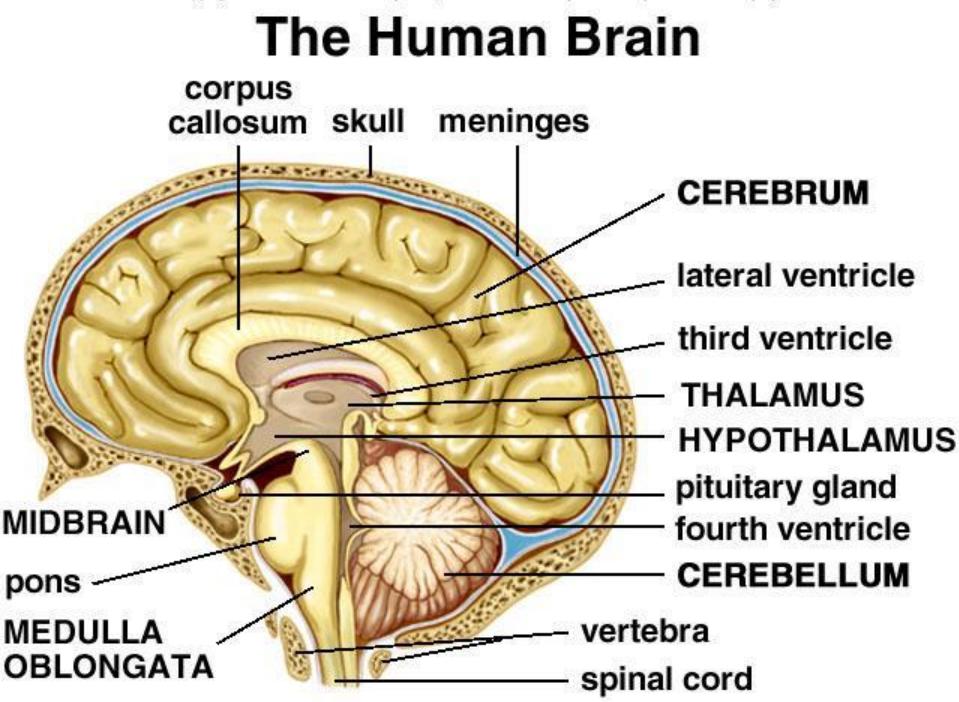


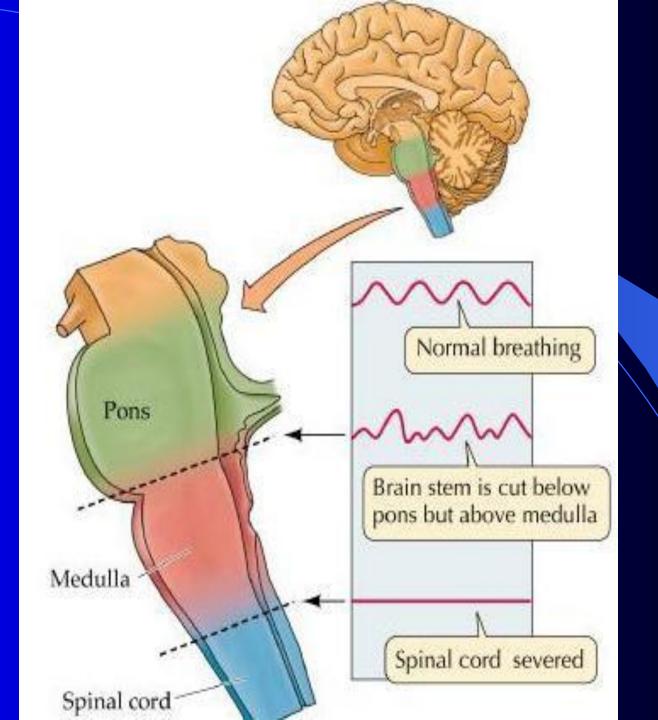
Regulation of the Respiration

I. Respiratory Center and Formation of the Respiratory Rhythm

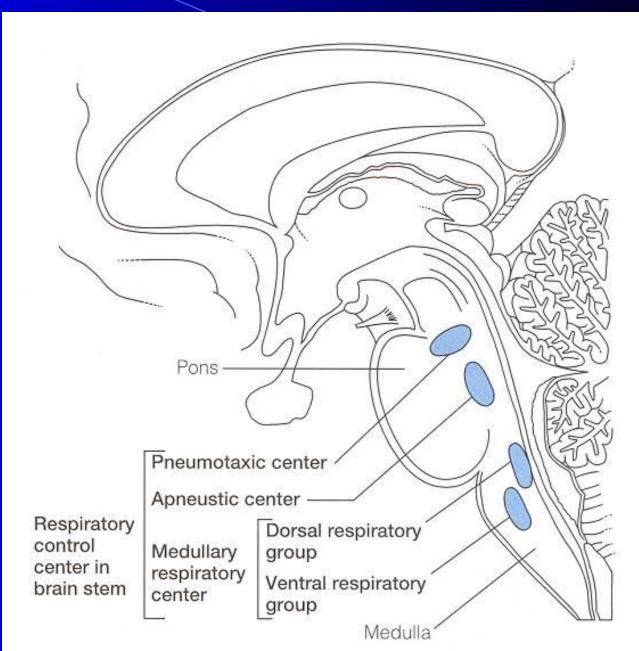
1 Respiratory Center

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Respiratory Centers

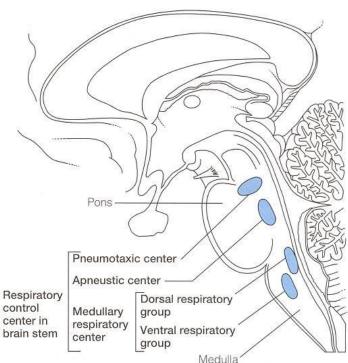


Two respiratory nuclei in medulla oblongata

Inspiratory center (dorsal respiratory group, DRG)

- more frequently they fire, more deeply you inhale
- longer duration they fire, breath is prolonged, slow rate

Expiratory center (ventral respiratory group, VRG)•involved in *forced* expiration



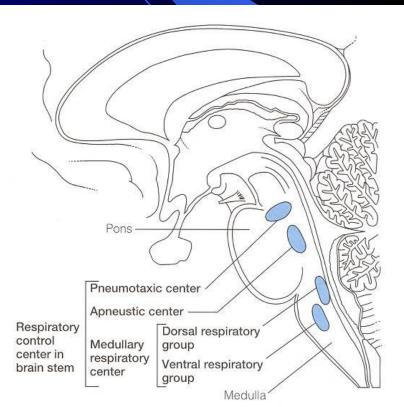
Respiratory Centers in Pons

Pneumotaxic center (upper pons)

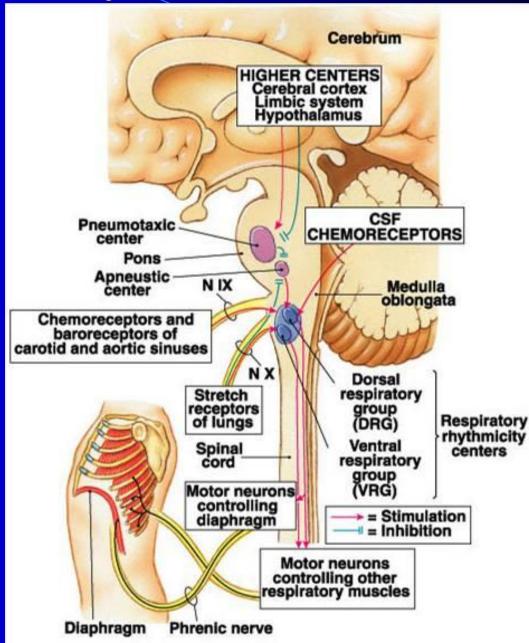
- •Sends continual inhibitory impulses to inspiratory center of the medulla oblongata,
- •As impulse frequency rises, breathe faster and shallower

Apneustic center (lower pons)

- •Stimulation causes apneusis
- •Integrates inspiratory cutoff information



Respiratory Structures in Brainstem



2. Rhythmic Ventilation (Inspiratory Off Switch)

Starting inspiration

 Medullary respiratory center neurons are continuously active (spontaneous)

 Center receives stimulation from receptors and brain concerned with voluntary respiratory movements and emotion

-Combined input from all sources causes action potentials to stimulate respiratory muscles

Increasing inspiration

More and more neurons are activated

Stopping inspiration

–Neurons receive input from pontine group and stretch receptors in lungs.

–Inhibitory neurons activated and relaxation of respiratory muscles results in expiration.

-Inspiratory off swithch.

3. Higher Respiratory Centers

- Modulate the activity of the more primitive controlling centers in the medulla and pons.
- Allow the rate and depth of respiration to be controlled voluntarily.
- During speaking, laughing, crying, eating, defecating, coughing, and sneezing.
- Adaptations to changes in environmental temperature --Panting

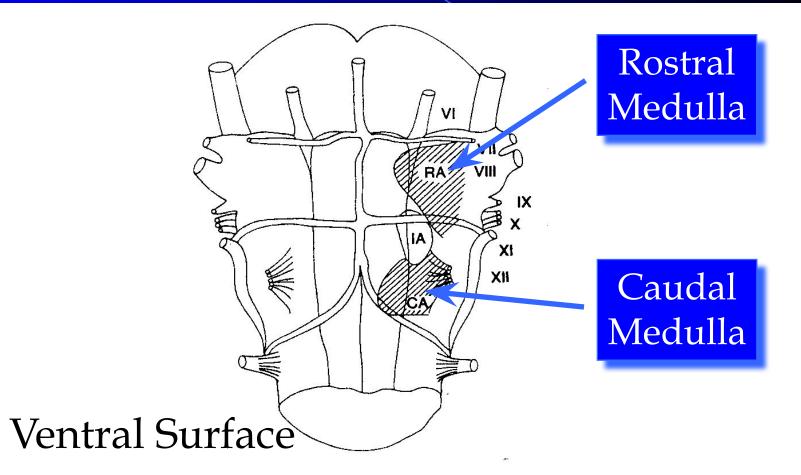
II Pulmonary Reflex

1. Chemoreceptor Reflex

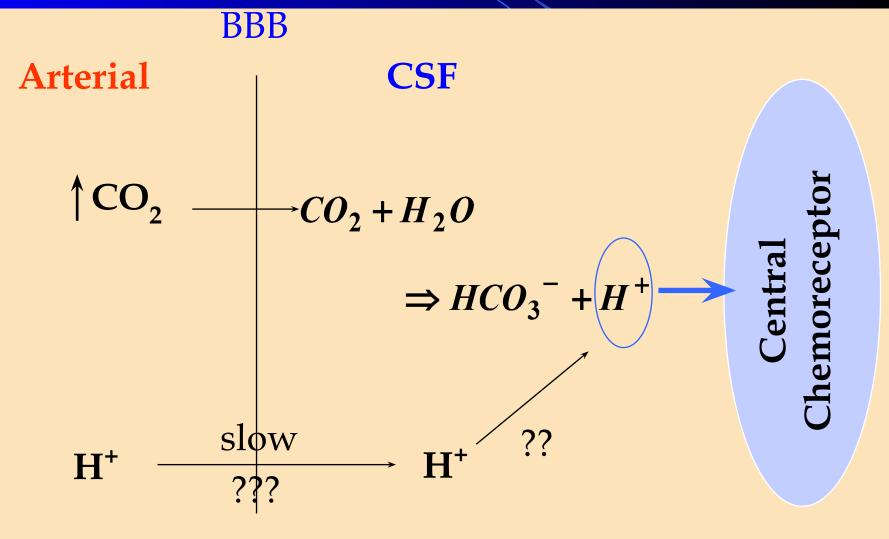
Two Sets of Chemoreceptors Exist

- Central Chemoreceptors
 - Responsive to increased arterial PCO
 - Act by way of CSF $[H^+]$ \uparrow .
- Peripheral Chemoreceptors
 - Responsive to decreased arterial PO₂
 - Responsive to increased arterial PCO₂
 - Responsive to increased H⁺ ion concentration.

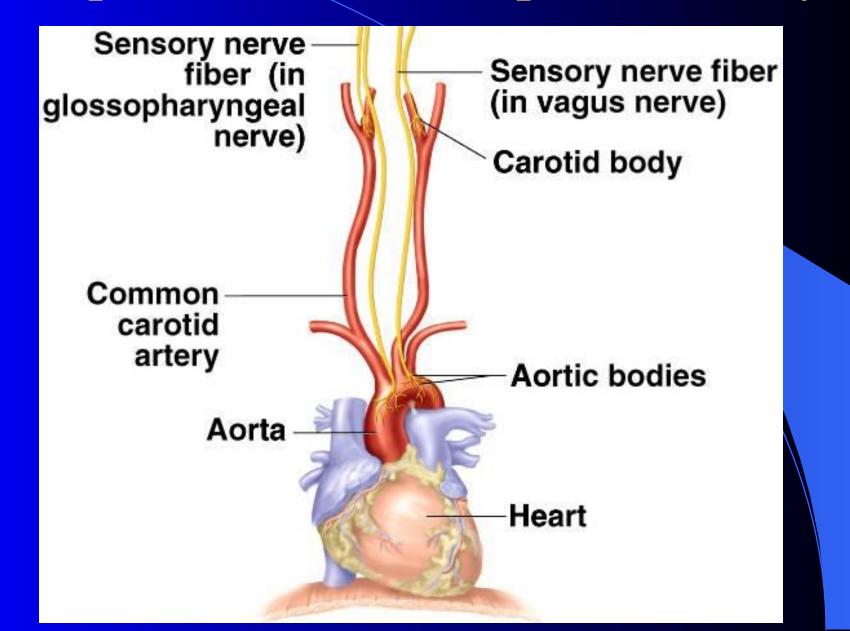
Central Chemoreceptor Location



Central Chemoreceptor Stimulation

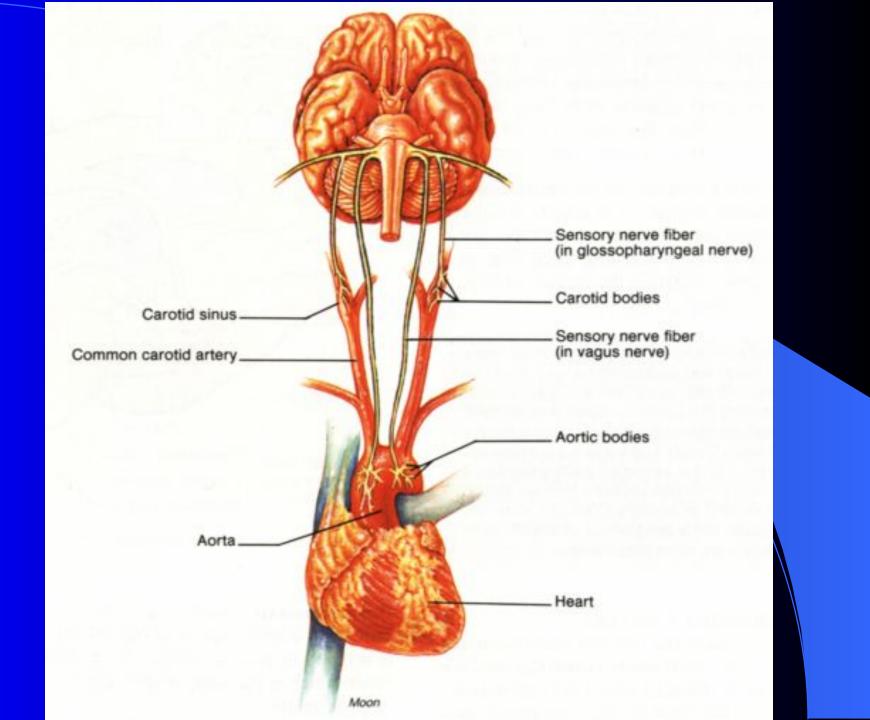


Peripheral Chemoreceptor Pathways



Peripheral Chemoreceptors

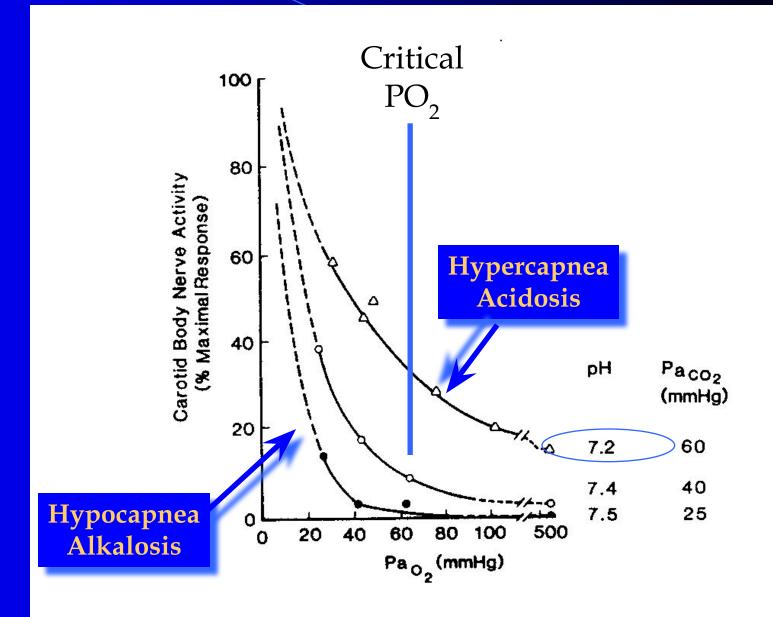
- Carotid bodies
 - Sensitive to: P_aO_2 , P_aCO_2 , and pH
 - Afferents in glossopharyngeal nerve.
- Aortic bodies
 - Sensitive to: P_aO_2 , P_aCO_2 , but <u>not</u> pH
 - Afferents in vagus



Carotid Body Function

- High flow per unit weight: (2 L/min/100 g)
- High carotid body VO₂ consumption: (8 ml O₂/min/100g)
- Tiny a-v O_2 difference: <u>Receptor cells see arterial PO</u>₂.
- Responsiveness begins at P_aO₂ (not the oxygen content) below about 60 mmHg

Carotid Body Response



Carbon Dioxide, Oxygen and pH Influence Ventilation (through peripheral receptor)

- Peripheral chemoreceptorssensitive to P₀₂, P_{C02} and pH
- Receptors are activated by increase in P_{CO2} or decrease in P_{O2} and pH
- Send APs through sensory neurons to the brain
- Sensory info is integrated within the medulla
- Respiratory centers respond by sending efferent signals through somatic motor neurons to the skeletal muscles
- Ventilation is increased (decreased)

Effects of Hydrogen Ions (through central chemoreceptors)

- pH of CSF (most powerful respiratory stimulus)
- Respiratory acidosis (pH < 7.35) caused by failure of pulmonary ventilation
 - hypercapnia $(P_{CO2}) > 43 \text{ mmHg}$
 - CO₂ easily crosses blood-brain barrier, in CSF the CO₂ reacts with water and releases H⁺, central chemoreceptors strongly stimulate inspiratory center
 - corrected by hyperventilation, pushes reaction to the left by "blowing off" CO_2 CO_2 (expired) + $H_2O \leftarrow H_2CO_3 \leftarrow HCO_3^- + H^+$

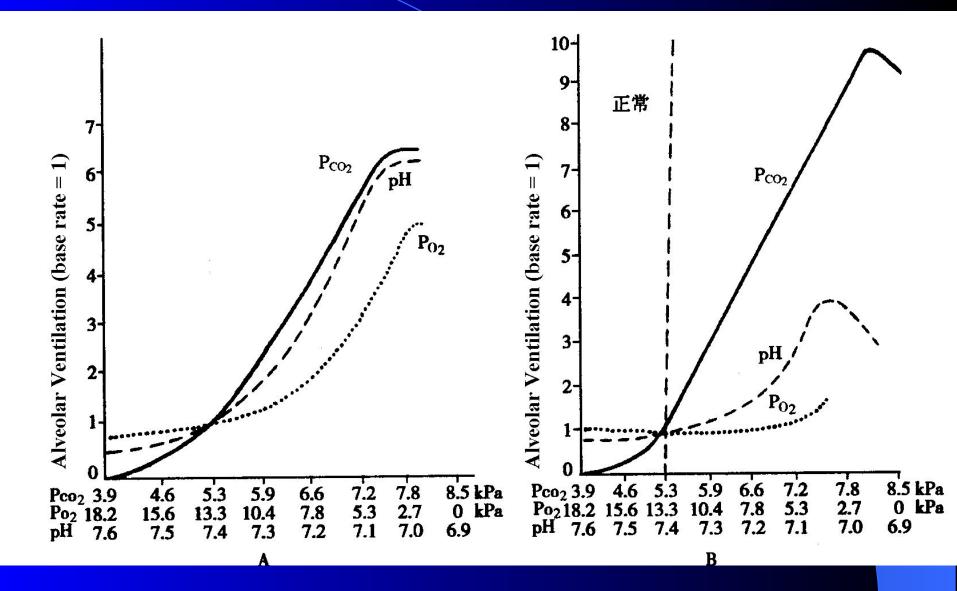
Carbon Dioxide

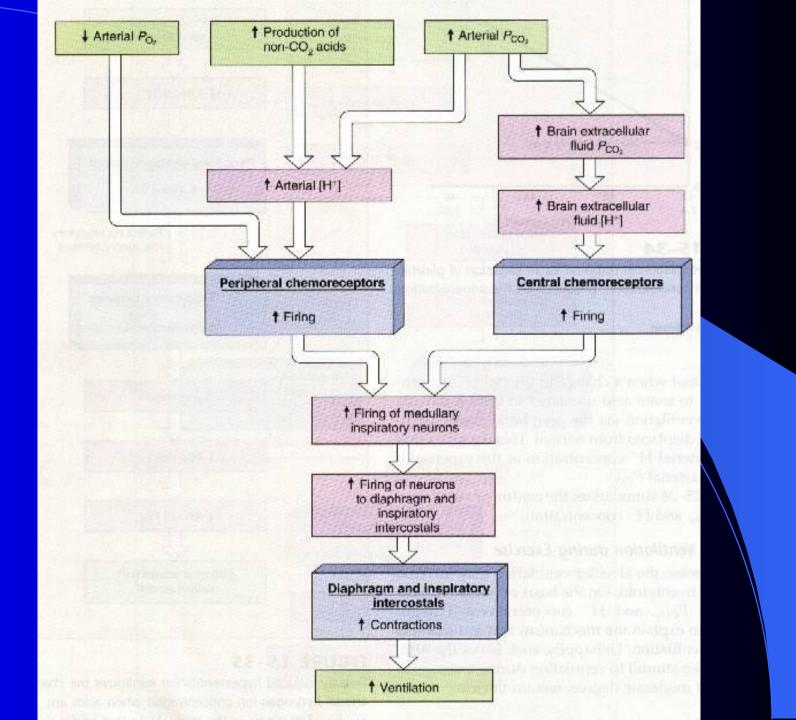
- Indirect effects
 - through pH as seen previously
- Direct effects
 - \u03c0 CO222 may directly stimulate peripheral
 chemoreceptors and trigger \u03c0 ventilation more quickly
 than central chemoreceptors
- If the PCO₂ is too high, the respiratory center will be inhibited.

Oxygen

- Direct inhibitory effect of hypoxemia on the respiratory center
- Chronic hypoxemia, PO₂ < 60 mmHg, can significantly stimulate ventilation
 - emphysema, pneumonia
 - high altitudes after several days

Overall Response toPco2, Po2 and pH

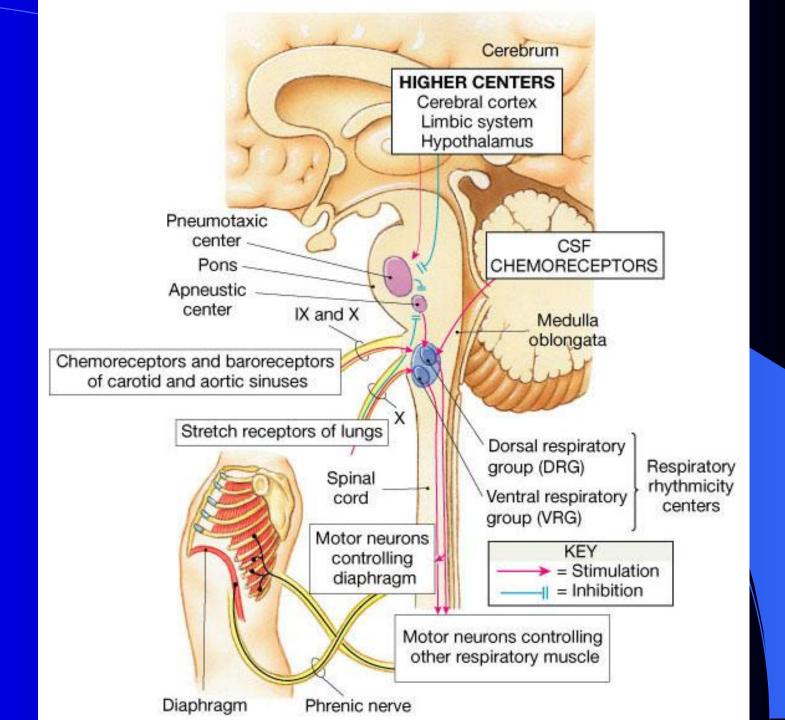




2. Neuroreceptor reflex

Hering-Breuer Reflex or Pulmonary Stretch Reflex

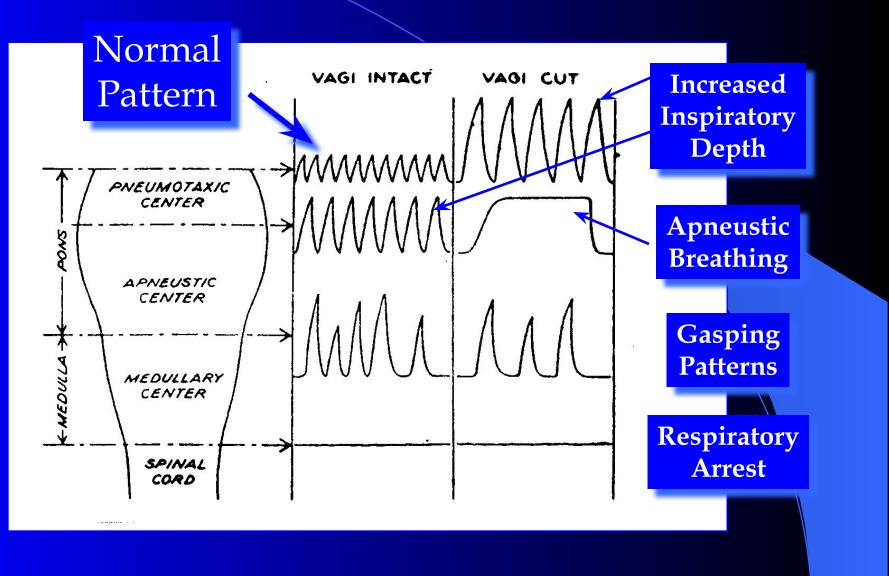
- Including pulmonary inflation reflex and pulmonary deflation reflex
- Receptor: Slowly adapting stretch receptors (SARs) in bronchial airways.
- Afferent: vagus nerve
- Pulmonary inflation reflex:
 - Terminate inspiration.
 - By speeding inspiratory termination they increase respiratory frequency.
 - Sustained stimulation of SARs: causes <u>activation of expiratory</u> <u>neurons</u>

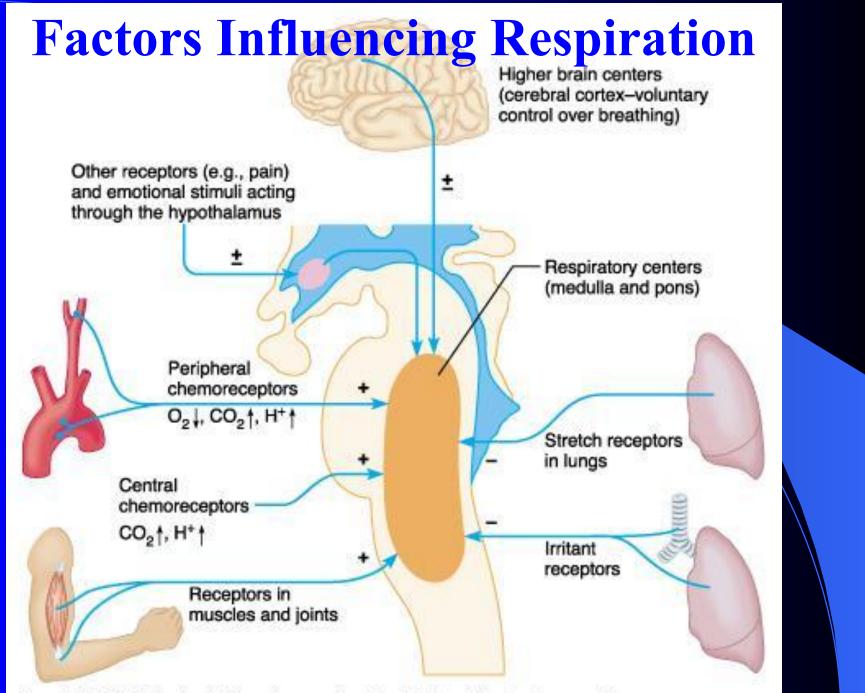


Significance of Hering-Breuer

- <u>Normal adults</u>. Receptors are not activated at end normal tidal volumes.
 - Become Important during exercise when tidal volume is increased.
 - Become Important in Chronic obstructive lung diseases when lungs are more distended.
- <u>Infants</u>. Probably help terminate normal inspiration.

Brainstem Transection





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