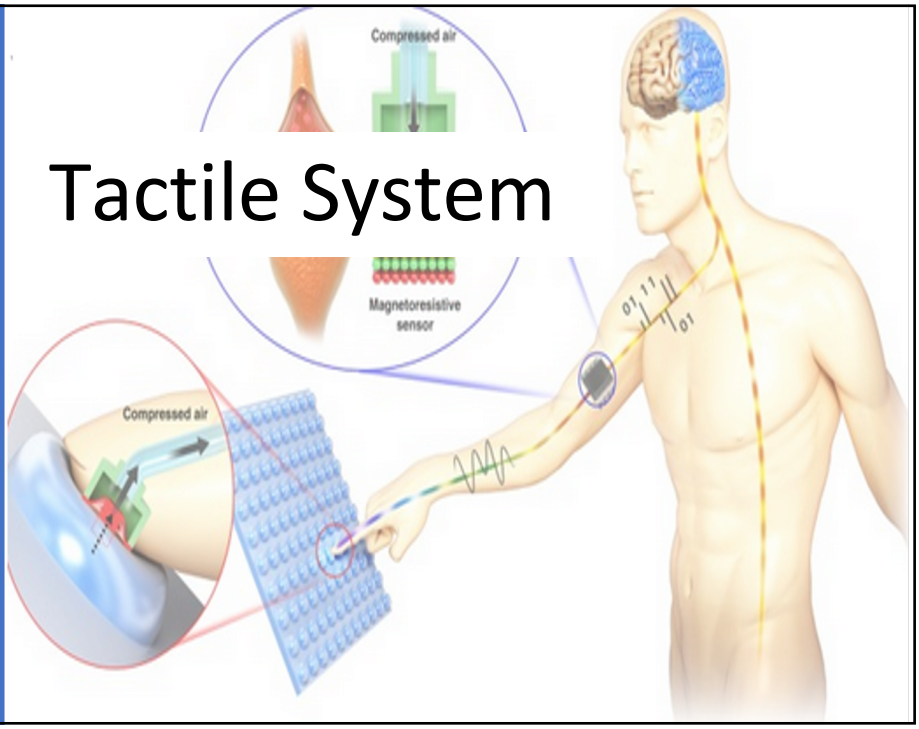
Tactile System

- Charlotte
- Nikki
- Noelia
- Sarah



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Learning Outcomes

1. Explain the breadth of functions of the sensory system and consider this relationship to people's participation in everyday life.
2. Describe and explore the development of the sensory system and consider its impact on performance in everyday life, across the lifespan.
3. Describe the structure and function of the sensory system, including the receptors, pathways (including relevant nuclei) and highlight and consider relationships with other sensory inputs en route to the cortex.

2

Welcome to the Neuroscience of Touch

https://youtu.be/FdAgrqocP40

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Development of Touch

Sense of touch develops in the womb

- 8 weeks Touch receptors in face – nose and lips
- 12 weeks Touch receptors – genitals, palms and soles of feet
- 17 weeks Touch receptors – Full abdomen
- 32 weeks Full tactile system developed. Sensitive enough to feel a single hair brush past the skin

Although babies have the sense of touch/pain they can't make sense of it until 29/30+ until the neuro pathways connect with the brain.

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Tactile During The Lifespan

Infancy

- There is significant evidence for the developmental importance of social touch in infancy, and early experiences with touch throughout the developing brain
- In humans, 65% of face to face interactions between mothers and infants involve touch communication, which is associated with immediate reductions in both behavioural (Stack and Muir, 1990) and physiological (Feldman et al., 2010) response to stress.
- The quality of the touch also matters, with gentle stroking touch generating more smiling in infants than static touch (Jean et al., 2009;), and infants as young as 9 months demonstrating decreased heart rate and increased engagement in response to pleasant, CT-targeted touch (Fairhurst et al., 2014).
- Observational evidence when parents stroke their infants, that they spontaneously adopt a speed of touch consistent with CT stimulation (Croy et al. 2016)
- Skin-to-skin contact has analgesic effects in healthy neonate and promotes weight gain, shorter hospital stays and stronger neural response (Maitre et al., 2017)
- Infants as young as 5 months also use touch to communicate their emotional state to their mothers 6-month old infants of mothers with depression show significant self-touch, interpreted as a compensatory behaviour for reduced positive touch from their mothers (Moszkowski and Stack, 2007).
- MRI studies suggest that suckling stimulation engages neural reward systems to a degree that outpaces cocaine administration (Febo, 2011;Ferris et al.,2005), and that this effect is likely mediated by oxytocin (Febo et al.,2005). Thus, even during the first few months of life, there is a reciprocity and an active component of social touch experience that shapes social, communication, and cognitive development in the months and years to come.
- Lack of social-sensory input has severe developmental consequences throughout the lifespan. Infants who are deprived of touch delivered by caregivers, or who avoid it, are at higher risk for sensory processing problems (Wilbargeret al., 2010)

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Tactile during the lifespan

Toddler and childhood

- Social touch continues to influence brain development beyond infancy
- Toddlers gain mobility, the parent-child touch expands to include more kinds of pragmatic touch such as postural repositioning and support, as well as more complex and frequent grooming touch, maintaining social relationships is mediated by the reinforcing properties of touch-related oxytocin and endogenous opioid release (Bai et al., 2016)
- Touch within the nuclear family is a primary predictor of children's sustained expression of positive emotions. Social touch plays a central role in play, a study found that the frequency of maternal touch during a play session between mothers and their five-year-olds was associated with the strength of connectivity of the posterior superior temporal sulcus and other nodes in the social brain (Brauer et al., 2016)
- The pattern of neural responses to CT-targeted touch appears similar in school-age children as in adults, including posterior insula and posterior superior temporal sulcus responding in young children. Response intensity appears to increase with age between early childhood and adulthood, suggesting that the circuitry for social touch continues to mature as the brain develops (Bjornsdotter et al., 2014)
- A study on behavioural effects of physical touch from non-familial adults on primary school children's behaviour, showed a friendly touch from an experimenter increased the likelihood of a child delaying gratification by complying with the request to wait for permission before eating a piece sweet in the classroom; positive touch from teachers has shown to increase on-task behaviour and decrease disruptive behaviour in young children (Leonard et al., 2014)

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Tactile During The Lifespan

Adolescence and adulthood

- Response to social touch is heavily influenced by sexuality and romantic attraction that develops during this stage. Discriminative touch abilities decline from the age of 18, perceived pleasantness of CT-targeted touch continues to increase into the ninth decade of life (Sehlstedt et al., 2016)
- CT-targeted stroking touch that is non-romantic recruits neural networks involved in social cognition and a broader reward

Social touch and disordered development: autism

- Children with autism exhibit irregular behavioural responses to touch which are strongly linked both with the core clinical symptoms of the disorder and with biomarkers such as distinct epochs in the somatosensory neural response white matter pathways (Pryweller et al., 2014), and genetic variants that increase serotonin transporter function (Schauder et al.,2015). Experimenter-delivered affective (pleasant and unpleasant) touch to children with autism elicits defensive reactions that are more severe in CT-innervated somatotopic regions (face and arm) than in non-CT-innervated regions (palm) (Cascio et al., 2016). A direct comparison of neural responses to CT- versus non-CT-targeted touch in children with autism suggests a dichotomous response, with reduced response in widespread social-affective brain networks to CT-targeted touch, and enhanced response in primary somatosensory cortex to non-CT-targeted touch (Cascio et al., 2016)
- Social touch is altered in autism both hypo-responsiveness and hyper-responsiveness to social touch may result in reduced input (occurring naturally or resulting from defensive/avoiding behaviours) that alters the trajectory of the developing social brain starting in infancy. Given the fundamental importance of social touch for infant's formation of secure attachment, cognitive and linguistic development, social reward, and emotion regulation, these differences have far-reaching effects, and refining early intervention on sensory features is paramount.
- Social touch is dynamic, integrative, and firmly rooted in reward learning processes that shapes the developing brain and ultimately adult behaviour. Changes with mobility, independence, widening spheres of social influence, sexual maturity, and aging all impact the perceptual experience of social touch. The nature of the relationships, culture, and social context, create a highly complex, flexible platform in which the rich affective information conveyed through the skin exerts a powerful impact on behaviour through learning over a lifetime.

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Functions of Touch

Functions of touch in the Womb

- Feel the amniotic fluid across the skin
- Amniotic fluid in their throat triggers a swallowing response and they learn to swallow
- They suck their thumbs

Functions of the Tactile System:

- The only sensory system that interacts with subjects – **when you touch you are being touched.**
- How well we integrate other sensory systems is dependent on our first experiences with touch and we interpret them – comforting and safe, scary and uncomfortable

Romania

8

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Tactile discrimination

Perceptual Awareness:

- Shape Size Texture, temp, weight
- Differences in elements of the things being touched
- Known/unknown – recognition safe not safe
- helps inform and refine information about the environment /our actions. "Touch is our last system of defence"
- Video

Body Recognition:

- Development body scheme
- Understanding where you begin and end in relation to the environment and objects
- How we use our body

Object Recognition:

- Feeling of familiar things / people
- Feelings of comfort vs excitement – depends on which neurons are firing
- Attaches emotions to things and places

Sweetie and Gloves

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Social Touch

- Attachment
- Early years experience of touch is vital.
- Power of touch has been removed over the years
- Premature Babies
- Massage for Pain
- Epidemic of Anxiety

Dr Jean Clinton and Tiffany Field www.youtube.com/watch?v=L58MrCQtKRo

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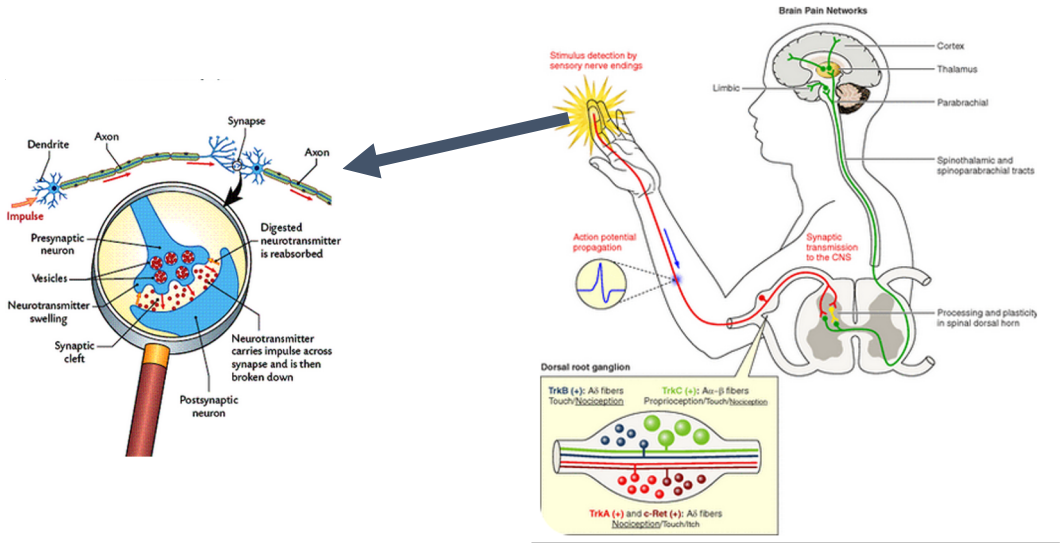
Sensory system: Overview structures



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Somatosensory receptors

We have somatosensory receptors located all over the body, from the surface of our skin to the depth of our joints. The information they send to the central nervous system is generally divided into four modalities:

-**Cutaneous senses** (senses of the skin),
-Nociception (pain, discomfort).
-proprioception (body position),
-kinesthesis (body movement)

The different types of information activate specific receptors that convert the stimulation of the skin to electrical nerve impulses, a process called **transduction.**

Transduction is the mechanism that converts stimuli into electrical signals that can be transmitted and processed by the Nervous System. Physical or chemical stimulation creates action potentials in a receptor cell in the peripheral Nervous System, which is then conducted along the axon to the CNS.

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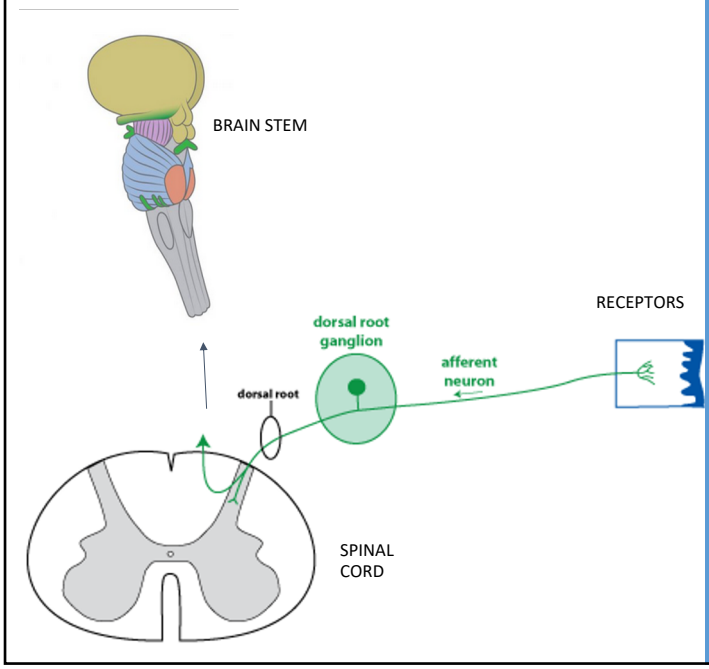

The nerve pathway - Step 1 (receptor- brain stem)

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Receptors

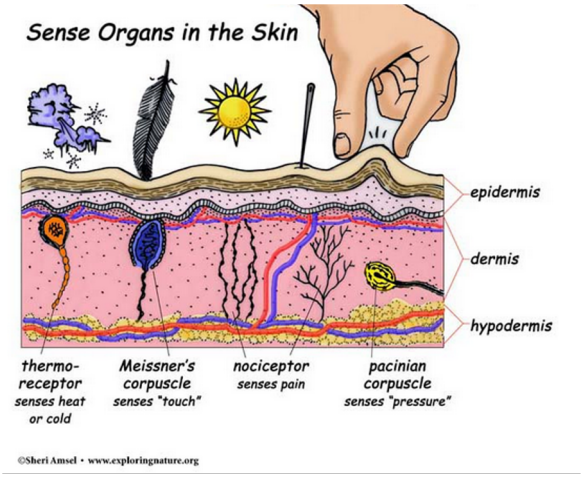
There are four main groups of cutaneous receptors in our skin:

-***Mechanoreceptors***, responding to mechanical stimuli, such as stroking, stretching, or vibration of the skin

-***Thermoreceptors***, responding to cold or hot temperatures

-***Chemoreceptors***, responding to certain types of chemicals either applied externally or released within the skin (such as histamine from inflammation).

-**Nociceptor**, stimulated by tissue damage



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Nerve fibers

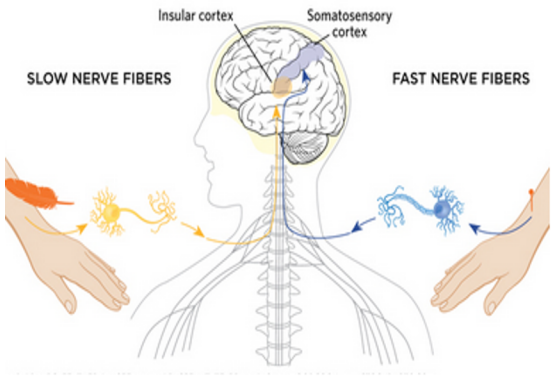
SLOW NERVE FIBERS

These respond to:

-Deep pain

-Temperature

-Pleasant touch



FAST NERVE FIBERS

These respond to:

-Fast Touch

-Pokes

-Pinpricks

-Pressure

-Vibration

-Spatial location

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How receptors works?

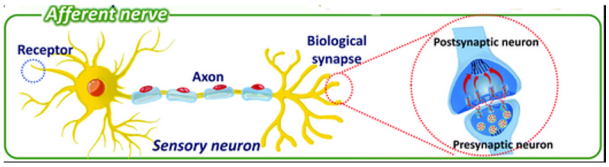

TABLE 8.2 Fibers That Link Receptors to the CNS

Sensory function(s)	Receptor type(s)	Axon type	Diameter (μm)	Conduction speed (m/s)
Proprioception (see Chapter 11)	Muscle spindle	Aα (A alpha)	13–20	80–120
Touch (see Figures 8.13 and 8.14)	Pacinian corpuscle, Ruffini's ending, Merkel's discs, Meissner's corpuscle	Aβ (A beta)	6–12	35–75
Pain, temperature	Free nerve endings; TRP2 Strong pain, burn	Aδ (A delta)	1–5	5–30
Temperature, pain, itch	Free nerve endings; TRPV1, CMR1 Mild pain, temp	C	0.02–1.5	0.5–2

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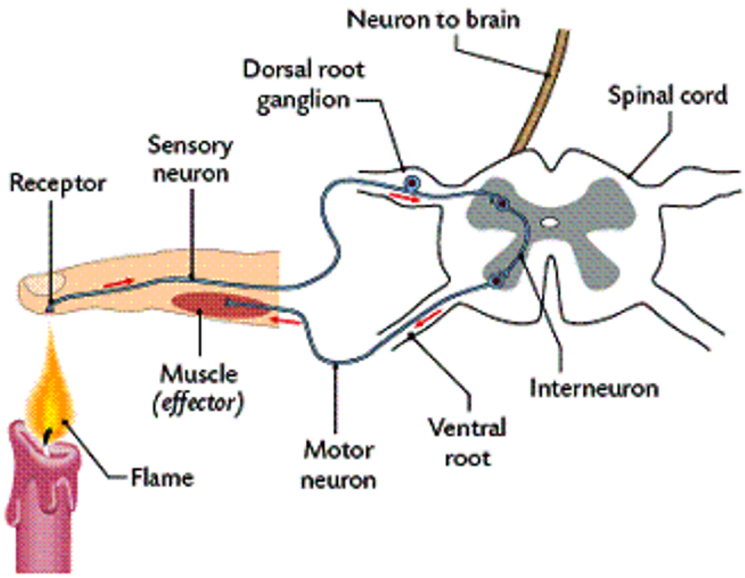

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2 primary ascending pathways for touch and pain:

1. **Dorsal Column Medial Lemnisal Pathway (DCML)** - Discriminative pathway associated with touch, vibration, 2 point discrimination and proprioception

1. **Spinothalamic Pathway** - Protective pathway associated with Pain, temperature and crude touch

In addition there is the **Trigeminothalamic pathway** - somatic sensation from the face. This pathway joins at the brain stem.

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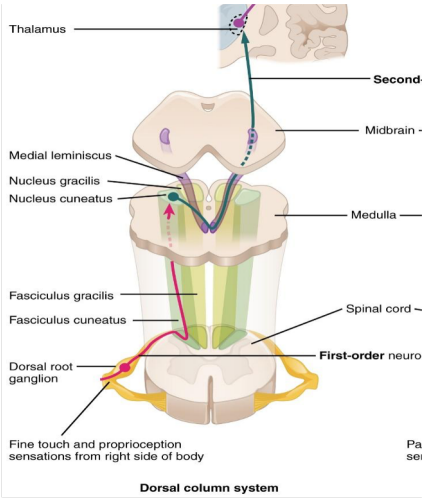
Tactile Nerve Pathway from Brain stem to Thalamus

The Dorsal Column-Medial Lemniscal Pathway (DCML)



- Transmits tactile, vibratory, touch-pressure and proprioceptive information.
- Fast, direct, 3 neuron pathway.
- ·The first synapse of the DCML is in the medulla.
- The second part of the pathway arises called the medial lemniscus.
- The medial lemniscus decussates (crosses over) to the other side of the brain before travelling up to the Ventral posterolateral (VPL) nucleus of the thalamus.

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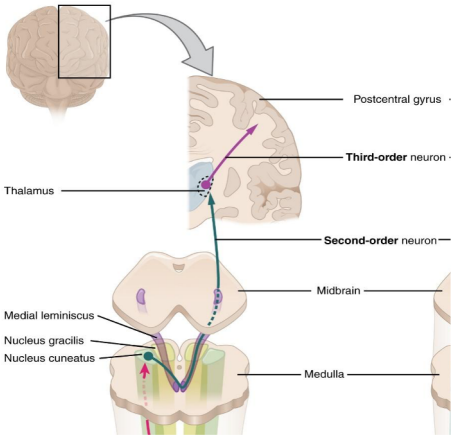
Tactile Nerve Pathway from Thalamus to Cortex

The Dorsal Column-Medial Lemniscal Pathway (DCML



- Thalamic neurons of the VPL then travel up to an area of the cortex called the postcentral gyrus in the parietal lobe.
- This contains the main sensory area for touch in the brain – the somatosensory cortex.
- · Specific parts of the somatosensory cortex receive signals from specific parts of the body – an arrangement known as the somatotrophic arrangement.
- · Information about the nature and location of the sensations are integrated in the somatosensory cortex, where the conscious perception of sensation begins.

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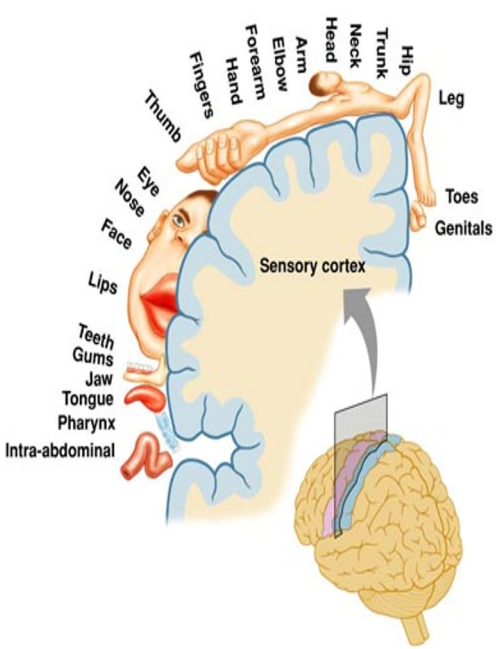

- · In the primary somatosensory cortex – the receptor density and location are represented by a distorted image of the body known as the **sensory homunculus.**

  (Penfield 1952 - electrical stimulation mapping)
- It has been shown that representation of the body at cortical level is flexible (Bundy and Lane 2020)
- Research has shown that areas representing specific parts of the body can be increased in size with intense use or decreased in size with disuse (Coq & Xerri, 1999:Mogliner et al 1993).

Sugar task!

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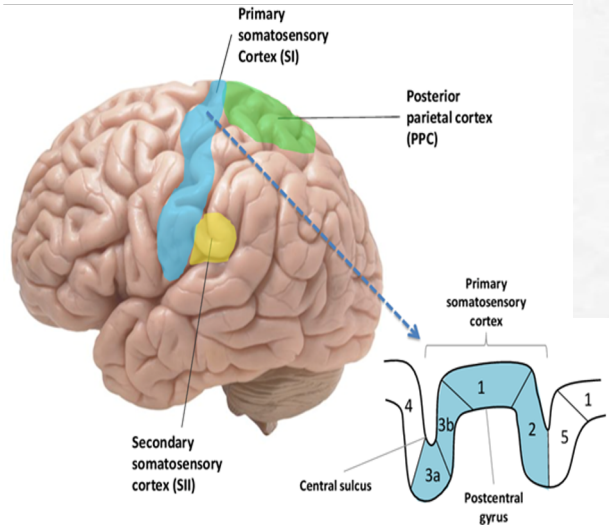

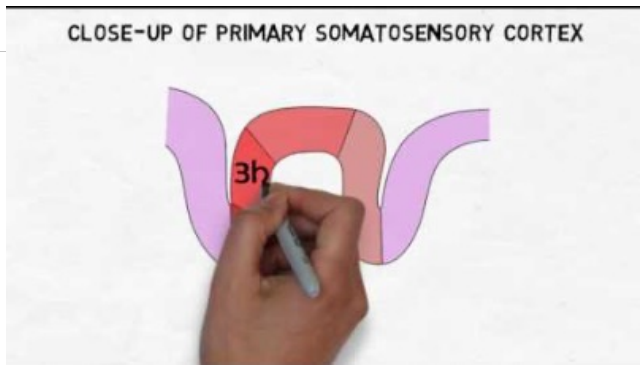

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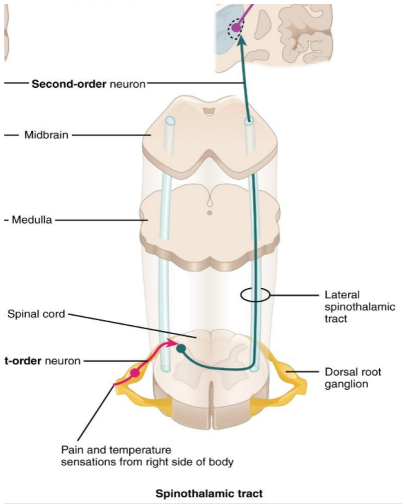
Tactile Nerve Pathway from Brain stem to Thalamus

The Spinothalamic Pathway



- This pathway conveys information about pain and temperature from the spinal cord to the brain.
- Upon entering the spinal cord the axons of the second order neurons immediately decussate (cross over to the other side) and ascend along the ventral surface of the spinal cord
- The spinothalamic fibres proceed through the medulla, pons and midbrain until they reach the ventral posterolateral (VPL) nucleus of the thalamus.

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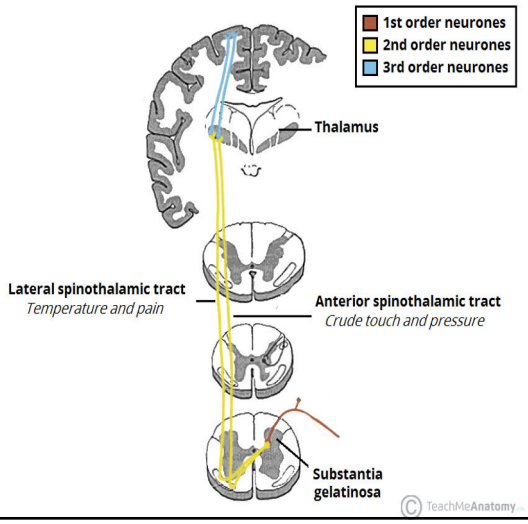
Tactile Nerve Pathway from Thalamus to Cortex

The Spinothalamic Pathway



- At the VPL they synapse with another neuron that carries information into the somatosensory cortex.
- Perception of pain relies on projections to the VPL of the thalamus where it may be interpreted as abnormal sensation of the skin (tingling, pricking, chilling, burning, numbness) or dull pain and pressure.
- Precise localisation of pain takes place in the cortex

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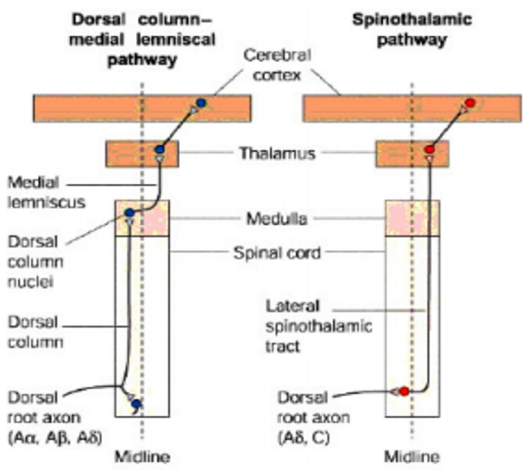
Touch vs Pain pathway



- Fine touch and proprioception (DCML) and pain and temperature (Spinothalamic) ascend the spinal cord on opposing sides.
- Clinical implications if there is an injury on one side of the spinal cord.
- What can you feel / not feel?
- Cannot feel pain or temperature below the level of injury on the opposite side BUT can feel fine touch and proprioception below the level of injury on the opposite side.
- If the touch signal came in on the SAME side of the injury you cannot feel touch below the point of injury on the SAME side, but you can feel pain and temperature below injury on the opposite side.

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Getting a balance between the Protective and Discriminative pathways

- In her book 'Sensory Integration and the child' (2005) - Jean Ayres discusses the role of the protective and discriminative tactile pathways and the importance of achieving a balance between them for occupational performance.
- Hypothesised imbalance could help explain tactile defensiveness and tactile reactivity. Ie too much protective / defensive activity and not enough discriminative processing.
- Also that proprioceptive input on the discrimination pathway could have an inhibitor role on the protective pathway eg rubbing the site of pain or using deep pressure to help modulate.
- The brain uses other sensations, particularly proprioception and vestibular input to balance the tactile sensory flow between the protective and discriminative pathways.

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Social Touch

The sensory pathway is a brain region called the primary somatosensory cortex, which is the first region to be hit by the experience of touch, it uses sequential stages of processing to gradually build up tactile images and perform the recognition of objects.

· The second pathway processes social and emotional information, determining the emotional content of mostly interpersonal touch using different sensors in the skin. This pathway activates brain regions associated with social bonding, pleasure and pain centres. The emotional context changes our physical experience of touch.

· Touch can actually feel physically different based on the social context of the encounter. An arm around the shoulder from a good friend, your partner, your boss or a person you don't like very much will change the way you experience that touch, even if your skin is being stimulated in the exact same way. This is because the emotional touch brain areas are getting information about the social context from other parts of the brain.(Linden 2017)

· What makes touch "social?" low-threshold unmyelinated peripheral afferent fibers (C-touch, or CT fibers). These fibers respond preferentially to gentle, slow, caress-like stroking and at temperatures near those of human skin (Ackerley et al., 2014). Importantly, CT activation is linked with positive affect: psychophysical ratings of touch "pleasantness" (Essick et al., 1999,2010) correspond closely to the firing frequency of these afferents (Löken et al., 2009), as do implicit measures of perceived pleasantness such as activation of the zygomaticushttps major muscles (needed for the upturning of the mouth seen in smiling)(Pawling et al., 2017). CT afferents are found only in hairy skin, but not the glabrous skin of the palm that is so central to discriminative touch. CT afferents project to the posterior insular cortex, rather than primary somatosensory (SI) cortex (Olausson et al.,2002) which is the primary target of myelinated fibers that carry the fine-grained signals used for discriminative touch and tactile manipulation of the environment. These properties further support a distinction of the CT system for affective touch from discriminative touch. The parallels between the effects of CT-mediated touch and oxytocin release on physiological arousal, pleasant feeling, and prosocial inter-action suggest CT fibers as a likely mediator of endogenous oxytocin(OT) release during affiliative and nurturing touch (Walker et al.,2017). Although OT has a central role in the neurobiology of close social relationships, it is only part of a complex system.

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Social Touch

https://youtu.be/ErWfdjdOah8

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