Week 8b – Respiration 3:

Basic respiratory control:

Limits to the duration & strength of inspiration & expiration are controlled by:

- Inhibitory connections between inspiratory & expiratory neuron groups
- Feedback via stretch & irritant receptors (vagus), and circulatory & medullary chemoreceptors.

Chemoreceptor control of ventilation:

- **Peripheral chemoreceptors:**
  - Are located in carotid bodies & aortic bodies.

Those located in *carotid* bodies:

- Respond to decreased P_aO_2 (less than 60mmHg), as well as increased P_aCO_2 (arterial partial pressure of CO_2) and increased H_+ ion concentration.
- Provide 20% of respiratory drive

Those located in *aortic* bodies:

- Respond (although rarely) to decreased total arterial oxygen content (e.g. during anaemia, carbon monoxide poisoning).

- **Central chemoreceptors:**
  - Are located in the medulla
  - Are directly responsive to H^+ ion concentrations in CSF (which is derived from arterial CO_2). Therefore, are indirectly responsive to P_aCO_2.
  - Are *not* responsive to circulating H^+ ions (i.e. pH)
  - Provide 80% of respiratory drive.

Ventilatory responses to O_2 & CO_2:

- There is a significant *peripheral* response to P_aO_2 when **P_aO_2 < 60mmHg.**
- There is a significant *central* response to P_aCO_2 when **$PaCO_2$ > 40mmHg**.

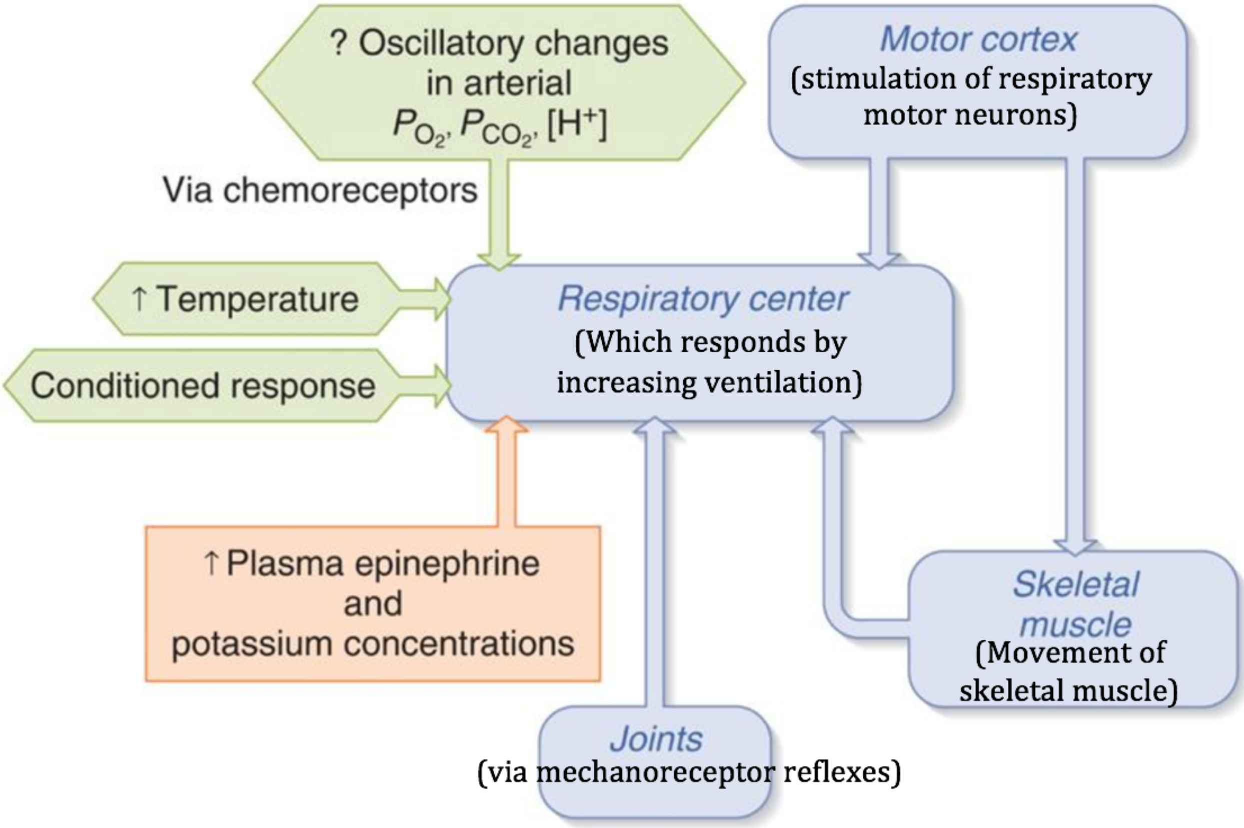
Hyperventilation:

- Where breathing is above than that of metabolic demands.
- CO_2 is blown off, decreasing P_aCO_2.
- Has no effect on P_aO_2, because it is already at its maximum (100mmHg) and haemoglobin is fully saturated.

Hypoventilation:

- Where breathing is below that of metabolic demands (e.g. holding your breath).
- Carbon dioxide is retained, increasing P_aCO_2 concentration. This stimulates ventilation.
- P_aO_2 may fall, but has no effect on ventilation until less than 60mmHg.

Respiratory control during exercise:



Hyperventilation at altitude:

- Is caused by a decrease in **P_aO_2** (partial pressure of arterial oxygen) acting on carotid body peripheral chemoreceptors.
- This leads to a reduction in P_aCO_2, and a compensatory increase in P_aO_2.
- This leads to respiratory alkalosis of both CSF & blood – which limits the increase of ventilation via the depression of central & peripheral chemoreceptors.
- When pH becomes more normal (within 2-3 days) via renal HCO^{3-} (bicarbonate) excretion, ventilation then increases again.
- People who are more acclimatized to high altitudes start to hyperventilate *earlier* (at lower altitudes).

Week 9a – Fluids & Electrolytes 1:

Functions of the kidney:

- **Regulation of:**
  - Water (blood volume, osmolarity)
  - Inorganic ion balance (e.g. Na^+, K^+, Ca^{2+})
  - Acid-base balance (e.g. H^+, pH)
- **Removal & excretion in urine of:**

- Metabolic waste products (e.g. urea, haemoglobin by-products)
- Foreign chemicals (e.g. drugs, food additives)

➢ **Production of hormones/enzymes**:
- Erythropoietin (EPO) – produced for red blood cell synthesis & release from bone marrow.
- Renin – produced for regulation of salt & water balance, and BP control.
- 1,25 dihydroxyvitamin D – released via parathyroid hormone to increase intestinal calcium reabsorption.

➢ **Gluconeogenesis** – a small amount during prolonged fasting.

Nephrons:

➢ The ***nephron*** is the functional unit of the kidney.

➢ There are 2 types of nephrons:
- Juxtamedullary nephron – spans both the cortex & the medulla.
- Cortical nephron – found in the cortex (outer layer of the kidney).

Structure of nephrons:

➢ Renal corpuscle – made up of the glomerulus & the Bowman's capsule

➢ Proximal tubule

➢ Loop of Henle

➢ Distal tubule (distal to the glomerulus convoluted tubule)

➢ Collecting ducts (cortical & medullary collecting ducts)

Renal processes:

➢ **Glomerular filtration:** filtration of water & electrolytes (filtrate is cell & protein free). The entire filtrate volume is controlled by the *glomerular filtration rate*. Filtration occurs at the renal corpuscle.

➢ **Tubular reabsorption:** 99% of filtrate entering the tubule is reabsorbed back into the bloodstream.

➢ **Tubular secretion:** secretion of substances from the peritubular capillary plasma to the renal tubular lumen.

⇒ Substances are excreted in urine when filtered load + secreted load > reabsorption

Proximal tubule:

➢ **The basolateral membrane** drives atypical Na^+ reabsorption via the Na^+/K^+ ATPase pump (as the pump removes sodium from the cell, creating an osmotic gradient for Na^+ to move back into the cell).
  - 65% of Na^+ reabsorption occurs at the proximal tubule.

➢ **The apical membrane** reabsorbs Na^+ coupled with organic substances (e.g. glucose, amino acids, phosphate), as well as secreting H^+ ions (moving H^+ ions out).

Loop of Henle:

➢ **Descending segment:** permeable to only water. No ion/substance transport can occur here.

➢ **Thick ascending limb segment:** completely impermeable to water. Generates an interstitial osmotic gradient for urine concentration.

- **In the basolateral membrane,** the Na^+/K^+ ATPase pump drives atypical Na^+ absorption.
- **In the apical membrane,** Na^+ reabsorption is achieved via Na^+, K^+, $2Cl^-$ co-transport. There is an overall net reabsorption of K^+ and Cl^-.
- There is **intracellular cation reabsorption** via a positive lumen electrochemical gradient.