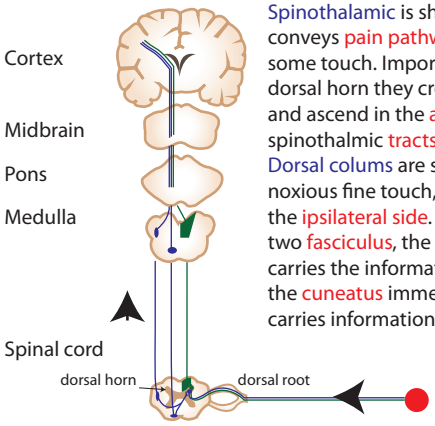
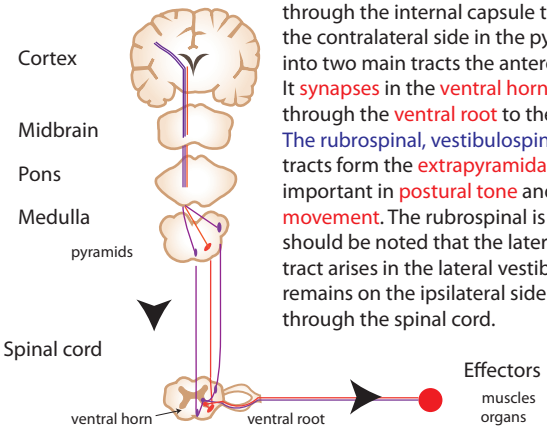
NERVOUS SYSTEM PHYSIOLOGY 2

Ascending sensory pathways The afferent nerve fibres enter the CNS via the spinal cord dorsal roots, the trigeminal and the vagus verve roots. After entering the spinal cord they ascend within the spinal cord to their final destination which is usually designated by the suffix There are six in total, only two are shown here the others being spino-reticuluar, -mesencephalic, -limbic, and -cervicothalamic.

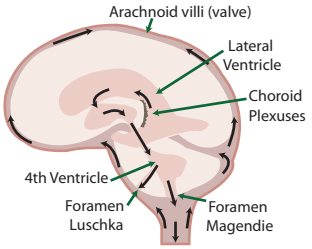


Spinothalamic is shown here in blue. It mainly conveys pain pathways as well as cold, warmth and some touch. Importantly following synapse in the dorsal horn they cross over to the contralateral side and ascend in the aterior (ventral) and lateral spinothalmic tracts.
Dorsal colums are shown in green and transmit non noxious fine touch, proprioception and vibration on the ipsilateral side. The dorsal column is divided into two fasciculus, the gracilis which is medial and carries the information from the toes up to T6 and the cuneatus immediately adjacent laterally which carries information from T6 and above.

Descending motor pathways from the cerebral cortex excite the spinal cord neurons both directly and indirectly. There are six descending motor pathways, two from the cerebral cortex (cortospinal and corticobulbar), and four from the brainstem (the rubrospinal, vestibulospinal, tectospinal and reticulospinal). The corticospinal tract (aka pyramidal tract) is the most important motor pathway and is shown here in purple. It originates in the motor cortex, travels through the internal capsule then crosses over to the contralateral side in the pyramids of the medulla into two main tracts the antero (ventral) and lateral. It synapses in the ventral horn, then travels out through the ventral root to the effector organ. The rubrospinal, vestibulospinal and reticulospinal tracts form the extrapyramidal tracts. They are important in postural tone and direct voluntary movement. The rubrospinal is shown here in red. It should be noted that the lateral vestibularspinal tract arises in the lateral vestibular nucleus and remains on the ipsilateral side during its course through the spinal cord.

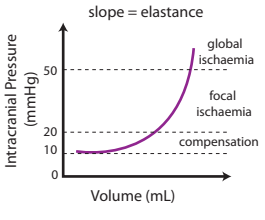


Cerebrospinal fluid is a specialised extracellular fluid located in the ventricles, the spinal cord central canal and the subarachnoid space that bathes the brain and the spinal cord. It has a total volume of 150mL in a male adult and is formed in two different places, the choroid plexus (70%) and the endothelial cells lining the brain capillaries (30%). The formation occurs by both passive filtration and active transport. This occurs at a rate of around 500mL/day, which equates to a turnover of 3-4 times per day. Its formation is dependent on the cerebral perfusion pressure, with the arterial pressure being most significant (production is unchanged with a modest increase in ICP). Under most conditions it assumed that the formation of CSF is constant. CSF is absorbed in the arachnoid villi and granulations and these act as valves with CSF escaping to the venous system but not backflowing, as the pressure increases the valves open wider. Whilst it is isotonic with plasma their compositions differ, CSF having minimal large components due to filtration, with negligable albumin, globulin and fibrinogen. It has increased Cl^-, and Na^+. CSF also has increased CO2 with a pCO2 of 50, leading to a pH of 7.32. CSF has less of the other major cations with less K^+, Ca^{++} and Mg^{++}. It has a number of important functions. Firstly it provides mechanical protection for the brain by making it bouyant and reducing its effective weight from 1400g to 50g. This prevents the brain from injury due to changes in position or due to acceleration and deceleration. The second function is maintaining a constant ionic environment and preventing sudden fluxes in ion composition. The CSF is also very important in acid base regulation, this is especially the case in terms of primary respiratory disorders. CO2, which diffuses across the membrane, changes to H^+ and HCO_3^- and acts on the central chemoceptors to adjust the respiratory rate. The CSF provides intracerebral transport for important substances such as amino acids and sugars. Finally it protects the brain by physically buffering increases in ICP by translocating to the extracranial space. CSF Flow is determined by the pressure in the lateral ventricle (normally 15cm H2O) and cilia direct flow towards the fourth ventricle. It exits the brain via two foramens, the Foramen of Luschka and Foramen Magendie.



Cerebral blood flow At rest the brain receives around 750ml of flow which equates to approximately 15% of total CO. It has a high myocardial consumption of 3-3.5 ml O_2/min/100g which when calculated using the weight of the brain (1400g) results in around 50 ml of oxygen which is 20% total consumption (remembering that total oxygen consumption is around 250ml/min). As always flow = pressure/resistance. In this setting it is the cerebral blood flow (CBF) = cerebral perfusion pressure (CPP) / cerebrovascular resistance (CVR). The CPP is normally MAP - CVP, however in pathological states where there is raised ICP a starling resistor model is set up. In this setting ICP>CVP and therefore the CPP = MAP -ICP. Extrinsic nerve and hormonal control have little influence on CBF. The cerebral circulation demonstrates a very well controlled autoregulation normally within the range of 50-150mmHg. It should be noted that in chronic hypertension this may be reset. The mechanism of autoregulation has not been fully elucidated, however it is believed to by primarily due to myogenic stretch factors. Local metabolic factors are significant also, but primarily from a regional cerebral flow perspective and may include adenosine, NO, H^+. The exceptions to this are arterial PCO_2 which demonstrates an almost linear relationship with CBF from 20mmHg-80mmHg, and to a lesser extent O_2 which when to oxygen content drops significantly (associated with a PaO_2 of less than 50mmHg which is on the steep part of the dissociation curve) there is an increase in CBF. Above this point oxygen saturations have little influence.

Intracranial pressure The intracranial space contains three compartments: brain tissue (80-85%), cerebrospinal Fluid (7-10%) and cerebral blood volume (5-8%). Intracranial pressure is determined by the total volume of each because the cranial vault is not distensible. The normal intracranial pressure is between 5-15mmHg. The Monroe-Kellie hypothesis states that for ICP to remain normal, an increase in any one of the volumes must be matched by a decrease in another. Brain tissue volume comprises mainly of ECF and ICF, CSF volume is determined primarily by the ration of production to absorption, and CBV is the sum of the arterial and venous blood volumes. The relationship between volume and pressure in the brain can be represented on an elastance curve (change in pressure/change in volume) which is the iverse of compliance. Initially CSF is displaced and this acts as a physical buffer to pressure changes but eventually there is a sharp rise in pressure with ongoing increases in volume.



Sleep is an essential, readily reversible physiological state characterised by unconsciousness, reduced muscle tone, analgesia, amnesia, respiratory and autonomic disturbances and dreaming. There are two main states of sleep, non rapid eye movement (NREM) sleep and REM sleep. NREM sleep is also known as slow wave sleep. It is a deep restful sleep and is characterised by decreases in peripheral vascular tone, blood pressure, respiratory rate, and metabolic rate. Slow wave sleep is brought about by the inhibition of the midline pontine and medullary nuclei (raphe nuclei). NREM sleep is divided into four stages. During progression through the stages the EEG becomes more synchronised and slows and the person becomes more difficult to rouse (stage 4 is the most difficult). REM sleep (paradoxical or stage 5) is distinct from slow wave sleep because the brain becomes quite active, skeletal muscle contractions occur and the EEG resembles rapid low-voltage, irregular (desynchronised) activity which is similar to alert humans. REM sleep lasts for 5-30 minutes and occurs at approximately 90 min intervals. This period of sleep is characterised by decreased muscle tone, irregular heart rate and respiration and increased barin metabolism by up to 20%. Natural sleep and anaesthesia are share many similarities, but they are clearly distinct. Both are characterised by unconsciousness, analgesia, amnesia, and atonia (in REM sleep). The EEG in sleep is characterised by predictble rhythmic variations generated endogenously. The effects of anaesthetics on the EEG are agent and dose dependent, but can resemble the patterns observed during different stages of sleep. Natural sleep is characterised by autonomic variability, whereas most anaesthetics produce autonomic stability even in the face of painful stimuli. Finally in contrast to anaesthesia natural sleep is characterised by easy arousability and spontaneous movements.

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