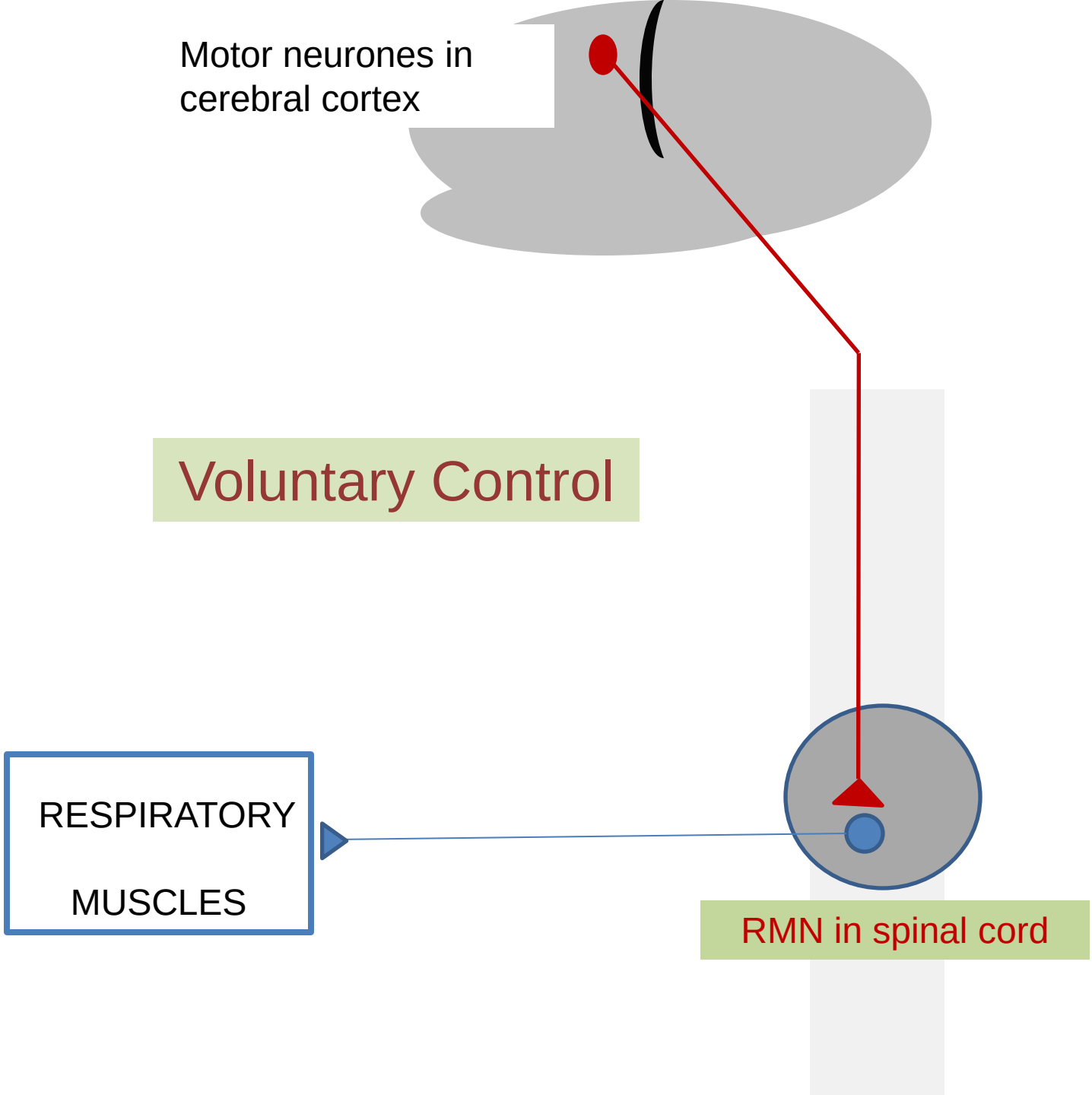
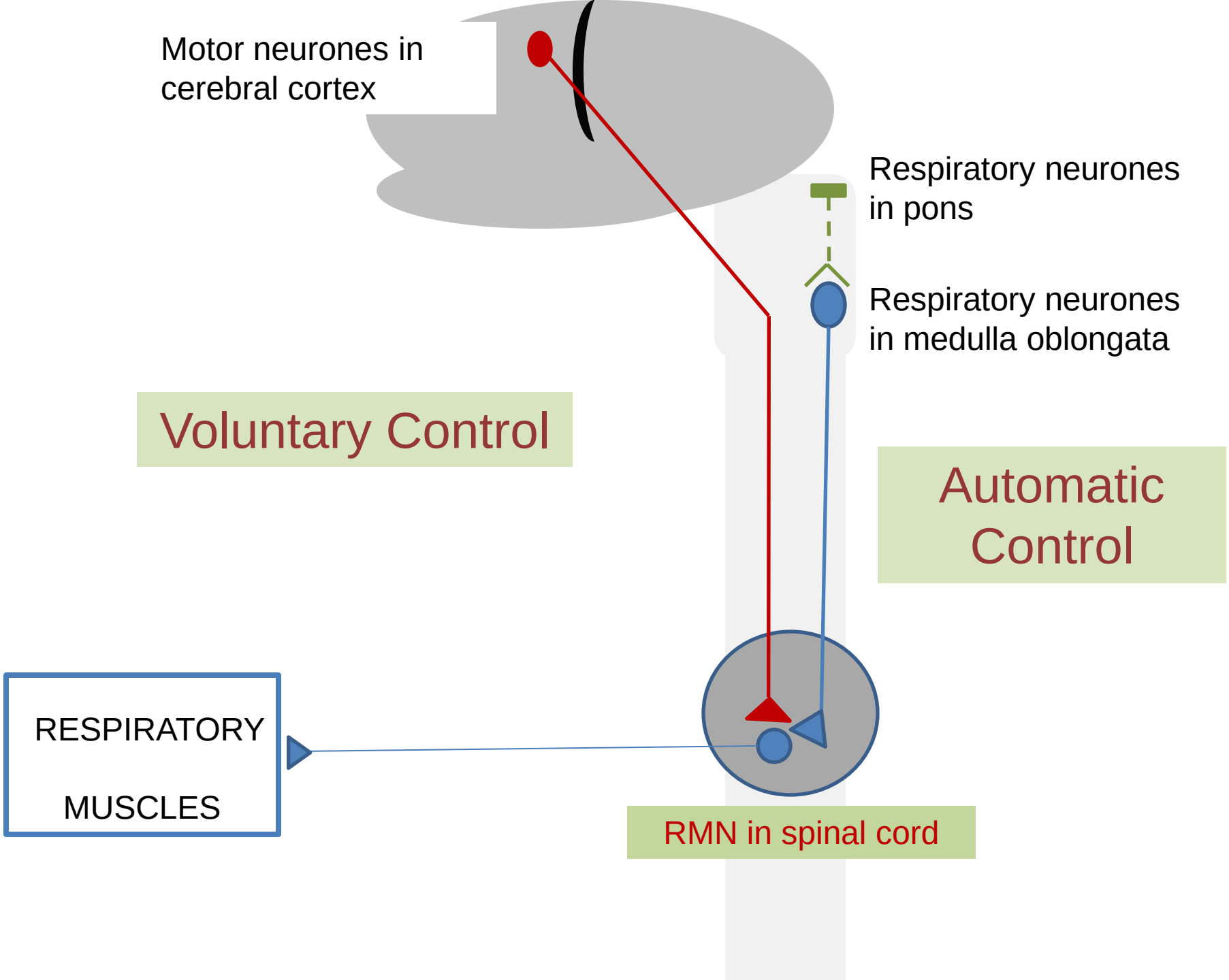
Respiratory Physiology

Dr. Lwin Aye Thet

Neural control of breathing

- Voluntary control system
- Automatic control system


Motor neurones in cerebral cortex
Voluntary Control
RESPIRATORY MUSCLES
RMN in spinal cord

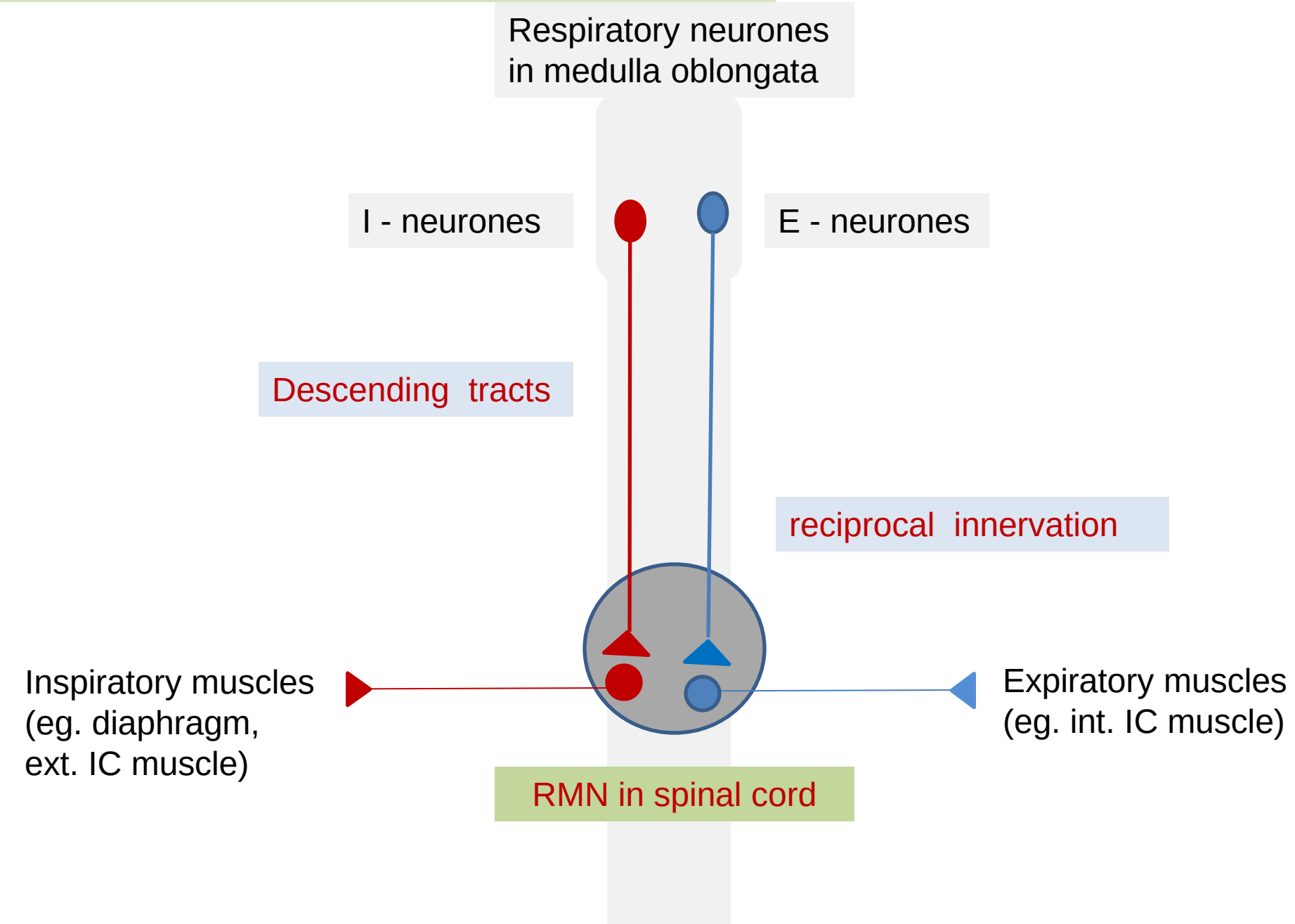

Motor neurones in cerebral cortex
Respiratory neurones in pons
Respiratory neurones in medulla oblongata
Voluntary Control
Automatic Control
RESPIRATORY MUSCLES
RMN in spinal cord

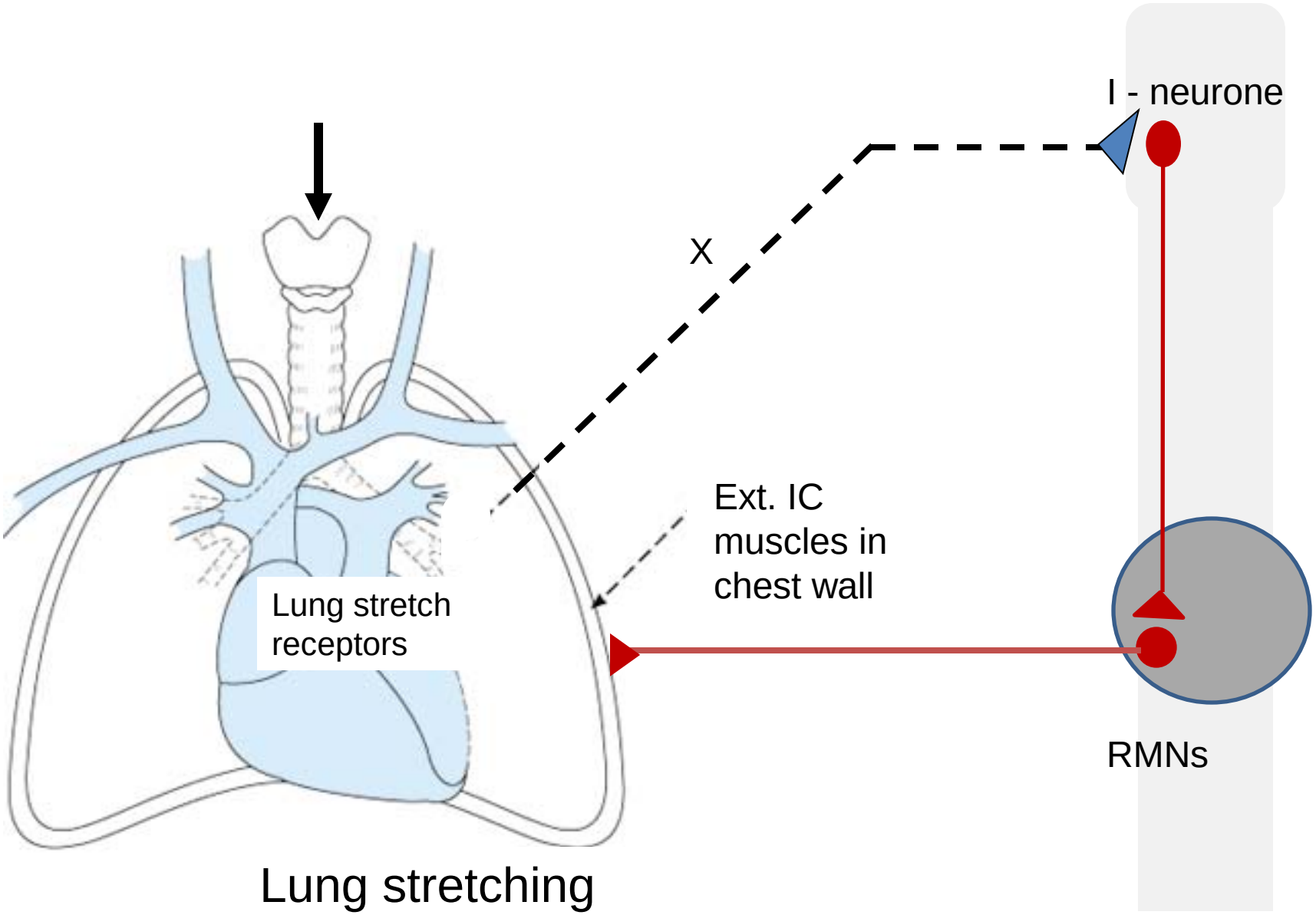
Neural control of breathing

Automatic control system

- **Pons**
- **Medulla:**
  - **dorsal group**
  - **ventral group**

Automatic Control




I - neurone
X
Ext. IC
muscles in
chest wall
Lung stretch
receptors
RMNs
Lung stretching

Neural control of breathing

Medullary system

Dorsal group

- **Location**
- **Composition**
- **Efferent**
- **Afferent**

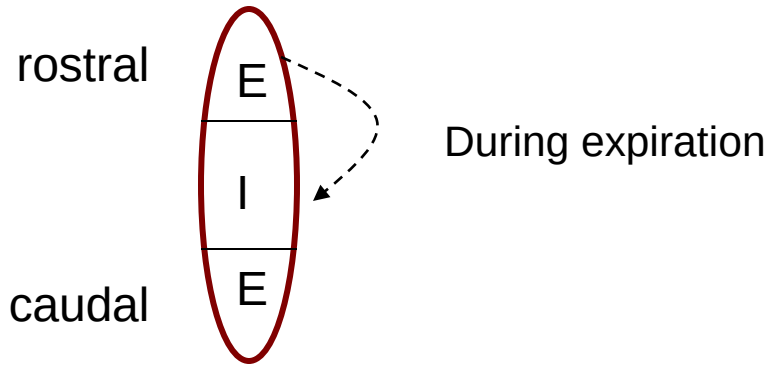
- **In and near the NTS**
- **I - neurones**
- **To RMNs**
- **Lung stretch receptors from airway**
- **Respiratory chemoreceptors**

Neural control of breathing

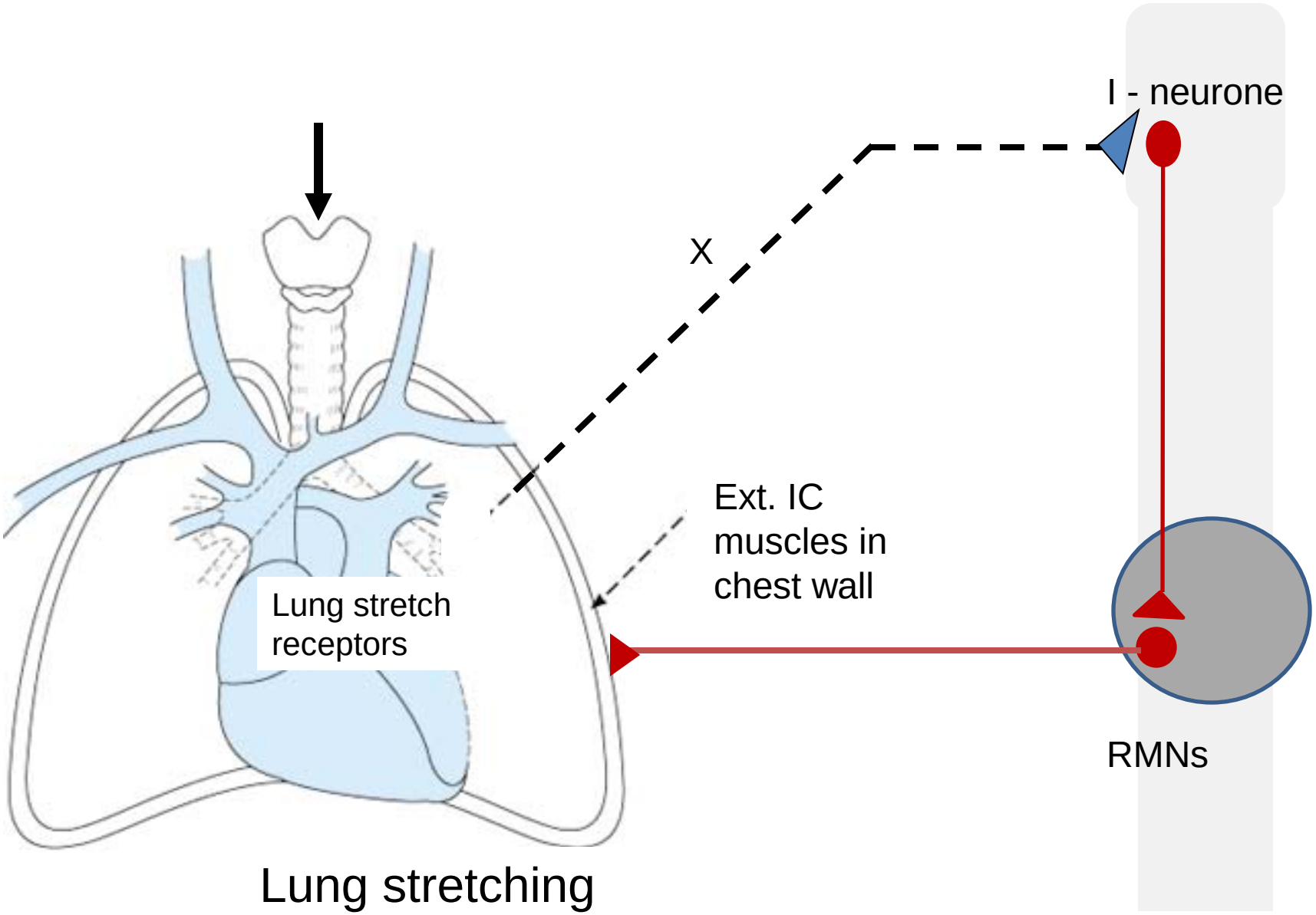
Medullary system

Ventral group

- **Location**
- **Extend through the NA and NRA**
- **Composition**
- **Both I and E neurones**



- **Efferent**
- **Some to RMNs**

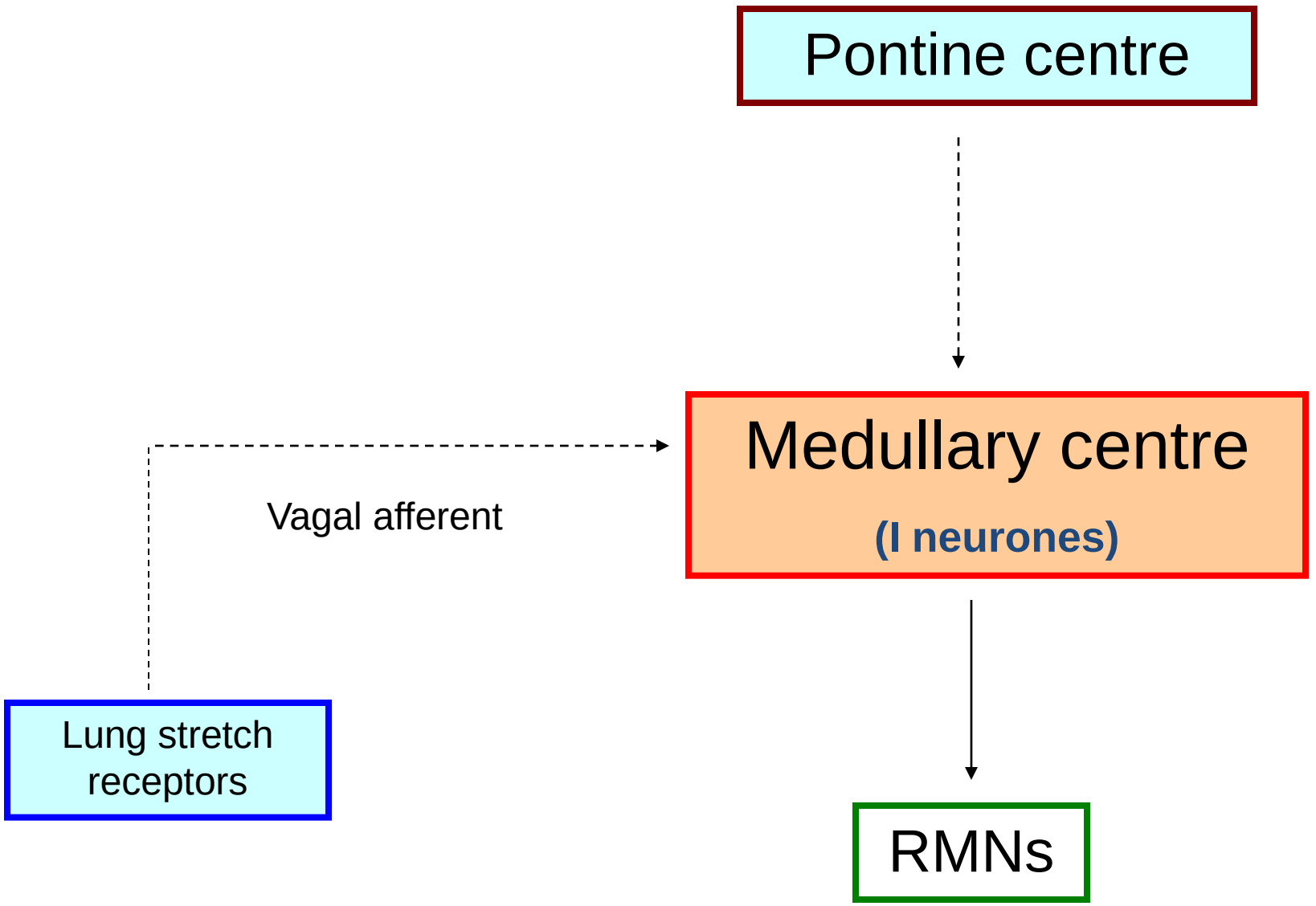

I - neurone
X
Ext. IC
muscles in
chest wall
Lung stretch
receptors
RMNs
Lung stretching

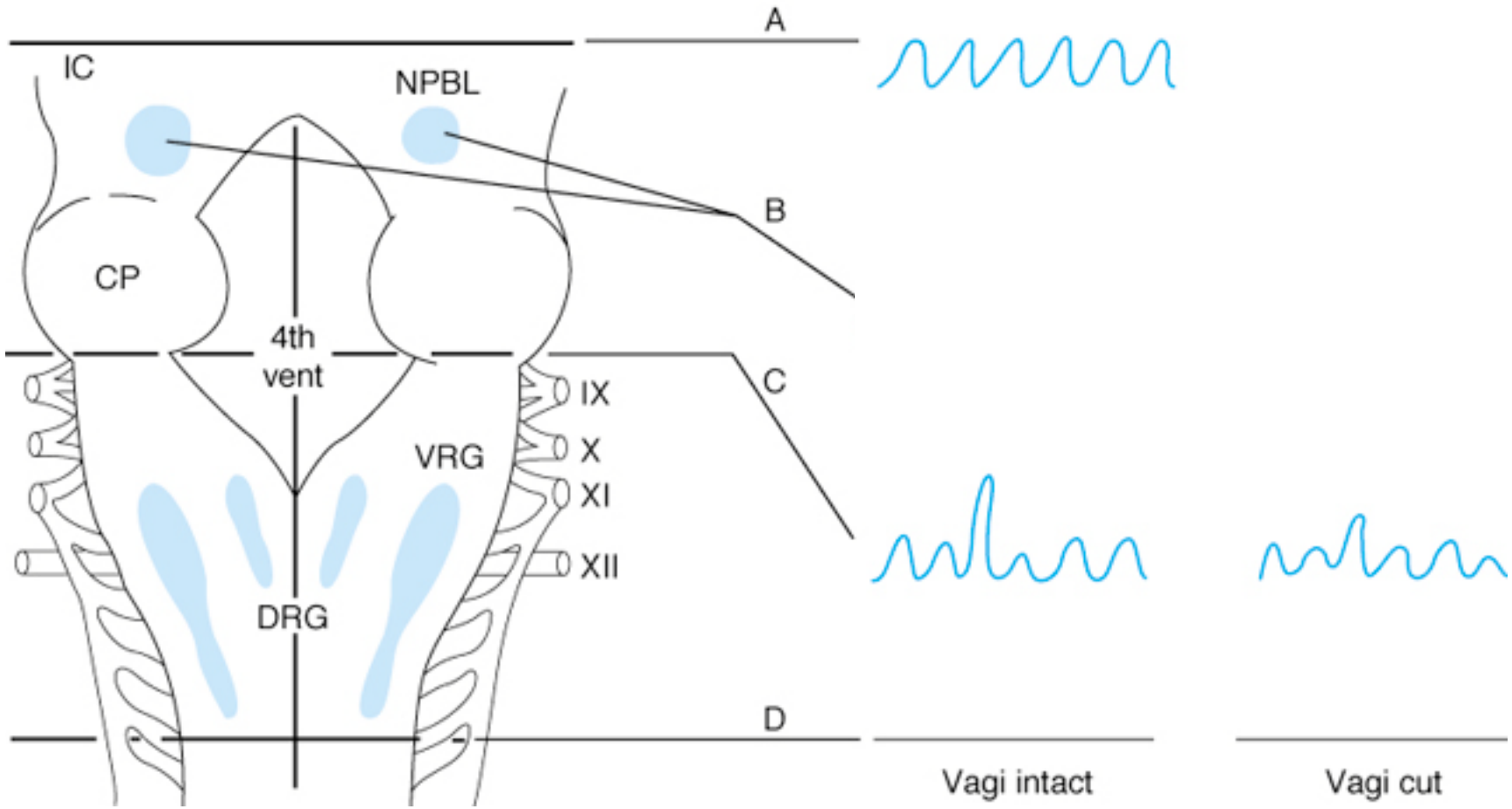
Neural control of breathing

Pontine centre (Pneumotaxic centre)

- **Location**
  - **In the medial parabrachial and K-F nuclei of the DL pons**
- **Composition**
  - **I and E – neurones**
  - **Both I/E**
- **Efferent**
  - **to medullary centre (Inhibitory)**

Neural control of breathing

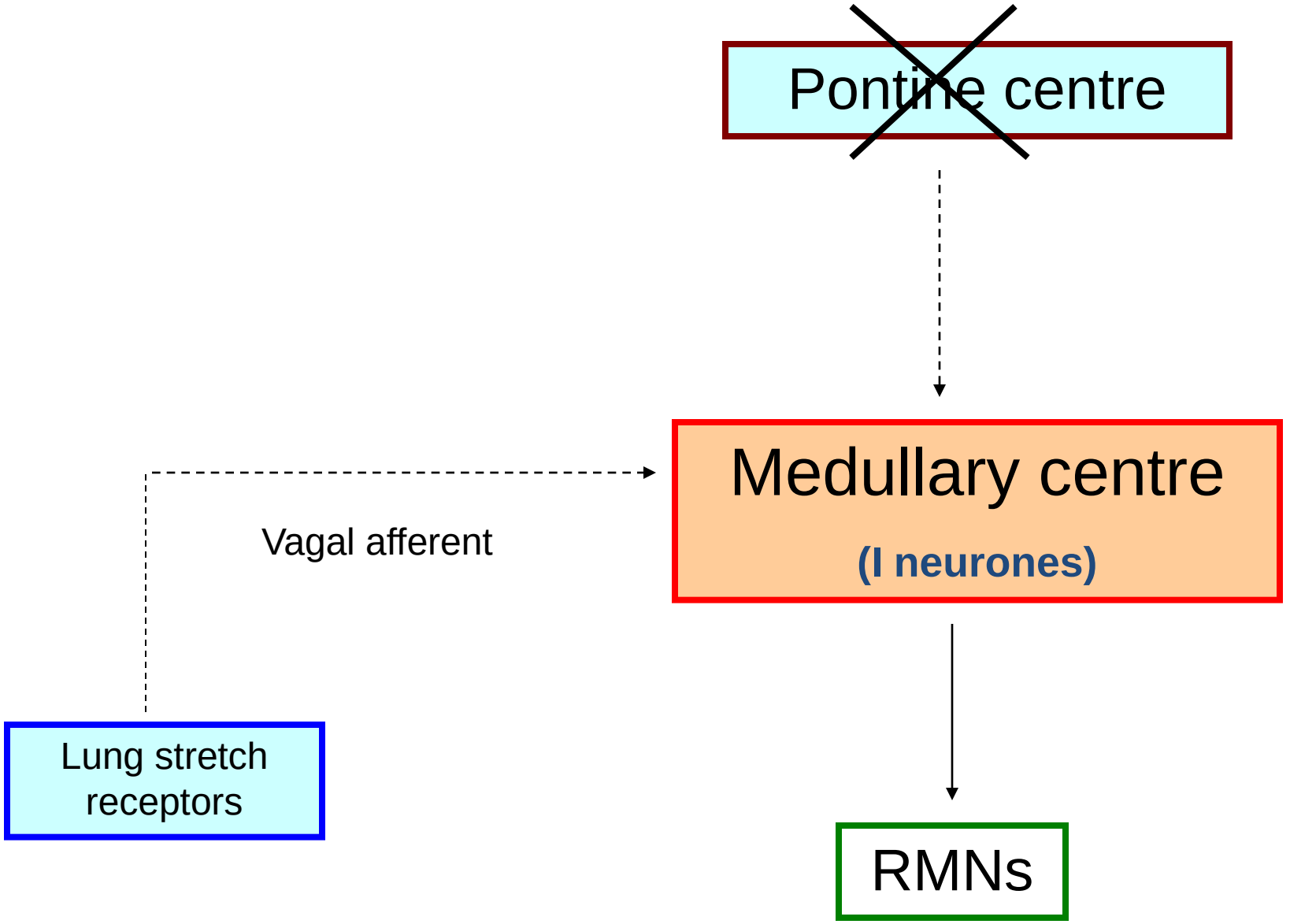


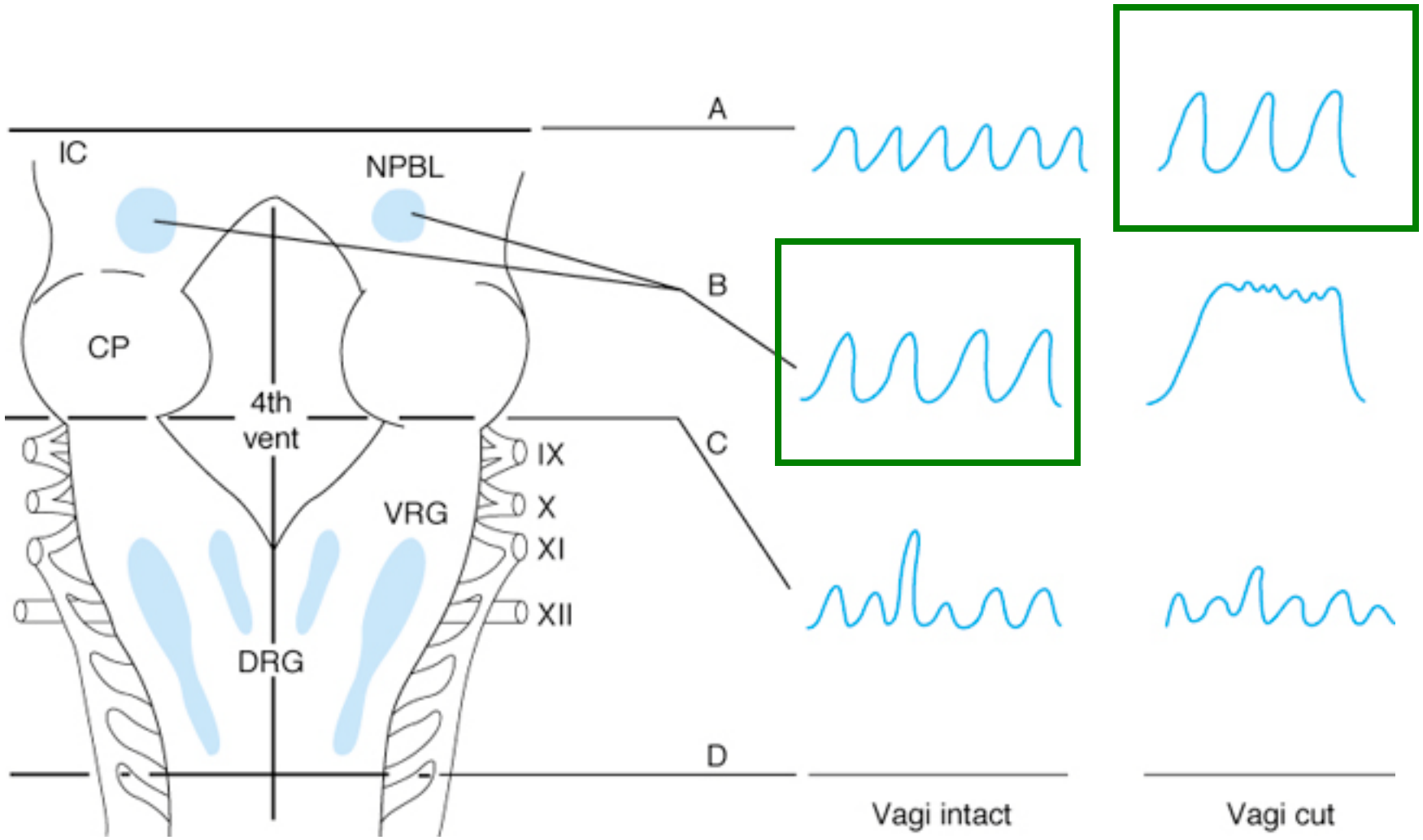


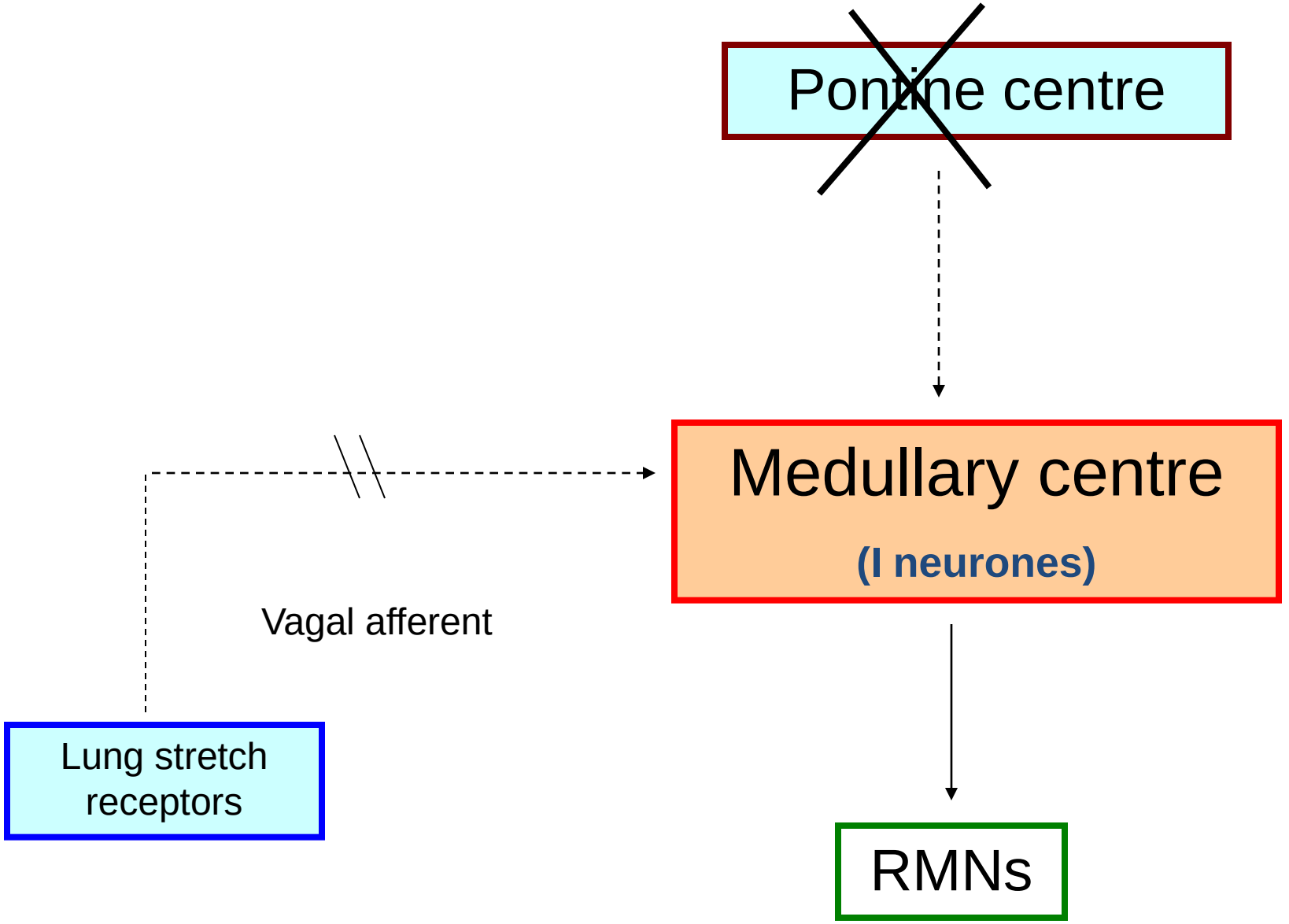
Respiratory pattern generator: Medulla

No pacemakers

Pre-Bottzinger complex: pacemaker


Pontine centre
Medullary centre
(I neurones)
Vagal afferent
Lung stretch receptors
RMNs


IC
NPBL
CP
4th
vent
VRG
DRG
IX
X
XI
XII
A
B
C
D
Vagi intact
Vagi cut


Pontine centre
Medullary centre
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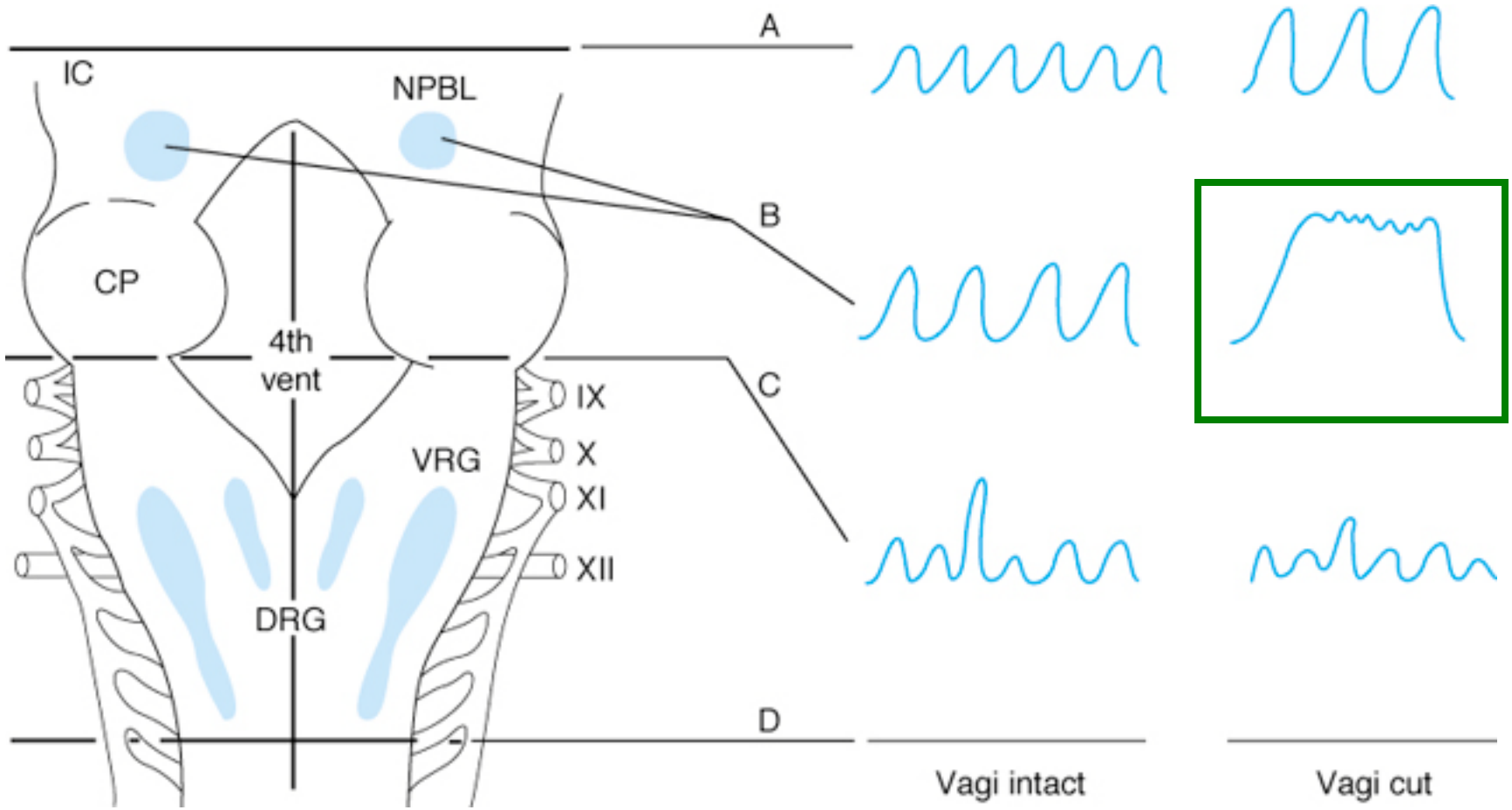
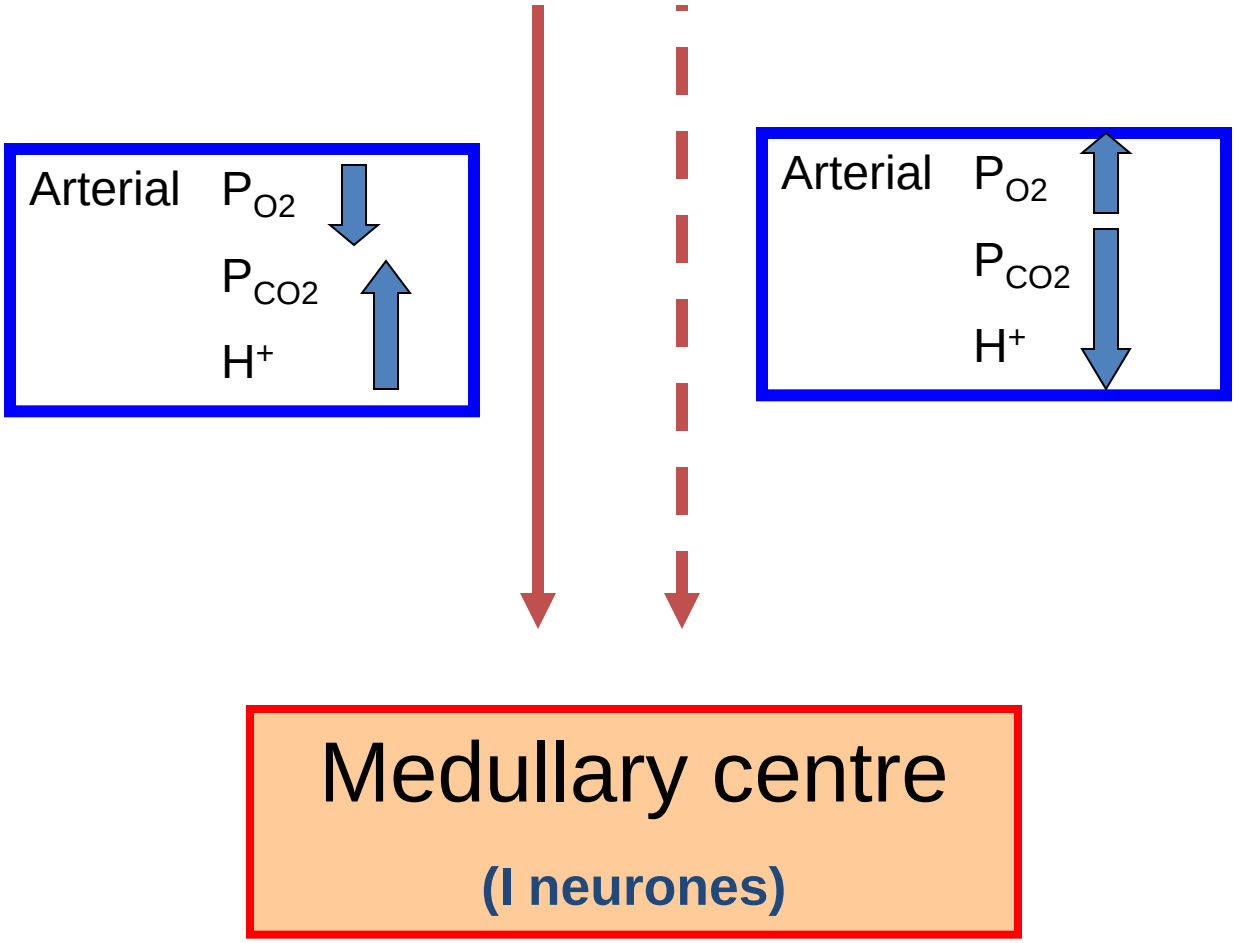


Function of the Pneumotaxic centre

- switching inspiration and expiration

Blood chemistry changes



Chemical control of breathing

Respiratory chemoreceptors

- Central chemoreceptors

  (medullary chemoreceptors)

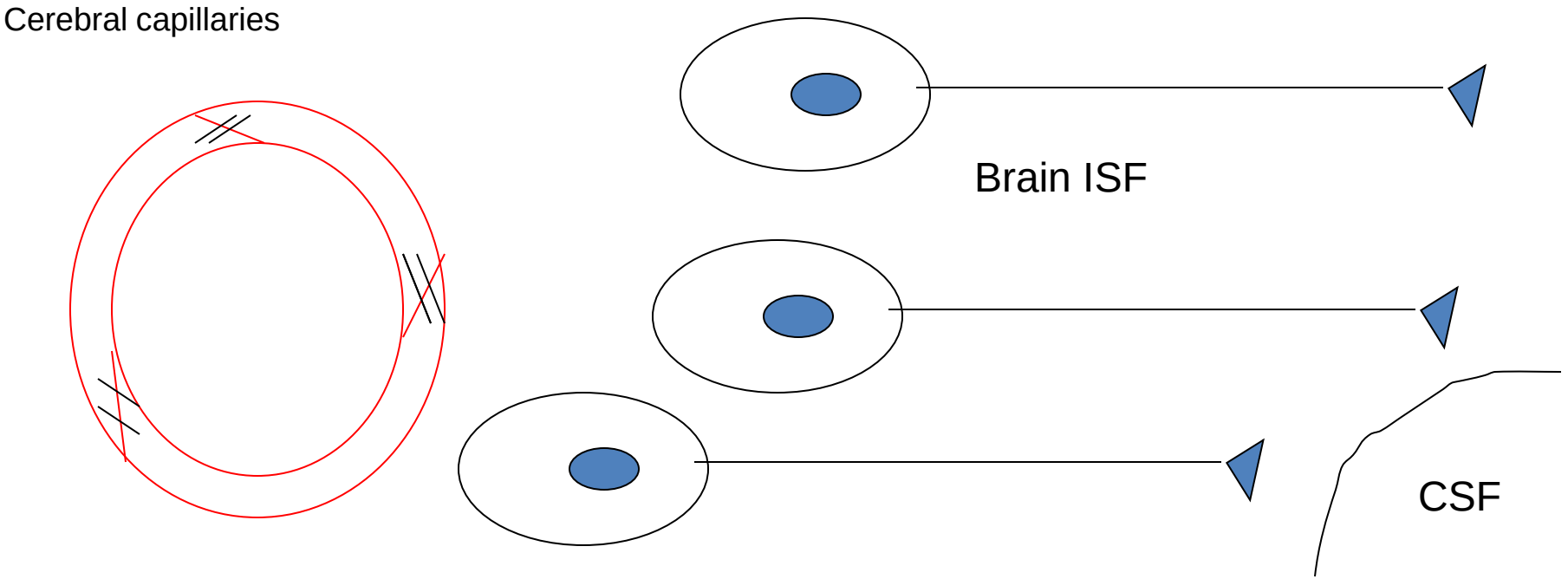
- Peripheral chemoreceptors

  (carotid body and aortic bodies)

Chemical control of breathing

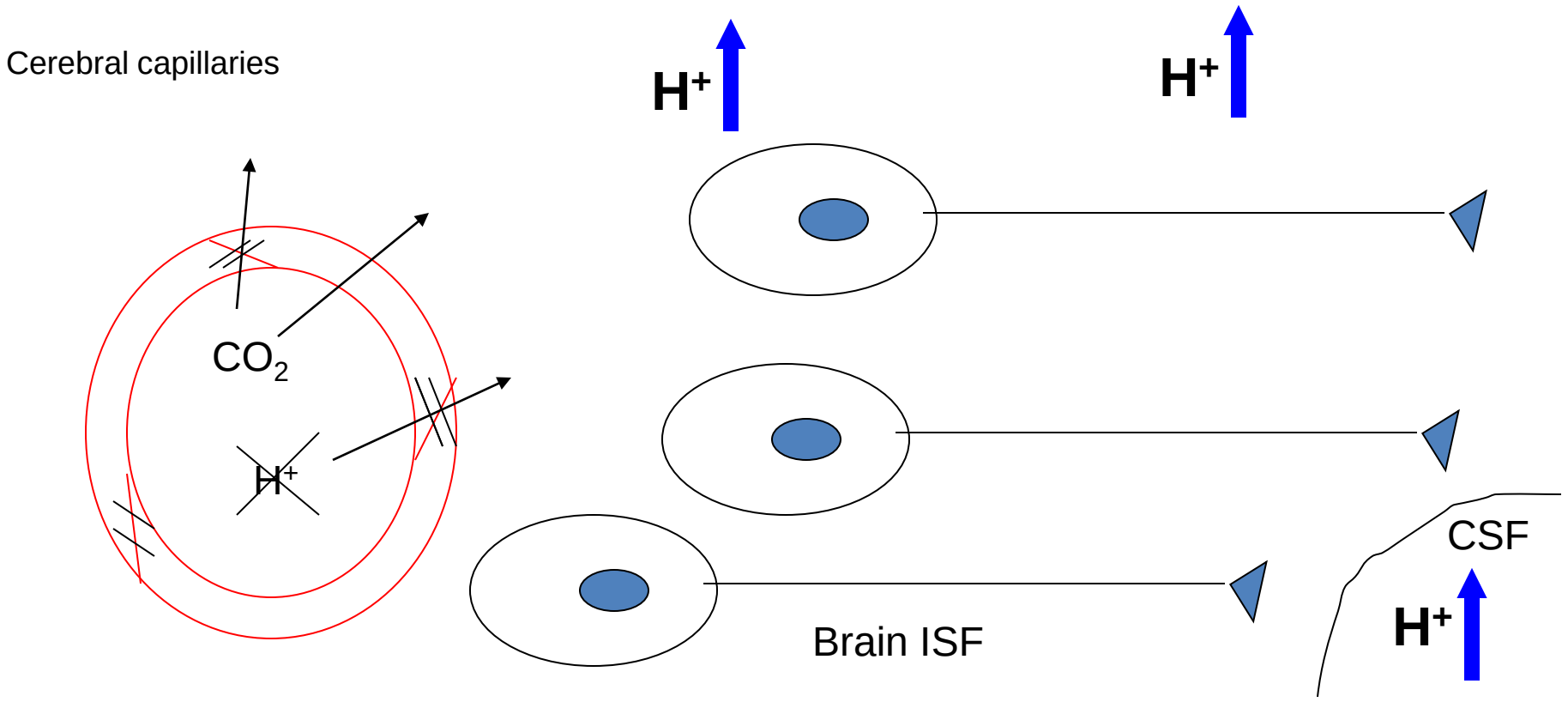
Central chemoreceptors (medullary chemoreceptors)

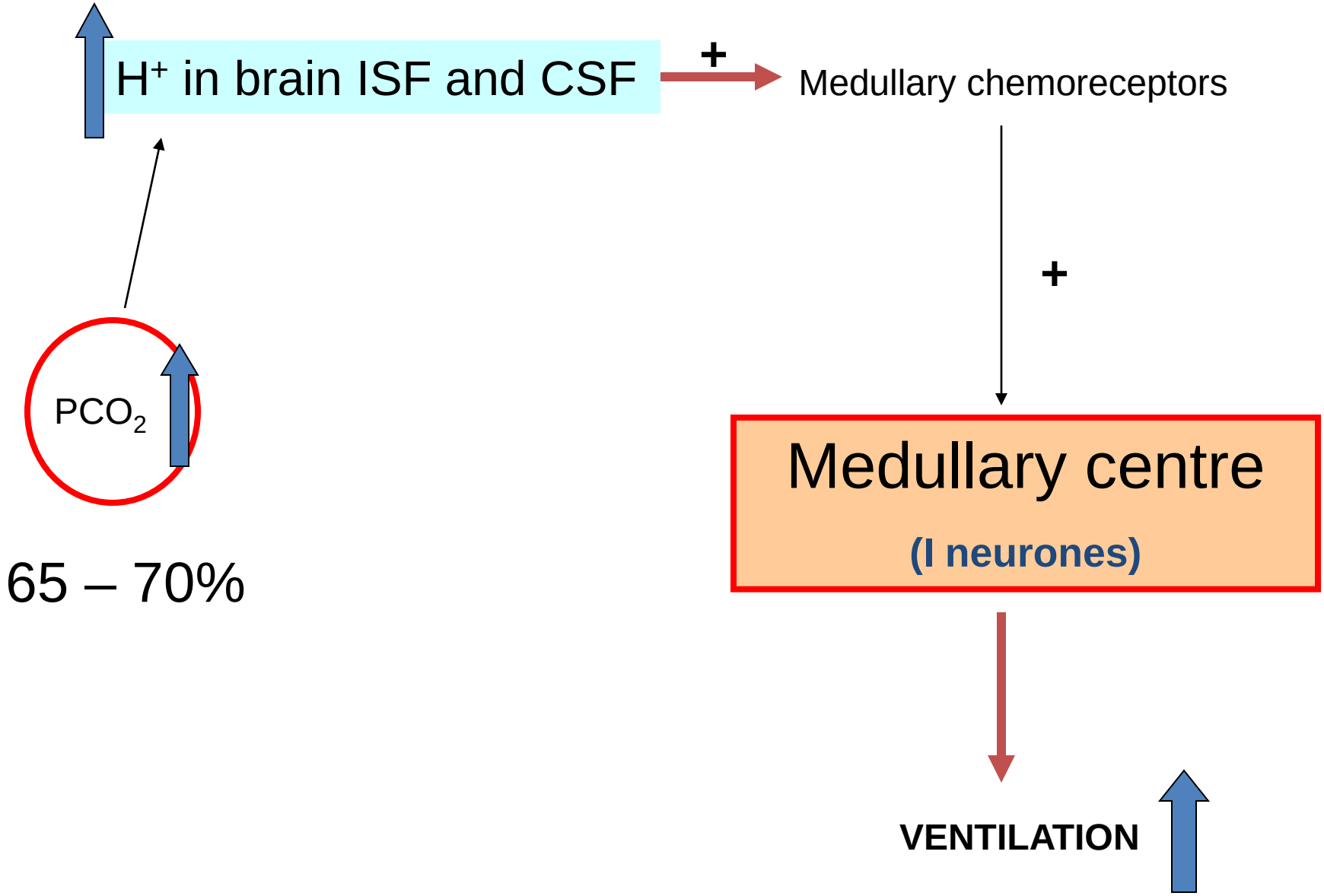
- in the ventral surface to medulla
- sensitive to $[H^+]$ of brain ISF and CSF



Chemical control of breathing

$$CO_2 + H_2O \longrightarrow H_2CO_3 \longrightarrow H^+ + HCO_3^-$$

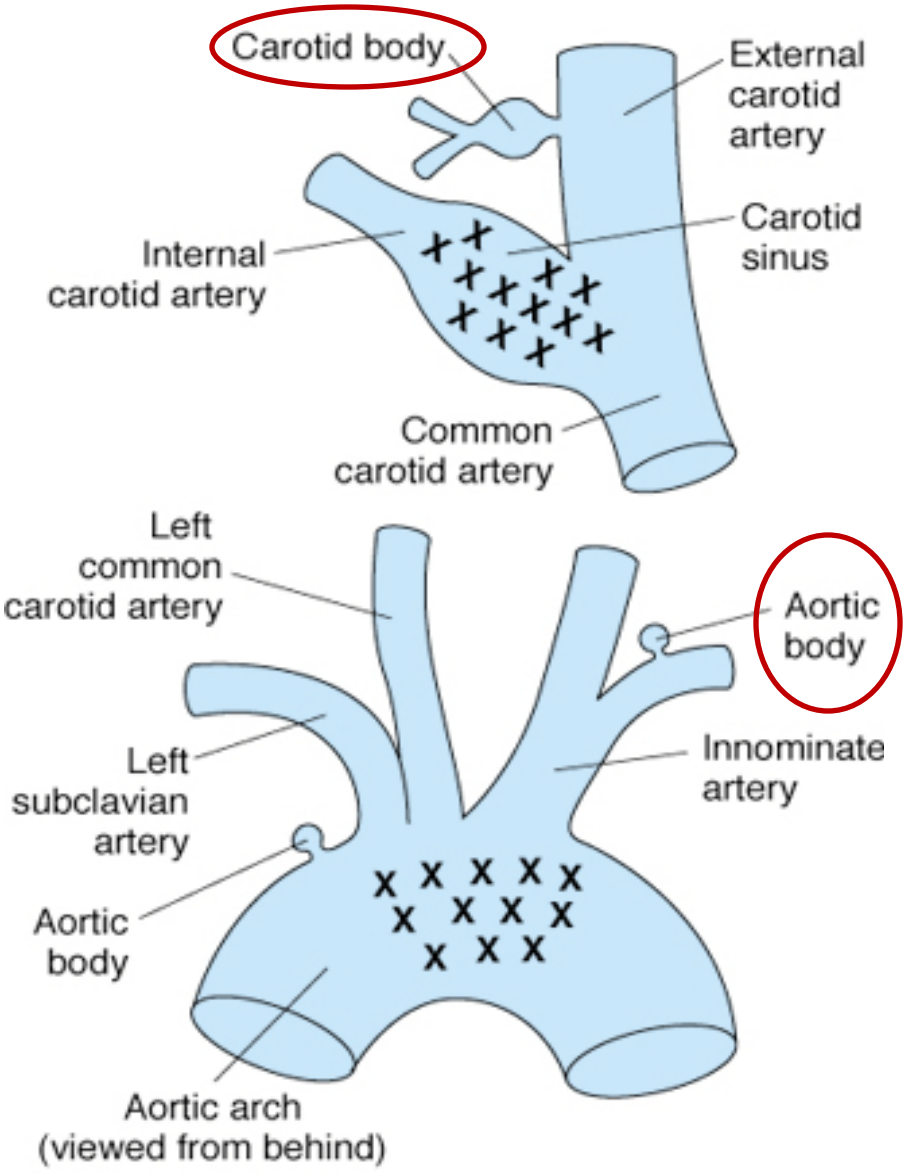



H+ in brain ISF and CSF
+
Medullary chemoreceptors
+
PCO2
65 – 70%
Medullary centre
(I neurones)
VENTILATION

Chemical control of breathing

Respiratory chemoreceptors

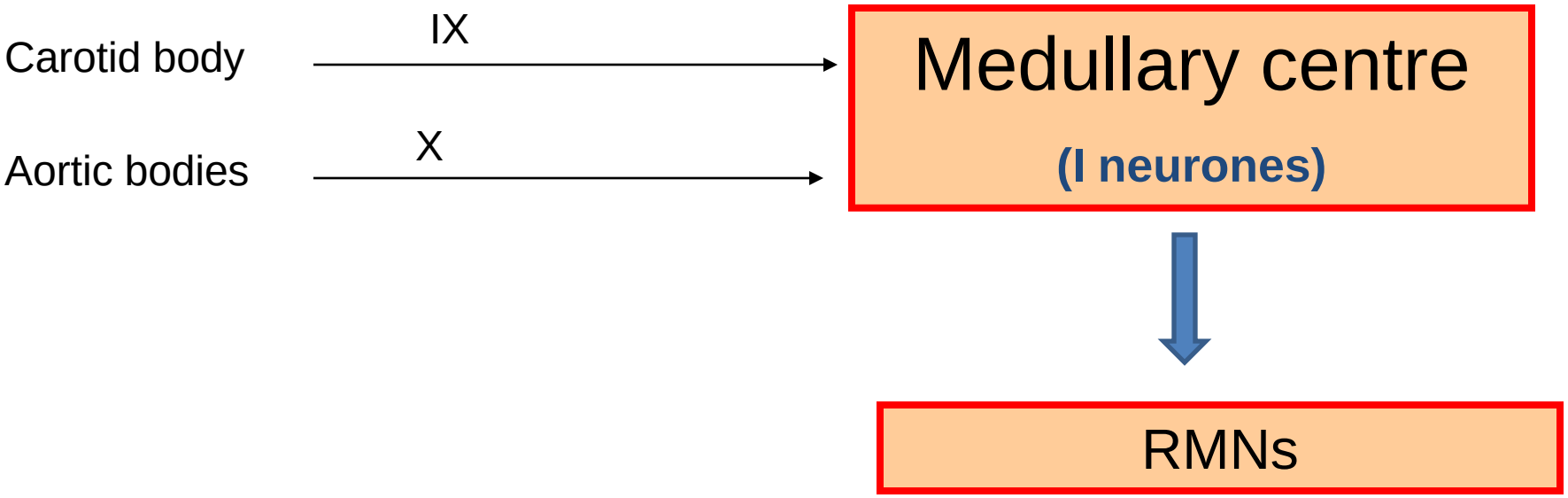
- Peripheral chemoreceptors
  - carotid body
  - aortic bodies



Chemical control of breathing

Respiratory chemoreceptors

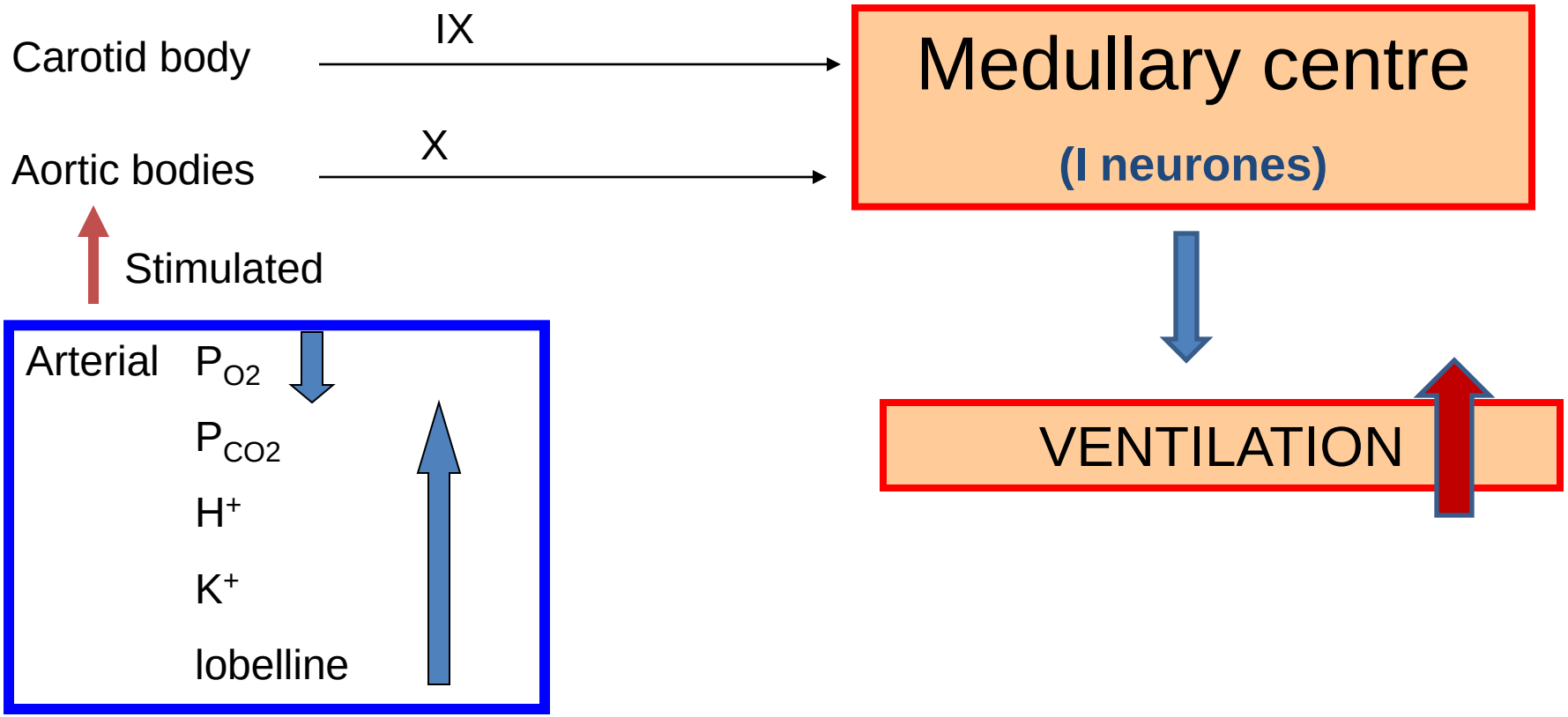
- Peripheral chemoreceptors (carotid body and aortic bodies)



Chemical control of breathing

Respiratory chemoreceptors

- Peripheral chemoreceptors (carotid body and aortic bodies)



PO_2 ↓ closed → O_2 sensitive K^+ channels (glomus cells)

↓

decrease in K^+ efflux

↓

depolarization

↓ open

V-G Ca^{++} channels

↓

increase in Ca^{++} influx

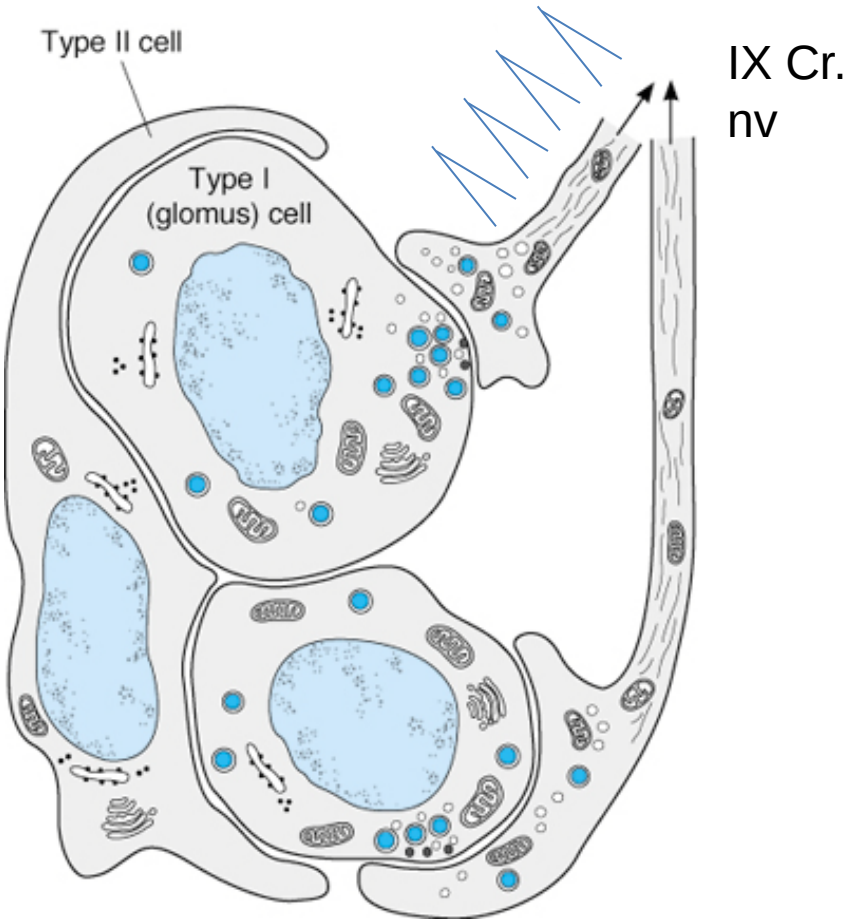
↓

exocytosis of NT (dopamine)

↓

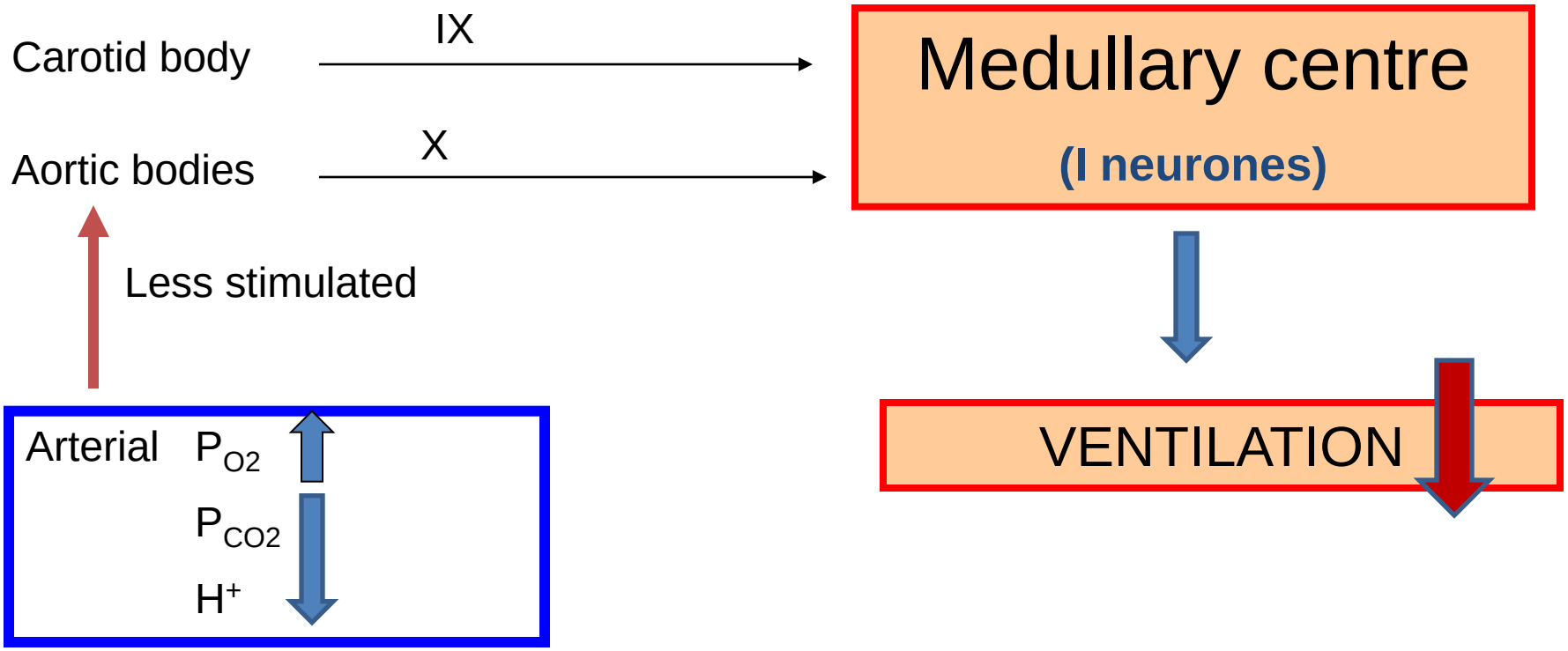
Excitation of afferent nvs (IX & X)

Carotid body

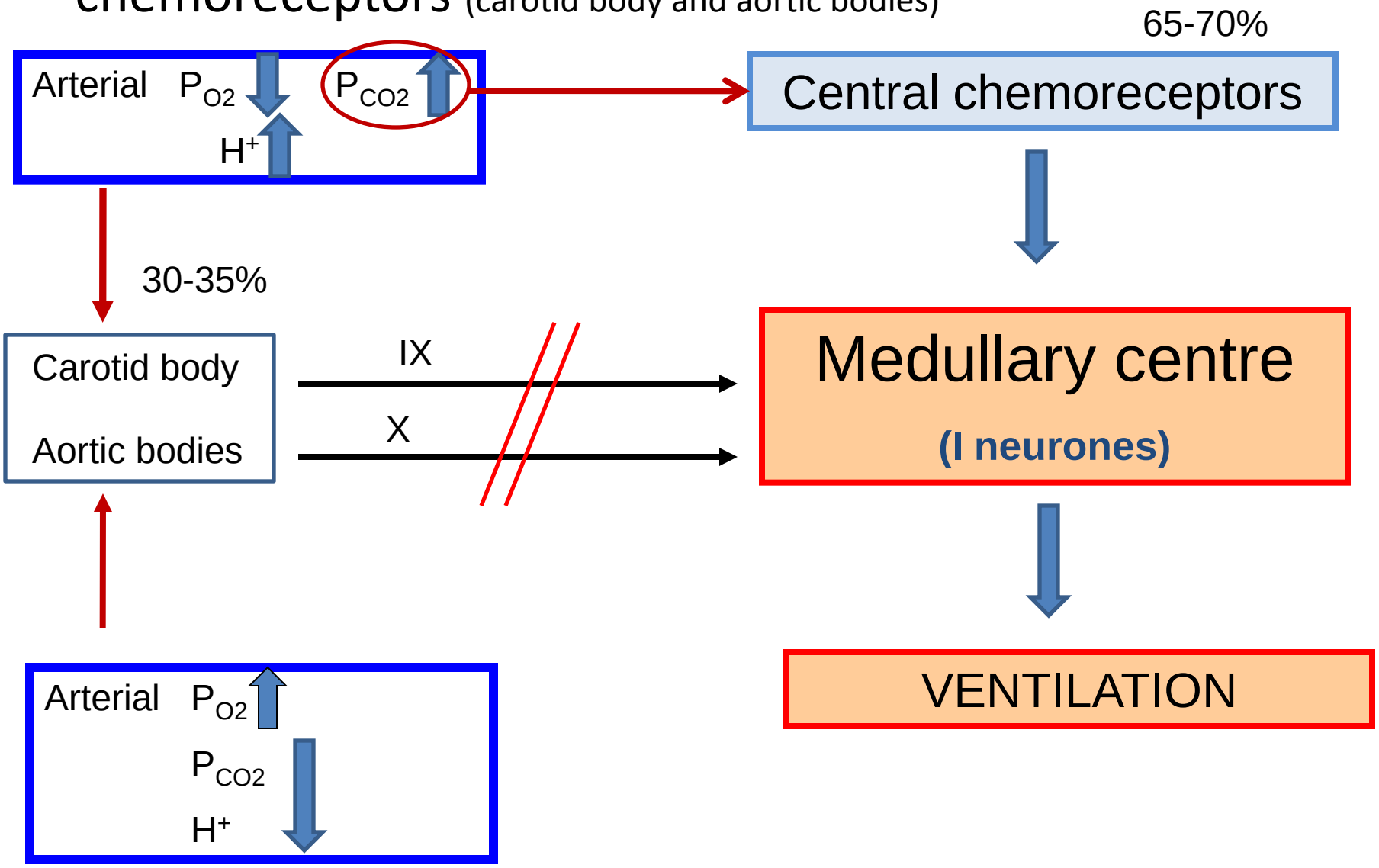


Respiratory chemoreceptors

- Peripheral chemoreceptors (carotid body and aortic bodies)



Denervation of afferent nerves from peripheral chemoreceptors (carotid body and aortic bodies)



Ventilatory response to P_{CO2} changes

Normal Pa_{CO2} = 40 mmHg

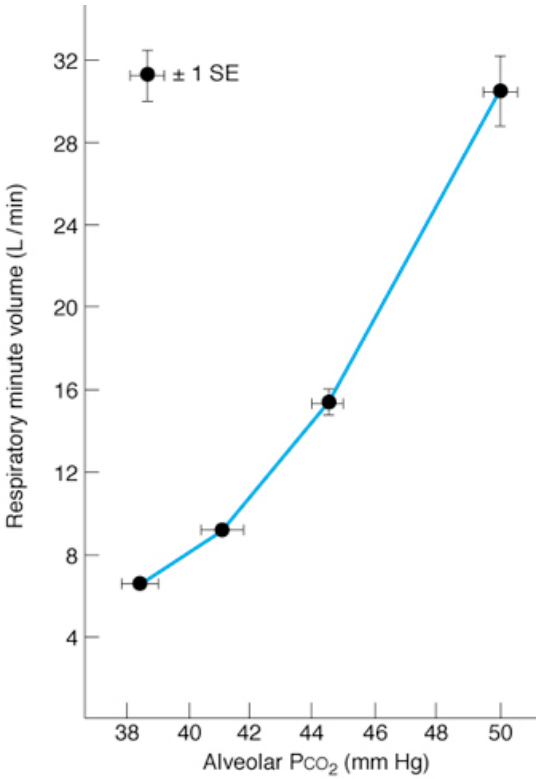
- Increased
- Decreased

through respiratory chemoreceptors

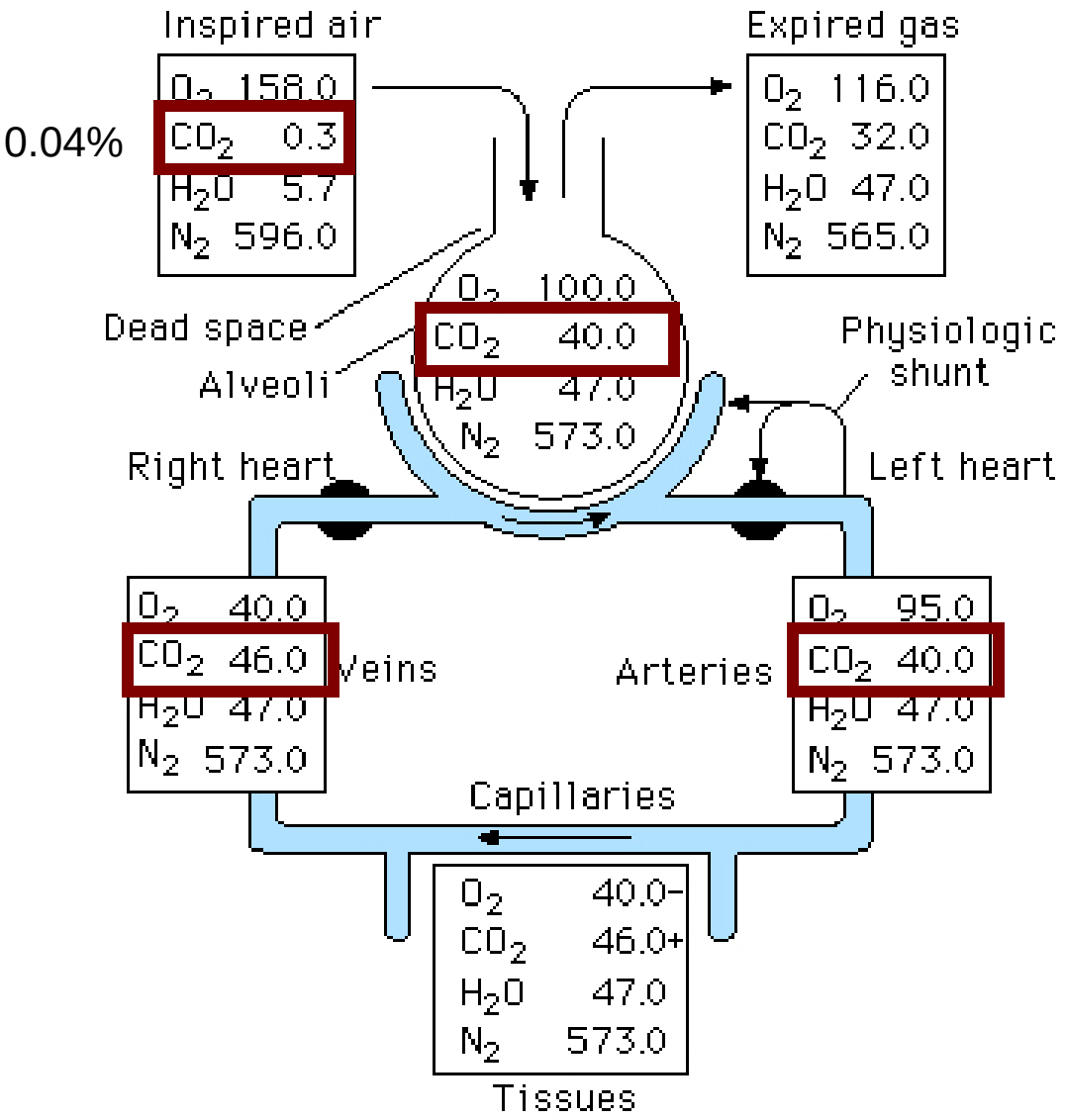
(both central and peripheral)

changes in VENTILATION

P_{CO2} → CB & AB → (XI & X) → Respiratory centre (medulla) → **VENTILATION** → CO_2 wash-out → back to normal → P_{CO2}



LINEAR relationship



CO_2 narcosis

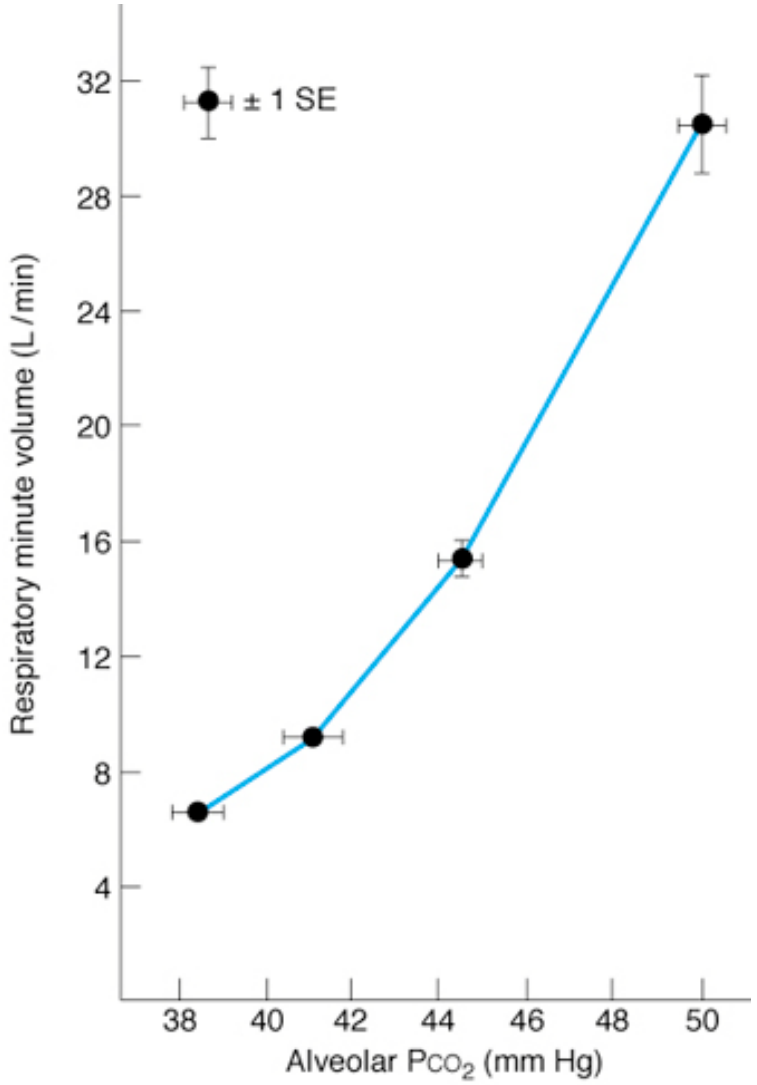
If inspired air P_{CO2}

> 7%

PA_{CO2} ↑

> 46 mmHg

Pa_{CO2} ↑



Pa_{CO2} ↑

HYPERVENTILATION

Pa_{CO2} ↑

(e.g. CO2 narcosis)

HYPOVENTILATION

Pa_{CO2} ↓

HYPOVENTILATION

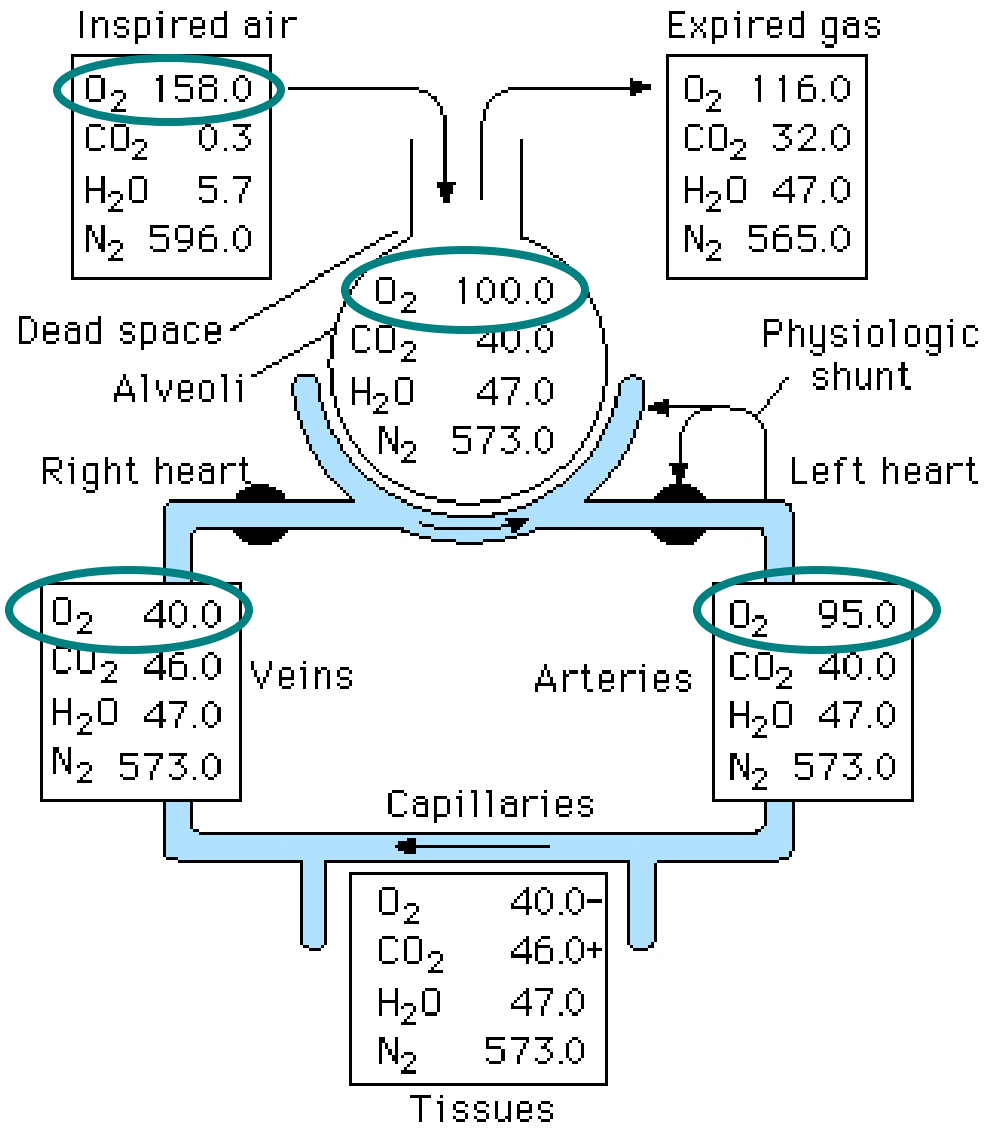
Ventilatory response to P_{O2} changes

Normal Pa_{O2} = 95 mmHg

- Increased
- Decreased

through respiratory chemoreceptors

changes in VENTILATION



PA_{O2}

Pa_{O2}

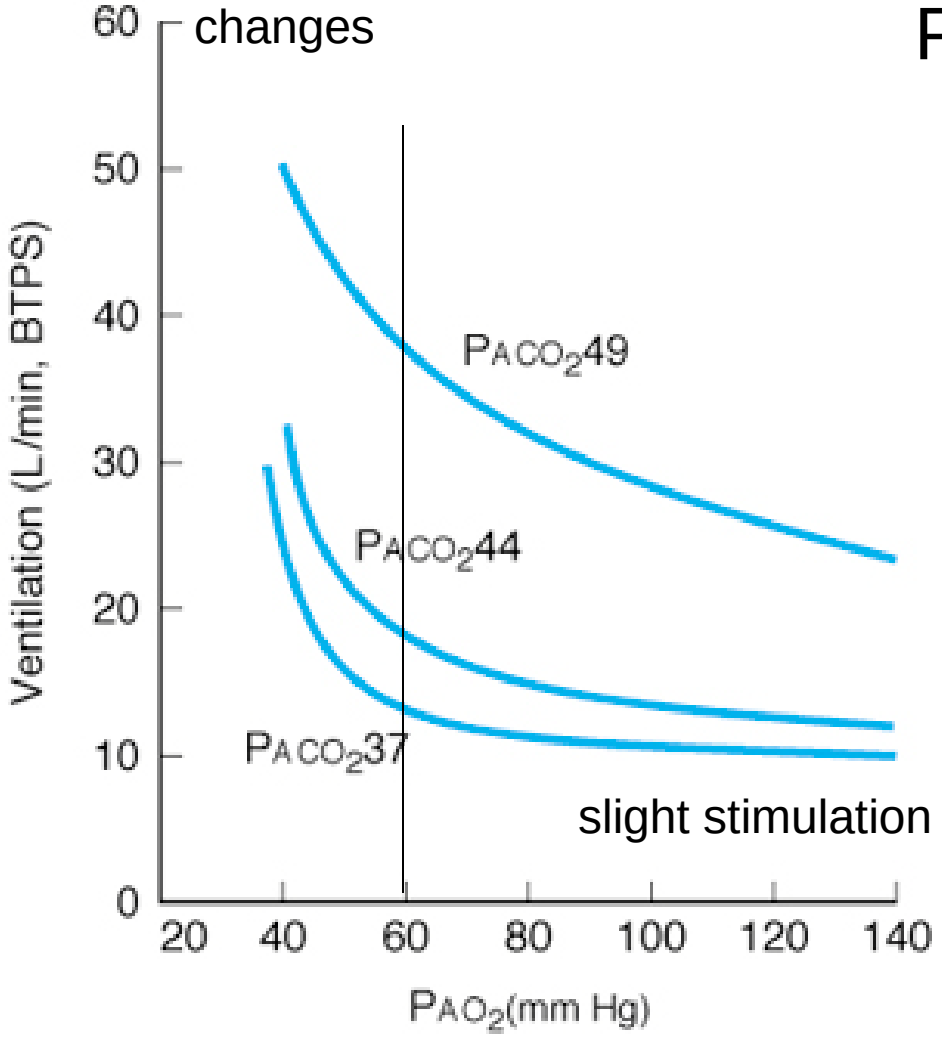
CB & AB

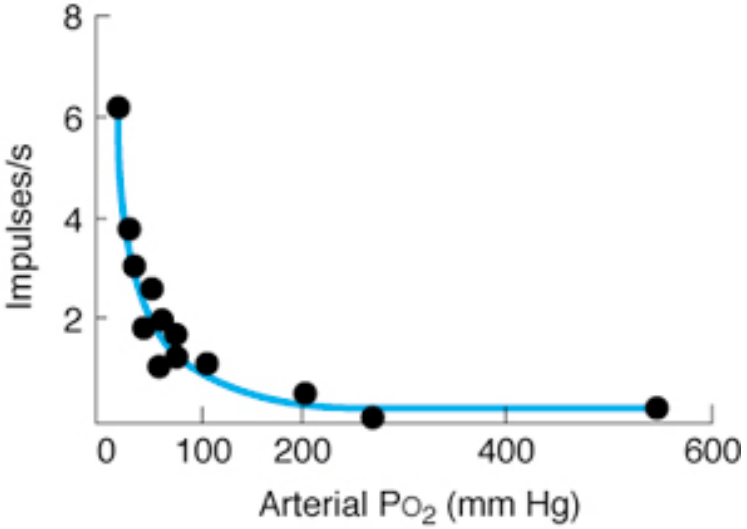
IX & X

VENTILATION

appreciable changes

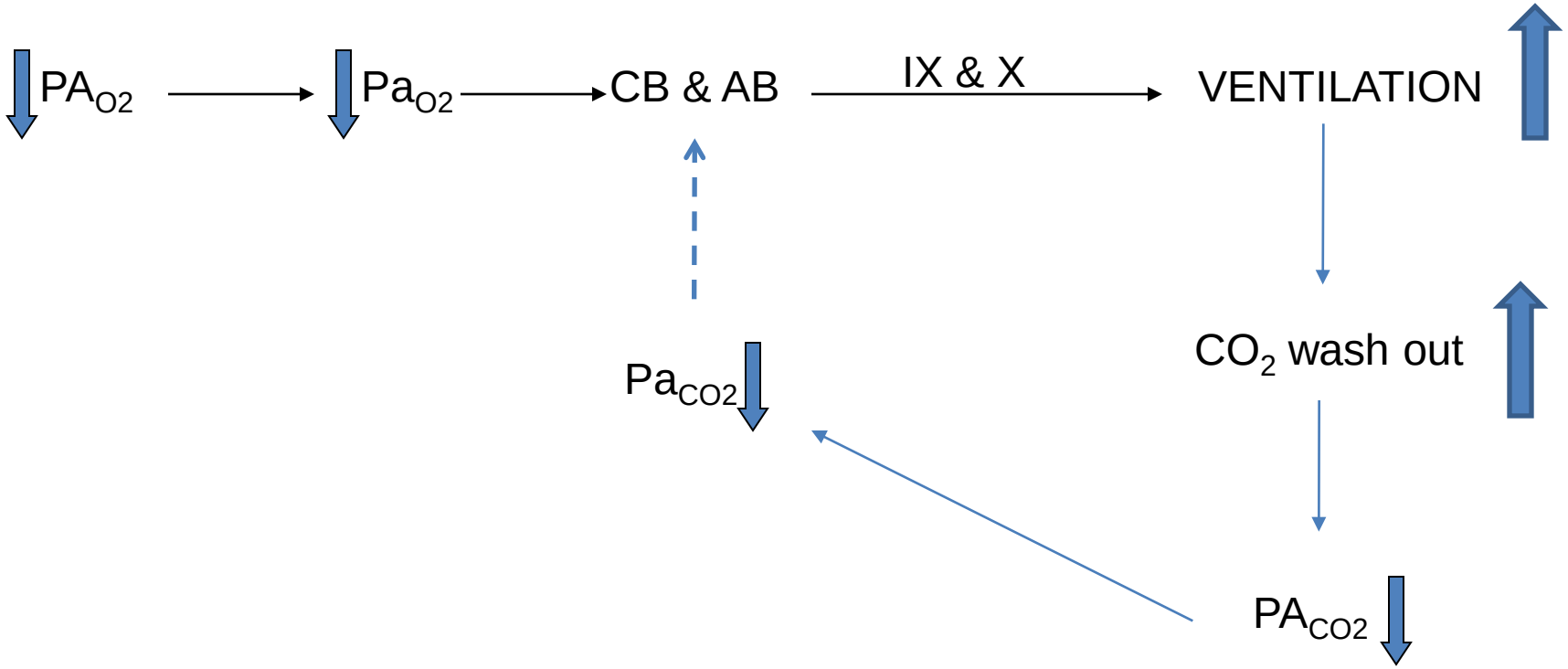
PA_{O2} < 60 mmHg



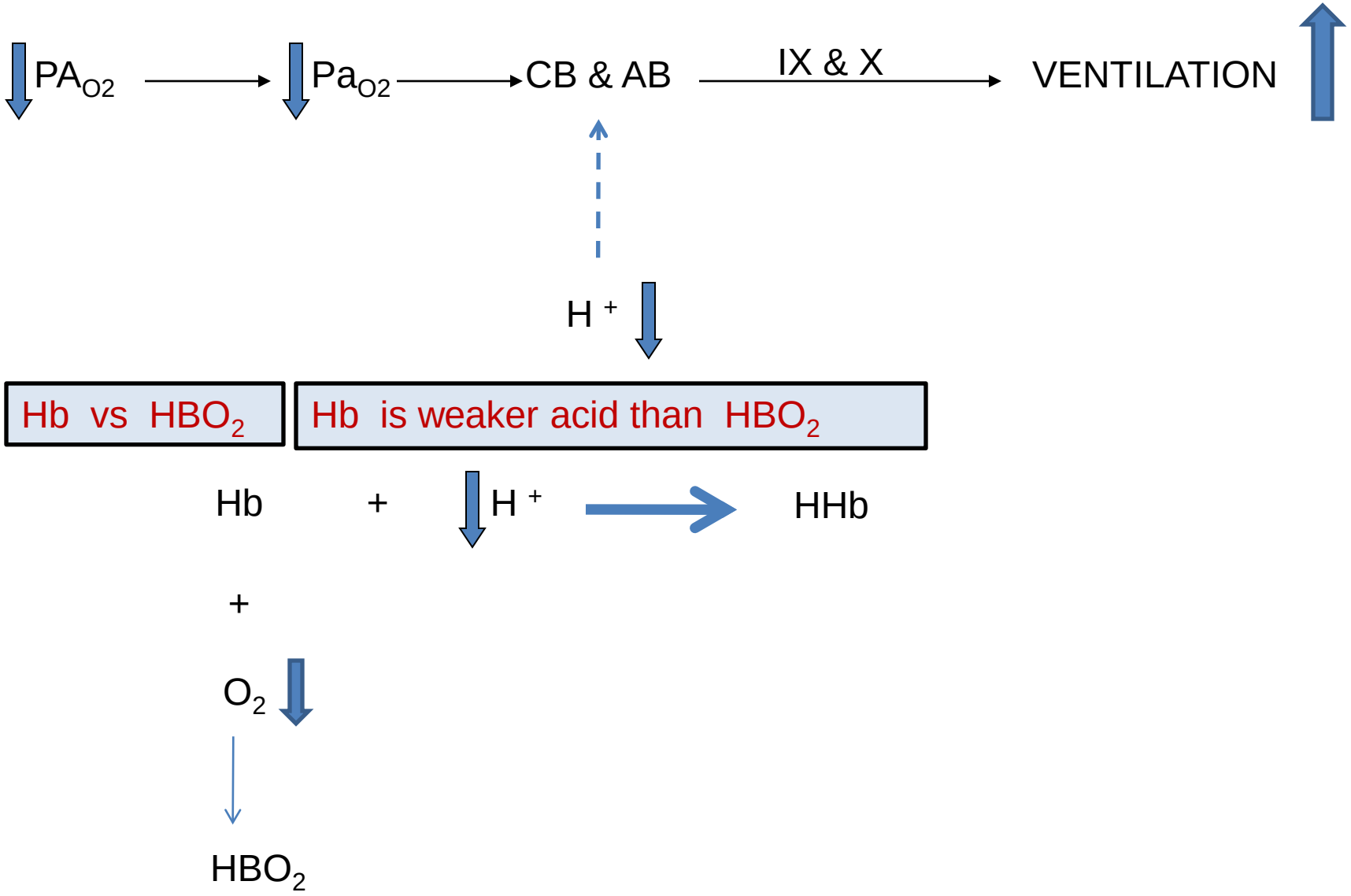


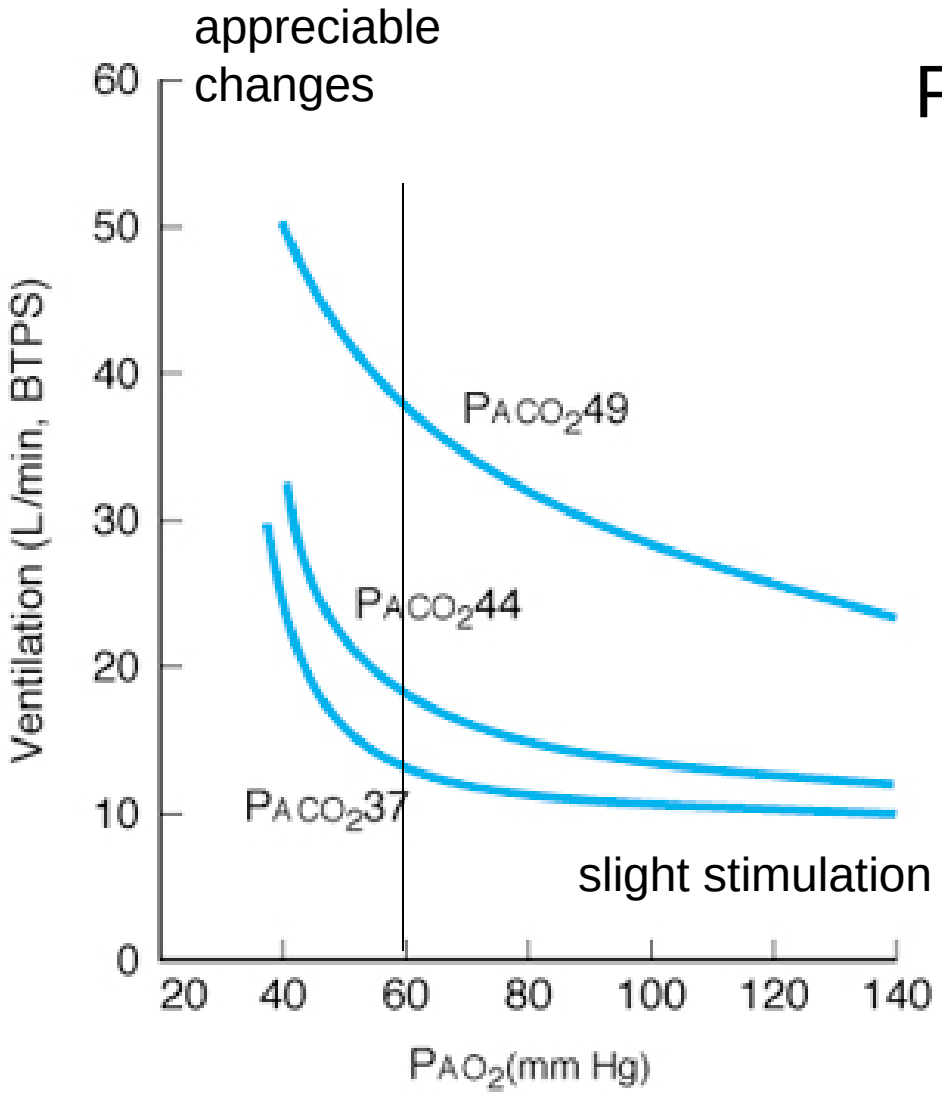
PA_{O2} → Pa_{O2} → CB & AB —IX & X→ RC ⇒ HYPERVENTI - LATION

Two counterbalancing mechanisms



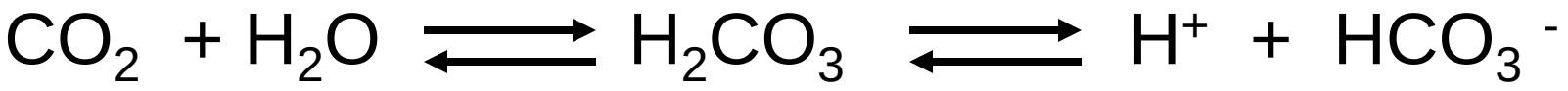
Two counterbalancing mechanisms




appreciable
changes
60
50
40
30
20
10
0
Ventilation (L/min, BTPS)
PACO2 49
PACO2 44
PACO2 37
slight stimulation
20
40
60
80
100
120
140
PAO2 (mm Hg)

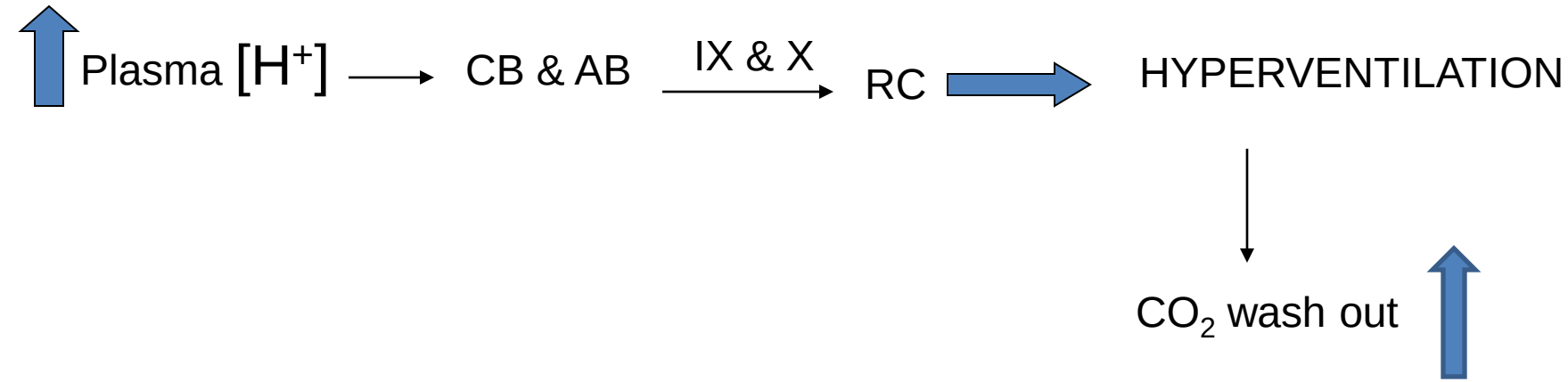
PA_{O2} < 60 mmHg

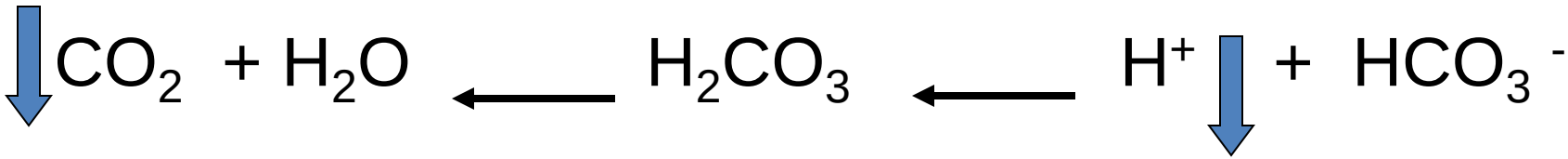
Ventilatory responses to change in acid base balance



Metabolic acidosis: respiratory stimulation

Metabolic acidosis (e.g. ketoacidosis in DM)

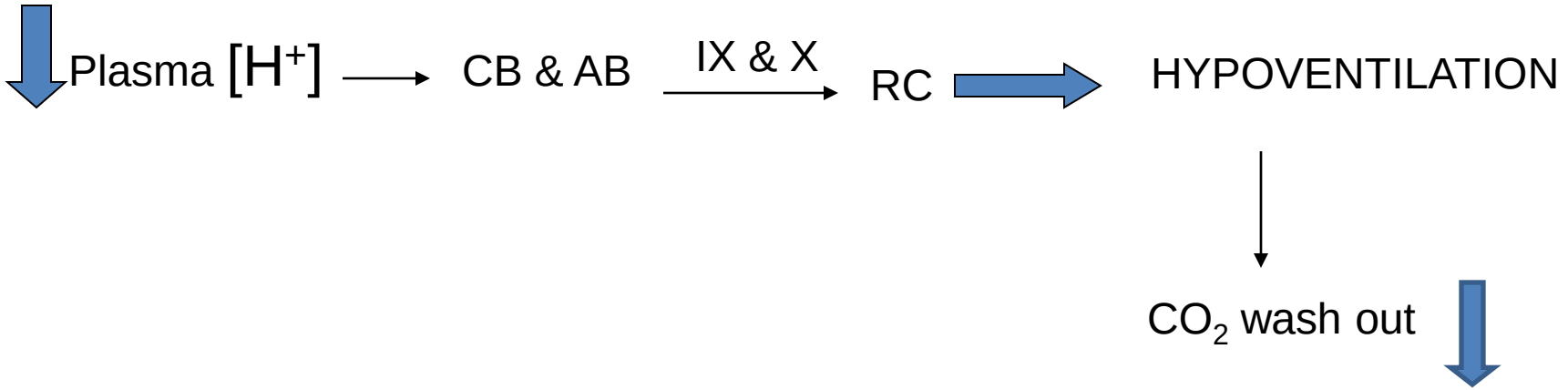


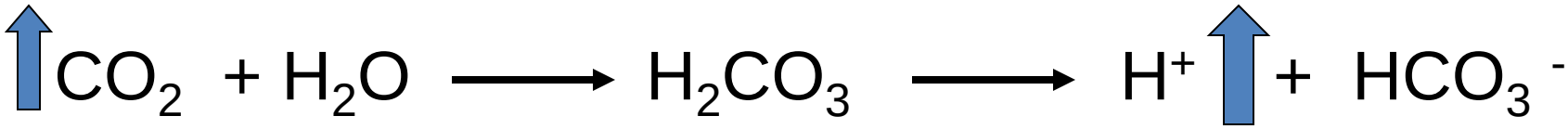


H^+ back to the normal

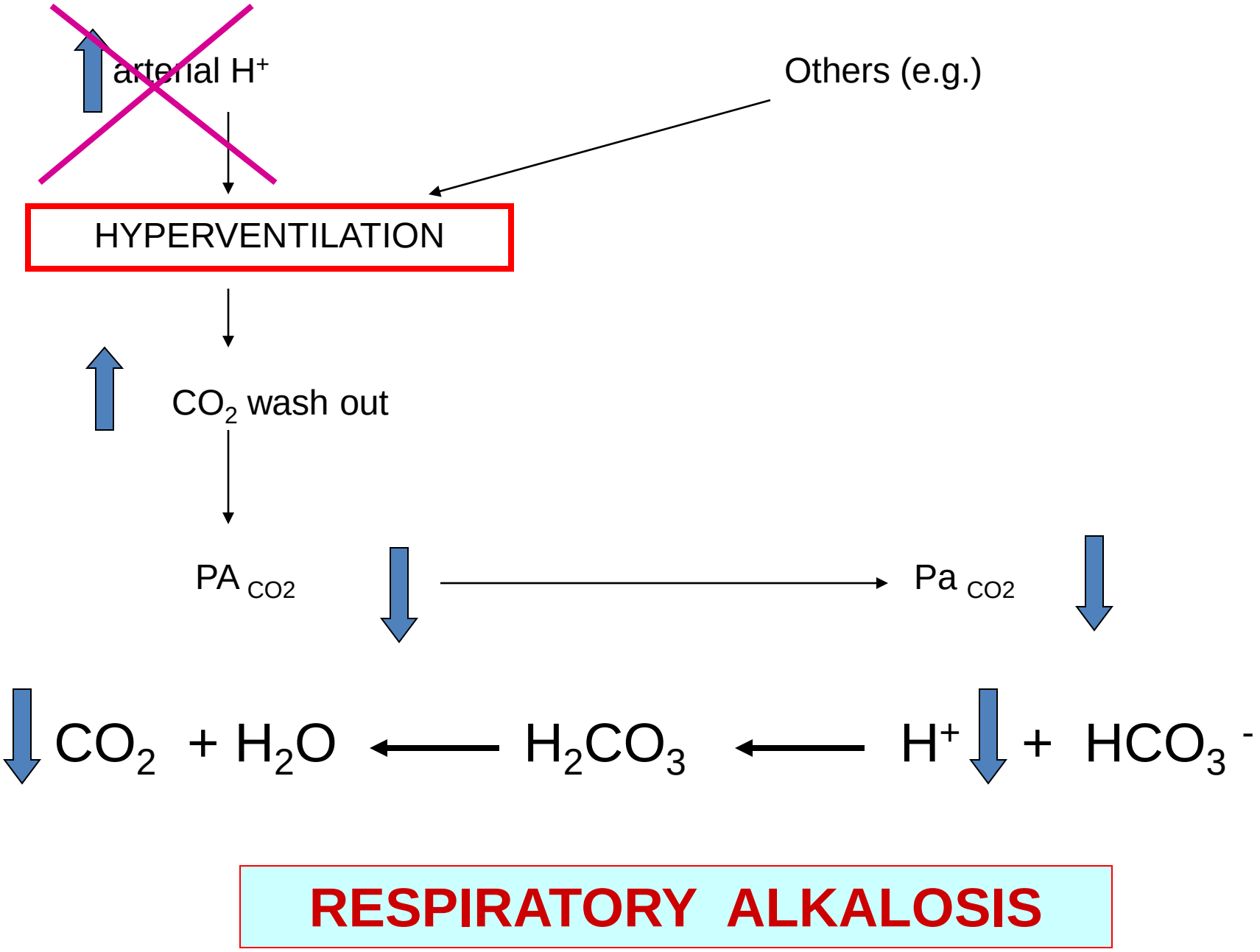
Metabolic alkalosis: respiratory depression

Metabolic alkalosis (e.g. loss of H^+ in vomiting)

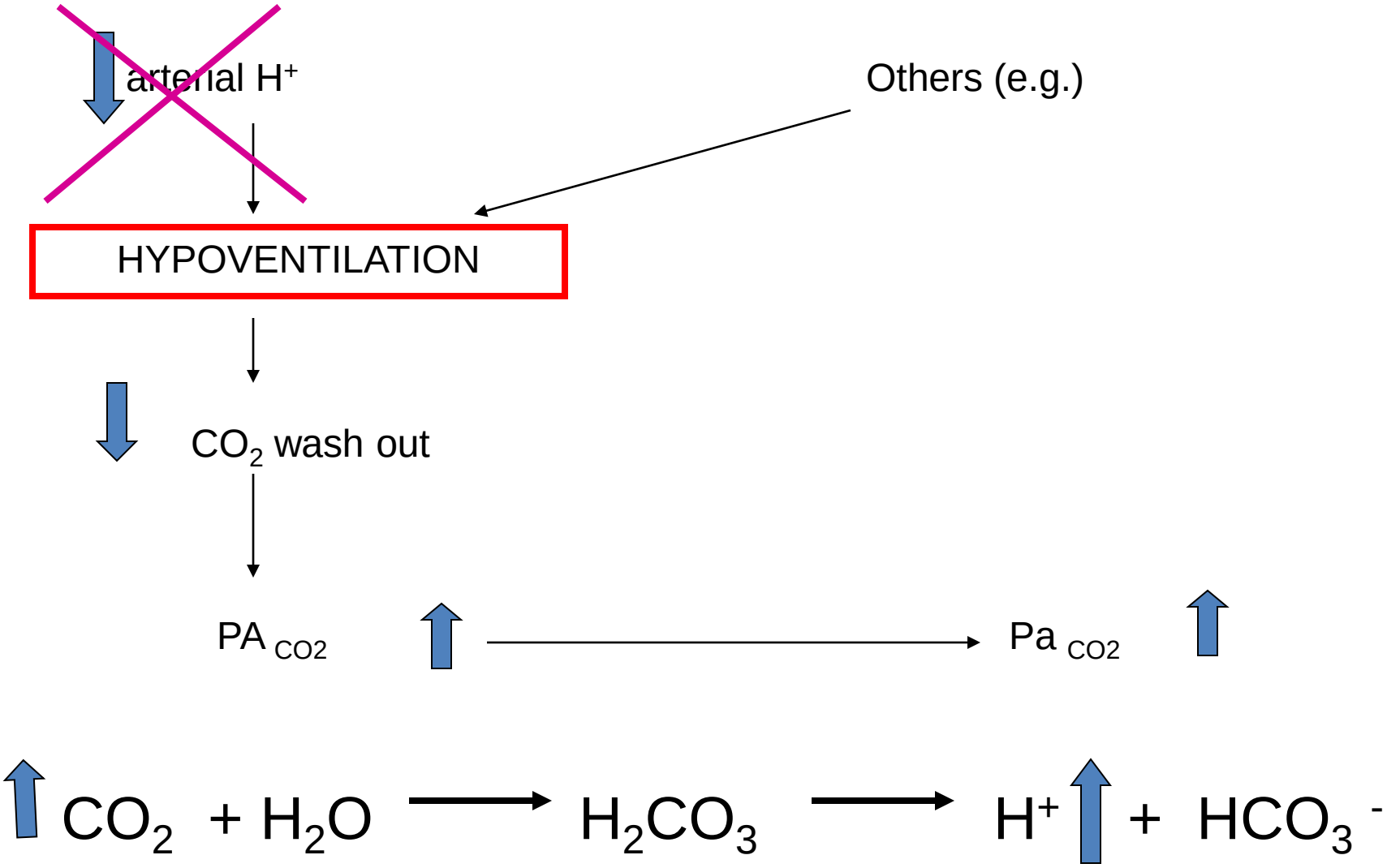




H^+ back to the normal



RESPIRATORY ALKALOSIS



RESPIRATORY ACIDOSIS

Metabolic acidosis

HYPERVENTILATION

HYPERVENTILATION

Respiratory alkalosis

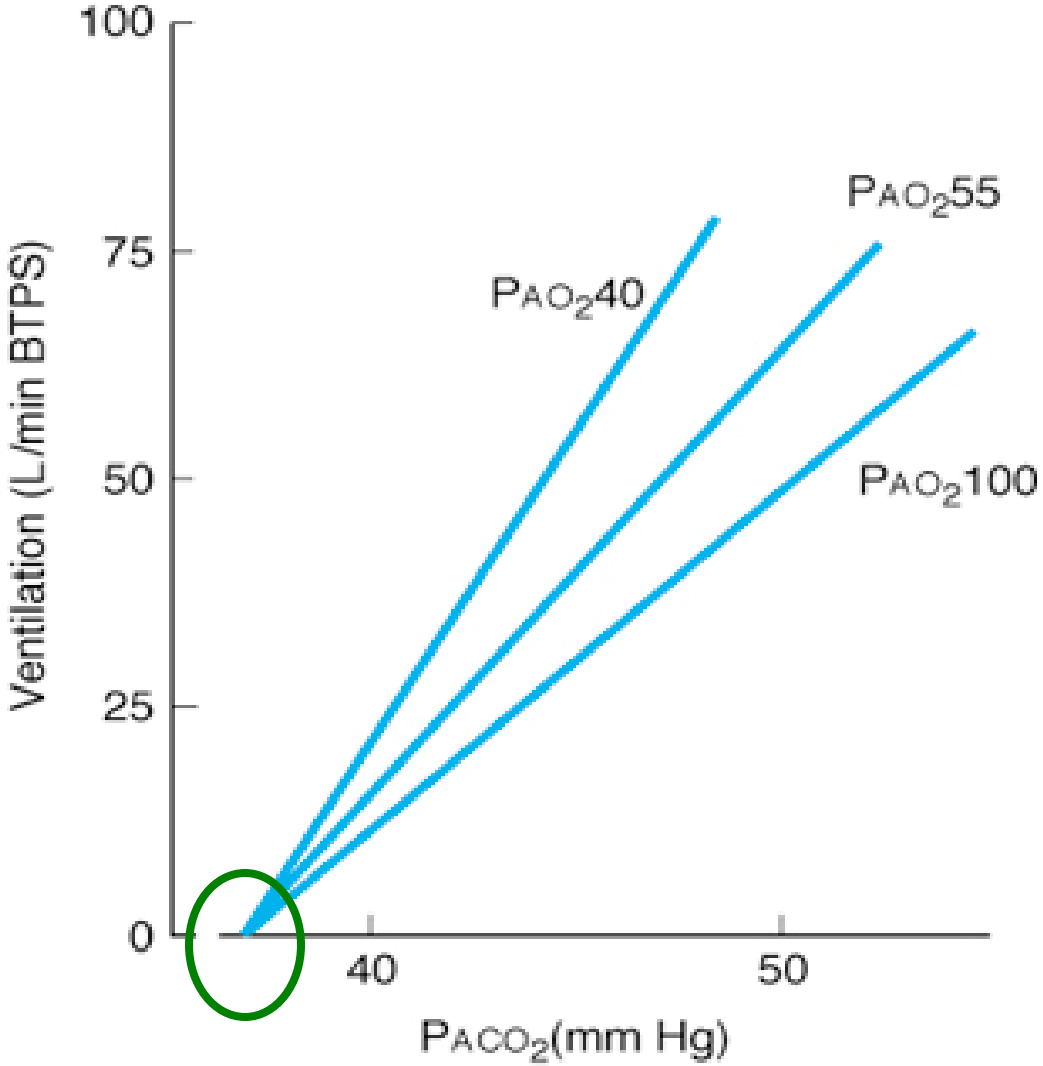
Metabolic alkalosis

HYPOVENTILATION

HYPOVENTILATION

Respiratory acidosis

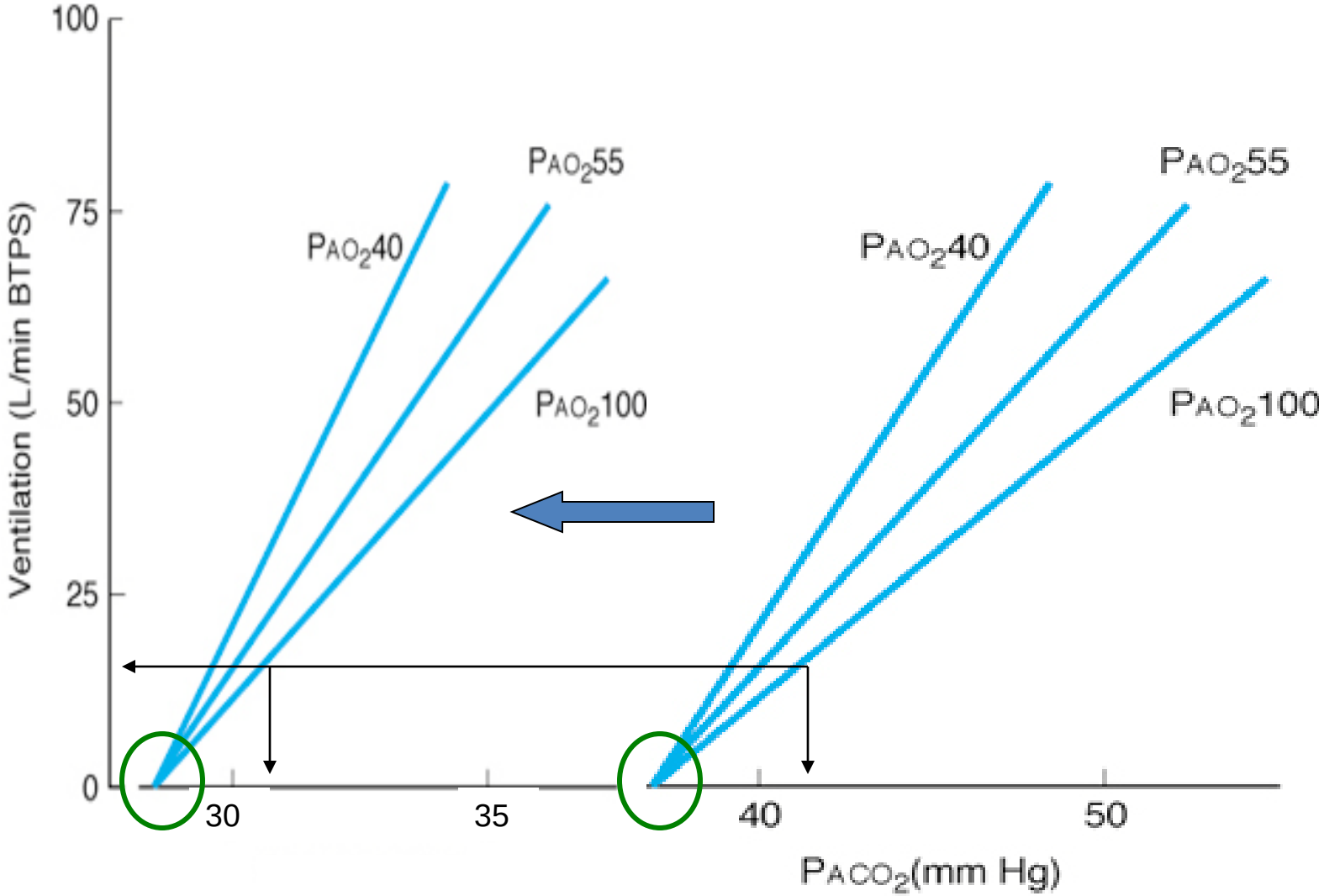
Effect of hypoxia on the CO_2 response



- **Slope**
  increased
- **Intersect**
  no change
- *makes more sensitive to an increase in P_{CO2}*
- *Normally, slight but definite CO_2 drive*

Effect of H^+ on the CO_2 response

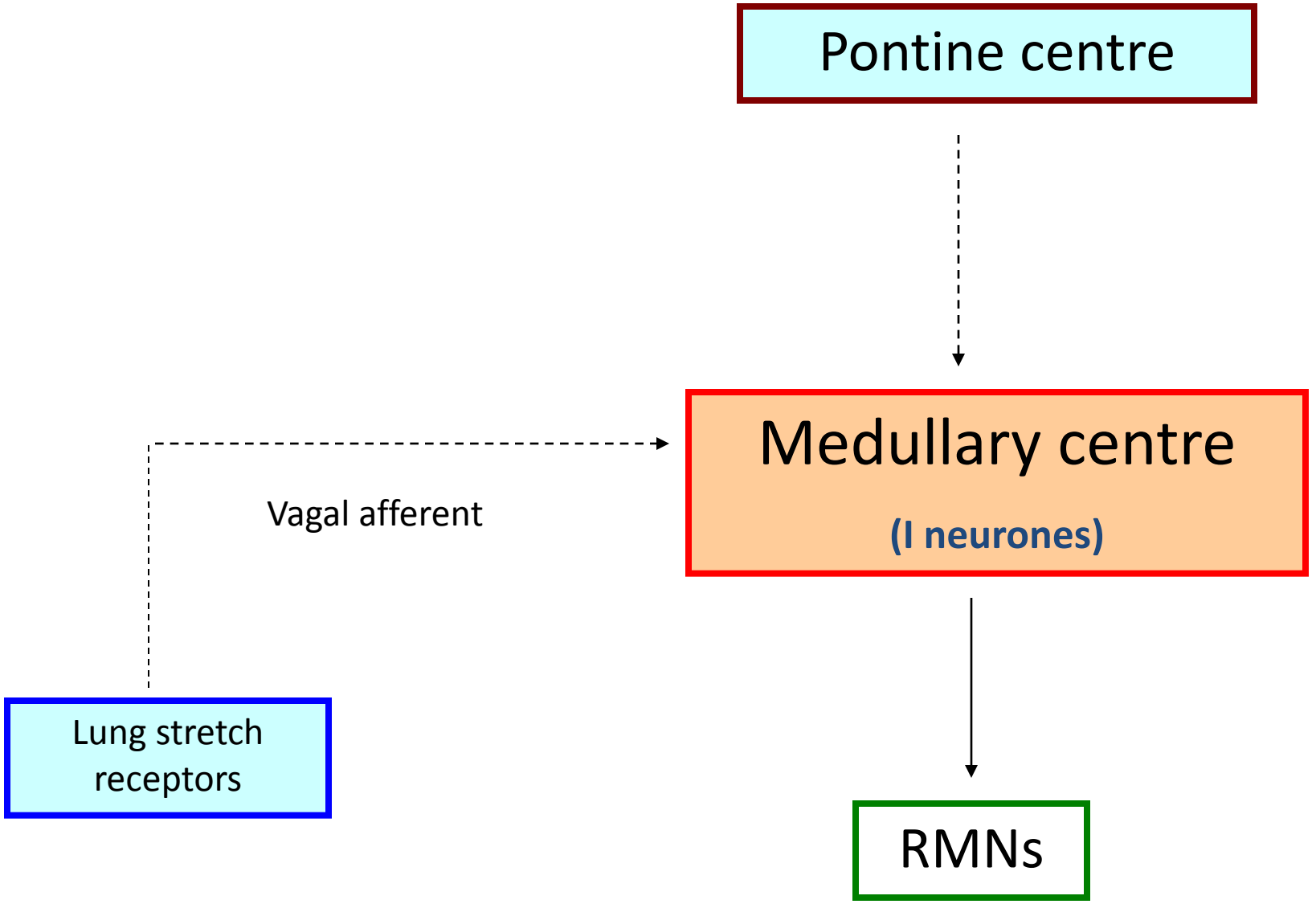
Metabolic acidosis



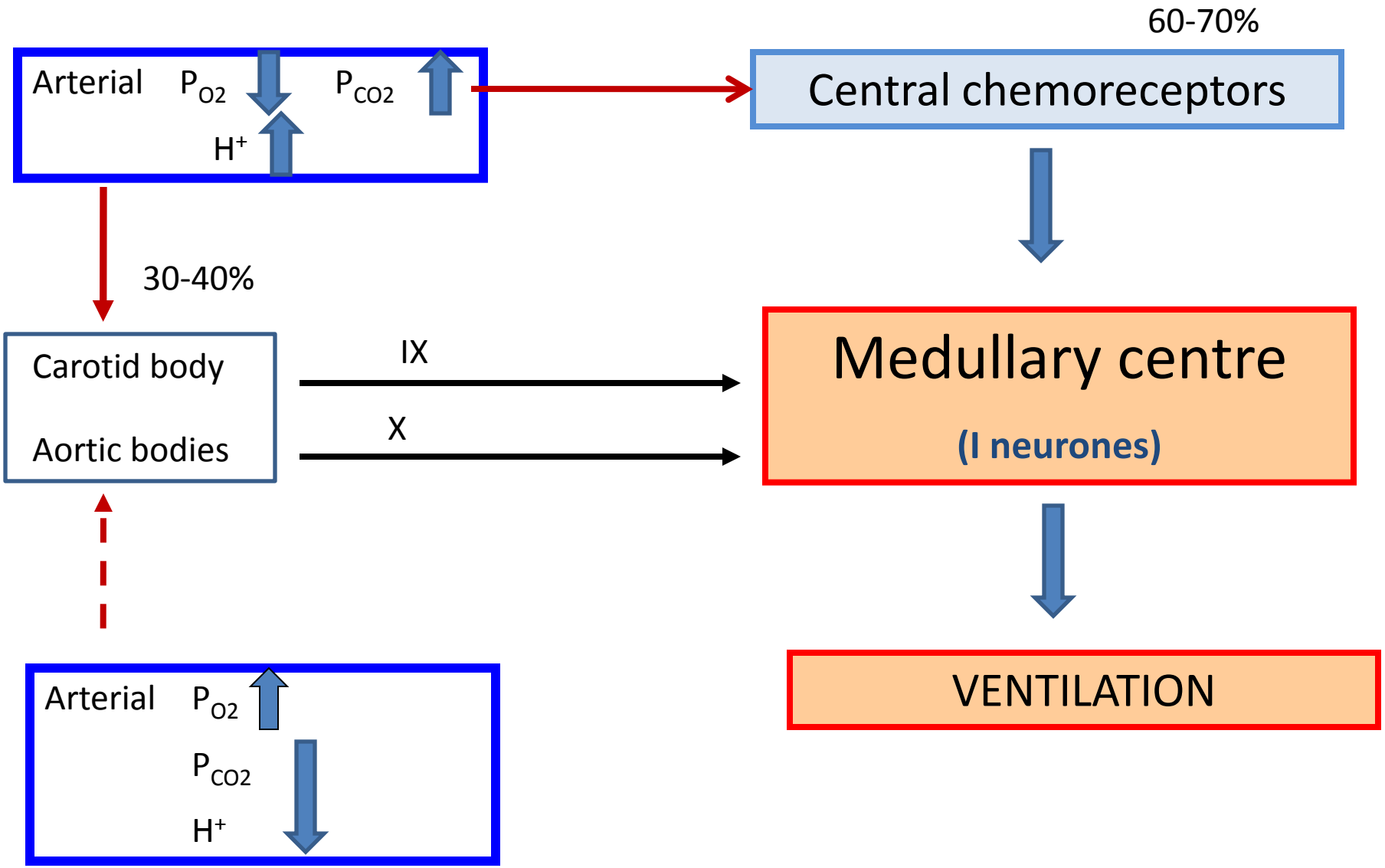
Effect of H^+ on the CO_2 response

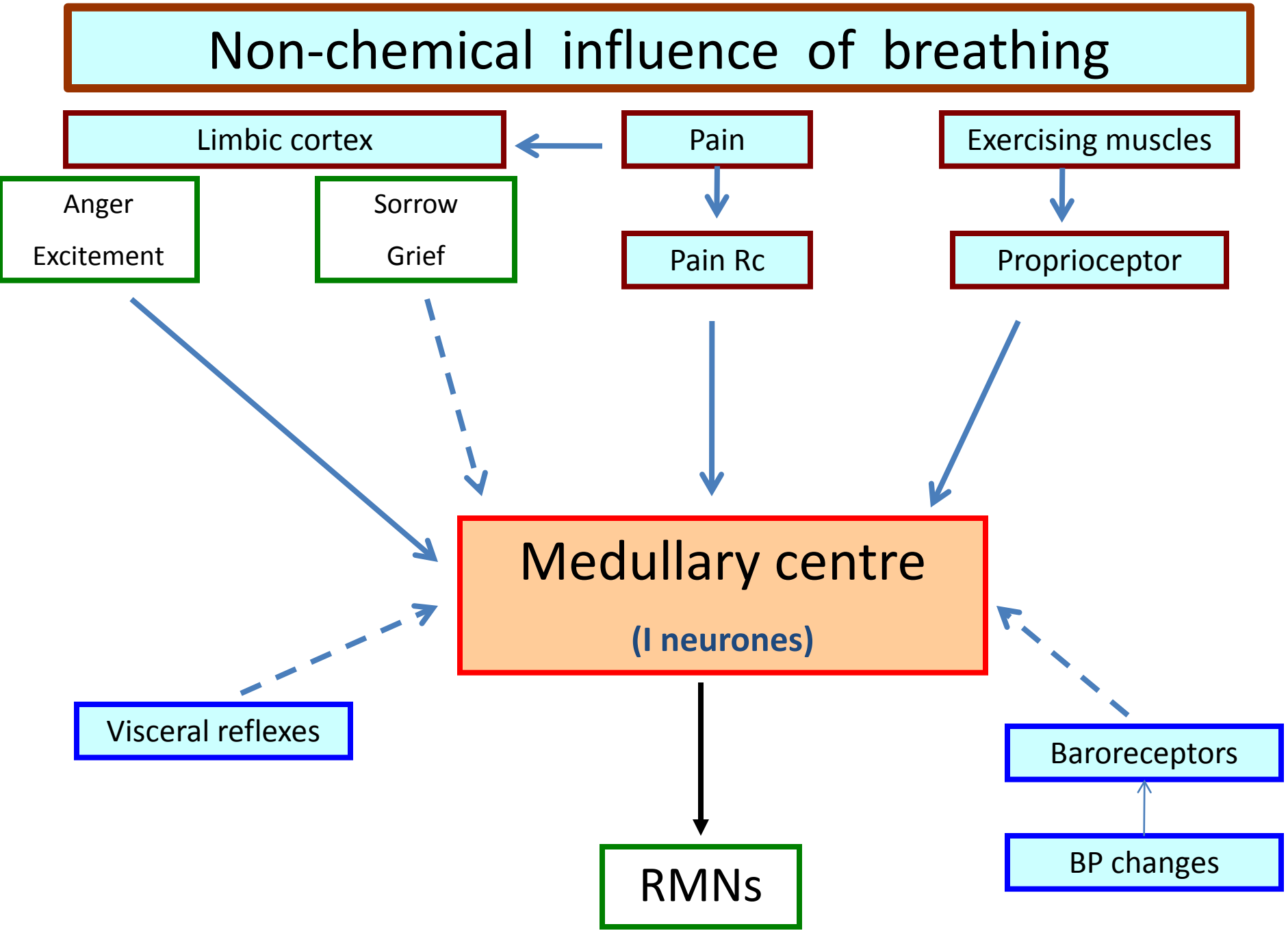
- **ADDITIVE**
- **Slope**
  no change
- **Intersect**
  shift to left
- *Same amount of respiratory stimulation is produced by lower arterial P_{CO2} level*

Neural control of breathing



Chemical control of breathing




Non-chemical influence of breathing
Limbic cortex
Pain
Exercising muscles
Anger
Excitement
Sorrow
Grief
Pain Rc
Proprioceptor
Medullary centre
(I neurones)
Visceral reflexes
Baroreceptors
BP changes
RMNs

Reflexes from airways and lungs

- Receptors from airways and lungs
- Unmyelinated vagal fibres
  - Pulmonary subgroup
  - Bronchial subgroup
- Receptors from airways and lungs
  - Slowly adapting
  - Rapidly adaption
- Myelinated vagal fibres

Hering-Breuer reflex

- Hering-Breuer inflation reflex
  - Stimulus : steady lung inflation
  - Response : an increase in duration of expiration
- Hering-Breuer deflation reflex
  - Stimulus : marked deflation of the lungs
  - Response : a decrease in duration of expiration

Irritant receptors (rapidly adapting receptors)
- by histamine

Irritant receptors
(in trachea)

- Coughing
- BC
- Mucus secretion

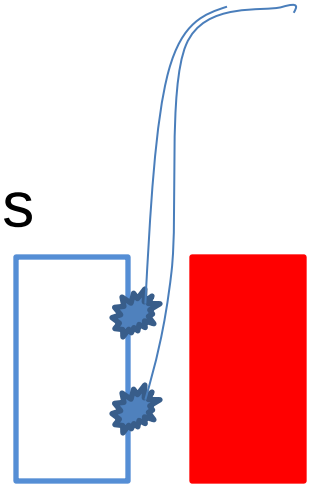
Irritant receptors
(in lungs)

- hyperpnoea

Coughing and sneezing: protective reflexes

J - receptors (Juxtacapillary receptors)

- C fibre endings lying close to pulmonary vessels



Stimulus

- Hyperinflation
- IV or Icardiac administration of chemicals (eg. Capsaicin)

Responses

- Apnoea followed by rapid breathing
- Bradycardia
- hypotension