Regulation OF RESPIRATION

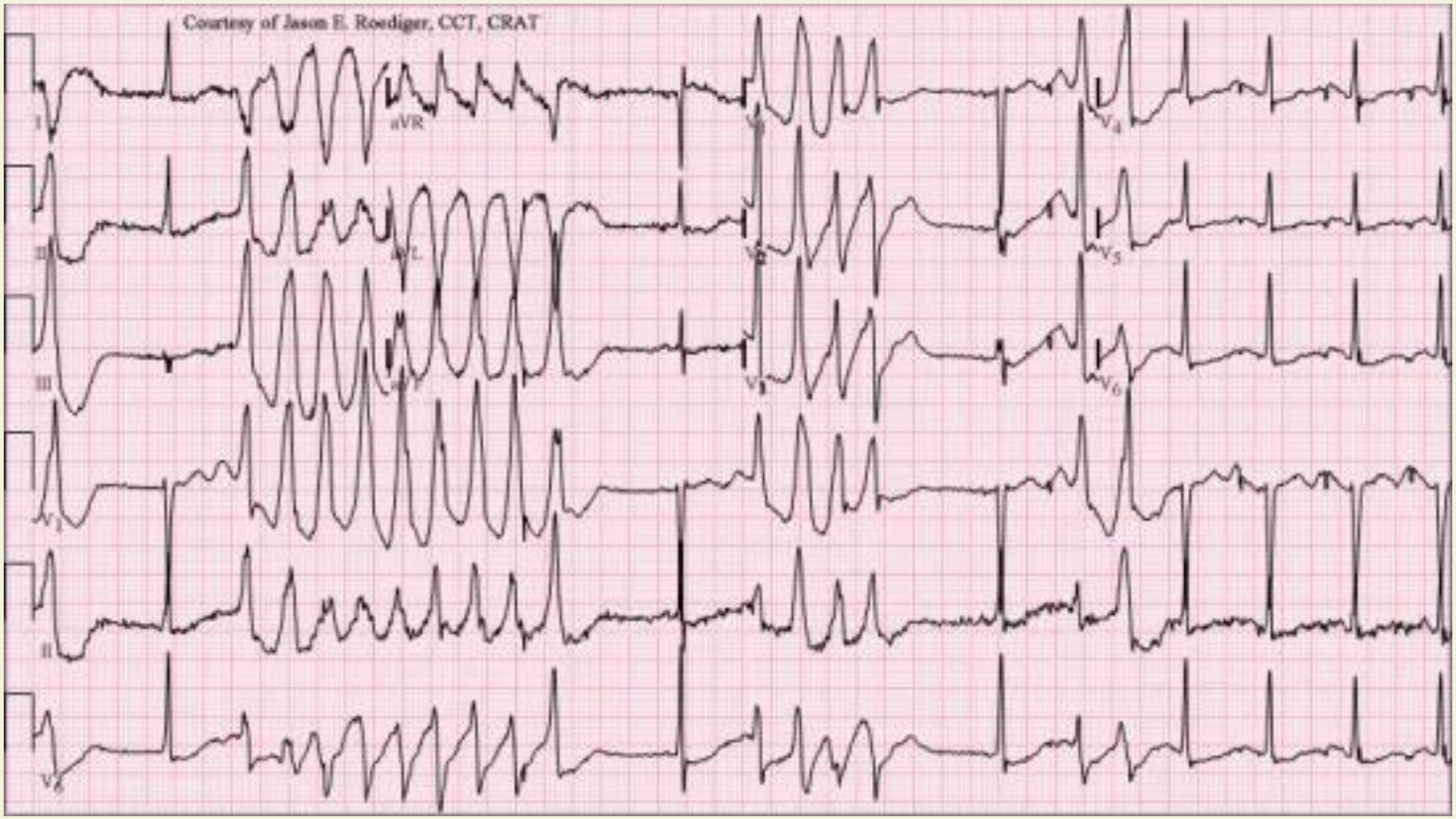
By

Dr Gul Muhammad

Remaining points in CVS

- Torsades de pointis
- Carotid massage
- Pulsus paradoxus
- Cardiac tamponade
- Electrical alternans
- Akinesia and aneurysm of the left ventricle
- CABG/By pass surgery
- haemodynamics in each valvular disease
- Nitrous Oxide effect in local blood flow to treat ED and PH

Torsades de pointis



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Learning Outcomes

- Define respiratory regulation
- Name the types of respiratory regulation
- Describe the components of nervous regulatory system
- Describe the chemical regulation of respiration
- Name the components of chemical regulation of respiration
- Name Other factors which take part in regulation of respiration

INTRODUCTION

- Like heartbeat, breathing must occur in a continuous, cyclic pattern to sustain life processes.
- Inspiratory muscles must rhythmically contract and relax to alternately fill the lungs with air and empty them.
- The rhythmic pattern of breathing is established by cyclic neural activity to the respiratory muscles.

- The nerve supply to the respiratory system is absolutely essential in maintaining breathing and in reflexly adjusting the level of ventilation to match changing needs for O2 uptake and CO2 removal.

- Respiratory activity can be voluntarily modified to accomplish speaking, singing, whistling, playing a wind instrument, or holding one’s breath while swimming.

OMPONENTS OF NEURAL CONTROL OF RESPIRATIONC

- Three distinct components:

1) Factors that generate the **alternating inspiration/expiration rhythm**

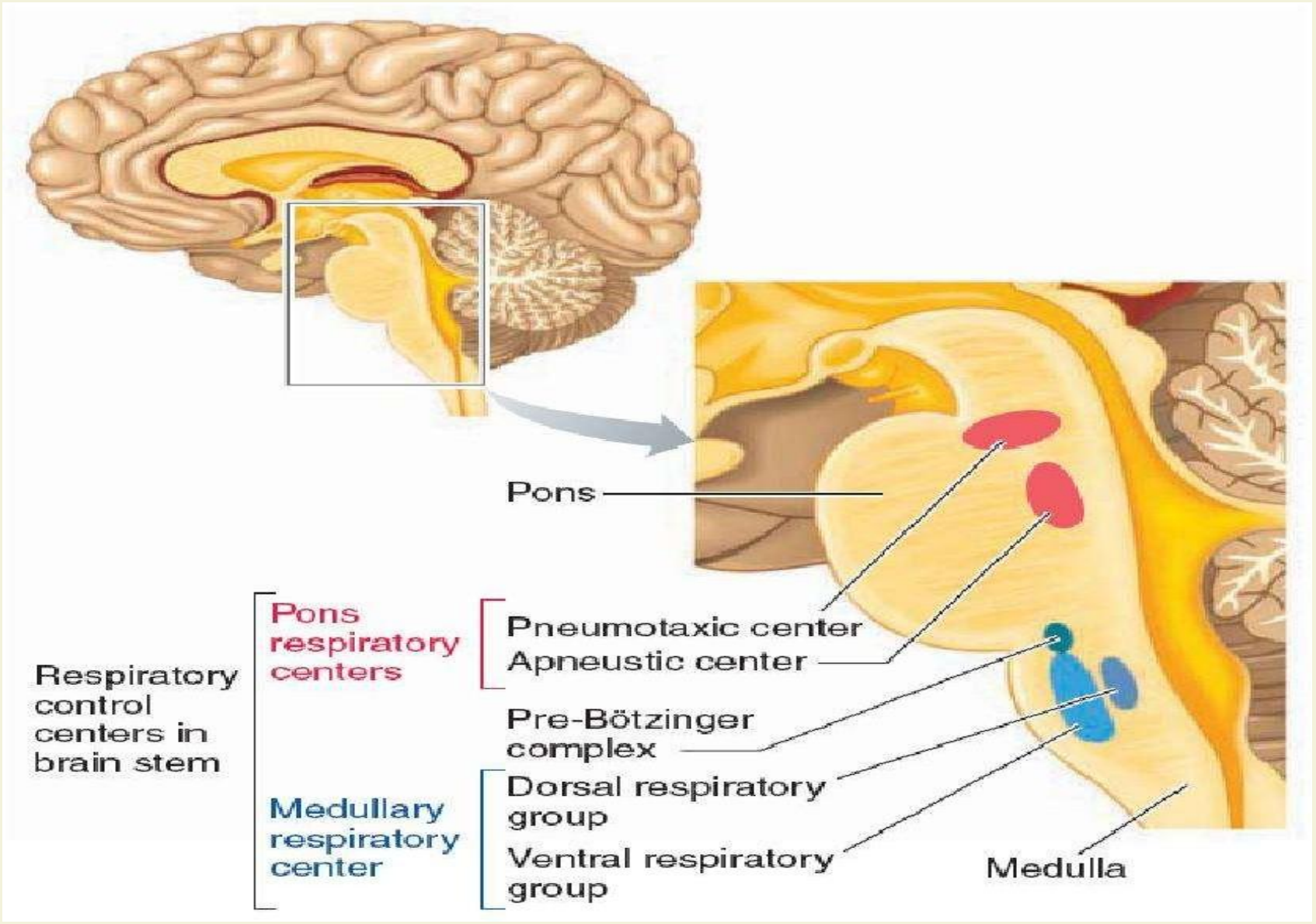
2) Factors that regulate the **magnitude of ventilation** (that is, the rate and depth of breathing) to match body needs,

3) Factors that **modify respiratory activity** to serve other purposes.

Neural Control

- The primary respiratory control center,
- **The *Medullary Respiratory Center***
  - *consists of several* aggregations of neuronal cell bodies within the medulla that provide output to the respiratory muscles.

- Two other respiratory centers lie higher in the brain stem in the pons
- **The *Pneumotaxic Center and Apneustic Center***
  - *These pontine* centers influence output from the medullary respiratory center


Pons
Respiratory control centers in brain stem
Pons respiratory centers
Pneumotaxic center
Apneustic center
Pre-Bötzinger complex
Medullary respiratory center
Dorsal respiratory group
Ventral respiratory group
Medulla

- The **medullary respiratory center consists of two neuronal** clusters known as the

- *Dorsal Respiratory Group (DRG)*

- *Ventral Respiratory Group (VRG)*

- The **dorsal respiratory group (DRG) consists mostly of** *inspiratory neurons whose descending fibers terminate on the* motor neurons that supply the inspiratory muscles.

- When neurons fire, inspiration takes place;
- When they cease firing, expiration occurs.

- The **ventral respiratory group (VRG)** is composed of *inspiratory neurons and expiratory neurons, both of which remain inactive* during normal quiet breathing.

- This region is called into play by the DRG as an "overdrive" mechanism during periods when demands for ventilation are increased.

- It is especially important in active expiration.

THE PNEUMOTAXIC AND APNEUSTIC CENTERS

- The respiratory centers in the pons exert “fine-tuning” influences over the medullary center

- The **pneumotaxic center** sends impulses to the DRG that help “switch off ” the inspiratory neurons, limiting the duration of inspiration.

- The **apneustic center prevents the inspiratory neurons from** being switched off , thus providing an extra boost to the inspiratory drive.

- In this check-and-balance system, the pneumotaxic center dominates over the apneustic center, helping halt inspiration and letting expiration occur normally.

- Without the pneumotaxic brakes, the breathing pattern consists of prolonged inspiratory gasps abruptly interrupted by very brief expirations. This abnormal breathing pattern is known as **apneusis**

REFLEX MODIFICATION OF BREATHING

HERING–BREUER REFLEX

- **When the tidal volume is large** (greater than 1 liter), as during exercise, the **Hering–Breuer reflex is triggered to prevent overinflation of the lungs.**

- **Pulmonary stretch receptors** within the smooth muscle layer of the airways are activated by stretching of the lungs at large tidal volumes.

- Action potentials from these stretch receptors travel through afferent nerve fibers to the medullary center and inhibit the inspiratory neurons.

JOINT RECEPTORS

- Impulses from moving limbs reflexly increase breathing

- Probably contribute to the increased ventilation during exercise

Deflation Reflex

- The deflation reflex is stimulated when the lungs are compressed or deflated, causing an increased rate of breathing.

- Precise mechanism for this reflex is not known.

Irritant Reflex

- When the lungs are exposed to toxic gases, the irritant receptors may be stimulated.
- These irritant receptors are subepithelial mechanoreceptors located in the trachea, bronchi, and bronchioles.
- When these receptors are activated, a reflex response causes the ventilatory rate to increase as well as cough and bronchoconstriction.

JUXTAPULMONARY-CAPILLARY RECEPTORS

- J receptors are located in the interstitial tissues between the pulmonary capillaries and the alveoli.
- When these J receptors are stimulated, a reflex response triggers rapid, shallow breathing.

- J receptors are activated by:
  - pulmonary capillary congestion
  - capillary hypertension
  - edema
  - lung deflation
  - serotonin
  - emboli

Factors That May Increase Ventilation During Exercise

- Reflexes originating from body movement
- Increase in body temperature
- Adrenaline release
- Impulses from the cerebral cortex
- Later: accumulation of CO_2 and H^+ generated by active muscles

INFLUENCE OF CHEMICAL FACTORS ON RESPIRATION

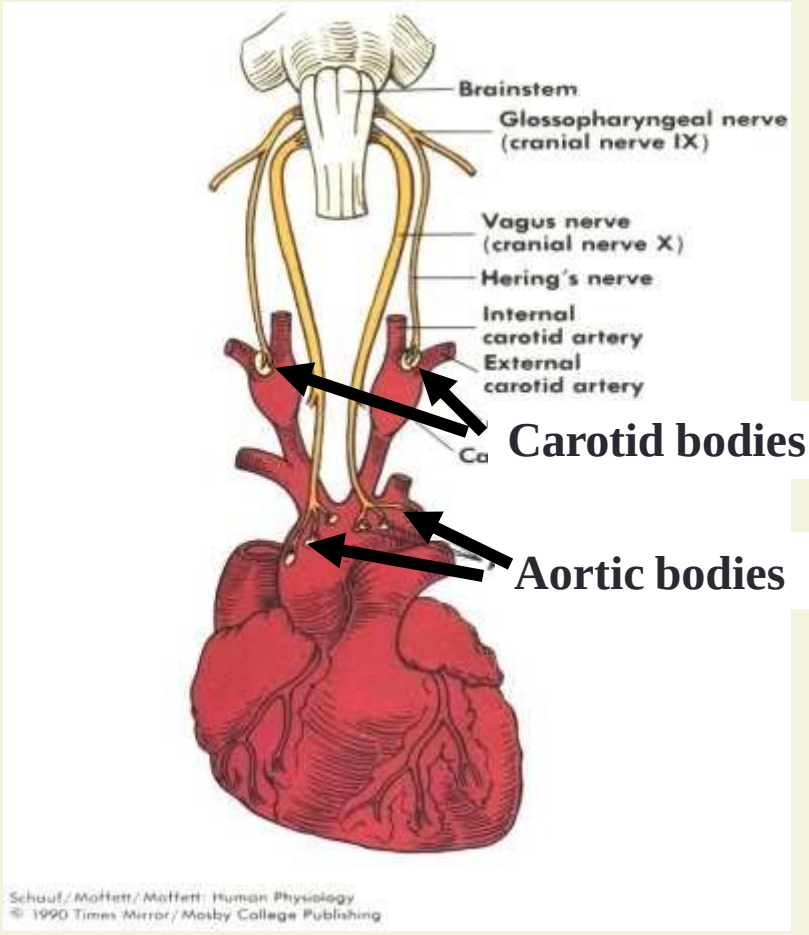
- The magnitude of ventilation is adjusted in response to three chemical factors:
  - ***PO2, PCO2, and H.***

- Arterial blood gases are maintained within the normal range by varying the magnitude of ventilation (rate and depth of breathing) to match the body's needs for O2 uptake and CO2 removal.

CHEMICAL CONTROL OF RESPIRATION

- An example of a **negative feedback control system**
- The controlled variables are the blood gas tensions, **especially carbon dioxide**
- **Chemoreceptors** sense the values of the gas tensions

Peripheral Chemoreceptors



Sense tension of oxygen and carbon dioxide; and $[H^+]$ in the blood

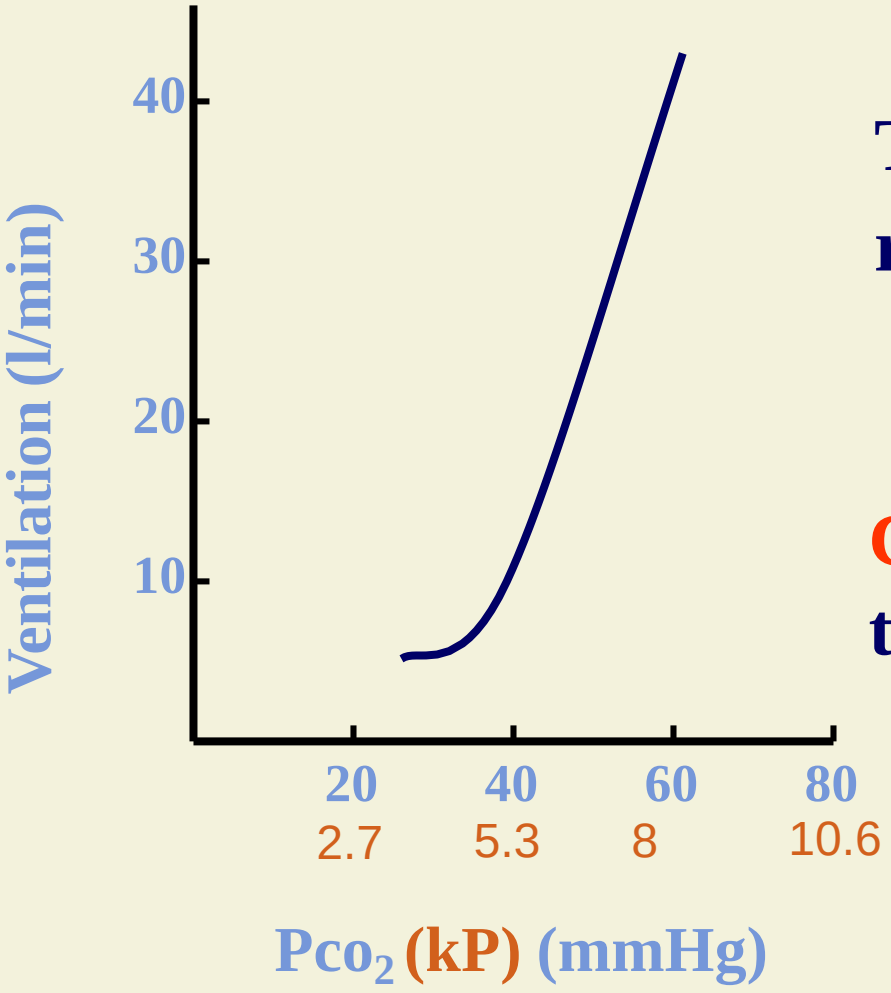
CENTRAL CHEMORECEPTORS

- Situated near the surface of the **medulla** of the brainstem
- Respond to the **[H^+]** of the cerebrospinal fluid (CSF)
- CSF is separated from the blood by the ***blood-brain barrier***
  - Relatively **impermeable to H^+** and HCO_3^-
  - **CO_2 diffuses readily**
  - **CO2 will work for first 2 to 3 days, then kidney compensation will occur through HCO3 retention.**

- **CSF** contains less protein than blood and hence is **less buffered than blood**

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

HYPERCAPNIA AND VENTILATION



The system is very responsive to P_{CO_2}

CO_2 generated H^+ through the central chemoreceptors

HYPOXIC DRIVE OF RESPIRATION

- The effect is all via the **peripheral chemoreceptors**
- Stimulated only when arterial **P_{O2}** falls to low levels
- Is **not important** in normal respiration
- May become important in patients with **chronic CO_2 retention** (e.g. patients with COPD)
- It is important at **high altitudes (acclimatization)**

THE H^+ DRIVE OF RESPIRATION

- The effect is via the **peripheral chemoreceptors**
- **H^+ doesn't** readily cross the blood brain barrier (**CO_2 does!)**
- The **peripheral chemoreceptors** play a major role in adjusting for acidosis caused by the addition of **non-carbonic acid H^+** to the blood (e.g. lactic acid during exercise; and diabetic ketoacidosis)
- Their stimulation by **H^+** causes **hyperventilation** and **increases elimination of CO_2 from the body** (remember **CO_2** can **generate H^+**, so its increased **elimination** help **reduce the load of H^+** in the body)
- This is important in acid-base balance

Other factors in regulation of respiration in abnormal condition

- Brain edema Cheyne - Stokes breathing
- Sleep apnoea
  - Obstructive sleep apnoea
  - Central sleep apnoea
- CPAP (continuous positive airway pressure)
- BiPAP (bi-level positive airway pressure)

INFLUENCE OF CHEMICAL FACTORS ON RESPIRATION

CHEMICAL FACTOR	EFFECT ON THE PERIPHERAL CHEMORECEPTORS	EFFECT ON THE CENTRAL CHEMORECEPTORS
↓ P_{O_2} in the Arterial Blood	Stimulates only when the arterial P_{O_2} has fallen to the point of being life-threatening (<60 mm Hg); an emergency mechanism	Directly depresses the central chemoreceptors and the respiratory center itself when <60mm Hg
↑ P_{CO_2} in the Arterial Blood (↑ H^+ in the Brain ECF)	Weakly stimulates	Strongly stimulates; is the dominant control of ventilation (Levels >70–80 mm Hg directly depress the respiratory center and central chemoreceptors)
↑ H^+ in the Arterial Blood	Stimulates; important in acid–base balance	Does not affect; cannot penetrate the blood–brain barrier

Thank You