THE BODY SENSES

The Somatosensory System

Somatosensory Transduction

- Tactile receptors:
    - Meissner's Corpuscles → superficial receptor which sits just under the epidermis where there's no hair on the skin, and selective to light touch.
    - Merkel's Disks → superficial receptor, lower than Meissner's corpuscles but still within the epidermis, and selective to light touch.
    - Ruffini's Corpuscles → deep receptor in the dermis, selective to pressure and vibration.
    - Pacinian Corpuscles → deep receptor in the subcutis, selective to the stretching of the skin.
- Thermoreceptors → "free nerve endings"
    - Warmth fibres - signal an increase in skin temperature.
    - Cold fibres - signal a decrease in skin temperature.
- Proprioception/Kinaesthesia
    - Muscle spindles → respond to muscle length and rate of stretch.
    - Golgi Tendon Organs → respond to muscle tension.
    - Joint receptors → respond to joint position.

Somatosensory Hierarchy

Two routes to the brain:

- Spinothalamic pathway → carries relatively slow temperature signals from free nerve endings.
- Lemniscal pathway → carries relatively fast signals from mechanoreceptors (touch, proprioceptors).
- The difference between the two pathways is because the lemniscal pathway is much more myelinated.
- Both pathways have branching circuits in the spinal cord that mediate reflex responses.

Cortical Organisation

- Primary somatosensory cortex is a thin strip running over the top of the head (ear to ear).
- Somatotopic organisation → bits next to each other on the body are represented next to each other in the cortex.
- Cortical magnification → some body parts (lips, hands) occupy a much greater cortical area than others.
    - The Somatosensory Homunculus → illustrates somatotopic organisation, and cortical magnification.

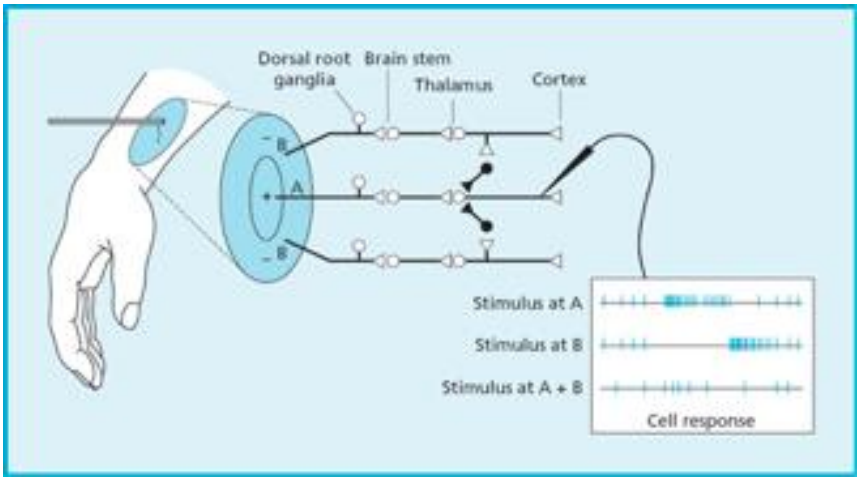
Discrimination: Two-Point Acuity

- Differences in perceived touch, the ability to discern that two nearby objects touching the skin are truly two distinct points, not one.

- Using a Yes/No or 2AFC procedure → a pair of calipers is placed on the skin surface, subject reports whether they feel 1 or 2 points.
- Calipers adjusted until subject can report the presence of points reliably (discrimination threshold or JND).
- Variation in acuity with body location mirrors cortical magnification.

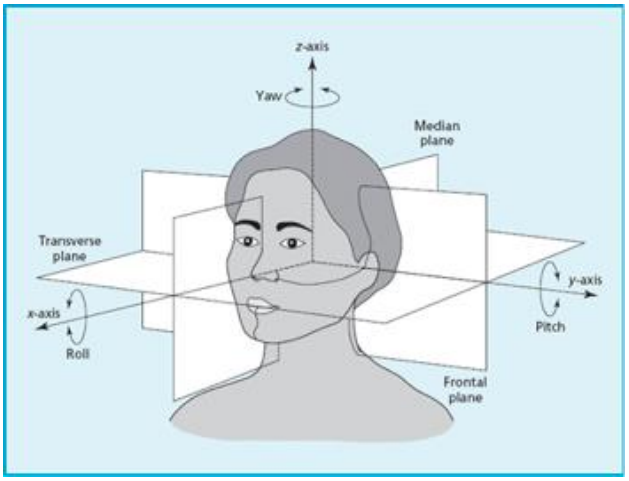
Selectivity: Cortical Receptive Fields

- Receptive fields → the area wherein touch affects activity in a given cell - each cortical cell responds to stimulation in a small area of the body surface.
- Centre-surround antagonism (aka 'Lateral Inhibition') → two concentric zones in the receptive field:
    - Cell activity is increased by stimulation in the centre (A), and firing rate is decreased by stimulation in the surround (B).
    - Stimulation in both areas results in hardly any change.
    - Amplifies responses to difference in stimulation within the receptive field.



The Vestibular System

- Signals head's acceleration and inclination relative to gravitational vertical.
- The body can move linearly along 3 axes (x, y, z) and can also rotate around them → x (roll), y (pitch), z (yaw).
- 3 semicircular canals → posterior, anterior and lateral (rotational acceleration)
- 2 otolith organs → utricle and saccule (linear acceleration and tilt).
- Stimuli for the vestibular system:
    - Linear acceleration along, or rotational acceleration around these axes.
    - Tilt with respect to gravitational vertical.
- Each are filled with fluid and a small patch of sensory hair cells → movement results in fluid flow, which displaces hair cells and leads to sensory responses.



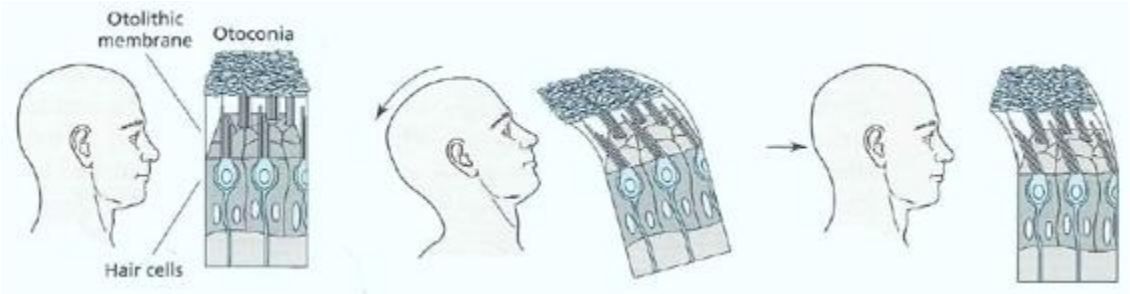
- Y-axis (nodding), Z-axis (no headshake), X-axis (head tilt).

Vestibular Transduction

- The utricle and saccule (linear acceleration and tilt) each contain a patch of hair cells (macula) covered in a gelatinous carpet (otolithic membrane).
- Each semicircular canal contains a bundle of hair cells called a cupula projecting across the canal.
- Head acceleration or static tilts deflect the hair cells away from their resting position, causing activity in the sensory nerves.

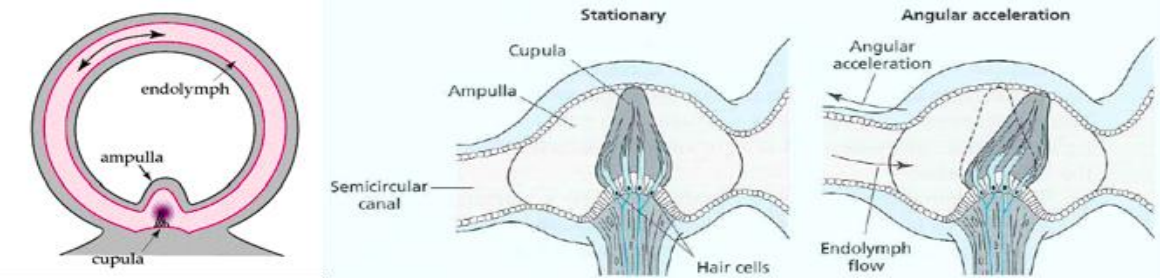
Otolith Responses to Linear Head Movement

- Either linear x-axis (forward) acceleration OR static head pitch (chin up) deflects the otolithic membrane, triggering responses in the underlying receptors (same for y-axis and roll) → equivalent stimuli.
- Receptors are arranged on a horizontal otolithic membrane in the utricle, but on a vertical membrane in the saccule.
    - Each respond to motion in various directions along the flat plane of the otolithic membrane.
    - Between them, the pair of utricles and saccules will respond to *linear acceleration or tilt* along any axis.



Canal Responses to Rotational Head Movements

- *Rotational acceleration* causes fluid movement relative to the canals, as the fluids “lag behind” (due to inertia) the head/canal.
- Fluid deflects the cupula, causing responses in hair cells.



Vestibular Hierarchy

- Sensory nerve fibres from the hair cells project to the vestibular nuclei of the brainstem, then signals of four ways:

1. Vestibulo-cerebellar
    - Some direct projections from vestibular organs to cerebellum.
    - Movement feedback and posture (“keeping you upright and letting you know how your movements are translating into the changes in your body angle and attitude”).
2. Vestibulo-spinal
    - Reflexive balance, including limb movements.
    - Doesn’t necessarily have to go to the brain, can just go to the spinal cord.
3. Vestibulo-thalamic
    - Projects to cortex for balance perception.
4. Vestibulo-ocular
    - Compensatory and stabilising eye movements (vestibulo-ocular reflex VOR).

<u>Vestibular Perception</u>

- The oculogyral illusion:
    - Spin rapidly, then stop → illusionary movement of the body and of stationary object occur.
    - Due to inertia, fluid in the semicircular canals decelerate more slowly than the canal when spin stops.
    - The resulting shear is in the opposite direction to that produced by the original rotation.
- The oculogravic illusion
    - When the body undergoes linear acceleration, an illusory impression of body tilt occurs.
    - Linear acceleration and static head tilts both trigger responses in the otoliths.