

## Announcements

- Exam returned at the end of the class (grades are good)
- Journals are graded
- No Prof. Tadin office hours today (faculty meeting)
- Note reading changes:

11/22	Touch & Haptics	Ch 12: 309-313 (pain); 316-end
11/24	THANKSGIVING BREAK	
11/29	Chemical senses: taste/smell I	CS 14 Ch 15: 355-387, 390-400; 406-407 & page 410
12/1	Chemical senses: taste/smell II	CS 13



## Perception journals

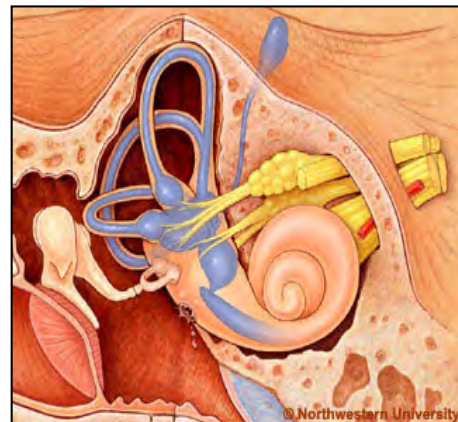
- Liz
- How I Met Your Mother
- backrests in Danforth
- Flaming Lips / Pixies / Mike Posner shows
- pirates and Myth Busters
- I-Doser
- Specific hungers
- Memory and smell
- music chills
- 2 Hours of "that sweet noise" everyone likes
- attention, attention, and attention

2

## Sensory systems "related" to touch

- Proprioception
- Balance
- Pain & Temperature
- Haptics

## Vestibular system



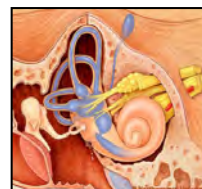
## Vestibular System

- Peripheral sensory apparatus: Semicircular canals & Otolithic organ
  - detects & relays information about **head orientation** and **head angular & linear acceleration** to the brain
  - orients the head with respect to gravity
- Central processing system
  - processes information in conjunction with other sensory inputs for position and movement of head in space
- Motor output system
  - generates **compensatory eye movements** and **compensatory body movements** during head & postural adjustments
    - E.g., vestibulo-ocular reflex (occulomotor reflex)
  - sense of orientation
  - detection of linear & angular acceleration

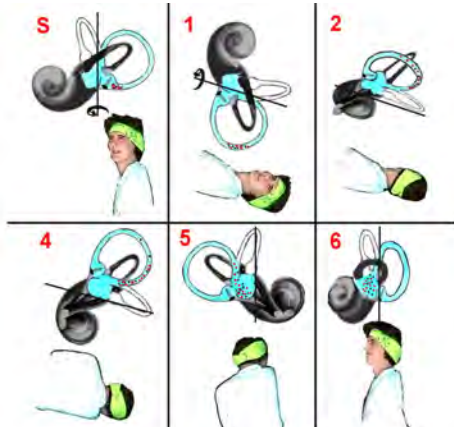


## Vestibular System

- Vestibular system detects movements and changes in head position
- **Semicircular canals**
  - right angles to each other
  - 1 for each major plane
  - detect rotational movements by using hair cells to sense fluid displacements
- **Otolithic organ**
  - detects linear acceleration & head orientation
  - otoconia crystals (think little rocks) stimulate hair cells in canals



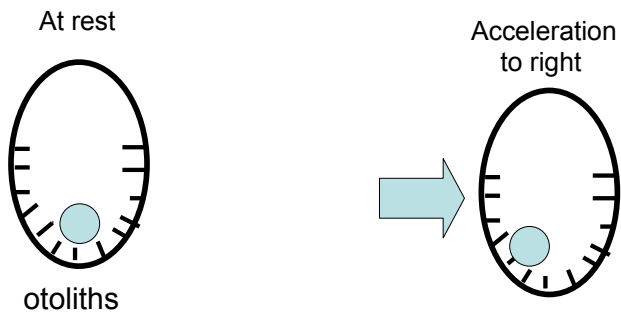
**Semicircular canals**  
detecting head rotation



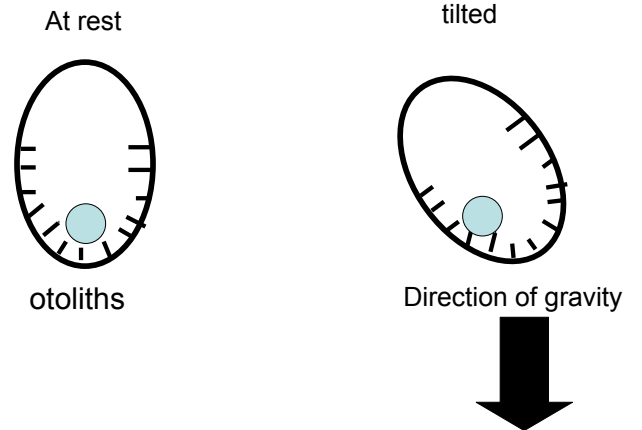
**Semicircular canals**  
detecting head rotation



**Otolithic organ**  
detecting head acceleration & tilt



**Otolithic organ**  
detecting head acceleration & tilt



Vestibular sensations & driving/flying simulation



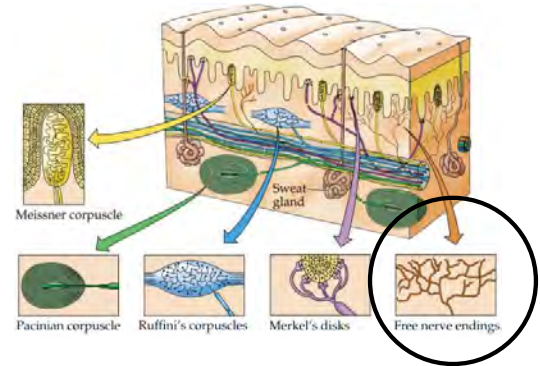
Vestibular sensations & driving/flying simulation



## Sensory systems “related” to touch

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## Pain & temperature



## Thermal Conductance

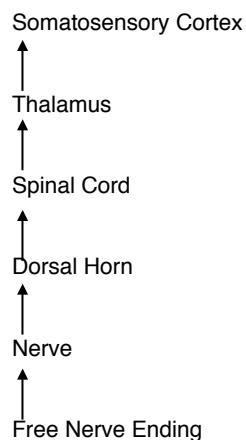
- A uniquely tactile object property
- **We DO NOT sense absolute temperature!**
  - BUT, the rate at which heat is gained or lost between the skin and an object.
- Metal objects, fluids etc. create a more extreme sensation of temperature than do other objects because heat energy is transferred more easily to and from them
- If a metal and a wooden block are both 150°, the metal block will feel hotter than the wooden block. Likewise for the same blocks at 0° the metal block will feel colder

## Dermo-optical perception



## Pain

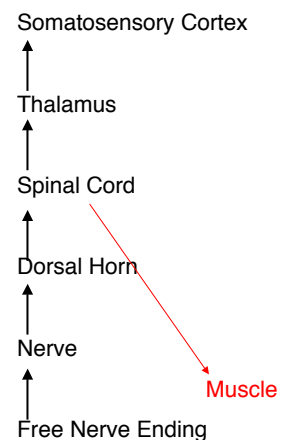
Full Pain Pathway  
Required for  
“conscious” pain



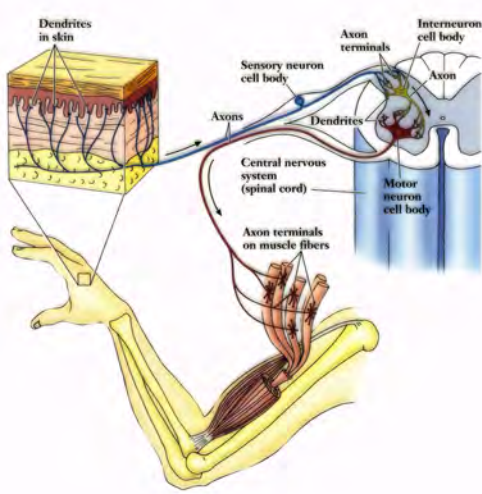
## Pain

### Pain Reflex

- Limb is pulled toward the body out of harms way
- Normal pain information continues to brain for more considered action

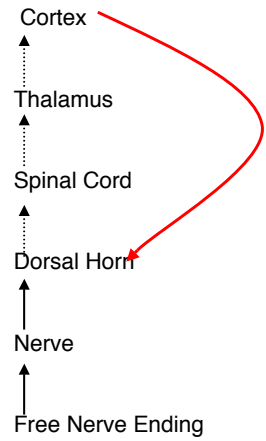


## Pain: The Reflex Arc



## Gaiting Pain

- Gate control theory of pain - pain is actively suppressed in emergency situations by messages sent from the brain to the Dorsal Horn
- This allows you to escape on a broken limb or with a gash
- Pain resumes when emergency is over



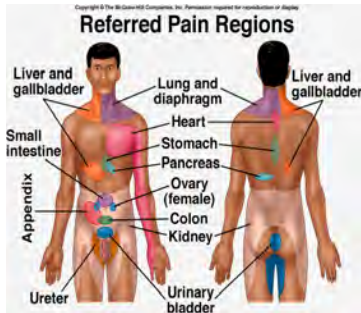
## Referred Pain

**referred pain** = pain that feels as if it is coming from some part of the body other than the part being stimulated.

Referred pain often arises in nerve pathways that carry impulses from skin areas that are stimulated often and organs that are not stimulated very often.

For example, when pain receptors in the heart are stimulated, the brain projects them as coming from the left shoulder and left upper limb because these regions and the heart share the same nerve pathways.

Since the brain is not accustomed to receiving pain impulses from the heart, the brain projects them as coming from the left shoulder or arm.



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## Putting it all together: Haptics

- **Haptics = Active touch**
- Haptic touch is the interaction of **proprioceptive** and **mechanoreceptive** information
- Haptics can detect gross features of objects form, mass, weight distribution, torque, ...
- Haptics allows us to determine the position of tactile features on an object relative to each other, e.g., Braille

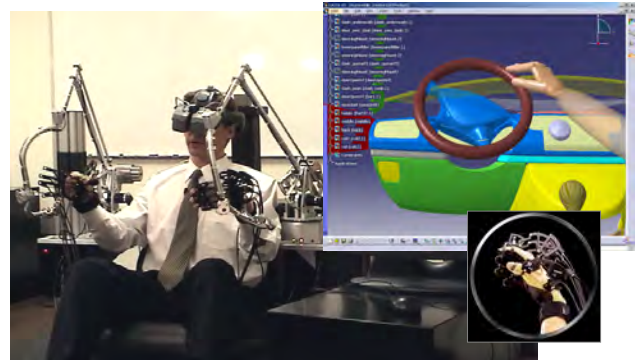
## Recognizing objects using haptics



## Haptics in Laparoscopy



## Haptics in Design & Simulation



## Interactions of Touch & Vision



## Neural basis of haptics

