CONTROL OF BREATHING

Objectives

1. Distinguish between the automatic and conscious/voluntary control of breathing and identify the key structures involved in generation of the breathing rhythm.
2. Specify key sources sensory input to the rhythm generator that modify its output to the respiratory muscles.
3. Identify the location and ventilatory response of the central & peripheral chemoreceptors to changes in arterial level PCO_2, pH and PO_2.
4. Describe how a decrease in plasma pH regulates ventilation & partial pressures of oxygen and carbon dioxide in the blood. Provide an examples in health and in disease.
5. Based on what you know about the chemical control of ventilation, explain the danger of hyperventilation prior to diving under water.

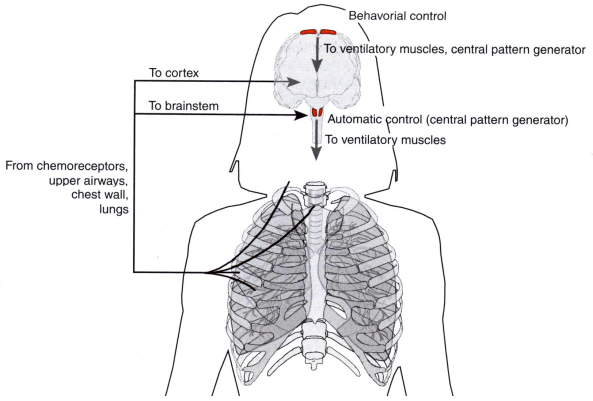
RHYTHM OF BREATHING IS ESTABLISHED IN THE CNS

Automatic *vs* Conscious/Voluntary Control

Breathing--

initiated in the medulla by aggregates of neurons

modified by higher structure of CNS & input from central & peripheral chemoreceptors & mechanoceptors in the lungs & chest wall

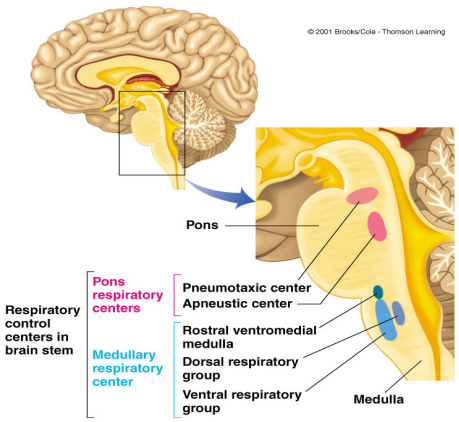


Compare the control of the rhythmic activity of the heart & generation of cardiac output to rhythmic activity of the chest wall & breathing

AUTOMATIC BREATHING IS INITIATED IN THE MEDULLA

DRG
-mainly inspiratory neurons (active during inspiration) driving the inspiratory muscles
-receives input from peripheral chemoreceptors & mechanoreceptors

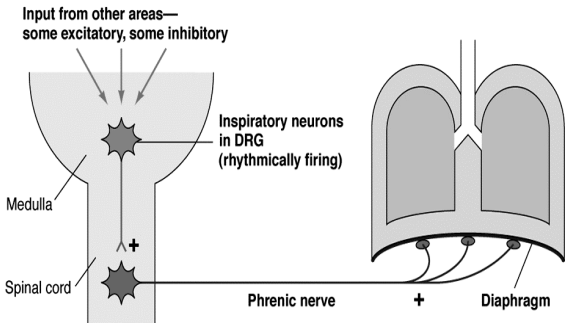
VRG
-mainly expiratory neurons,silent during quiet breathing & active during active expiration driving the expiratory muscles



Pontine nuclei
- apneusis=outcome of pontine ablation)

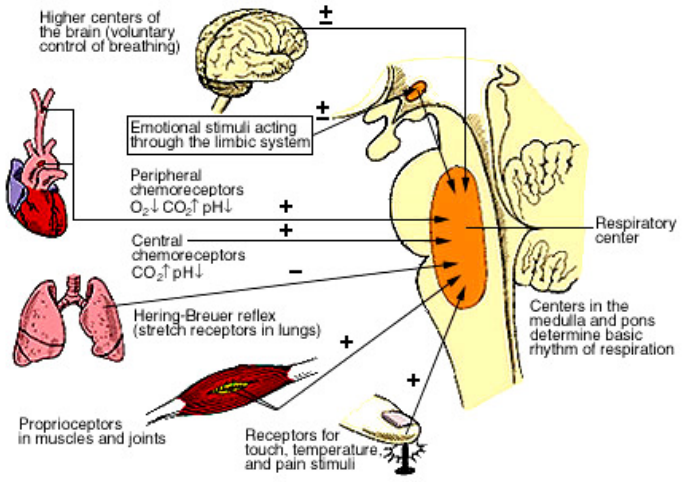
BULBOSPINAL INSPIRATORY NEURONS INITIATE INSPIRATION
VIA SPINAL NERVES TO THE INSPIRATORY MUSCLES
The Phrenic Nerves Supply Motor Input to the Diaphragm

- Formed by rootlets exiting the cervical spine C3,C4 &C5, bilateral phrenic nerves, supply the hemi-diaphragm. "C345 keep the diaphragm alive"
- Intercostal nerves, exiting the thoracic & lumbar spine, provide neural input to the intercostal & abdominal muscles



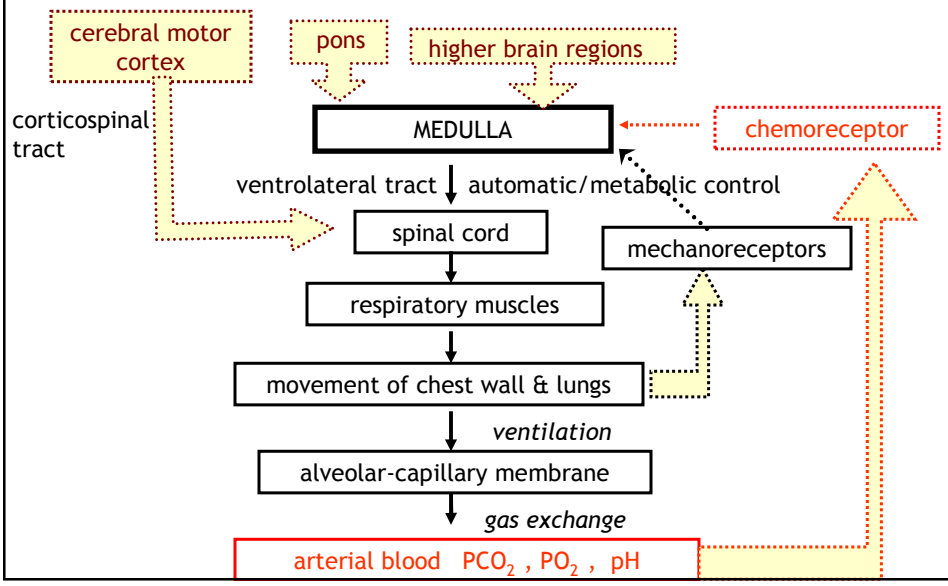
•Cranial nerves supply the motor output to the upper airway dilator muscles

MANY INPUTS TO THE MEDULLA CONTRIBUTE TO THE RHYTHM OF BREATHING



FEED BACK & FEED FORWARD INPUT

to the Medullary Respiratory Centre



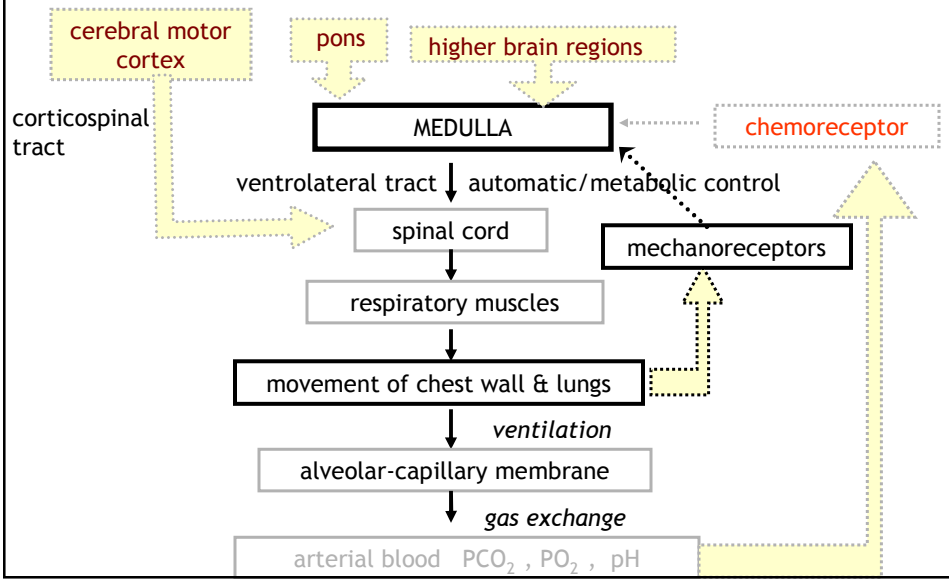
THE HERING BREUER REFLEX

An early historic (1868) example of the many mechanoreceptor inputs regulating the rhythm of breathing

- a reflex triggered to prevent over inflation of the lungs.
- stretch receptors in the smooth muscle of the airways respond to stretching of the lung during inflation, allowing expiration to occur- reflex is mediated by the vagus nerve.
- early physiologists believed the reflex played a major role in establishing the rate and depth (rhythm) of breathing in humans- - true for most mammals, not the case for adult humans at rest.
- the reflex may determine breathing rate and depth in newborns & in adult human when tidal volume > 1 L, as during exercise

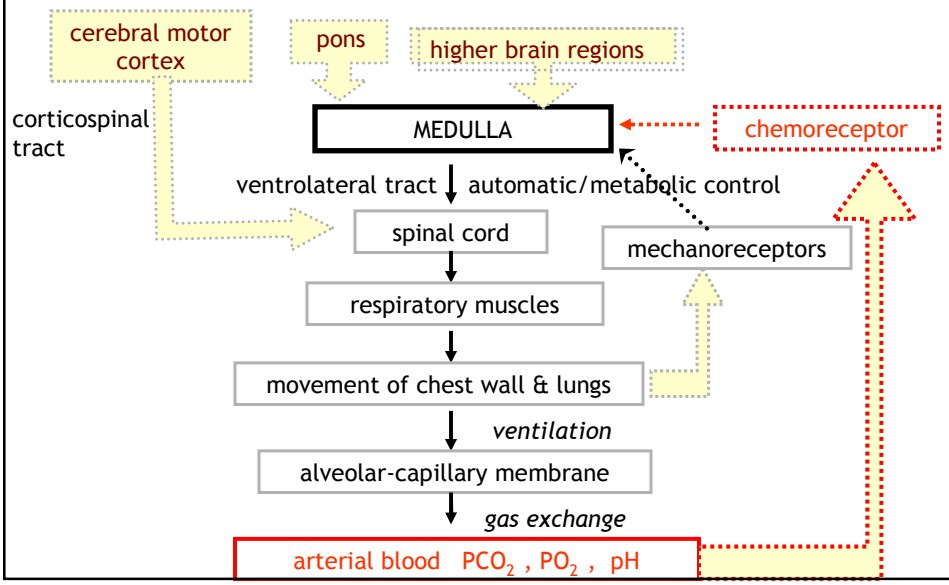
MECHANORECEPTOR FEED BACK

To The Medullary Respiratory Centre



CHEMORECEPTOR FEED BACK

To The Medullary Respiratory Centre

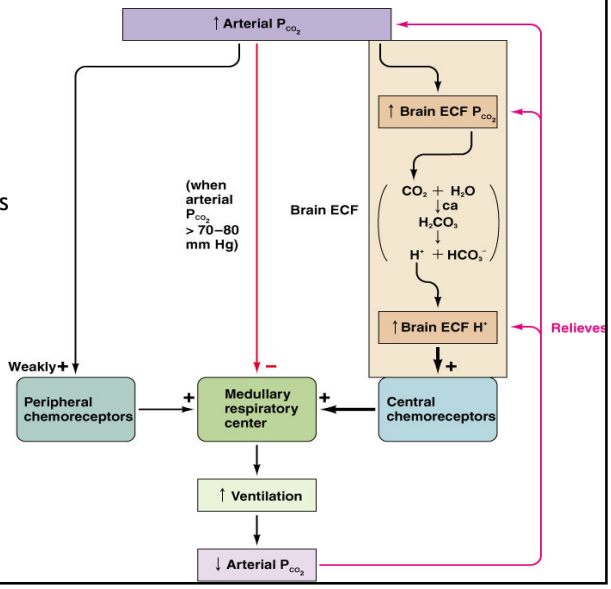


TWO TYPES OF CHEMORECEPTORS PROVIDE FEEDBACK TO THE RESPIRATORY NEURONS IN THE MEDULLA

CENTRAL CHEMORECEPTORS

- few mm below the ventral surface of the medulla
- stimulated by small changes (few mm Hg) in arterial PCO2 via the associated changes in [H+] in the brain ECF
- arterial PCO2 primary regulator of breathing normal range=35-45 mmHg
- What would happen to arterial PCO2 if you

1. held your breath
2. hyperventilated

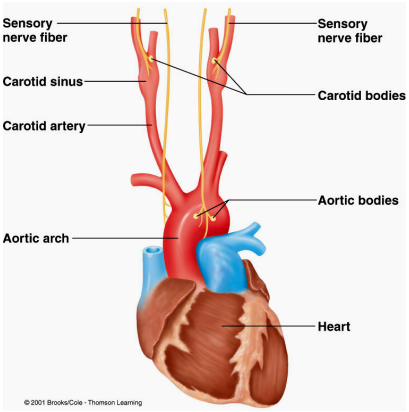


TWO TYPES OF CHEMORECEPTORS PROVIDE FEEDBACK TO THE RESPIRATORY NEURONS IN THE MEDULLA

PERIPHERAL CHEMORECEPTORS

- Carotid & Aortic Bodies
- v. small structures "tasting" blood [supply ↑]
- sense mainly arterial PO2 as well arterial PCO2 & pH
- separate entities from baroreceptors (stretch receptors) close by

- CB sensory information carried via glossopharyngial nerves [IX CN]
- AB sensory information carried via vagus nerves [Xth CN]



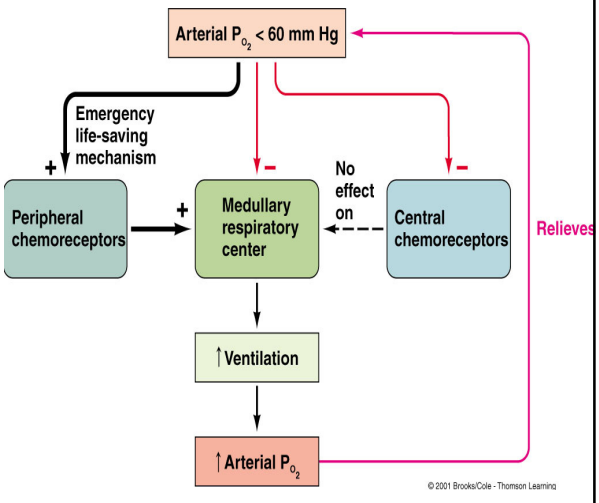
PERIPHERAL CHEMORECEPTORS

Key Oxygen Sensors

PERIPHERAL CHEMORECEPTORS

- mainly sense a decrease in arterial PO2 levels below 60 mmHg with exposure to high altitude or in disease states

- Ventilatory response to such low PO2 is hyperventilation which decreases PCO2 and elevates PO2



CHEMICAL CONTROL OF BREATHING

Think about—

the potential danger of hyperventilating before diving under water

shallow water blackout-death through cerebral hypoxia

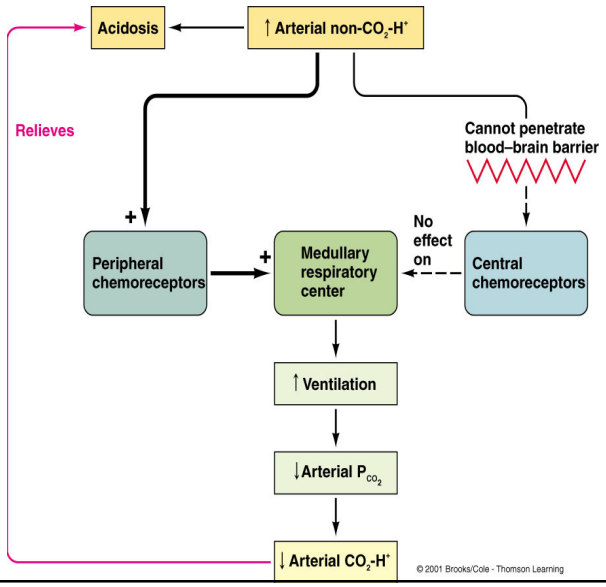
SENSING ARTERIAL PLASMA pH

The role of peripheral chemoreceptors

Metabolic acids stimulate peripheral chemoreceptors & increase ventilation

•lactic acid produced by muscles during intense exercise

•diabetic ketoacidosis [Kussmaul breathing]



VOLUNTARY CONTROL OF BREATHING

Congenital Central Hypoventilation Syndrome

"Ondine's curse"—forgetting to breath

- a rare disorder in children (400 cases known world wide)

- breathing is adequate when awake

- breathing is inadequate or absent during sleep (Rx mechanical ventilation/diaphragm pacing)

- some have low or absent ventilatory response to elavated CO2, low O2, metabolic acidosis- poor integration of chemoreceptor input at the medulla?