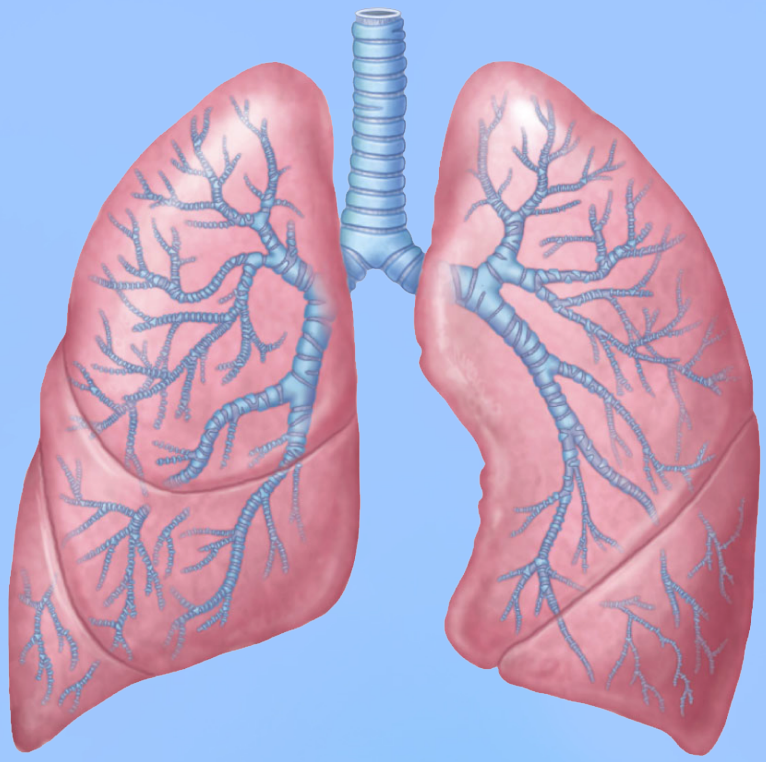
8

Control of breathing

Physiology Team 433



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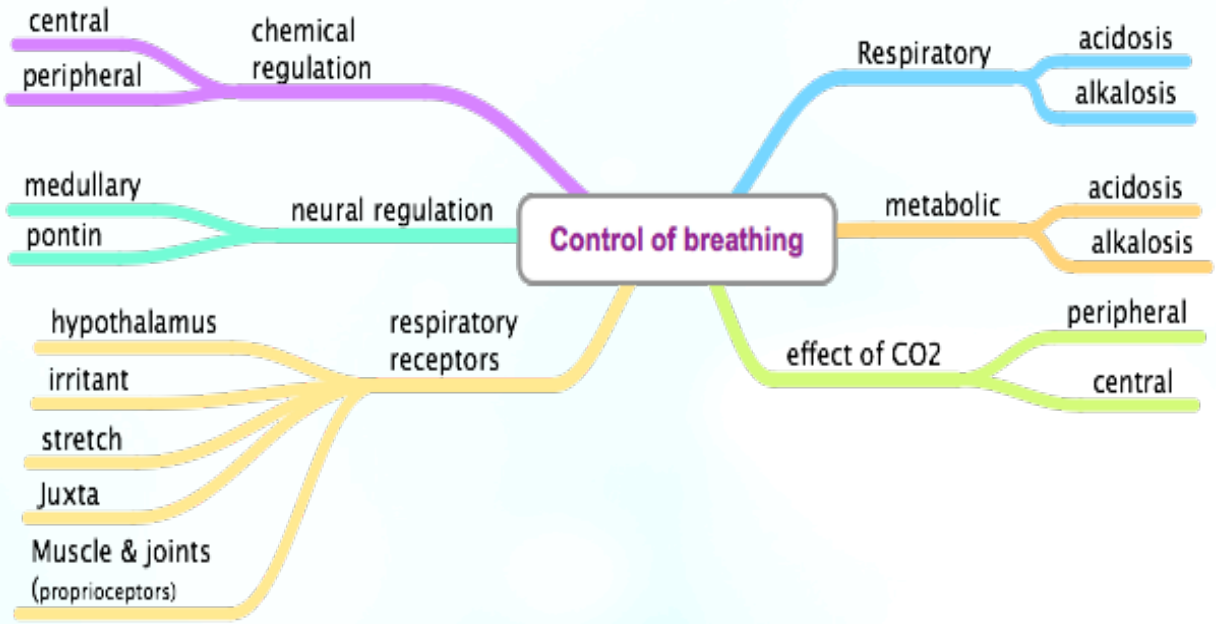
Respiratory Block

Objectives:

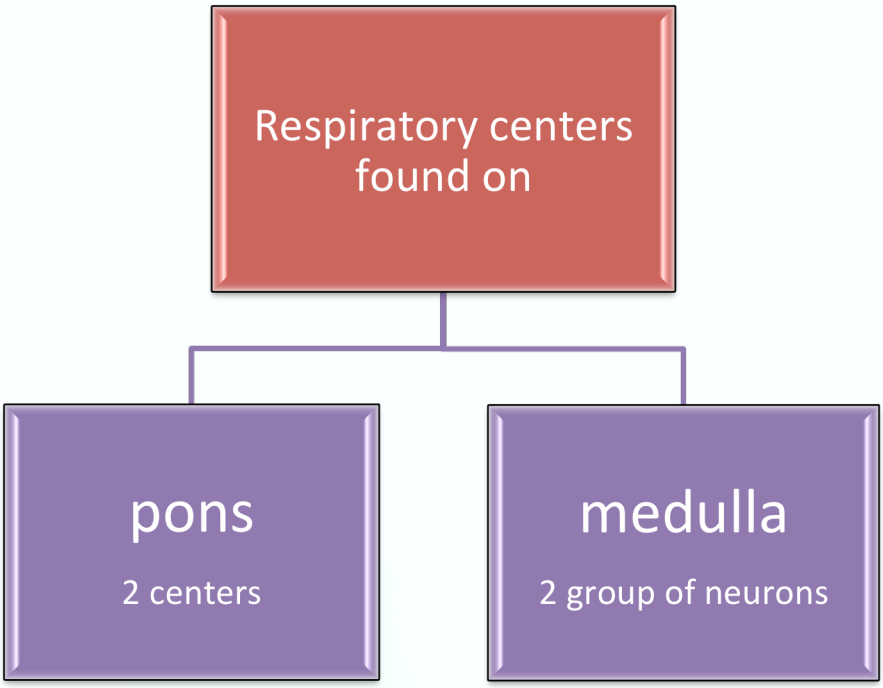
- **Understand the role of the medulla oblongata in determining the basic pattern of respiratory activity.**
- **List some factors that can modify the basic breathing pattern like e.g. a- The Hering-Breuer reflexes, b- The proprioreceptor reflexes, and c- The protective reflexes, like the irritant, and 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.**

Mind Map:



Controls of rate and depth of respiration

Arterial po_2	When po_2 is very low (hypoxia), ventilation increases.(to allow more air to get inside and extract o_2)
Arterial pco_2	The most important regulator of ventilation is pco_2, small increases in pco_2, greatly increases ventilation (to get rid of co_2)
Arterial pH	As hydrogens ions increases(acidosis), alveolar ventilation increases .



1) So, 2 factors that increase the ventilation (hyperventilation):

1- Decreases po2
2- increases pco2

2) CO2 is a source of H

3) ↑PCO_2 → ↓PH → ↑ H → increases ventilation

Neural regulation

Medullary respiratory centers

Inspiratory area (dorsal respiratory group) DRG Located bilaterally in the dorsal portion of the medulla oblongata in / close to the nucleus of .the tractus solitarius	Expiratory area (ventral respiratory group) VRG extend through the nucleus ambigus and nucleus retroambigus in the ventrolateral part of the medulla oblongata
- Source of basic inspiratory impulses(forced-resting) - Origin of phrenic and intercostal nerves which innervate inspiratory muscles. - Causes contraction of diaphragm and external intercostal. - Determines basic rhythm of breathing (according to the discharge impulses) - DRG discharges impulses for 2 seconds.	- Source of impulses for forceful expiratory muscles. - Inactive during normal quiet breathing. - Activated by inspiratory areas during forceful breathing (by a portion of excess DRG discharge impulses will go and stimulate VRG) - Causes contraction of internal intercostal and abdominal muscles. - VRG discharges impulses for 3 seconds.
Respiratory rate = 12 breathes (2+3= 5 sec/breath) - DRG and VRG discharging duration remains constant except if there is a change in the respiratory rate	

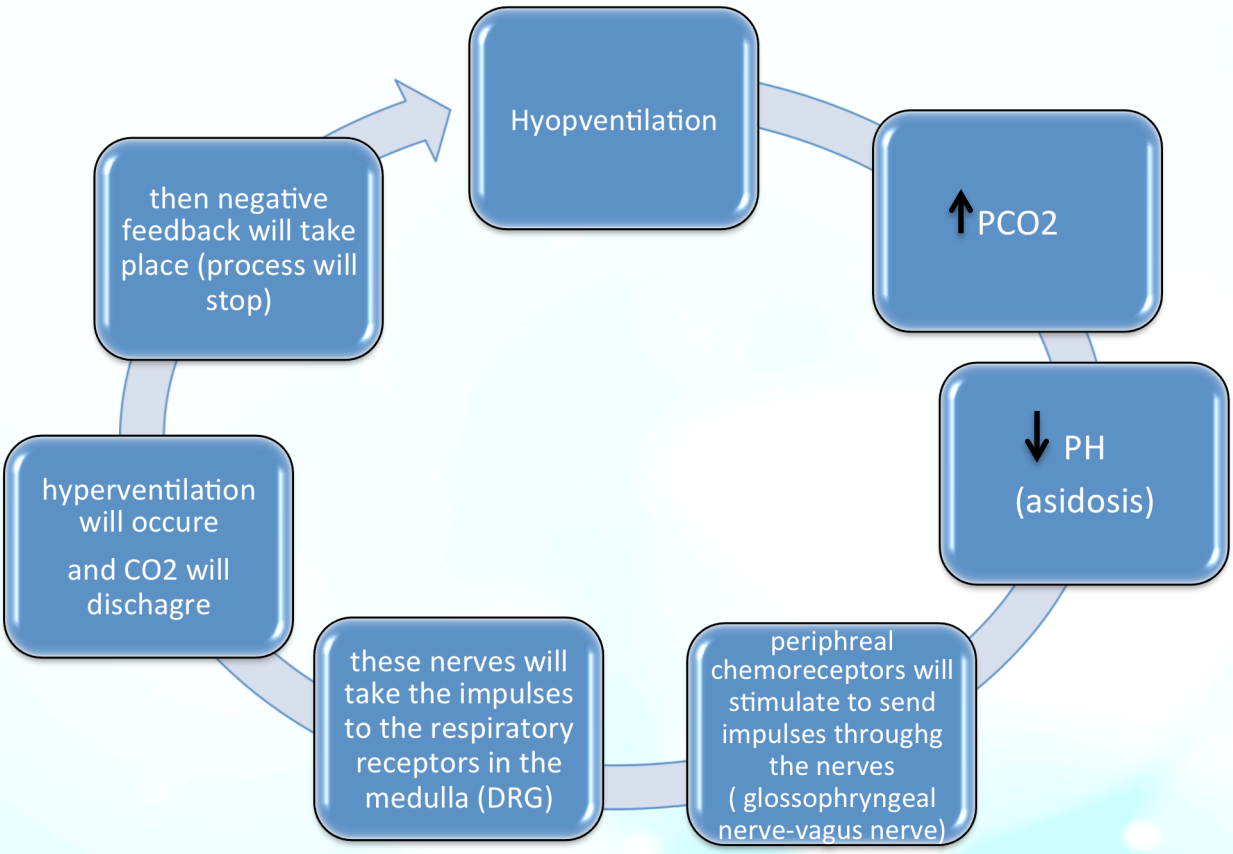
Pontine respiratory centers

Pneumotaxic area located dorsally in the nucleus parabrachialis of the upper pons	Apneustic area Located in lower pons
- Inhibits inspiratory area of medulla (DRG) to stop inhalation. - Breathing is more rapid when pneumotaxic area is active. - If it overstimulate it will lower the respiratory cycle. - When these signals are strong inspiration lasts for 0.5 sec. When weak, inspiration lasts as long as 5 seconds, filling the lungs with excess air.	- Stimulates inspiratory area of medulla (DRG) to prolong inhalation. - If it overstimulate it will prolong the respiratory cycle.
Pontine respiratory centers: it control the transition between inhalation and exhalation	

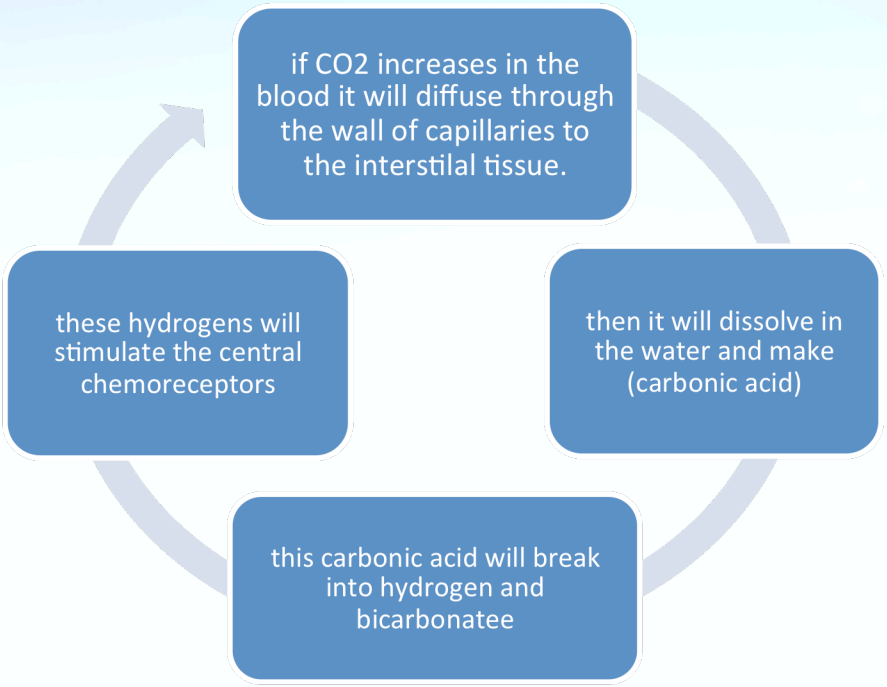
Chemical regulation

Chemoreceptors control of breathing	
Peripheral chemoreceptors	**Central chemoreceptors**
- By: 1- Aortic bodies on aortic arch. 2- Carotid bodies on carotid sinus. It senses the changes in the concentration of CO_2 , O_2 and PH. Normally, PO_2 in the arterial blood is 95 mmhg, peripheral chemoreceptors doesn't sense the decreasing until it reaches a partial pressure under 60 mmgh, then it will sense the hypoxia.	- It doesn't sense the changes in PO_2

Effects of blood CO2 level on peripheral chemoreceptors



Effects of CO2 on the central chemoreceptors



Important notes:

1- Central chemoreceptors are not sensitive to CO_2 itself, but they recognize it because CO_2 produces H^+ (sensitive to H^+)
2- CO_2 makes an indirect stimulation of central chemoreceptors.
3- H^+ makes direct stimulation of central chemoreceptors.
4- CO2 makes more effects on the ventilation than H^+ in the arterial blood, because H^+ can't penetrate the wall of the capillaries.
5- H+ makes more effects on the ventilation than CO2 in the medulla (interstitial fluid of the medulla)

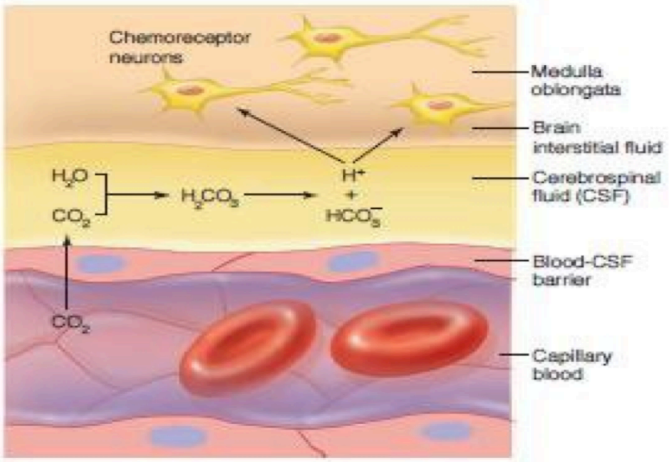


Figure 16.29 **How blood CO_2 affects chemoreceptors in the medulla oblongata.** An increase in blood CO_2 stimulates breathing indirectly by lowering the pH of blood and cerebrospinal fluid (CSF). This figure illustrates how a rise in blood CO_2 increases the H^+ concentration (lowers the pH) of CSF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

Hyperventilation: increase the rate and depth of breathing.

Hypoventilation: decrease the rate and the depth of breathing.

Other respiratory receptors:

in muscles and joints

- When we move ,these receptors send impulses to the respiratory centers to ventilate

Hypothalamus

- Emotional stimuli or pain will act through hypothalamus by sending impulses to the respiratory centers to ventilate.Also, changes in the tempreature will stimulate it.

irratant receptors

- If it stimulates by an irratant it will send impulses to the respiratory centers tto take a deep inspiration followed by a forced expiration (cough reflex)

J receptors

- Juxta receptors : between the alveoli and pulmonary capillaries.
- It senses the pulmonary capillaries pressure if it increased.
- If the pulmonary capillaries pressure increases this will lead to hyperventilation and edema.
- Usually patientes complain from dyspnea .

Note

Pulmonary edema: fluid in the interstitial tissue of the lungs, it may diffuse to alveoli

Acidosis

- ↑H or↓ PH

Alkalosis

- ↓H or ↑PH

Respiratory acidosis	Respiratory alkalosis
- Duo to respiratory problems - Caused by hypoventilation. - Accumulation of CO_2 in the tissues. - PCO_2 increases. - H^+ increases. - PH decreases.	- Duo to respiratory problems. - Caused by hyperventilation. - Excessive loss of CO_2 - PCO_2 decreases (less than 35mmhg) - PH increases.

metabolic acidosis	metabolic alkalosis
- Duo to metabolism problems: 1- Ingestion, infusion or production of a fixed acid. 2- Decreased renal excretion of h ions. Loss of bicarbonate or other bases from the extracellular compartment.	- Duo to metabolism problems: 1. Excessive loss of fixed acids from the body. 2. Ingestion, infusion, or excessive renal reabsorption of bases such as bicarbonate (so it will lose H^+) 3. PH increases.

- Respiratory system can fix metabolic acidosis by hyperventilation, and metabolic alkalosis by inhibit ventilation to build up co2.
- Metabolic system can't fix respiratory acidosis or alkalosis.

Q1: When PO2 is VERY low(Hypoxia), ventilation will :

A- Increase
B- Decrease
C- Normal

Q2: The most important regulator of ventilation

A- PO2
B- PCO2
C- PH

Q3: Expiratory area will activated by :

A- inspiratory area during rest
B- inspiratory area during forceful breathing
C- expiratory area during forceful breathing

Q4 : Inspiratory area is ..

A- Ventral Respiratory Group
B- Dorsal Respiratory Group
C- Apneustic area and Pneumotaxic area

Q5: Pneumotaxic area ..

A- Inhibits inspiratory area of Pontine to stop inhalation.
B- Inhibits inspiratory area of medulla to stop inhalation.
C- stimulates inspiratory area of medulla to prolong inhalation.

Q6 :stretch receptors located in ..

A- epithelium of trachea
B- wall of bronchi & bronchioles
C- wall of the alveoli

Q7: pH increases in

A- Respiratory Alkalosis & Metabolic Alkalosis
B- Metabolic Acidosis
C- Respiratory Acidosis

Q8: peripheral chemoreceptors sense the changes in po2 of arterial blood if it is:

A- Under 60 mmhg
B- More than 95 mmhg
C- None of them.

Answers: 1- A 2- B 3-B 4-B 5-B 6-B 7-A 8- A

Summary

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1. **2 factors that increase the ventilation (hyperventilation):**
   1- Decreases po2 2- increases pco2

2. **Central chemoreceptors are not sensitive to CO_2 itself, but they recognize it because CO_2 produces H^+ (sensitive to H^+)**
3. **CO_2 makes an indirect stimulation of central chemoreceptors.**
4. **H^+ makes direct stimulation of central chemoreceptors.**
5. **CO2 makes more effects on the ventilation than H^+ in the arterial blood, because H^+ can't penetrate the wall of the capillaries.**
6. **H+ makes more effects on the ventilation than CO2 in the medulla (interstitial fluid of the medulla).**

http://www.youtube.com/watch?v=gd3ICLDrO2Q **central and peripheral chemoreceptors**

http://www.youtube.com/watch?v=xjXnz2kYcXE **control of ventilation**