Control of Breathing

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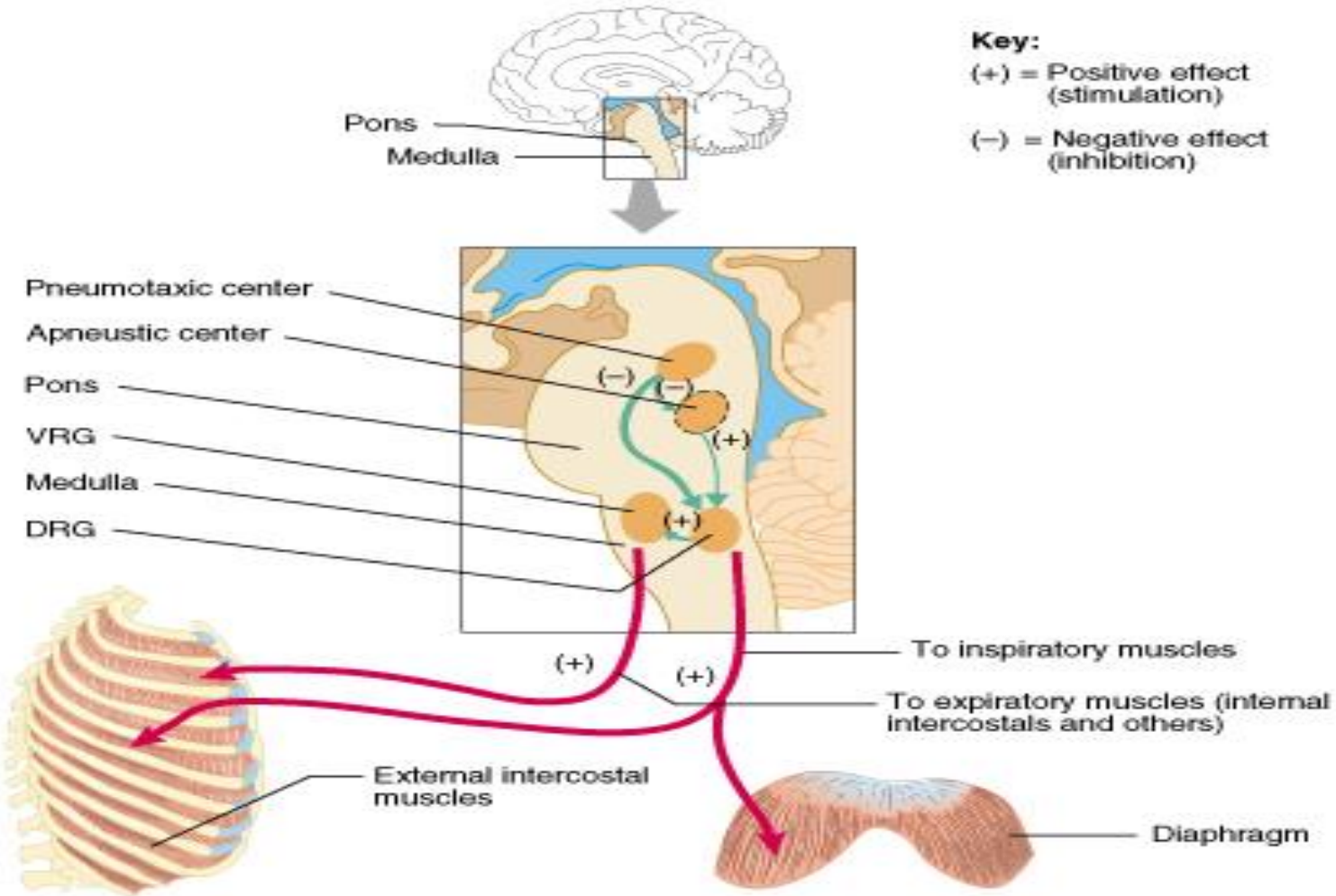
Objectives

- By the end of this lecture you should 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 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 PO_2, PCO_2, 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

- Arterial PO2
  - When PO2 is VERY low (Hypoxia), ventilation increases
- Arterial PCO2
  - The most important regulator of ventilation is PCO2, small increases in PCO2, greatly increases ventilation
- Arterial pH
  - As hydrogen ions increase (acidosis), alveolar ventilation increases.

Respiratory Centers



Medullary Respiratory centers

- Inspiratory area (Dorsal Respiratory Group) DRG
  -Determines basic rhythm of breathing
  -Causes contraction of diaphragm and external intercostals
- Expiratory area (Ventral Respiratory Group) VRG
  -Inactive during normal quiet breathing
  -Activated by inspiratory area during forceful breathing
  -Causes contraction of internal intercostals and abdominal muscles
- The medullary respiratory center stimulates basic inspiration for about 2 seconds and then basic expiration for about 3 seconds (5sec/ breath = 12breaths/min).

Pontine Respiratory centers

- Transition between inhalation and exhalation is controlled by:

Pneumotaxic area

Inhibits inspiratory area of medulla to stop inhalation.

Breathing is more rapid when pneumotaxic area is active.

Apneustic area

Stimulates inspiratory area of medulla to prolong inhalation.

Chemical regulation

(Peripheral and central chemoreceptors)

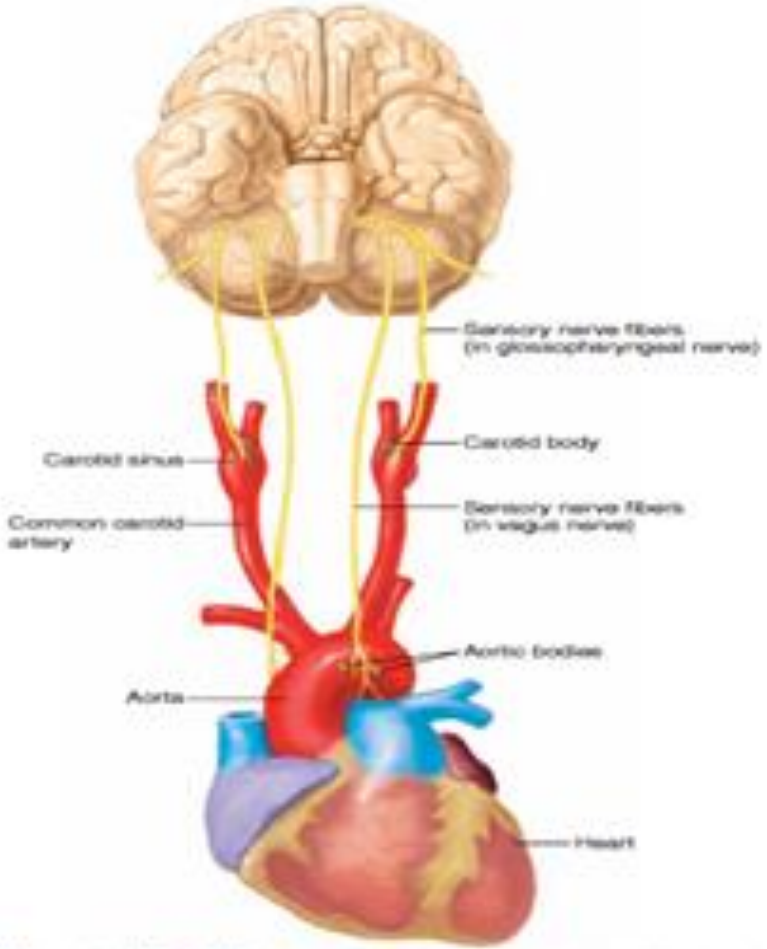
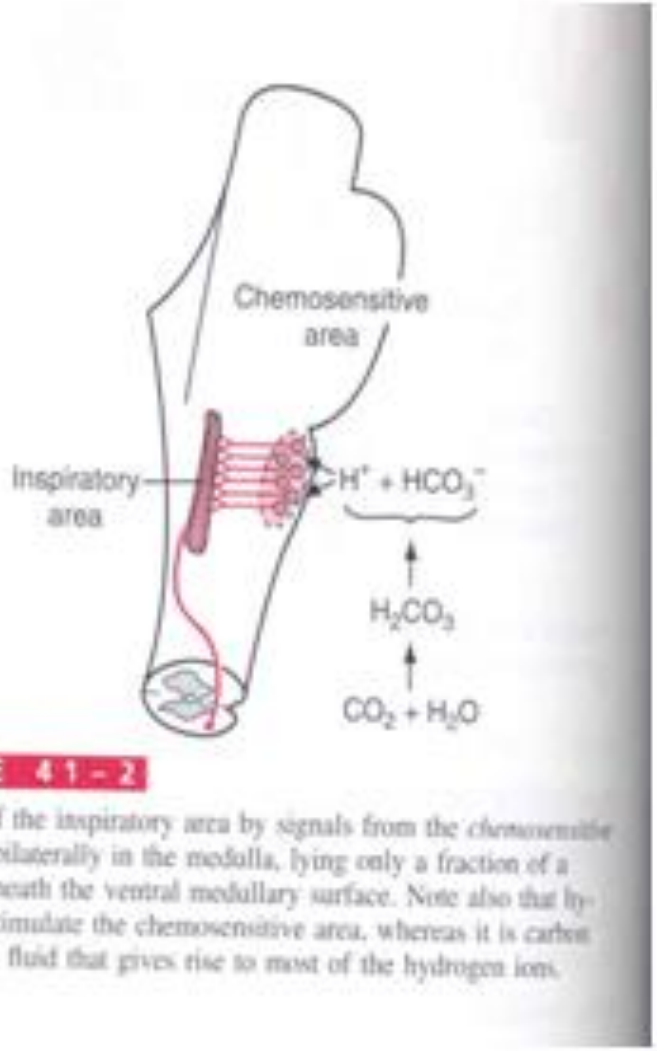


Figure 16.25 **Sensory input from the aortic and carotid bodies.** The peripheral chemoreceptors (aortic and carotid bodies) regulate the brain stem respiratory centers by means of sensory nerve stimulation.

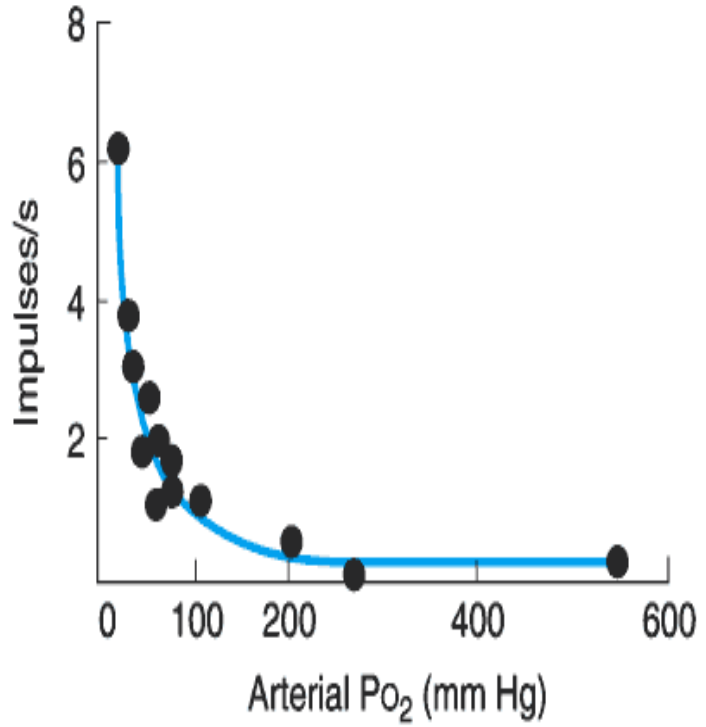


IGURE 41-2

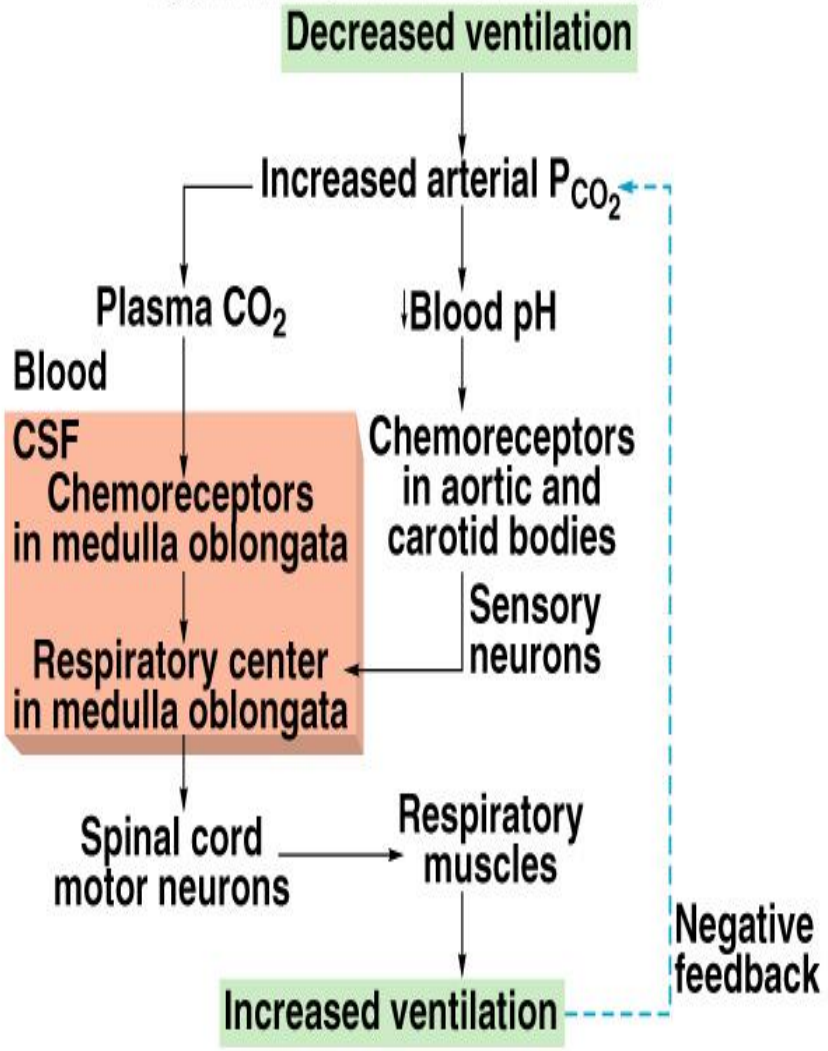
imulation of the inspiratory area by signals from the *chemosensitive* ea located bilaterally in the medulla, lying only a fraction of a illimeter beneath the ventral medullary surface. Note also that hy- ogen ions stimulate the chemosensitive area, whereas it is carbon oxide in the fluid that gives rise to most of the hydrogen ions.

Chemoreceptor Control of Breathing

Figure 36–6.



Change in the rate of discharge of a single afferent fiber from the carotid body when arterial PO_2 is reduced. (Courtesy of S Sampson.)



Effect of blood CO2 level on central chemoreceptors

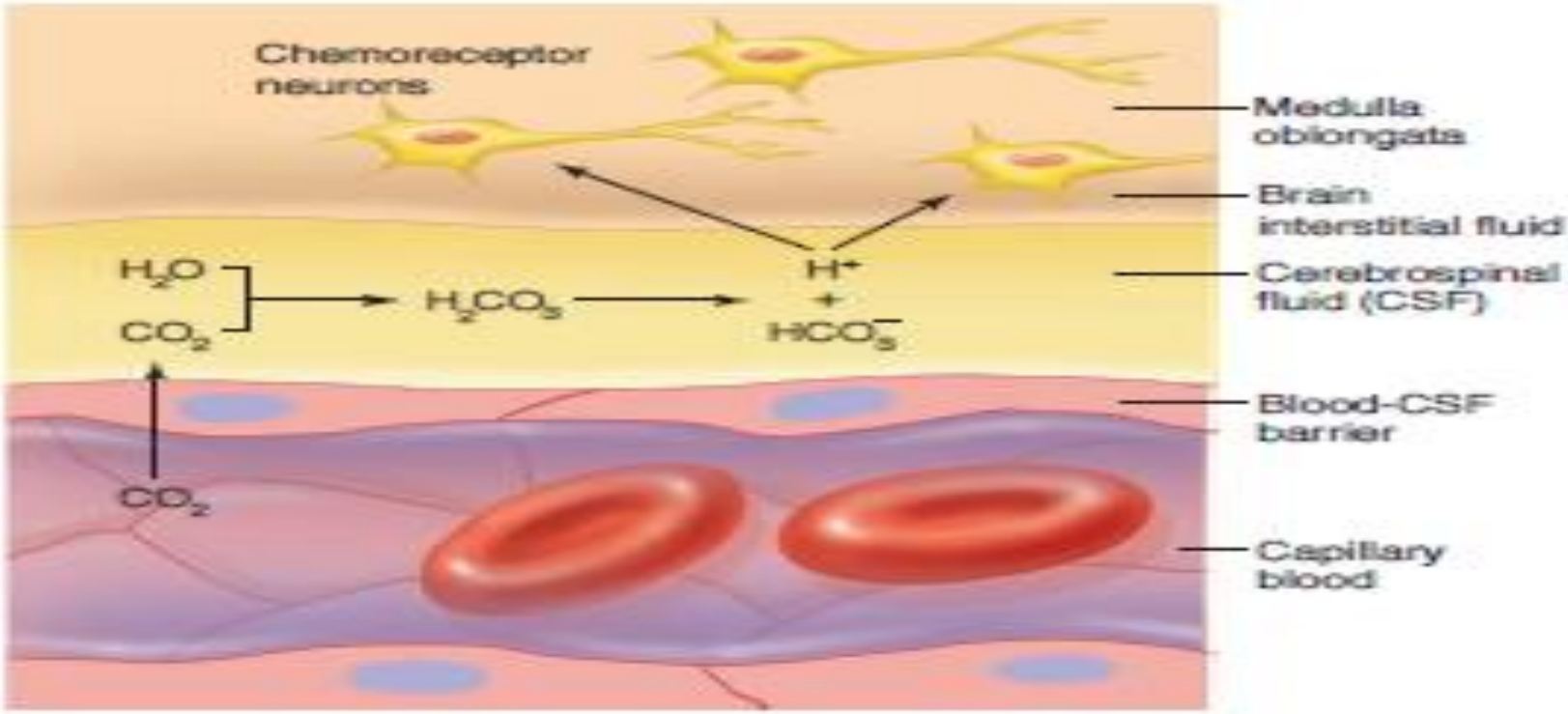
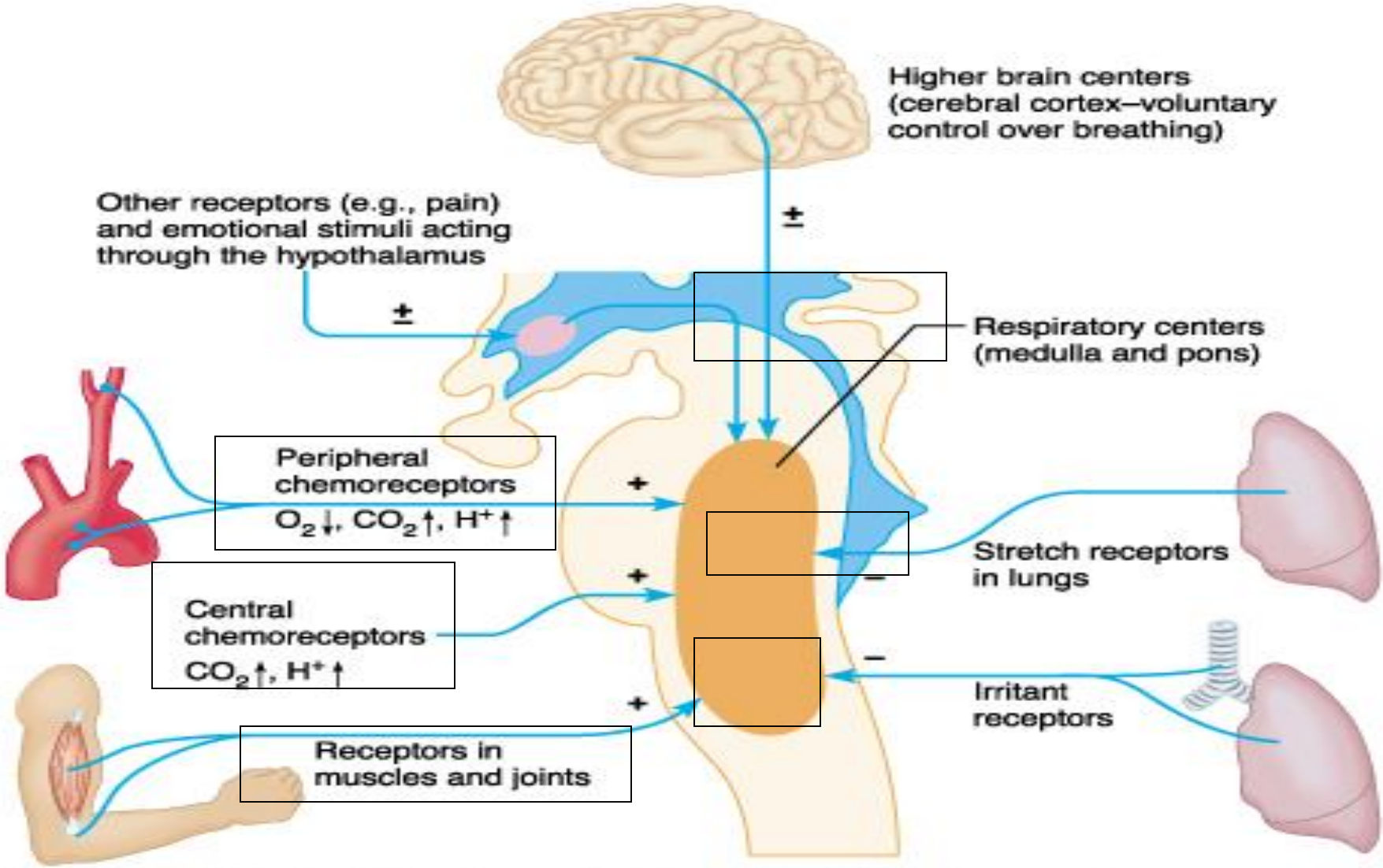


Figure 16.29 **How blood CO_2 affects chemoreceptors in the medulla oblongata.** An increase in blood CO_2 stimulates breathing indirectly by lowering the pH of blood and cerebrospinal fluid (CSF). This figure illustrates how a rise in blood CO_2 increases the H^+ concentration (lowers the pH) of CSF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

Factors Influencing Respiration



Hering-Breuer inflation reflex

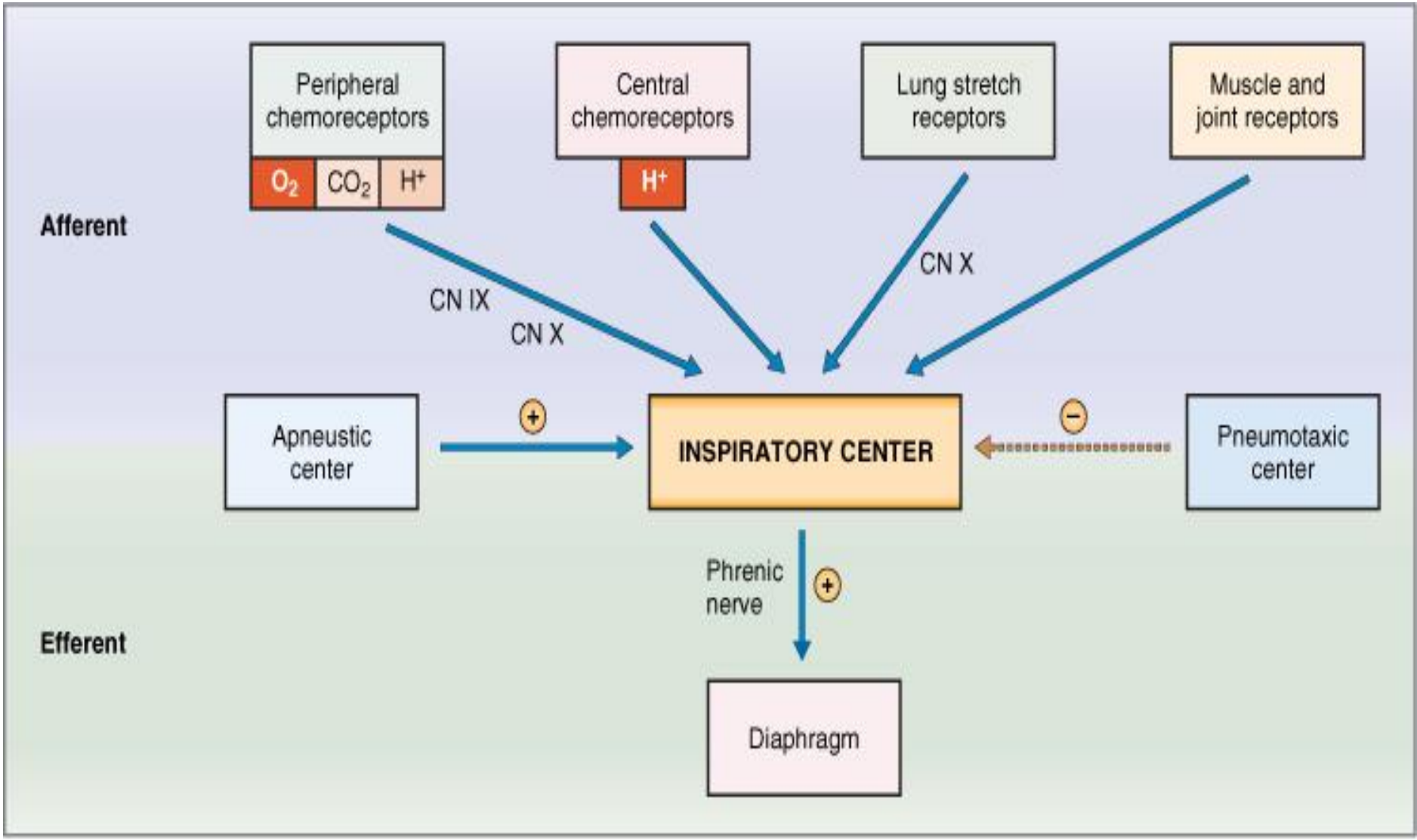
- When the lung becomes overstretched (tidal volume is 1 L or more), stretch receptors located in the wall bronchi and bronchioles transmit signals through vagus nerve to DRG producing effect similar to pneumotaxic center stimulation
- Switches off inspiratory signals and thus stops further inspiration .
- This reflex also increase the rate of respiration as does the pneumotaxic center.

Cont. factor affecting respiratory centers

- **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.

Cont..factors affecting respiration



Respiratory Acidosis

- Hypoventilation.
- Accumulation of CO_2 in the tissues.
  - P_{CO2} increases
  - pH decreases.

Respiratory Alkalosis

- Hyperventilation.
- Excessive loss of CO_2.
  - P_{CO2} decreases (↓35 mmHg).
  - pH increases.

Metabolic Acidosis

- Ingestion, infusion, or production of a fixed acid.
- decreased renal excretion of hydrogen ions.
- loss of bicarbonate or other bases from the extracellular compartment

Metabolic Alkalosis

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

The respiratory system can compensate for metabolic acidosis or alkalosis by altering alveolar ventilation