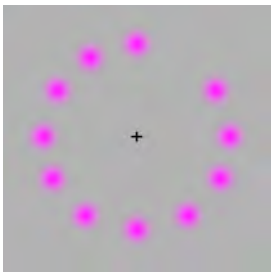
Announcements

• No class on Tues (office hours instead)

• Turn in your Journals either at the end of the class, or stop by my office before 12:20pm on Tuesday (Meliora 317)

• Exam 3 and Journals will be returned after Thanksgiving

• Remember, the final grade curve will ensure than more than a half of the class will have A and B grades



Touch

- Why touch?
- Detection of tactile sensations
- Cortical mechanisms of touch
- Plasticity of touch
- Proprioception
- Examples of touch research
- Super-touch in star nosed mole

Helen Keller (1880-1968)

Power of Touch

"My world is built of touch-sensations, devoid of physical colour and sound. Every object is associated in my mind with tactual qualities which, combined in countless ways, give me a sense of power, of beauty, or of incongruity....

All palpable things are mobile or rigid, solid or liquid, big or small, warm or cold, and these qualities are variously modified. **The coolness of a water-lily rounding into bloom is different from the coolness of an evening wind in summer, and different again from the coolness of the rain** that soaks into the hearts of growing things and gives them life and body. The velvet of the rose is not that of a ripe peach or of a baby's dimpled cheek....

What I call beauty I find in certain combinations of all these qualities, and is largely derived from the flow of curved and straight lines which is over all things."

Helen Keller (1880-1968)

Power of Touch

"My hand is to me what your hearing and sight together are to you.

In large measure we travel the same highways, read the same books, speak the same language, yet our experiences are different.

All my comings and goings turn on the hand as on a pivot. It is the hand that binds me to the world of men and women."

Ian Waterman

"How can one explain a total loss of touch & proprioception - a sense most people don't even know they have?"

He could feel nothing from the neck down. Nor could he feel his mouth and tongue. Not only couldn't he feel anything to touch, he had no idea of where the various parts of his body were without looking at them… he had no awareness of their position..

He could make an arm movement but he had no ability to control the speed or direction of the movement. If he turned his gaze away for a few seconds [away from looking at his arm] his arm would often come up and hit him or someone sitting close by.

He had difficulty chewing and had to be careful not to bite his tongue. He didn't know if he had chewed enough, or if the food was in the right place at the back of the mouth to be swallowed.

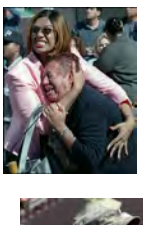
Touch, Metaphorically Speaking

- "out of touch with reality"
- "tangible evidence"
- "sense of touch"
- "ticklish situation"
- "tactful reply"
- "blunt statement"
- "handle with kid gloves"
- "thorny problem"
- "touchy person"
- "manual labor"
- "give me a hand"
- "hired hand"
- "handicap"
- "touché"

Touch In Our Everyday Lives

- walking
- typing, writing
- iPhone vs. standard phone
- lifting objects
- scratching
- identifying objects and people
- judging texture and firmness of objects
- eating and drinking (video example)

Touch In Our Social Lives





Touch In Our Social Lives

- holding hands
- caressing
- kissing
- hugging
- giving a hand
- therapeutic touch
- slapping
- shaking hands (no weapons)
- patting backs
- creating sounds by touch
  - applause
  - snapping fingers
  - tapping foot
- touch taboos
  - women touch women more than men touch men
  - cultural differences in touching
- subliminal touch
  - waitresses who touch get more tips

Importance of touch during development

- **Mother/infant bonding**
  - In many species, mothers initiate frequent tactile contact with infants, by licking, nursing and guiding - this stimulates production of growth hormone
  - classic studies by Harlow on importance of touch for normal development in primate infants (separation studies)
  - considerable literature suggesting that mother/infant contact is crucial in human bonding
  - premature infants grow more rapidly if stroked/massaged; also are more alert and tolerate noise

- **Mothers can recognize their own newborns by tactile cues alone (Kaitz et al, 1992 - *Developmental Psychology*, 28, 35-39)**
  - mother wore blindfold and mask over nose
  - stroked back of baby's hand using middle and index fingers, for no longer than 10 sec
  - did this with 3 asleep babies, one of which was the mother's
  - mother guessed which was hers
  - *Result*: women who had less than 1 hr contact prior to test performed at chance; those with more than 1 hour contact were significantly above chance (70%)
  - mothers report relying on texture and temperature

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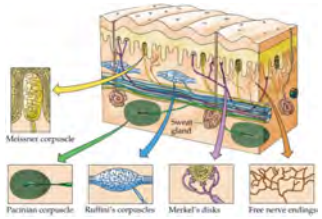
Skin

- Skin is the largest organ in the body, both by weight and surface area. In adults, your skin accounts for about 16% of your total body weight.

- The skin serves many purposes:
  - serves as a **barrier** to the environment
  - protects us from water loss, friction, wounds
  - uses specialized pigment cells to protect us from ultraviolet rays of the sun
  - produces vitamin D in the epidermal layer, when it is exposed to the sun's rays
  - helps regulate body temperature through sweat glands
  - helps regulate metabolism
  - has esthetic and beauty qualities
  - **houses touch receptors**

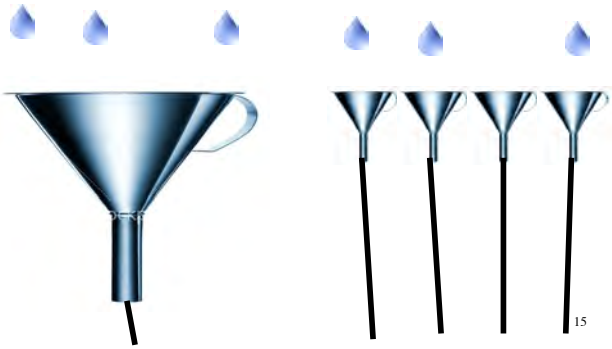
"General" Sense of Touch

- **Discriminative touch** - perception of pressure, vibration, and texture; mediated by **four** different categories of ***Mechanoreceptors*** in the skin.
- **Pain and temperature** - *free nerve endings* throughout skin, muscle, bone, and connective tissue register changes in temperature and presence of pain
- **Proprioception** - registration of tension and stress in muscles and joints, via receptors sensitive to stretching.



Receptive Field

Sensitivity vs. **Resolution**



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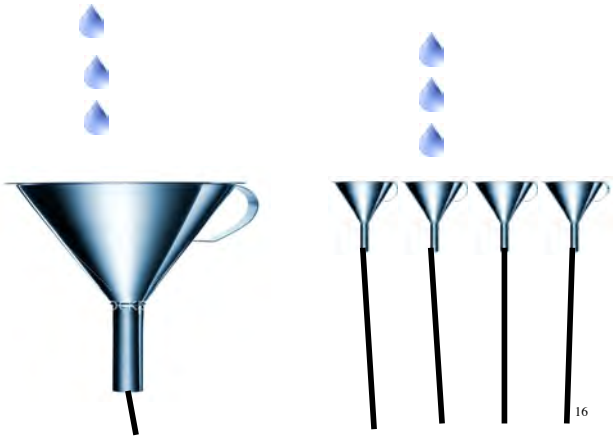
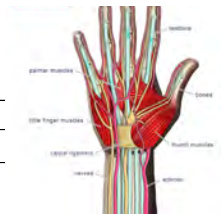


Discriminative touch: Types of Fibers

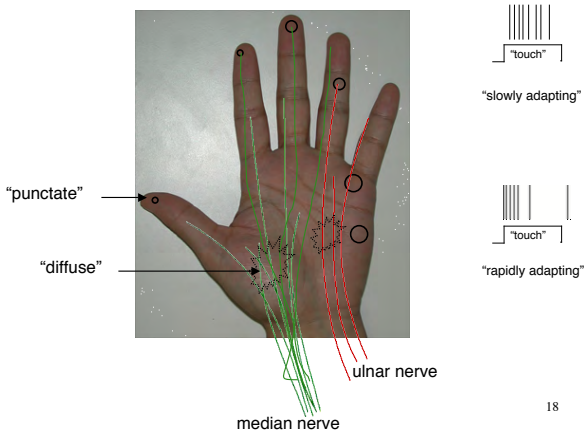
	Rapidly adapting	Slowly adapting
Punctate	RA-Punctate	SA-Punctate
Diffuse	RA-Diffuse	SA-Diffuse



- **Rapidly Adapting** (RA) - respond to changes in stimulation, but do not continue to respond to constant stimulation
- **Slowly Adapting** (SA) - respond to constant stimulation
- **Punctate** - small receptive fields with distinct boundaries
- **Diffuse** - large receptive fields with non-distinct boundaries

Sensitivity vs. **resolution**

Receptive Field: Sensitivity vs. resolution



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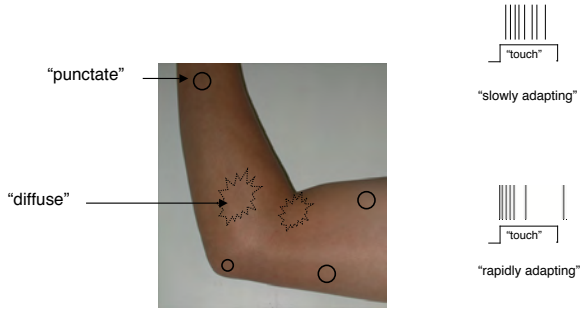
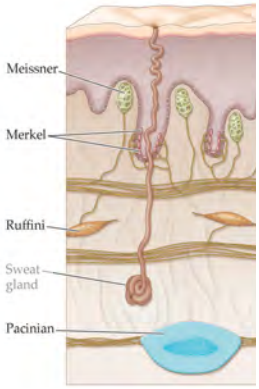


The nerve fibers enervate **four receptor types**

	Slowly adapting	Rapidly adapting
punctuate	**Merkel Disks** constant sources of stimulation over a small area such as if you were carrying a pebble (shallow)	Meissner Corpuscles respond best to active touch involved in detailed object exploration (shallow)
diffuse	Ruffini ending constant stimulation over a larger area also detects skin stretch (deep)	Pacinian Corpuscles extremely sensitive over a large receptive field blow gently on the palm of your hand (deepest)



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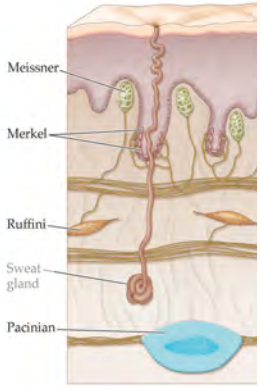

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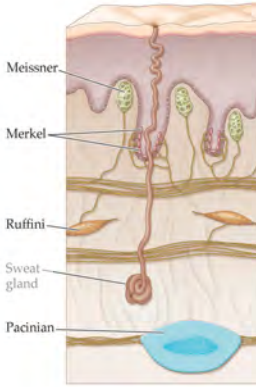

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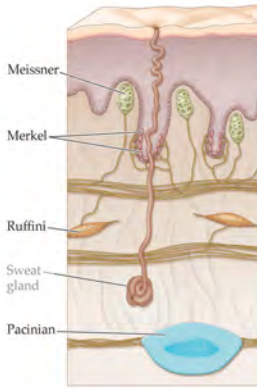
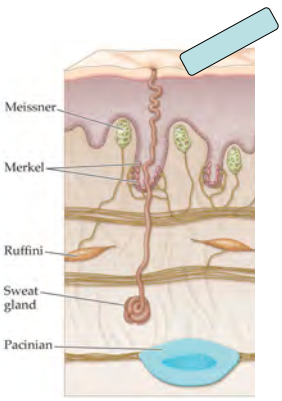


How this works?



Step 1: mechanical stimulus (e.g., pressure) deforms receptors' membrane.

Step 2: this starts a cascade of events that ultimately result in an action potential.

Case A: if the pressure is continuous, SA receptors (Merkel & Ruffine) keep "responding," while RA receptors adapt (Meissner & Pacinian)

Case B: if the pressure is intermittently applied, all receptor types "respond"

Case C: if the pressure is very localized (e.g., pen point), punctuate receptors respond (Merkel & Meissner)

Case D: if the pressure is distributed over a larger area of skin, diffuse receptors respond (Ruffini & Pacinian)

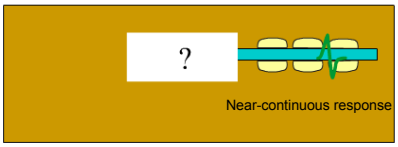
Why all this?

How this works?

In the brain, the same response often signals very different sensations. How do we know what the stimulus is?

Suppose that this is the response of an afferent that sends a signal to the brain.

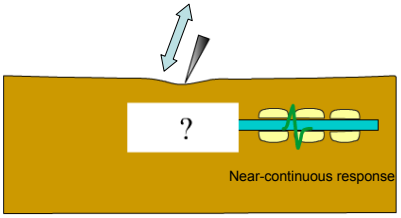
What is the stimulus?



How this works?

In the brain, the same response often signals very different sensations. How do we know what the stimulus is?

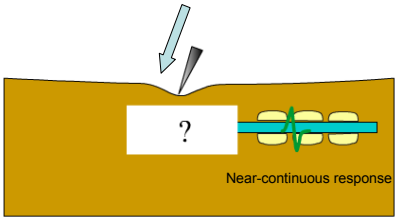
It could be a **RA** afferent activated by **vibration**.



How this works?

In the brain, the same response often signals very different sensations. How do we know what the stimulus is?

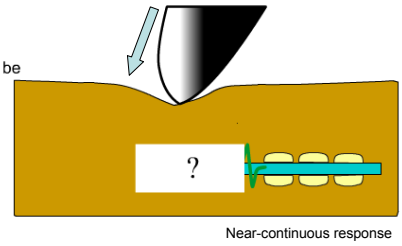
It could also be a **SA** afferent activated by a **steady pressure**.



How this works?

In the brain, the same response often signals very different sensations. How do we know what the stimulus is?

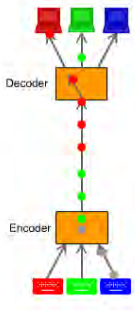
If the afferent comes from **deep tissue**, then it could be something **big**.



How this works?

In the brain, the same response often signals very different sensations. How do we know what the stimulus is?

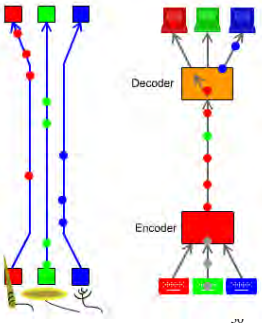
A similar problem occurs on the Internet.
When you use the Internet, your message, as well as those of many others, travels down a shared **common line**. To separate your message from that of others, each packet of information is given a **tag or label**. At the end of the line a decoder separates your packet from that of others.



How this works?

In the brain, the same response often signals very different sensations. How do we know what the stimulus is?

The sense of touch solves this same problem in a different way. It gives each type of touch sensor its own **private line**. This is called its **labeled line.** Because of this, there is **no** reason for **encoding and decoding** each packet of information. But you do need **lots of lines** in your spinal cord.



How this works?

In the brain, the same response often signals very different sensations.
How do we know what the stimulus is?

This is similar to **place coding** in the **auditory system**.

We know the **frequency** of a sound **not by how fast** a fibre is firing but by **which fiber** it is, i.e. where on the basilar membrane it is coming from.

Labeled lines illustrate an important principle as to how the brain codes information for touch and for the other senses.

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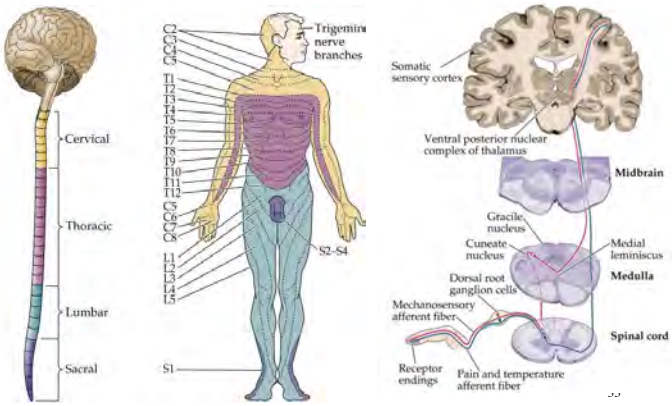
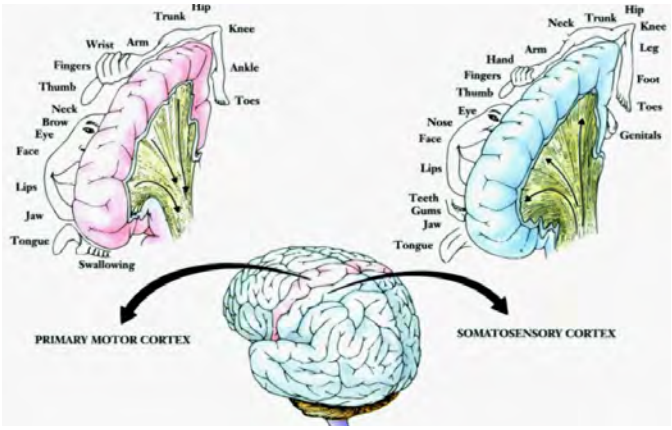
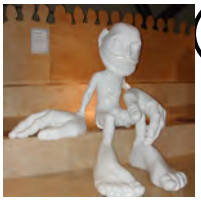
Touch Pathways to the Brain



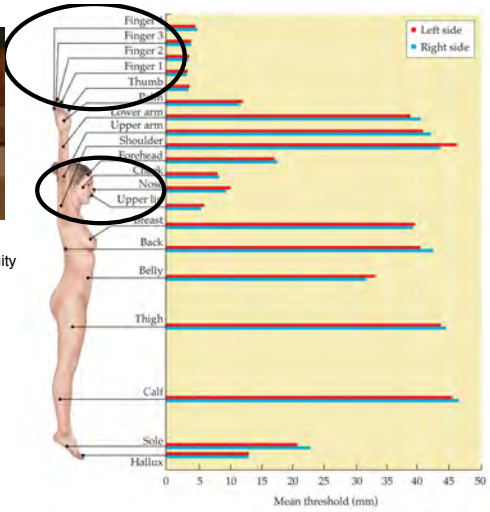
Touch Pathways to the Brain



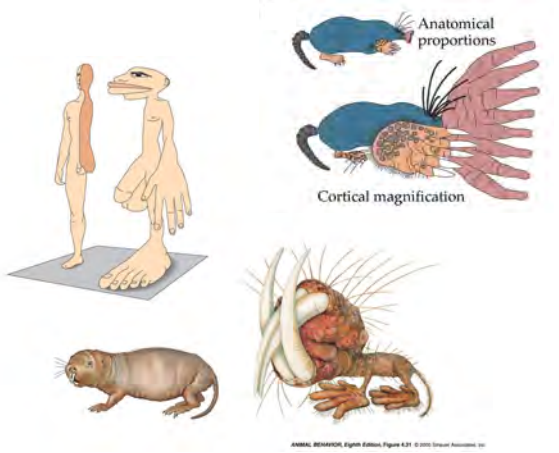
Cortical magnification -> The “Homunculus”



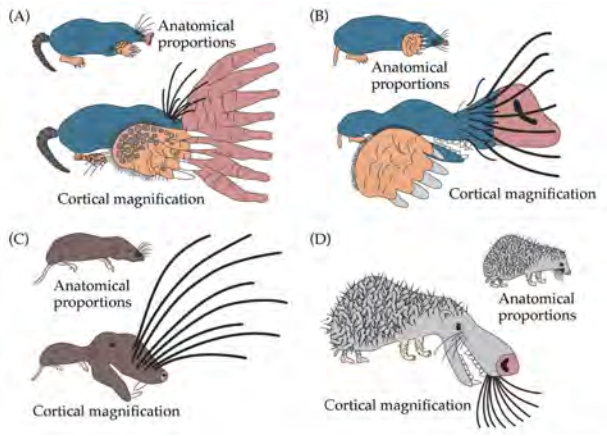
Cortical Magnification corresponds to greater acuity



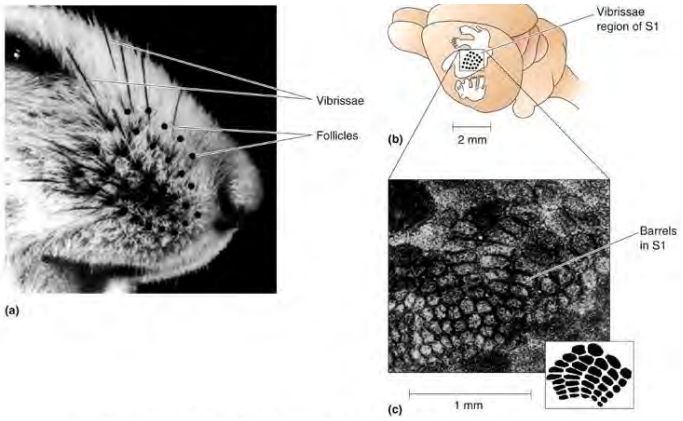
Relative cortical area devoted to different body regions (cortical magnification)



A = star nose mole; B = eastern mole; C = masked shrew; D = African hedgehog



Rat barrel cortex - whisker representation



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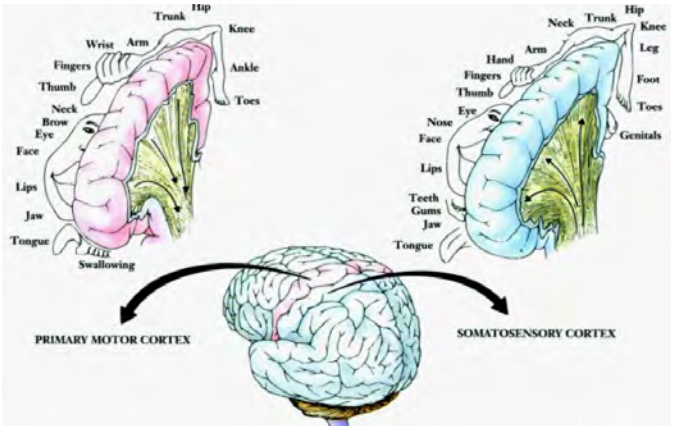
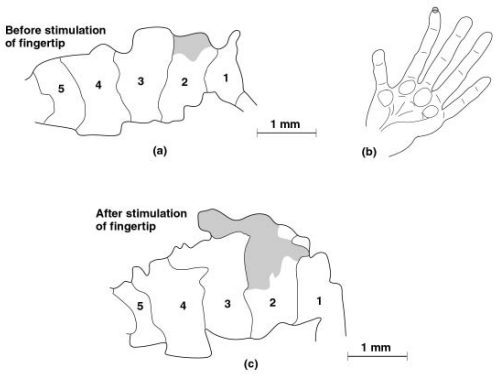
Touch Cortex = fixed or plastic?



Cortical Plasticity for Touch



Phantom Limb Phenomenon

"For the patients, long after the amputation is made, say they still feel pain in the amputated part. Of this they complain strongly, a thing worthy of wonder and almost incredible to people who have not experienced this.."

Ambrose Pare (French battlefield surgeon, 1510 - 1590)

"Look ye, carpenter, I dare say thou callest thyself a right good workmanlike workman, eh? Well, then, will it speak thoroughly well for thy work, if, when I come to mount this leg thou makest, I shall nevertheless feel another leg in the same identical place with it; that is, carpenter, my old lost leg; the flesh and blood one, I mean. Canst thou not drive that old Adam away?" "Truly, sir, I begin to understand somewhat now. Yes, I have heard something curious on that score, sir; how that a dismasted man never entirely loses the feeling of his old spar, but it will still be pricking him at times. May I humbly ask if it really be so, sir?"

Herman Melville (1819 - 1891), from *Moby Dick*

http://www.acponline.org/journals/annals/01jan98/phantom.htm

Phantom Pain

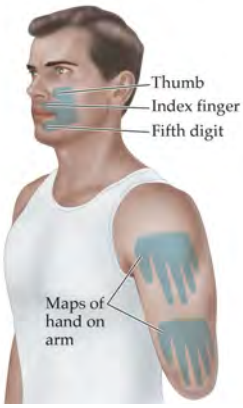
- After surgical removal of a limb, sensations resume in the limb
- In 90% of patients, the sensations are very painful
- In 60% the pain is excruciating: described sometimes as an arm on fire, being torn or punctured, great pressure

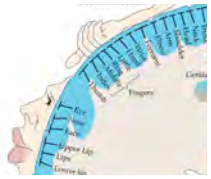
- Stimulating certain areas of skin (e.g., face) may aggravate phantom pain.
- Severing the nerve doesn't help. Blocking the nerve doesn't help. Removing the portion of the thalamus that relays the information to the brain doesn't help!

Phantom Limb Phenomenon

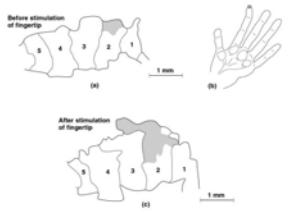
http://www.youtube.com/watch?v=1mHIv5ToMTM

Phantom Limb Phenomenon





The cortical areas for the face annex the cortical areas for the arm and fingers.



Phantom limb therapy: using **vision** to control touch

http://www.youtube.com/watch?v=gc3CmS8_vUI

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Proprioception: why we need it?

Muscle command

Automatic outcome sensor (proprioception)

Desired state

Compare outcome to desired state

Proprioception: why we need it?

Muscle command

Desired state

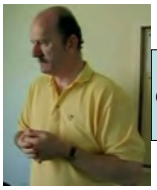
Compare outcome to desired state

Ian Waterman

http://www.youtube.com/watch?v=FKxyJfE831Q

Proprioception: why we need it?

Muscle command



Non-automatic outcome sensor (**VISION**)

Desired state

Compare outcome to desired state

Ian Waterman

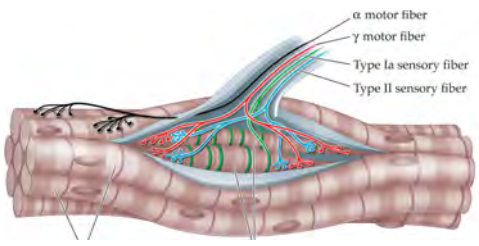
Proprioception

- The sensory system's detection and reception of movement and spatial position of limbs, trunk, and head
  - synonymous with the term "**kinesthesis**"
- Brian receives proprioception information from sensory neural pathways that begin in specialized sensory neurons known as **proprioceptors**
  - Located in muscles, tendons, ligaments, and joints
- Three primary types of **proprioceptors**
  - Muscle spindles
  - Golgi tendon organs
  - Joint receptors

Proprioception

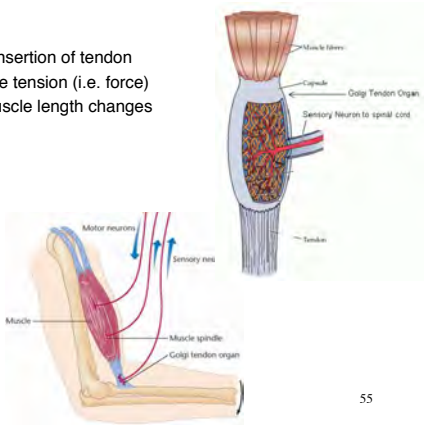
1. **Muscle spindles**

- In most skeletal muscles in a capsule of specialized sensory neurons
- Mechanoreceptors that detect changes in muscle fiber length (i.e. stretch) and velocity (i.e. speed of stretch)
- Function as a feedback mechanism to the brain to maintain intended limb movement position, direction, and velocity



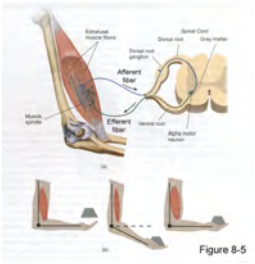
Proprioception

2. **Golgi-Tendon Organs**
- In skeletal muscle near insertion of tendon
- Detect changes in muscle tension (i.e. force)
  - Poor detectors of muscle length changes



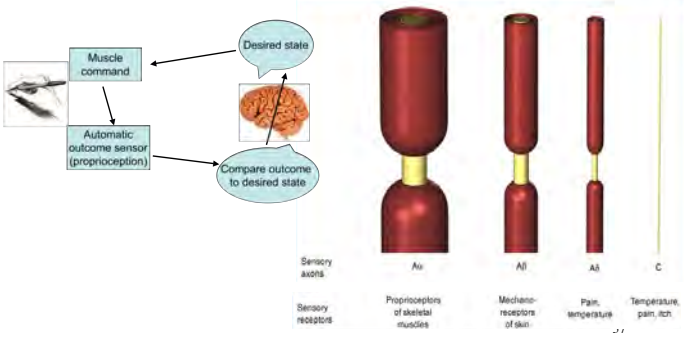
Proprioception

3. **Joint Receptors**
- Several types located in joint capsule and ligaments
- Mechanoreceptors that detect changes in
  - Force and rotation applied to the joint,
  - Joint movement angle, especially at the extreme limits of angular movement or joint positions



Peripheral Pathways for General Touch

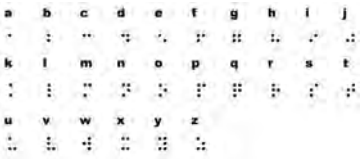
Importance of Axon Diameter & Myelination



Touch

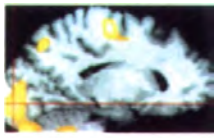
- Why touch?
- Detection of tactile sensations
- Cortical mechanisms of touch
- Plasticity of touch
- Proprioception
- Examples of touch research
- Super-touch in star nosed mole

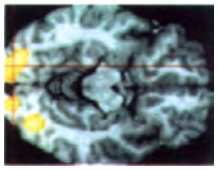
Touch Activates Visual Cortex in the Blind



http://www.afb.org/braillebug/thenamegame.asp

Lexical decision task: word or non-word?





Sadato et al (1996) Nature, 380, 526-528.

Rubber hand illusion

http://www.youtube.com/watch?v=sxwn1w7MJvk