Respiratory Physiology

By

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Outline

- Introduction
- Hypoxia
- Dyspnea
- Control of breathing
- Ventilation/perfusion ratios
- Respiratory/barometric changes in exercise
- Intra-pulmonary & intra-pleural pressure
- Gas laws

Hypoxia

- This is defined as lack of oxygen in tissue (oxygen starvation)
- Preceded by hypoxemia
- Hypercapnia & hypocapnia

Types of hypoxia

- Hypoxic hypoxia
- Anemic hypoxia
- Circulatory/ischemic hypoxia
- Histotoxic hypoxia

Dypsnea

- Shortness of breath

- In 85% of cases it is due to asthma, pneumonia, cardiac ischemia, interstitial lung disease, congestive heart failure, chronic obstructive pulmonary disease, or psychogenic causes, such as panic disorder and anxiety.

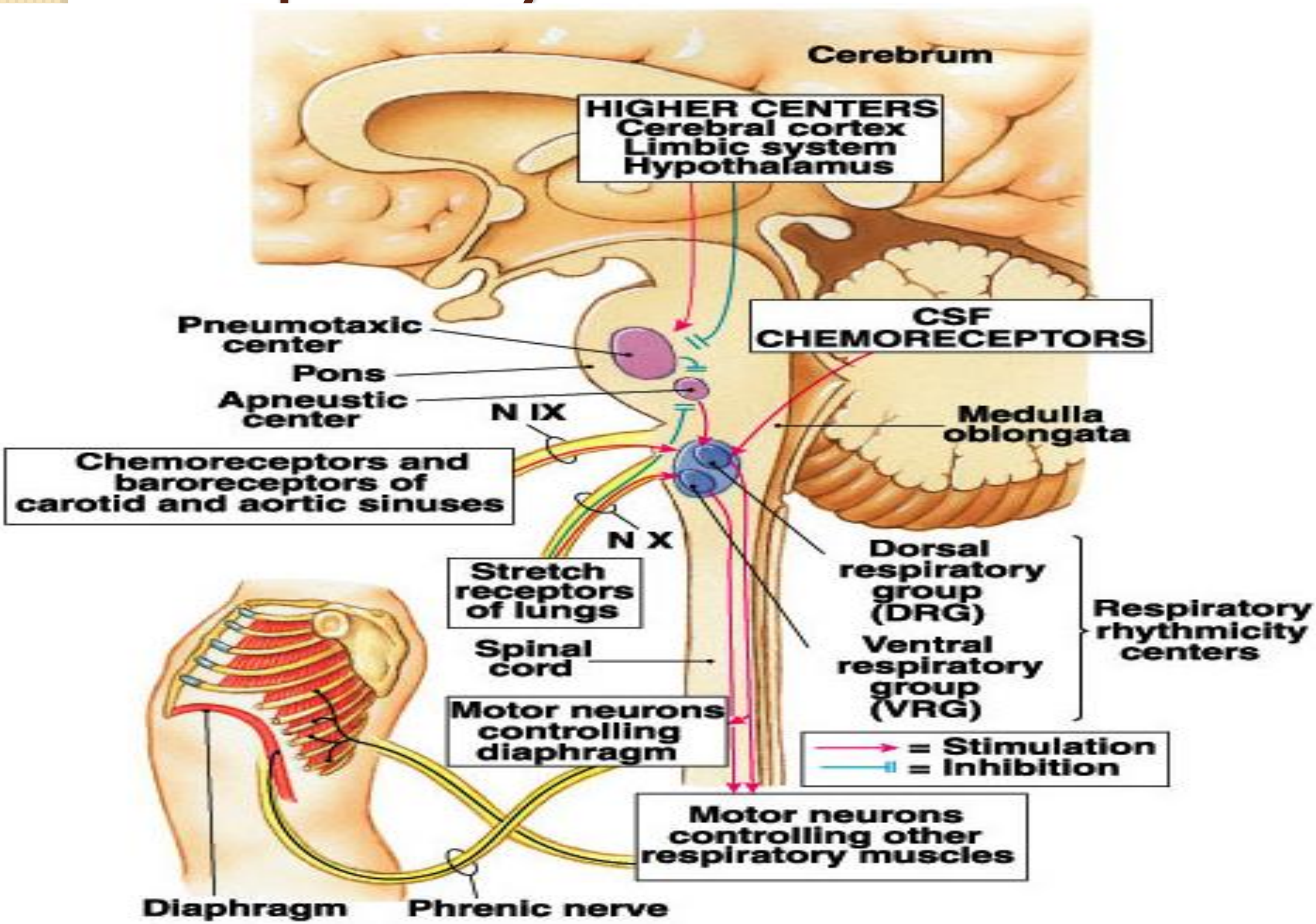
Control of breathing

- Voluntary control

- Involuntary control

a. Neural control
b. Chemical control

Respiratory centers



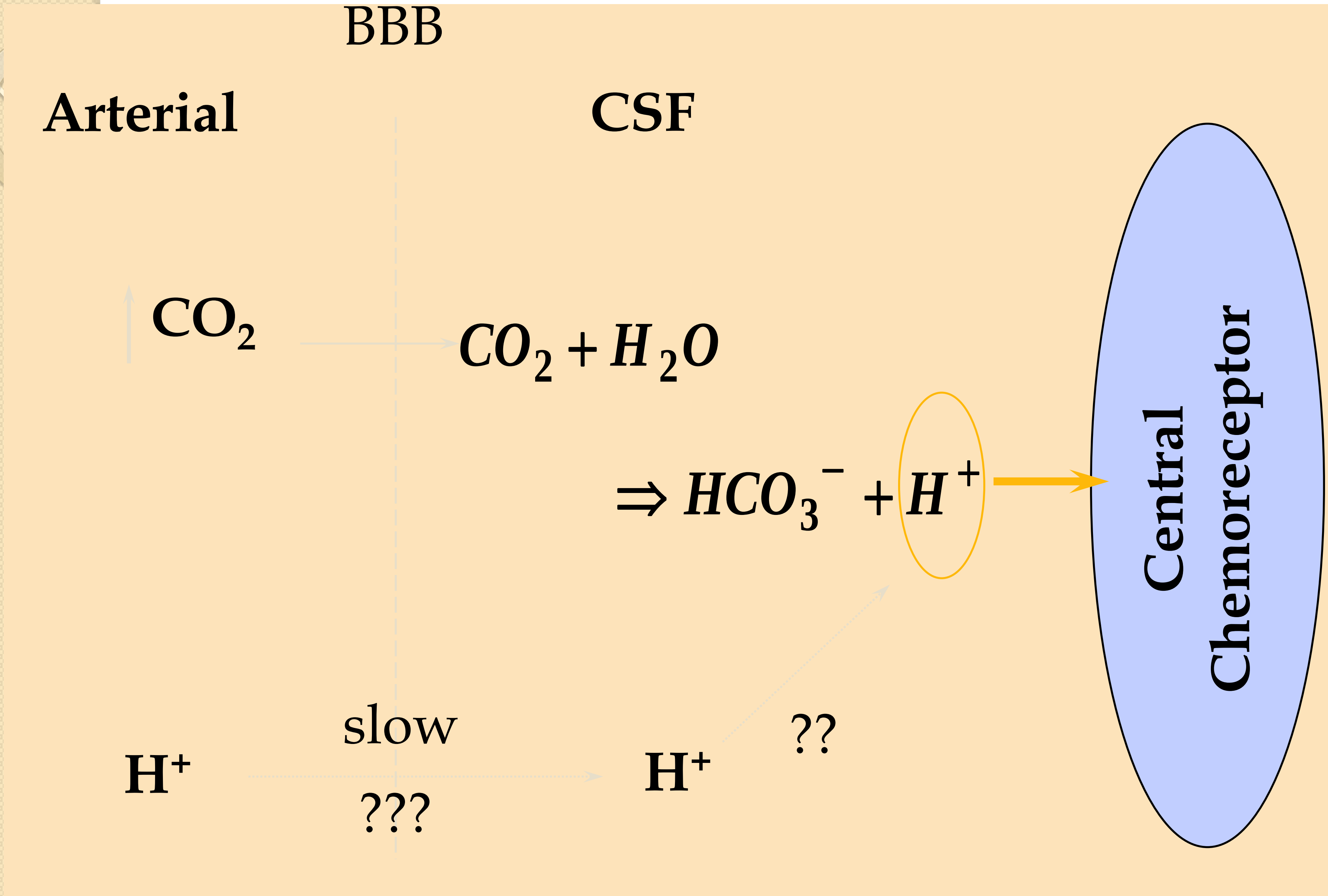
Neural control

- Dorsal Respiratory Group (DRG)
- Ventral Respiratory Group (VRG)
- Pneumotaxis centre
- Apneustic center

Chemical control (chemoreceptor's)

- Central Chemoreceptors
  - Responsive to increased arterial PCO_2
  - Act by way of CSF $[H^+]$.
- Peripheral Chemoreceptors
  - Responsive to decreased arterial PO_2
  - Responsive to increased arterial PCO_2
  - Responsive to increased H^+ ion concentration.

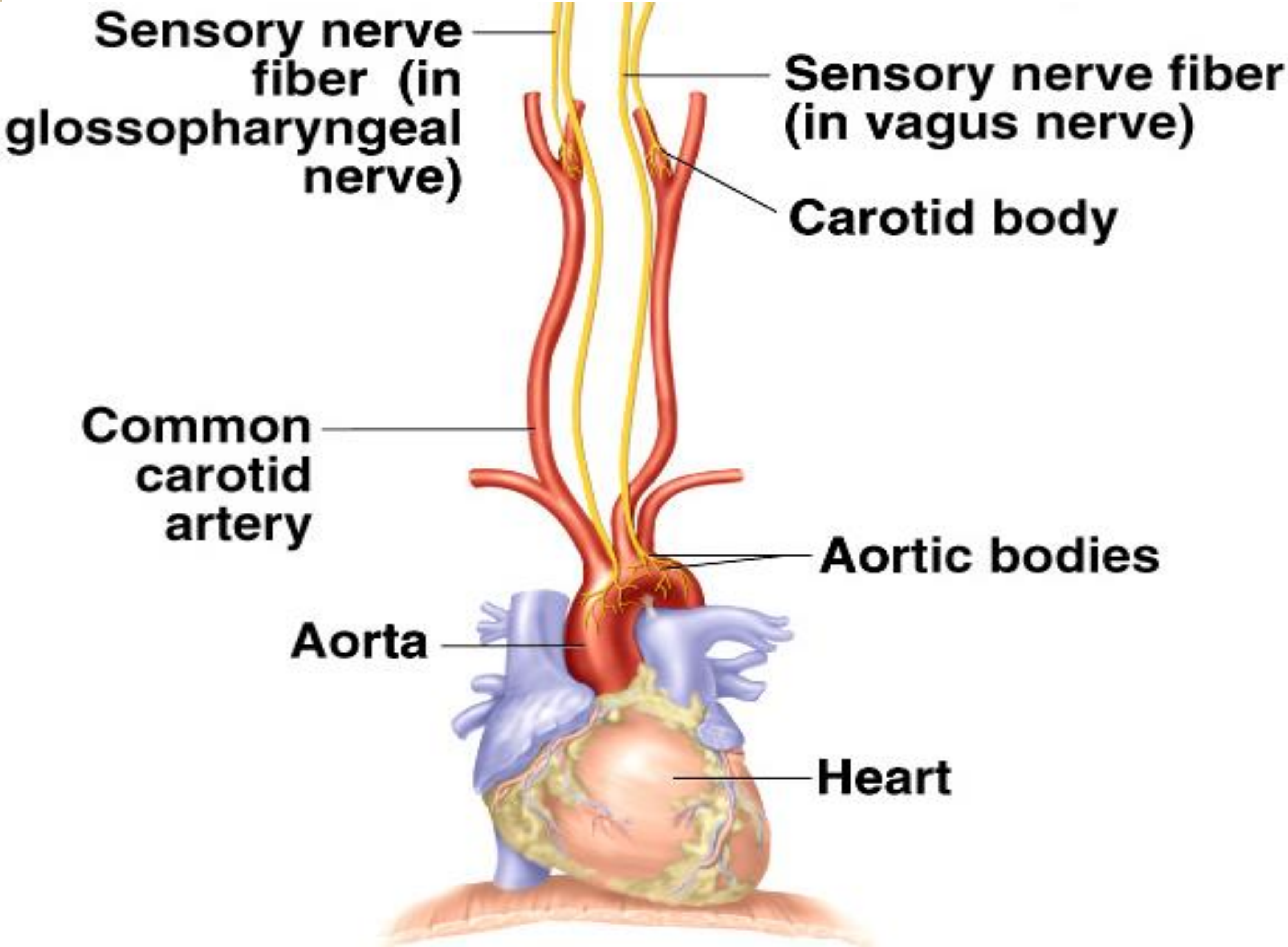
Central chemoreceptors

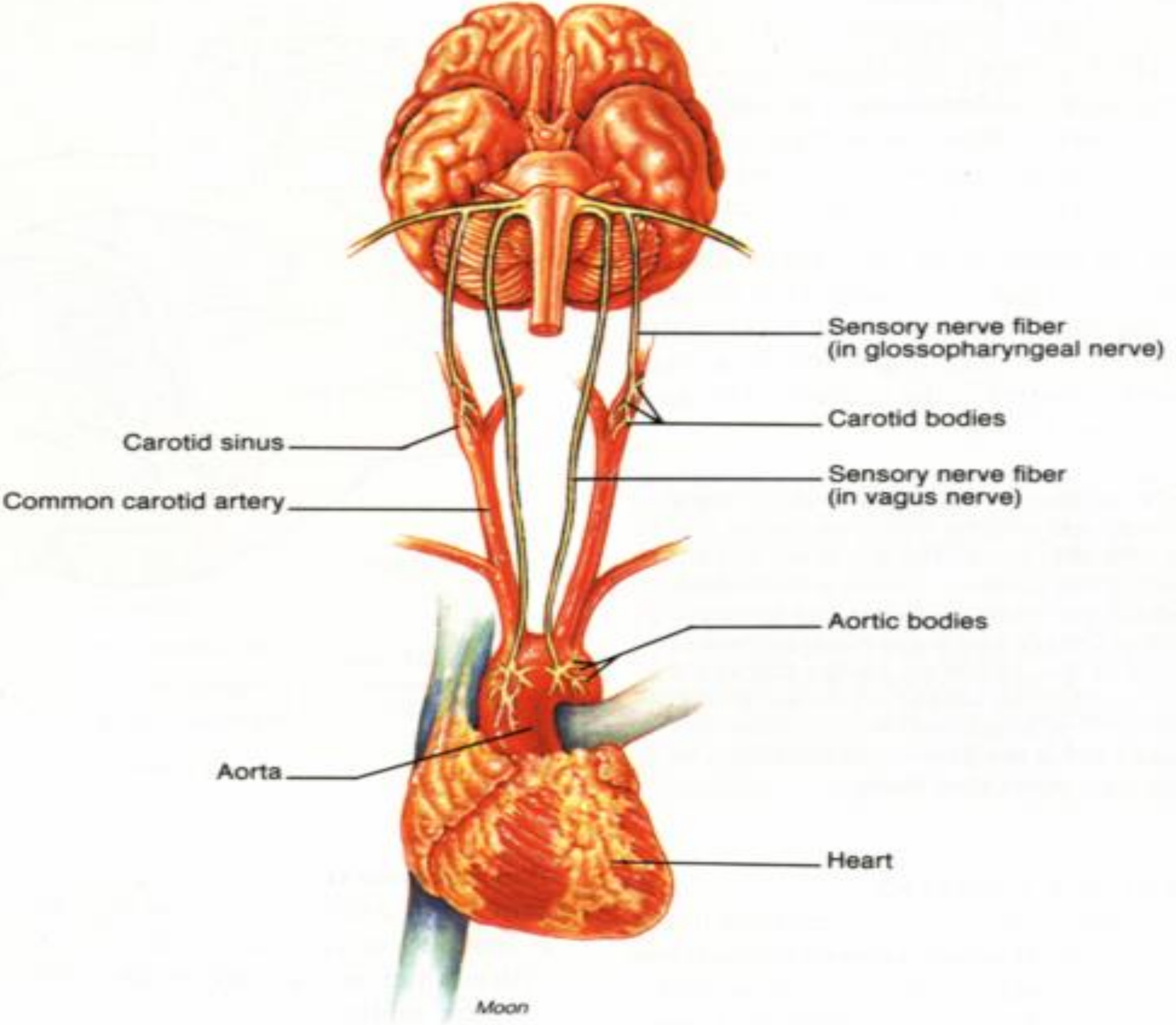


Peripheral chemoreceptors

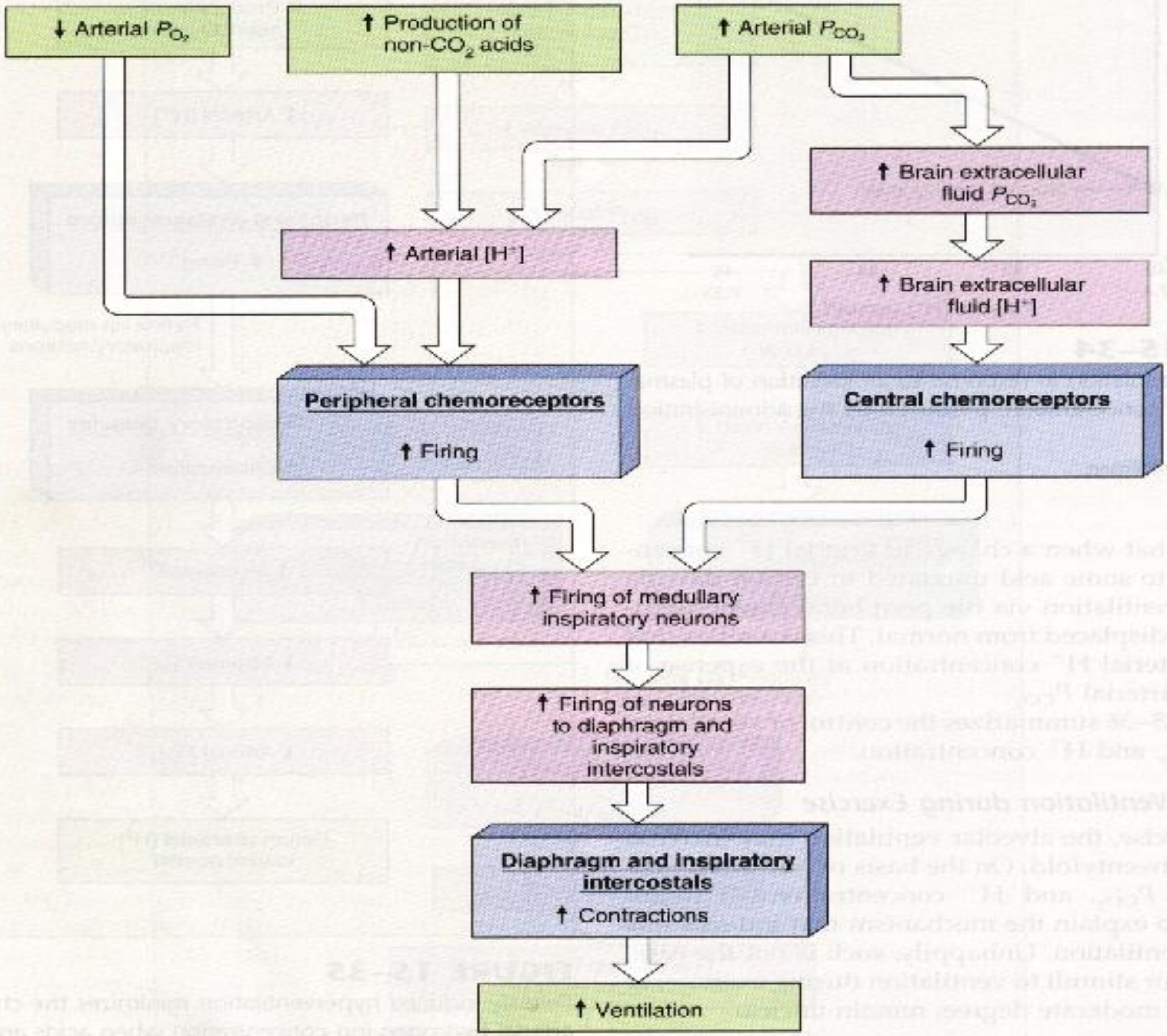
- Carotid bodies
  - Sensitive to: P_aO_2, P_aCO_2, and pH
  - Afferents in glossopharyngeal nerve.
- Aortic bodies
  - Sensitive to: P_aO_2, P_aCO_2, but not pH
  - Afferents in vagus

Peripheral Chemoreceptor Pathway





Sensory nerve fiber
(in glossopharyngeal nerve)
Carotid bodies
Carotid sinus
Sensory nerve fiber
(in vagus nerve)
Common carotid artery
Aortic bodies
Aorta
Heart
Moon



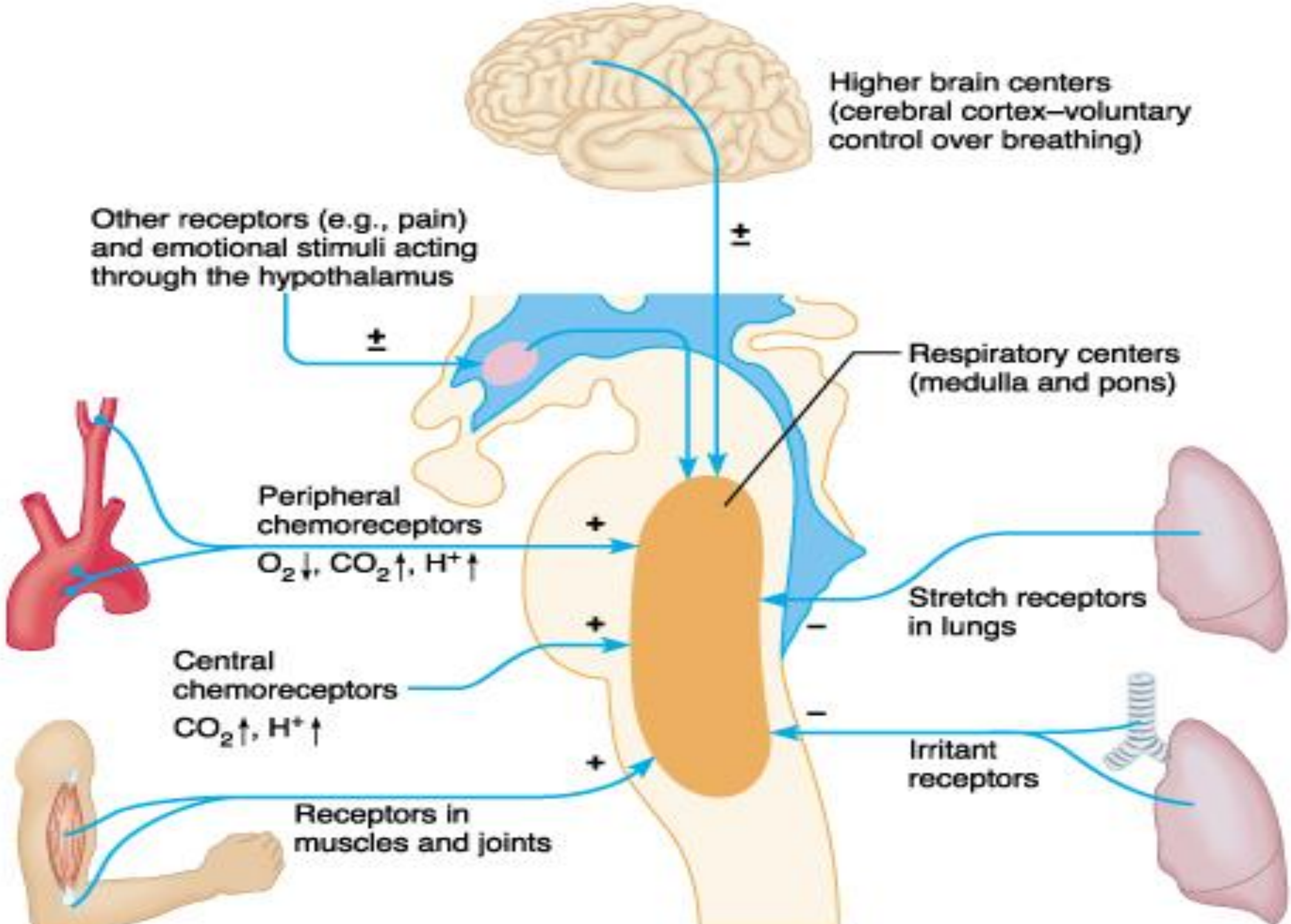
↓ Arterial P_{O_2}
↑ Production of non-CO_2 acids
↑ Arterial P_{CO_2}
↑ Brain extracellular fluid P_{CO_2}
↑ Arterial [H^+]
↑ Brain extracellular fluid [H^+]
Peripheral chemoreceptors
↑ Firing
Central chemoreceptors
↑ Firing
↑ Firing of medullary inspiratory neurons
↑ Firing of neurons to diaphragm and inspiratory intercostals
Diaphragm and inspiratory intercostals
↑ Contractions
↑ Ventilation

Hering-Breuer Reflex or Pulmonary Stretch Reflex

- Including pulmonary inflation 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.

Factors Influencing Respiration



Ventilation-Perfusion Ratio (Va/Q)

- Alveoli Oxygen and Carbon Dioxide Partial Pressure when Va/Q Equals Zero
- Alveoli Oxygen and Carbon Dioxide Partial Pressure when Va/Q Equals infinity
- Gas Exchange and Alveoli Partial Pressures when Va/Q Equals Normal.

Ventilation-Perfusion Ratio (Va/Q)

- Physiologic Shunt : inadequate ventilation despite normal perfusion
- Physiologic dead space : Great alveoli ventilation but alveoli blood flow is low

Clinical correlate- Abnormal Ventilation/Perfusion Ratio

- Va/Q of Upper and Lower Normal lungs
- Abnormal Va/Q in Chronic Obstructive Lung Disease.

Intrapulmonary pressure

- The pressure within the lungs is called the intrapulmonary, or intra-alveolar, pressure.
- • Between breaths, it equals atmospheric pressure, which has a value of 760 millimeters of mercury at sea level.
- • During inspiration, the volume of the thoracic cavity increases, causing intrapulmonary pressure to fall below atmospheric pressure. This is also known as a negative pressure. Since air moves from areas of high to low air pressure, air flows into the lungs.
- • During expiration, the volume of the thoracic cavity decreases, causing the intrapulmonary pressure to rise above atmospheric pressure. Following its pressure gradient, air flows out of the lungs, until, at the end of expiration, the intrapulmonary pressure again equals atmospheric pressure

- Intra-pleural pressure also called **intrathoracic pressure**) refers to the pressure within the pleural cavity. Normally, the pressure within the pleural cavity is slightly less than the atmospheric pressure, in what is known as *negative pressure*.[1] When the pleural cavity is damaged/ruptured and the intrapleural pressure becomes equal to or exceeds the atmospheric pressure, pneumothorax may ensue.

Gas Laws

- Dalton's Law
  - Law of Partial Pressures
    - The total pressure of a mixture of gases is equal to the sum of the individual gas pressures.

    - If we know the total atmospheric pressure (760 mm Hg) and the relative abundances of gases (% of gases)
      - We can calculate individual gas effects!
      - P_{atm} x % of gas in atmosphere = Partial pressure of any atmospheric gas
        - P_{O2} = 760mmHg x 21% (.21) = **160 mm Hg**

- Boyle's Law
  - Describes the relationship between pressure and volume
    - "the pressure and volume of a gas in a system are inversely related"
    - $P_1V_1 = P_2V_2$
- How does Boyle's Law work in us?
  - As the thoracic cavity (container) expands the volume must go up and pressure goes down
    - If it goes below 760 mm Hg what happens?
  - As the thoracic cavity shrinks the volume must go down and pressure goes up
    - If it goes above 760 mm Hg what happens

Gas Laws contd.

- Fick's Law of diffusion: State that the rate of diffusion of a substance through a membrane is directly proportional to the area of the membrane, the solubility of the substance in the membrane and inversely proportional to the thickness of the membrane and the square root of the molecular weight.

Assignment

- State and explain the significance of Henry's Law in respiration.