THE NERVOUS SYSTEM

Spinal Nerves

- Mixed spinal nerves run from the spinal column, before separating into the dorsal and ventral primary rami
  - Dorsal is much smaller than the ventral, because it is much less things to control

Somites

- Derived form the mesoderm
  - Divided into scleroderm, myoderm and dermomyotome
    - Skeletal system, muscle and the skin, respectively

Level of Control of Muscles

- Cortical control can essentially manage activity in the whole body
  - However, we do not have to actively think about all the movements we are doing
- All muscles have a nerve, which are a mixture of motor and sensory
  - Sensory systems take information about tension, pressure and temperature etc. to allow feedback
  - Sensory systems are called muscle spindles

Ventral Horn Cells

- If ventral horn cells are stimulated, movement will be initiated
- Consist of a long axon which goes out to a series of muscle fibres
- These cells drive contraction of muscles
  - Information travels across a neuromuscular junction to trigger a contraction
    - The neurotransmitter in this instance is acetylcholine

Spinal Pathways

- White matter around the outside is conversed primarily of axons and cells which support axons
- Grey matter is where the cell body of the neurones reside
- Dorsal medial sulcus is at the back, and the ventral median fissure is the groove at the front
- Central canal runs through the spinal cord and is filled with CSF
- Nerve axons run up and down the spinal cord in bundles
  - Dorsal column conveys fine touch and proprioception
  - Lateral corticospinal tract carries movement information
  - Ventral corticospinal tract carries motor information to axial muscles
  - Lateral spinothalamic tract conveys pain and temperature
  - Anterior spinothalamic tract carries crude touch sense to the brain
    - Decussation of tracts known as the anterior white commissure

Dorsal Column - Medial Lemniscus Pathway

- Dorsal column conveys fine touch and proprioception
- Four nerve endings which may sense fine touch, which begin the pathway
  - Cell bodies for these sensory neurones sit in the dorsal root ganglion
  - These cells have an axon which runs in two directions
  - These neurones project from the body to the spinal cord
- Axons from limbs travels up through the dorsal column
- Pathway then ascends through the brain stem
  - In the medulla, there are two nuclei which are the targets for the dorsal column
  - At this point, the axons synapse and decussate
- After this point, they synapse in the thalamus
- First neurone exists in the dorsal root ganglion, second in the gracile nucleus in the medulla, then in the nucleus of the thalamus

Spinothalamic Tract

- Conveys the sensations of pain, temperature and touch
- Beings with nerve endings in the muscles sending information down the axon of a neurone
  - These neurones have cell bodies in the dorsal root ganglion
- Tract enters the spinal cord and synapses onto a cell body in the dorsal horn of the grey matter
  - Then decussates, before ascending
- Tract then ascends through the brain stem, before synapsing onto the thalamus

- Thalamus sends projections to the post-central gyrus
- Three neurone pathway:
  - First is in the dorsal root ganglion, second in the dorsal root of the spinal cord, and the third in the thalamus

Corticospinal Tract
- Pathway which conveys motor control
- This pathway arises from the pre central gyrus
- Two neurones present, one for the axial and one for the limb muscles
  - Leave the pathway by first travelling through the internal capsule
  - Then descends to the medulla, where about 70% of the fibres decussate (mostly limb pathway)
    - This point is called the pyramids
- After leaving the brain stem, these fibres run through the anterior and lateral corticospinal tract
- Fibres then synapse to a neurone in the anterior horn of the grey matter
  - Neurones in the cortex is an upper motor neurone
- Neurones in the anterior horn then project to the limb and axial muscles

Autonomic Nervous System
- Functions without us being conscious of it
- Also called the visceral nervous system
  - Comes from “viscus”, Latin for internal organ
- Present in both the central and peripheral nervous system
- Higher control is mostly controlled by the hypothalamus
- Generally involved with involuntary muscle
  - Consists of both the smooth muscle and cardiac muscle
  - Also involves glands, which are controlled by
- Nervous system dependent on a lot of feedback
  - When feedback goes to an organ, it is described as efferent
    - Stimulation of a visceral muscle can result in it being excited or inhibited
  - When it is going to the CNS from the PNS, it is afferent
    - A comes before E (like in the alphabet)

Sensations
- Sensations arising from internal organs hardly ever reach conscious level
  - However, internal organs are sensitive to threatening events, such as pressure, stretching or ischaemia
  - Pain from internal organs cannot really be distinguished
  - Also cannot be accurately pinpointed

Sympathetic and Parasympathetic Nervous System
- Parts of the autonomic nervous system; i.e. we do not control them
- Essentially have opposite effects on target organs
  - Sympathetic stimulates the heart to contract faster and more viciously, parasympathetic
  - Sympathetic stimulation allows the bronchi to relax to absorb more oxygen
- Functioning of an organ usually depends on balance of the sympathetic and parasympathetic systems

Control of Involuntary Muscles
- Autonomic pathways contain two neurones between the brain stem and the visceral structures
  - Skeletal muscles only have one
- The body of the first neurone is in the CNS, neurone two is outside the CNS
  - The axon of neurone 1 terminates at a ganglion, and the impulse is passed to the second neurone
  - The axon before the ganglion is called the pre ganglionic nerve fibre
- The pre ganglionic fibres of the sympathetic division come from the thoracic and lumbar parts of the spinal nerve
  - The exit of these neurones are called the thoracolumbar outflow
  - These fibres move to the sympathetic chain, which consists of ganglia
- Parasympathetic is much more simple, ganglia are close to the organs that they control
  - These nerve fibres then travel to target organs

LOCOMOTION

Bipedalism

- The ability to walk on two legs
- Recognised from Australopithecus afarensis right through to Homo sapiens
- One of the most important developments in the hominin lineage
- Using only two limbs, in humans they are the hind limbs
  - Bipeds need much longer hind limbs, which enables us to stride efficiently
  - Striding is the putting of one limb behind the axis of our hip

Reasons for Bipedalism

- Characteristic of hominins for the last 5-6 million years
- All people walk very differently because we develop it individually
- All walking is habitual, upright, bipedal striding
- We are fully committed to bipedalism, rather than incidental bipedalism which occurs in apes and other animals
- Bipedalism predated the expansion of brains by millions of years
  - Therefore, Darwin's theory of freeing our hands to get bigger brains is wrong
  - Other reasons include:
    - Adaptation to wading life, carrying things, to threaten, as a sexual display and to peer over long distance
- Thermoregulation is a motivator for running
  - Research indicates that when standing upright you have less solar heat, more breeze, etc
- Energy efficiency is the strongest motivator for specific bipedalism
  - Heat regulation and water conservation contribute to energy efficiency
  - For each molecule of glucose metabolised, heat is produced and water is consumed
  - We need water to keep us cool etc.
  - We use almost the same number of calories lying down as we do standing up
  - Human method of walking around is 75% more efficient in energy

Adaptations of Bipedalism

- Around the late Miocene climates started drying (7.2-5.3 mya)
  - Caused a movement from an arboreal to a terrestrial lifestyle
  - When spending 70% of time on the ground, it becomes more efficient to develop bipedalism than it is to conserve arboreal traits
- Bipedalism also minimises the energy cost of finding good fuel
  - Development of brain means a better memory, means you can find food easier
- Walking in open savannah pays to have a long striding motion and good feet

Running as a Biped

- Humans are relatively unstable and slow at sprinting
- When running, we use our legs as springs rather than pendulums
- Adaptation of nuchal ligament gives us a stable back and head when running
- Ridge is seen in homo but not in Australopithecus and Pans
  - Means we were likely better than them at running
- Greater gluteal muscles and bigger attachment areas on the iliac spine to allow for more stability

Cost of Transportation

- Metabolic cost of walking is minimal at about 1.5 m/s, which is similar for horses
  - However, horses will maintain this parabolic shape when running, humans' endurance running will become more efficient as speed increases
- We have adapted to being very efficient at endurance running likely to hunt for nutritious meals

Bringing the Support Under the Body

- Having limbs not under the body is not energy efficient
- Looking at all the most efficient locomotoers, all have the legs underneath the body
  - However, only humans have been able to balance the centre of mass underneath the head perfectly
  - This allows us to be very stable when we are walking and running and standing upright