the rate to only 3 to 5 breaths per minute.

The apneustic center of pons sends signals to the dorsal respiratory center in the medulla to delay the 'switch off' signal of the inspiratory ramp provided by the pneumotaxic center of pons. It controls the intensity of breathing. The apneustic center is inhibited by pulmonary stretch receptors



Special thanks to team 436

As we said , there are some chemical substances that regulate respiration such as Oxygen and Carbon dioxide. Receptors detect changes in a substance level so,it will send signals to CNS to influence and overcome the condition.

Most of the chemoreceptors are in the *carotid bodies*. However, a few are also in the *aortic bodies*, and very few are located elsewhere in association with other arteries of the thoracic and abdominal regions.

1- Excess CO_2, H^+ in the blood mainly acts directly →Central

2- Others in arteries of the thoracic and abdominal regions →Peripheral

If we compare the peripheral and the central: if there is an increase in P_{CO2} the peripheral is faster but weaker (e.g. increase ventilation 2 times within seconds), the central is slower but more powerful (e.g. increase the ventilation 4 times within minutes).

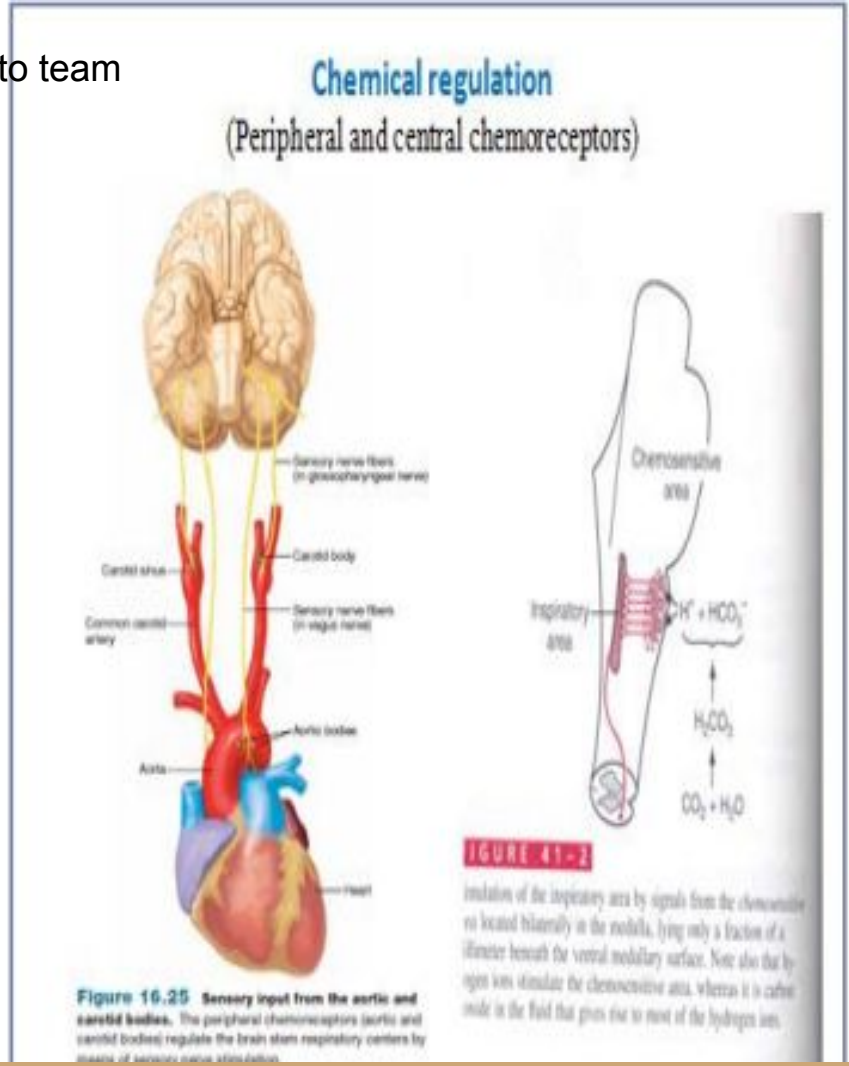
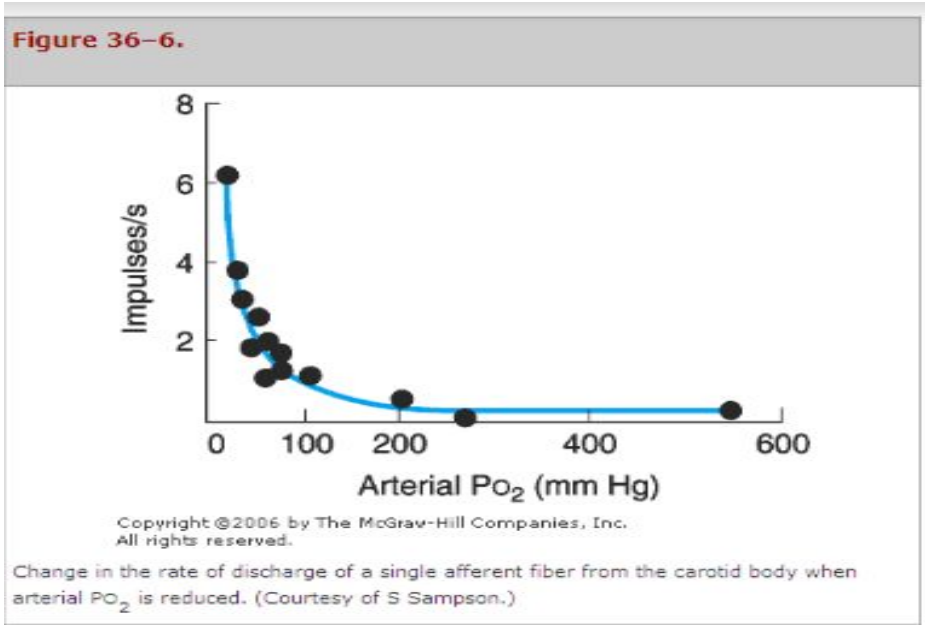
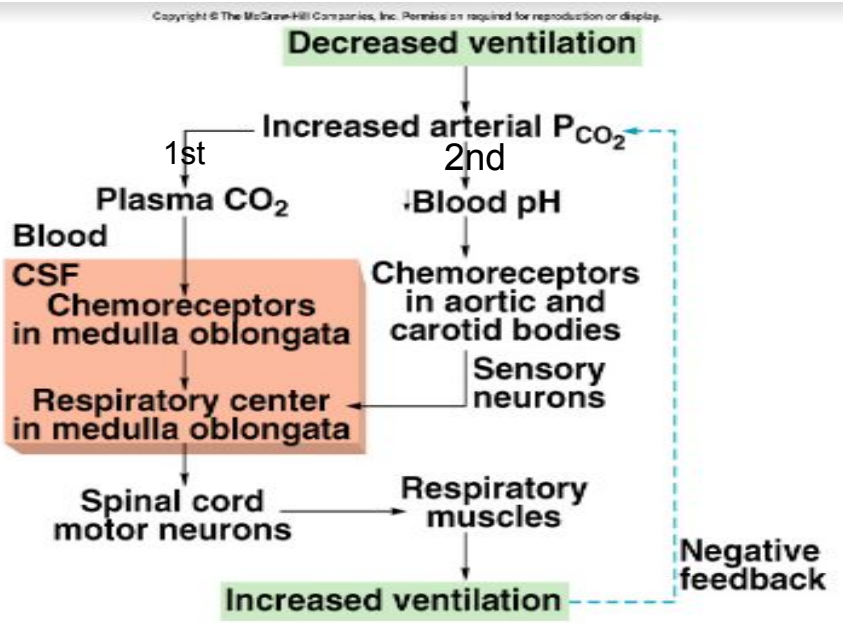


Figure 16.25 **Sensory input from the aortic and carotid bodies.** The peripheral chemoreceptors (aortic and carotid bodies) regulate the brain stem respiratory centers by

Chemoreceptor Control of Breathing





If the person has acidosis due to metabolic problem only the 2nd pathway will be stimulated, but if he has a problem which leads to an increase in Pco2 the two pathways will be stimulated, so it will have a bigger impact than if the problem were only in the pH.

Effect of blood CO2 level on central chemoreceptors

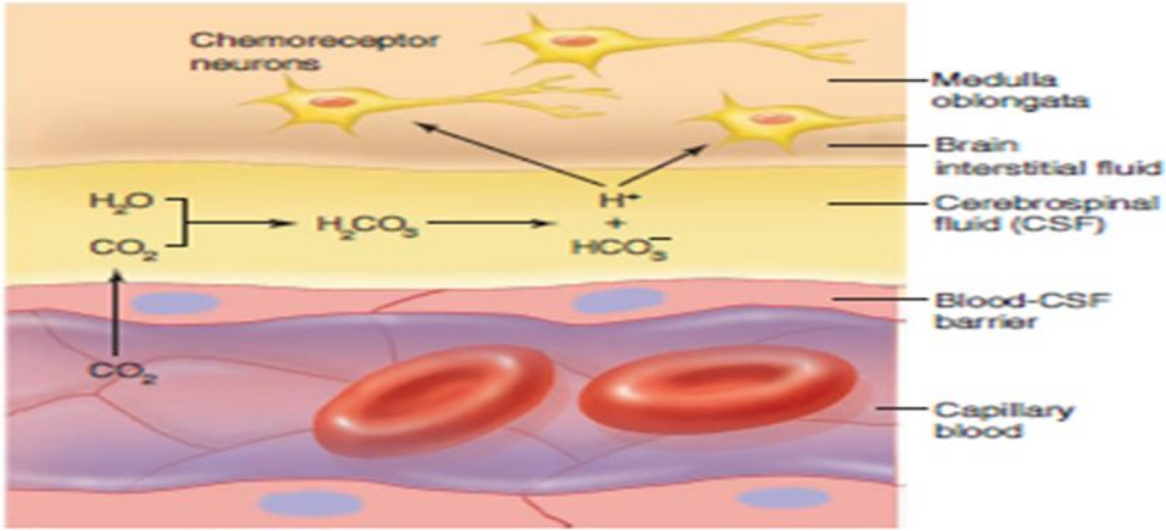


Figure 16.29 How blood CO_2 affects chemoreceptors in the medulla oblongata. An increase in blood CO_2 stimulates breathing indirectly by lowering the pH of blood and cerebrospinal fluid (CSF). This figure illustrates how a rise in blood CO_2 increases the H^+ concentration (lowers the pH) of CSF and thereby stimulates chemoreceptor neurons in the medulla oblongata.

Hering-Breuer inflation reflex

Some references call it stretch reflex

•When the lung becomes overstretched (tidal volume is 1 L or more), stretch receptors located in the wall bronchi and bronchioles transmit signals through vagus nerve to DRG producing effect similar to pneumotaxic center stimulation. اذا عبيت صدرك زيادة عن الطبيعي , هذه الزيادة بتحسس مستقبلات على جدار الرئة عشان توقف عملية التنفس

• Switches off inspiratory signals and thus stops further inspiration .

•This reflex also increases the rate of respiration as does the pneumotaxic center.

Lung Inflation Signals Limit Inspiration—The Hering-BreuerInflation Reflex

In addition to the central nervous system respiratory control mechanisms operating entirely within the brain stem, sensory nerve signals from the lungs also help control respiration. Most important, located in the muscular portions of the walls of the bronchi and bronchioles throughout the lungs are *stretch receptors* that transmit signals through the *vagi* into the dorsal respiratory group of neurons when the lungs become overstretched. These signals affect inspiration in much the same way as signals from the pneumotaxic center; that is, when the lungs become overly inflated, the stretch receptors activate an appropriate feedback response that "switches off" the inspiratory ramp and thus stops further inspiration. This is called the *Hering-Breuer inflation reflex*. This reflex also increases the rate of respiration, as is true for signals from the pneumotaxic center.

In humans, the Hering-Breuer reflex probably is not activated until the tidal volume increases to more than three times normal (>≈ 1.5 liters per breath). Therefore, this reflex appears to be mainly a protective mechanism for preventing excess lung inflation rather than an important ingredient in normal control of ventilation.

These are factors that can exert effect on respiration

Cont. factor affecting respiratory centers

These are receptors found mainly in the epithelium of conduction zone of respiratory system known as **irritant receptors** that detect any foreign body that enters ,so it will stimulate cough or sneezing reflex to get rid of the foreign body.

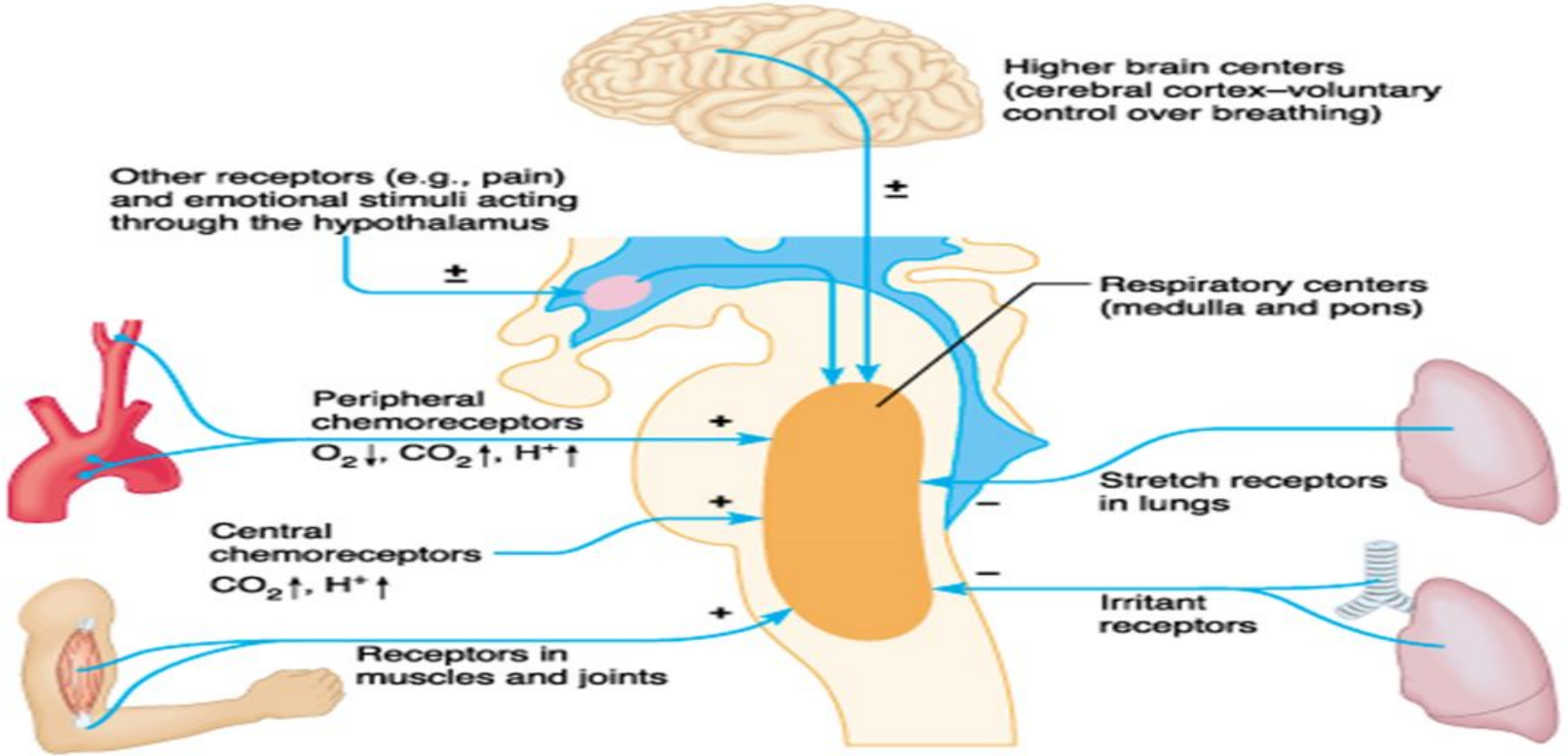
- **Effect of Irritant receptors in the airways:** the epithelium of trachea, bronchi, and bronchioles is supplied by irritant receptors that are stimulated by irritants that enter the respiratory airways causing coughing, sneezing and bronchoconstriction in bronchial asthma and emphysema.
- **Function of lung J receptors**.

Few receptors in the wall of the alveoli in juxta position to the pulmonary capillaries. They are stimulated especially when pulmonary capillaries become engorged by blood or when pulmonary edema occur e.g in CHF, their excitation cause the person a feeling of dyspnea.

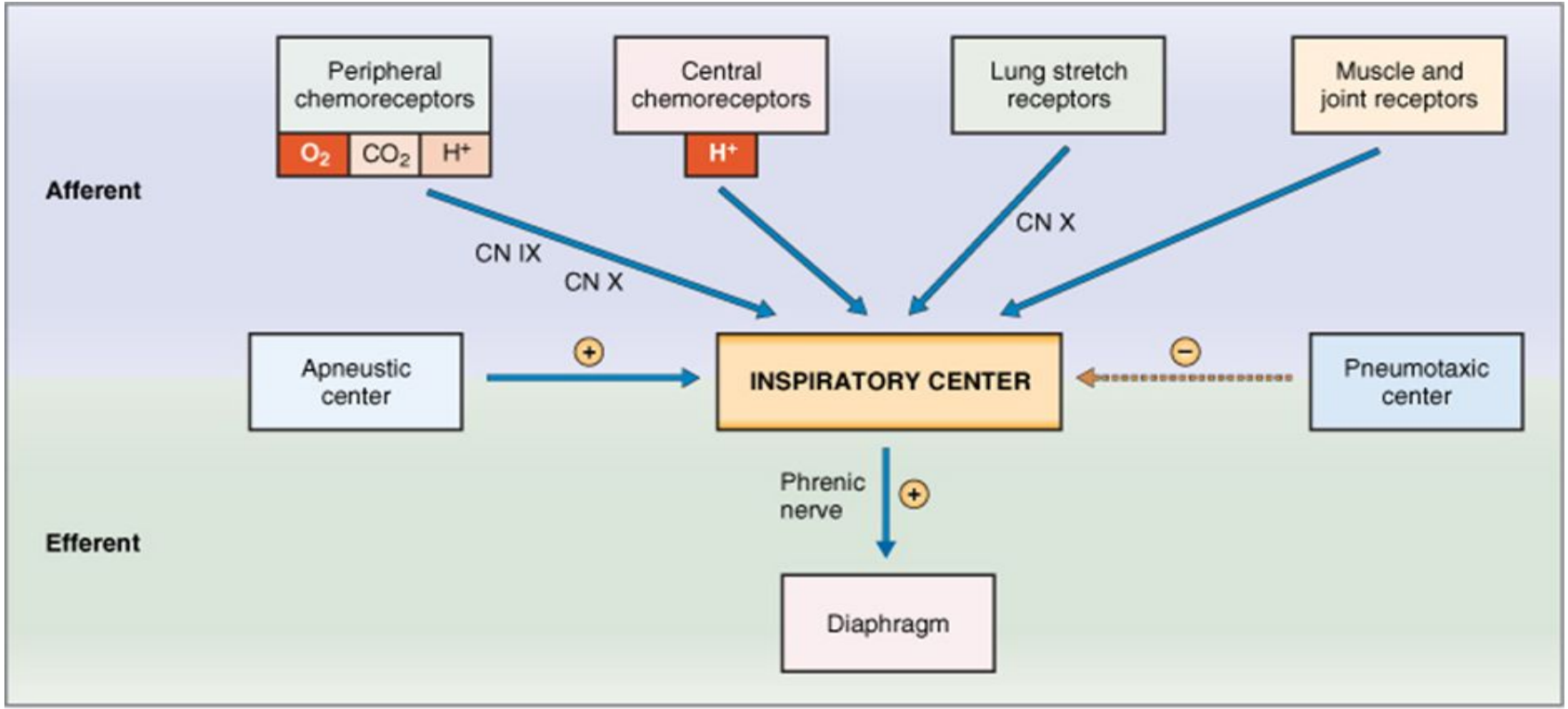
Lung J receptors are found in the wall of alveoli that is in contact with pulmonary capillaries. In case of pulmonary edema, these receptors will get activated and try to increase rate of respiration to compensate since edema will narrow the gases exchange area.

Factors Influencing Respiration

Summary of the factors the influence respiration



Cont..factors affecting respiration



Respiratory Acidosis

Respiratory Alkalosis

In level of gases

-Hypoventilation.

-Accumulation of CO_2 in the tissues .

- P_{CO2} increases
- pH decreases.
- P_{O2} decreases.

تنفس بقوة لمدة نصف دقيقة

-Hyperventilation."washing out CO2"

-Excessive loss of CO_2.

- P_{CO2} decreases (↓35 mmHg).
- pH increases.
- P_{O2} increase.

Gases change acidity or basicity of the blood

Metabolic Acidosis

- Ingestion, infusion, or production of a fixed acid.
- decreased renal excretion of hydrogen ions. H+
- loss of bicarbonate or other bases from the extracellular compartment. HCO3-
- pH decrease " more acidic"

In level of cells

Metabolic Alkalosis

- Excessive loss of fixed acids from the body.
- Ingestion, infusion, or excessive renal reabsorption of bases such as bicarbonate HCO3-
- pH increases." more basic"

Products of the cell change acidity or basicity of the blood

The respiratory system can compensate for metabolic acidosis or alkalosis by altering alveolar ventilation. Hypoventilation ⟺ Hyperventilation

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