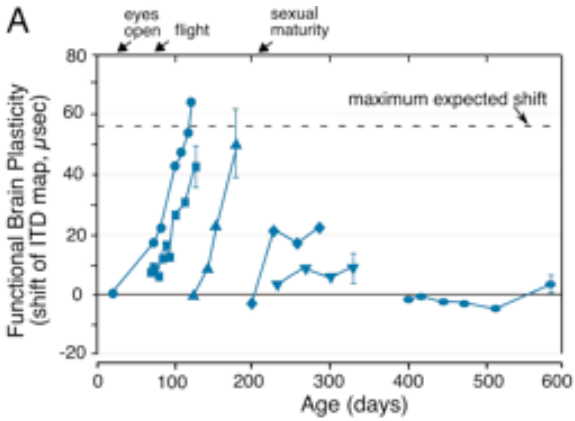
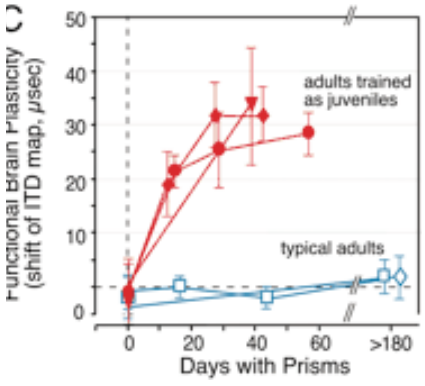
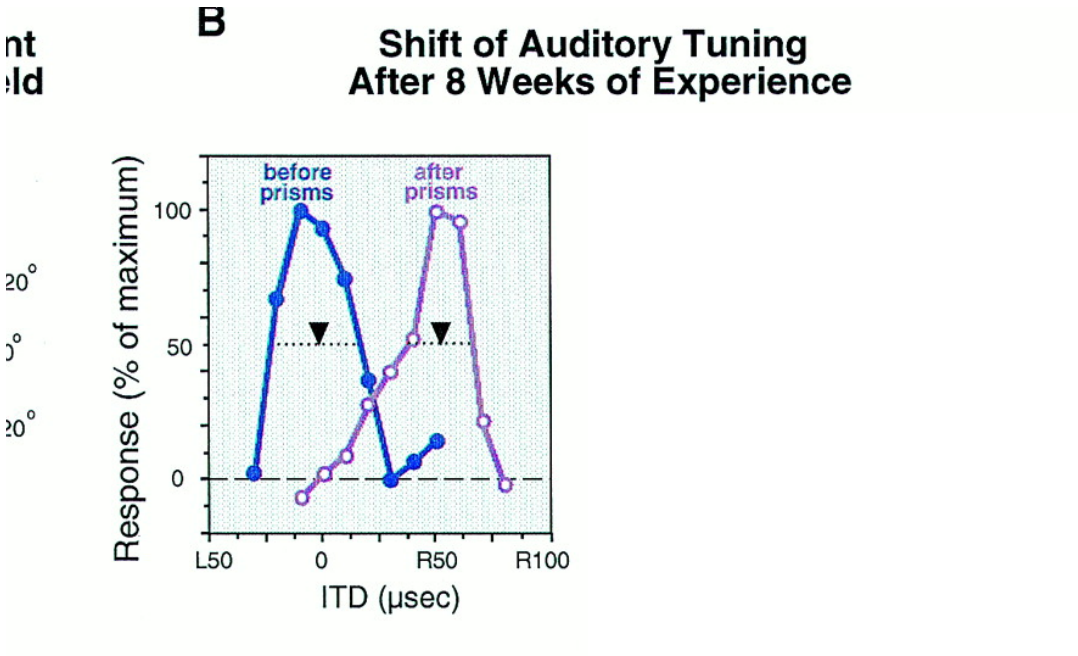


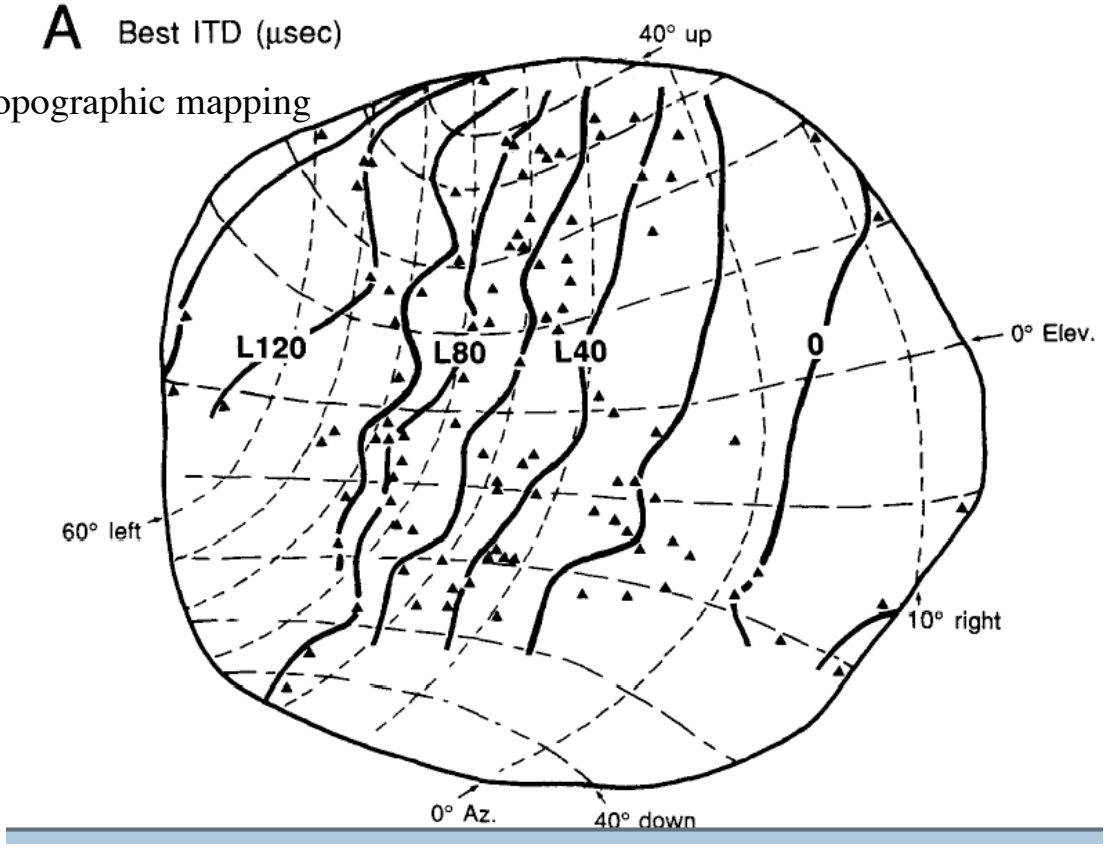
Critical period for this plasticity

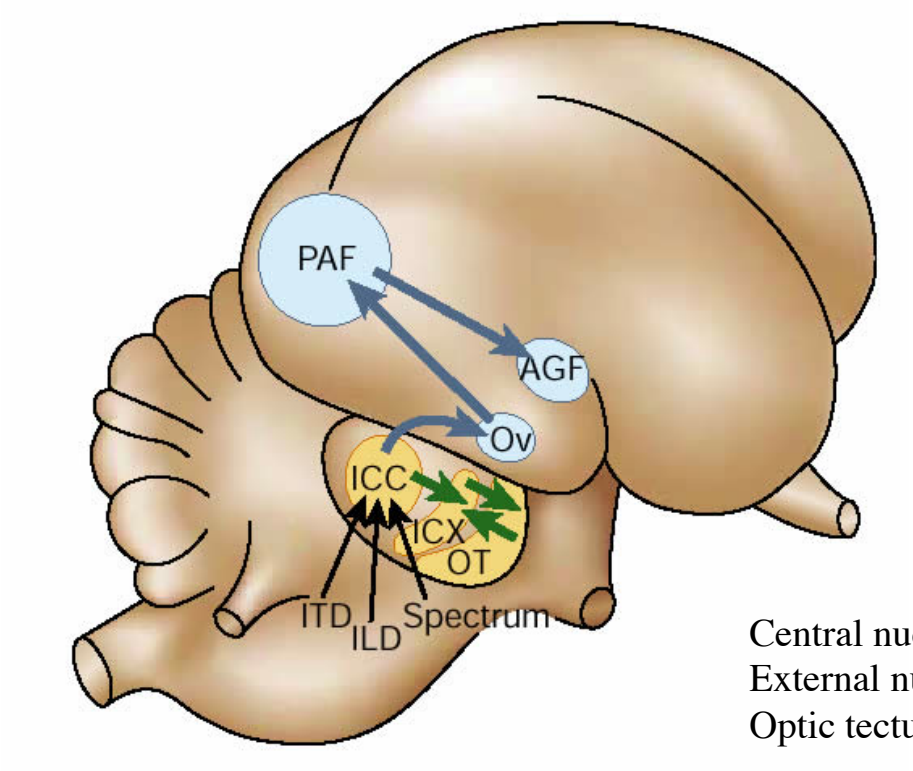




Knudsen E I et al. PNAS 2000;97:11815-11820

Topographic mapping





Central nuc
External nuc
Optic tectum

Amazing specificity

1. Single cell recording

2. Important perceptual ability

3. See how learning occurs in precise neural circuits

4. Can only achieve this with animal model

Touch and pain

Reading: 7.2 and pages 143-5

Study Questions

1. **From this and other lectures, give several examples of "top-down" influences on sensory processing.**

2. **How does the brain reorganize in relation to sensory stimulation?**

Kids who feel no pain

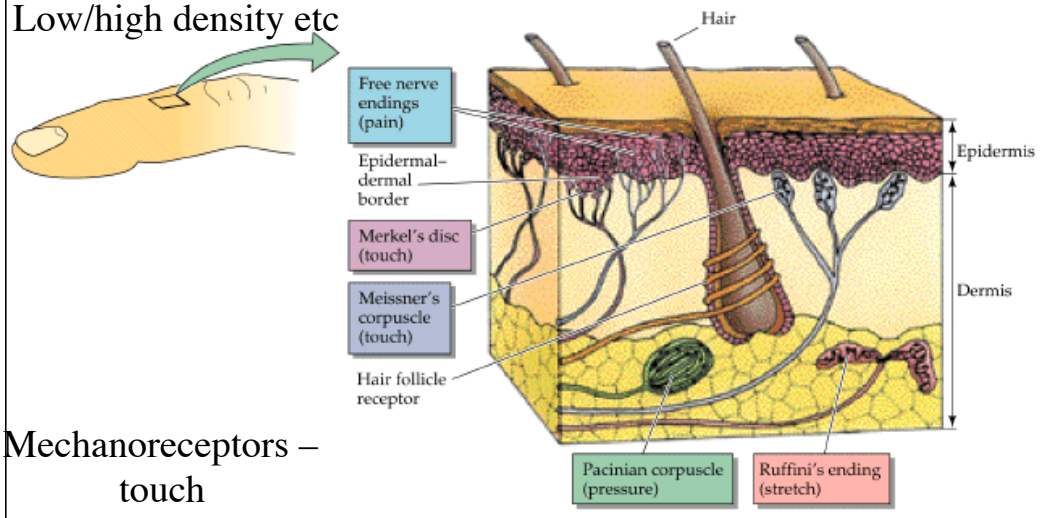
http://video.gainesville
441679854001

Heart attack felt in shoulder

Pain in amputated limbs

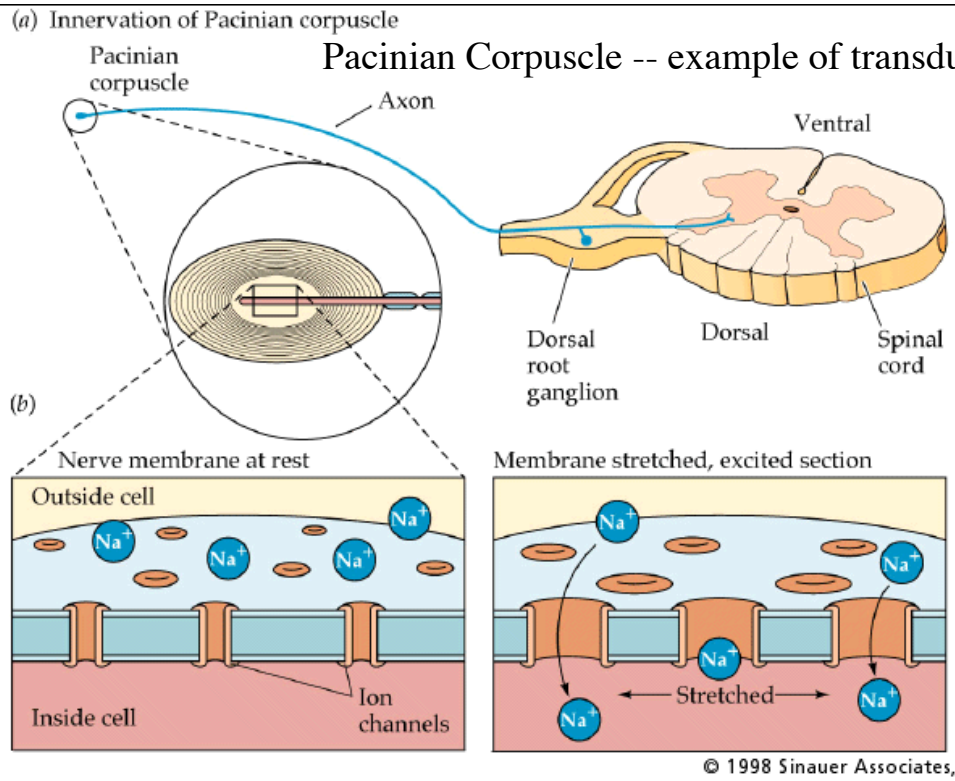
Placebo = significant pain relief

Fast/slow adapting
Free/encapsulated endings
Low/high density etc



Mechanoreceptors –
touch
position
Nociceptors -- pain
Thermoceptors – temperature

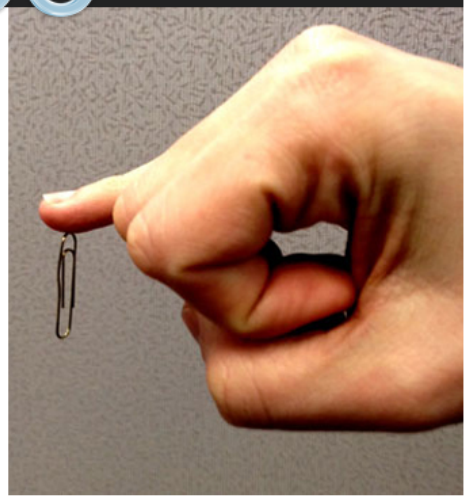
Pacinian Corpuscle -- example of transduction



GIZMODO

TOP STORIES

The real MAGNETO

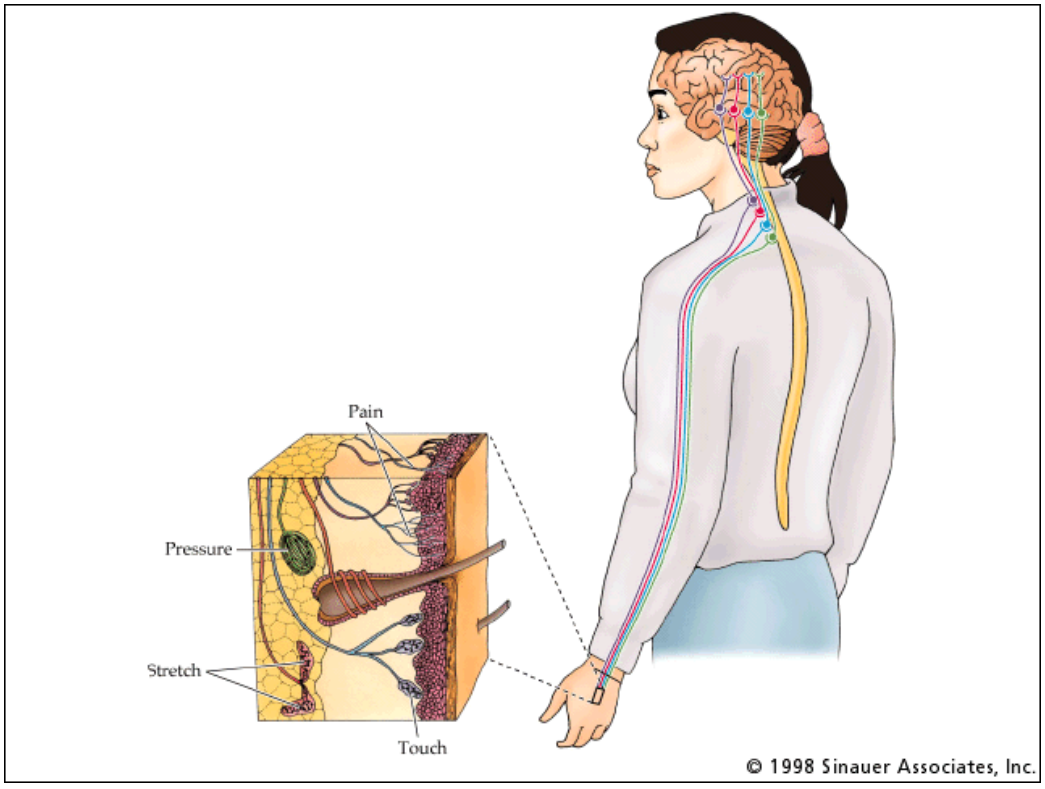


BODY HACK

I Have a Magnet Implant In My Finger

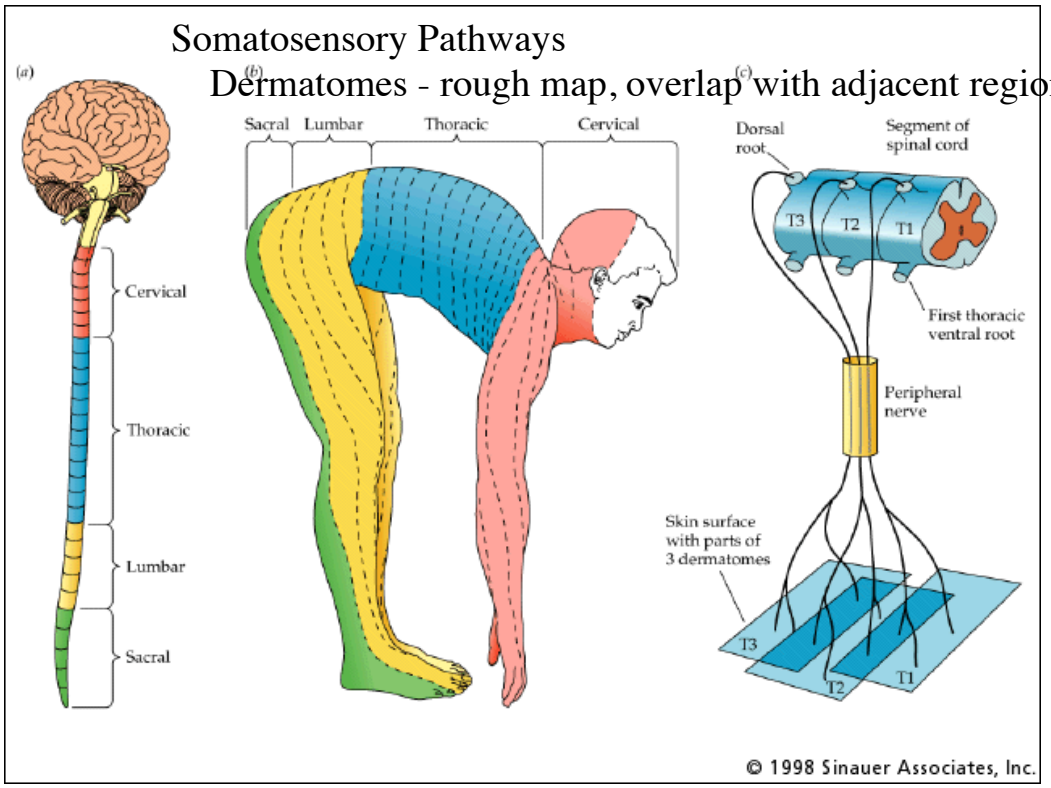
Let's talk about magnet implants. I don't really bring it up much, but I have a small rare earth magnet implanted in the pinkie finger on my right hand. I've had it for around three years now.

BY DANN BERG MAR 22, 2012 1:00 PM



Somatosensory Pathways

Dermatomes - rough map, overlap with adjacent regions



To the brain:

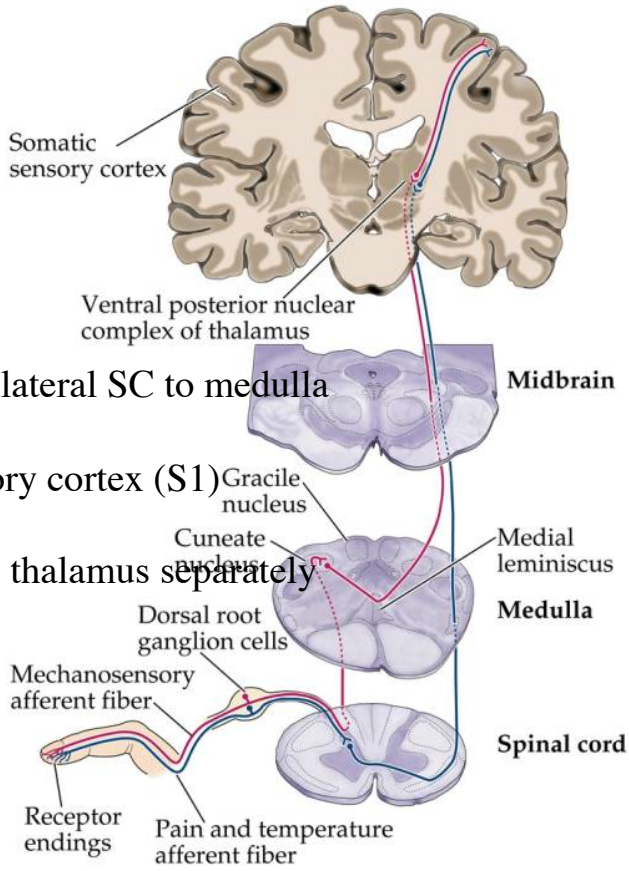
dorsal root ganglia

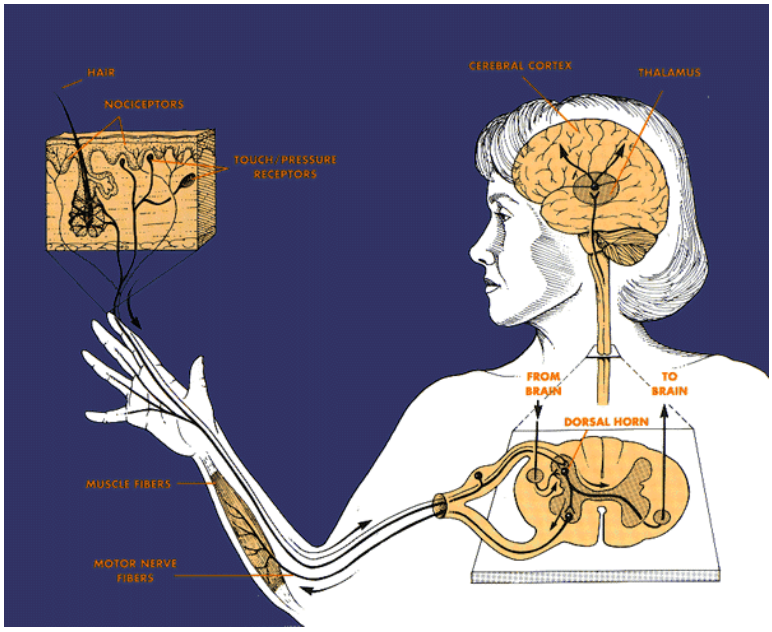
Mechanoreceptors ipsilateral SC to medulla

to thalamus

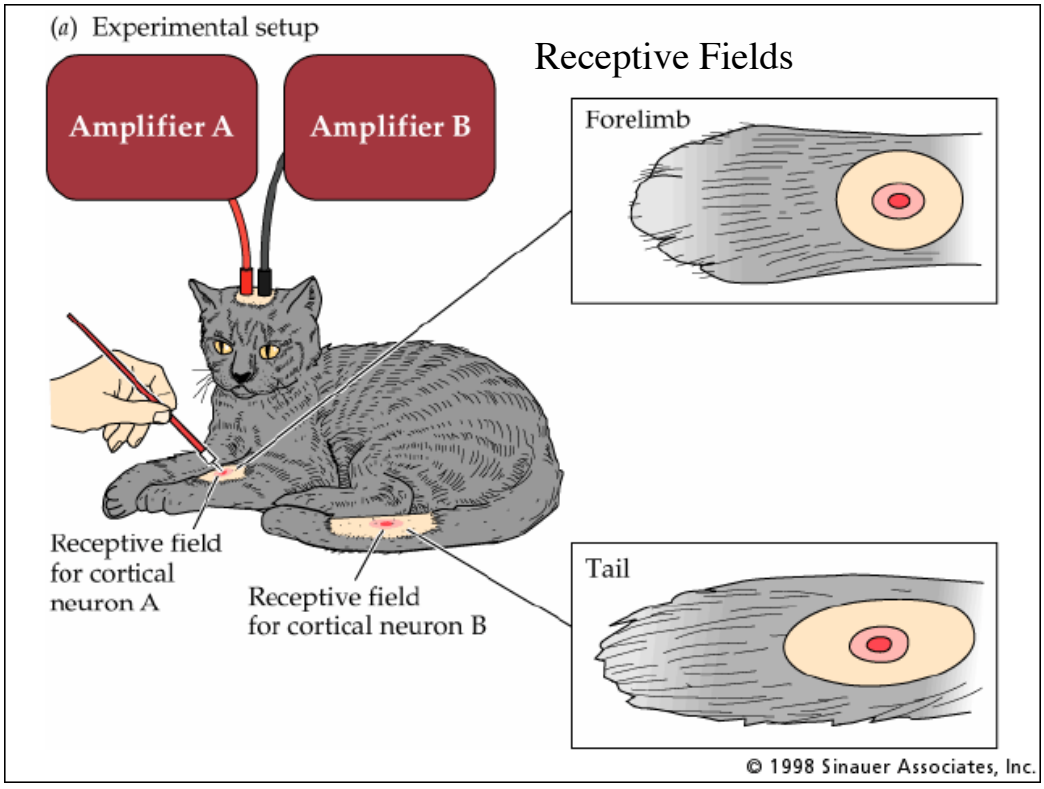
layer 4 of somatosensory cortex (S1)

Pain/temperature get to thalamus separately

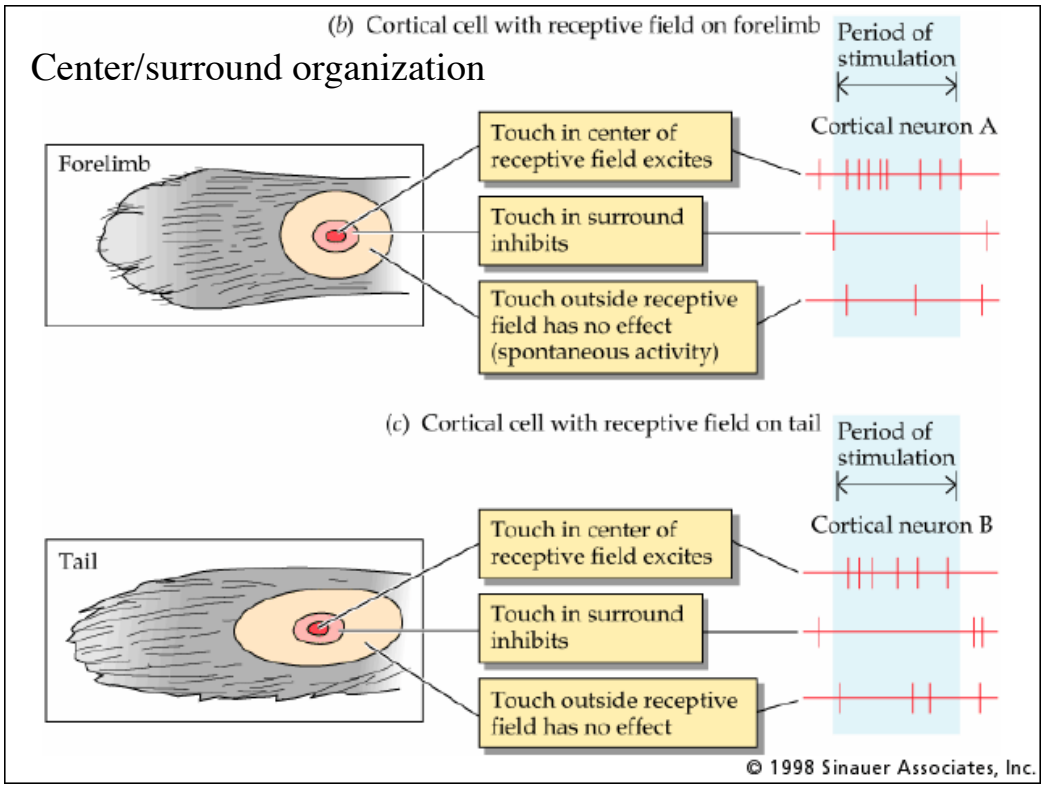




Massive descending projections to spinal cord
Modify incoming information



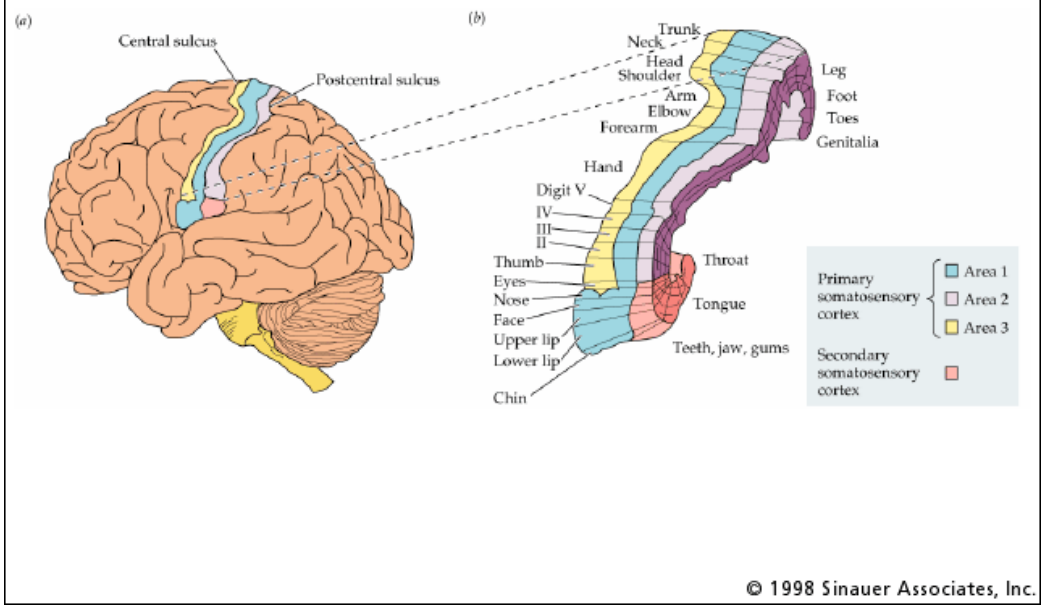
Center/surround organization



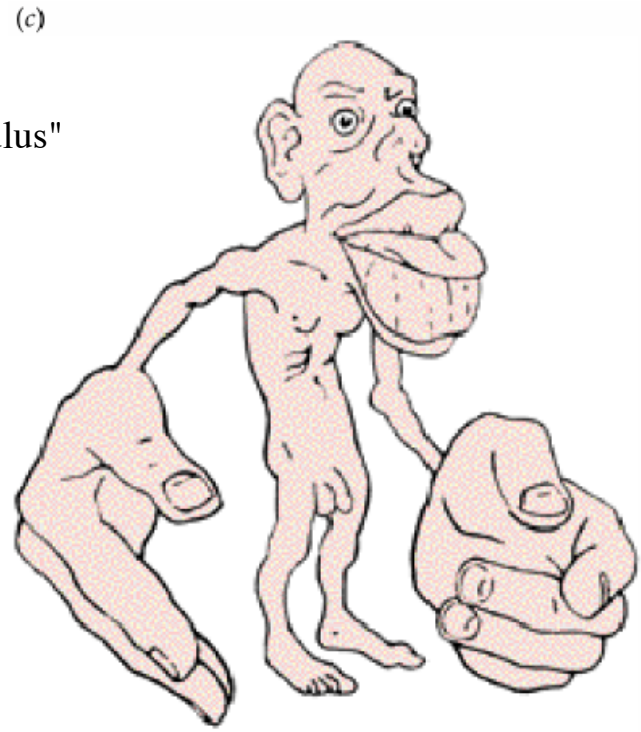
Primary Somatosensory Cortex = S1

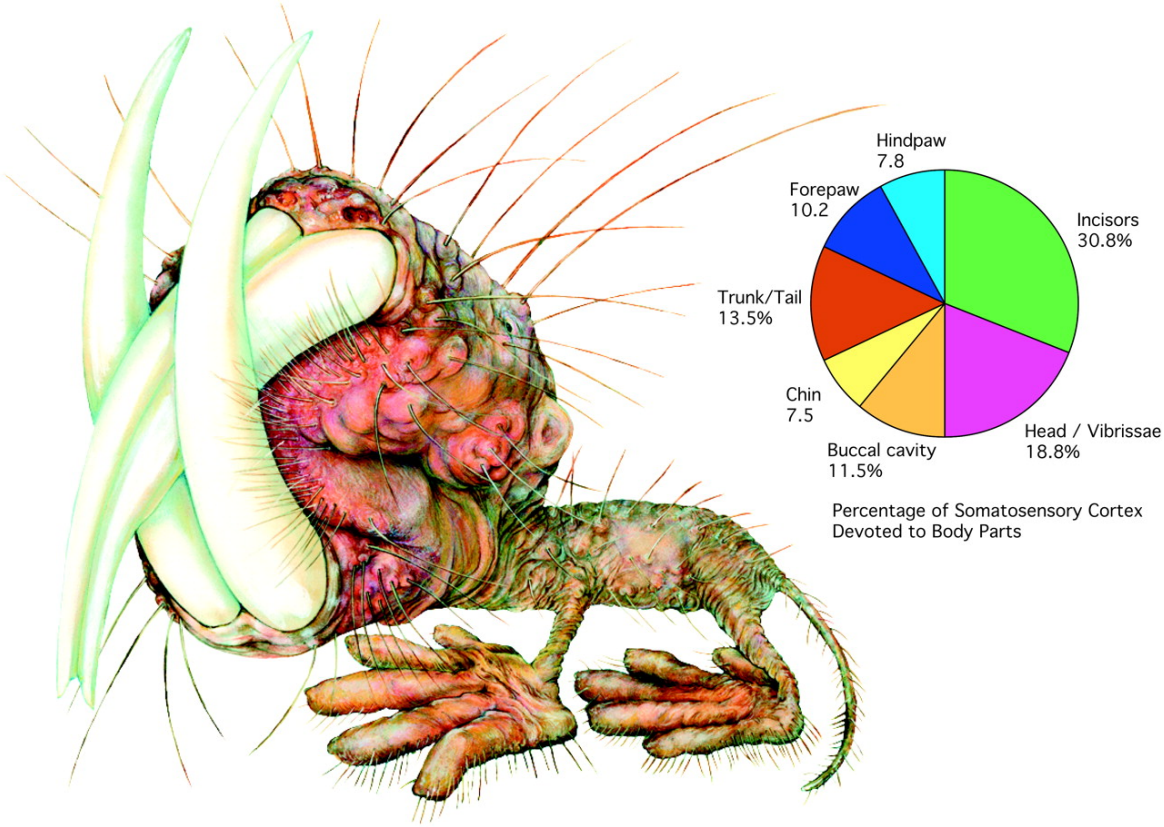
Brodmann Areas 3b, 1,2, 3a

Topographic map of body

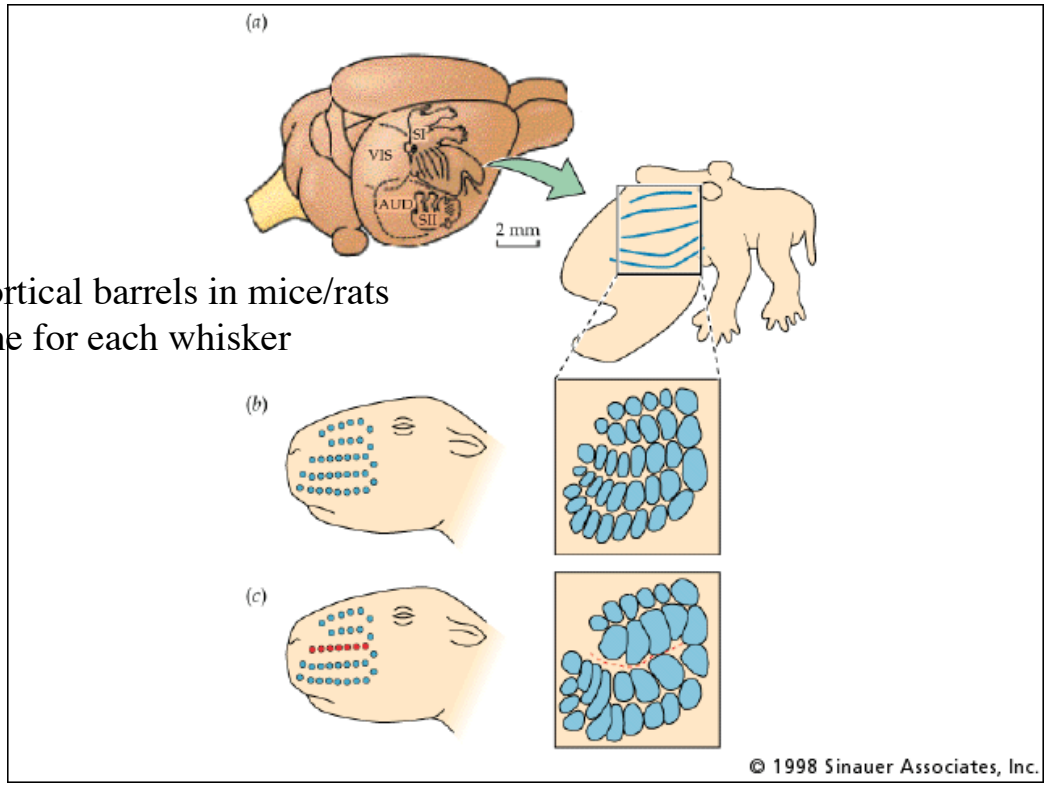


"Homunculus"

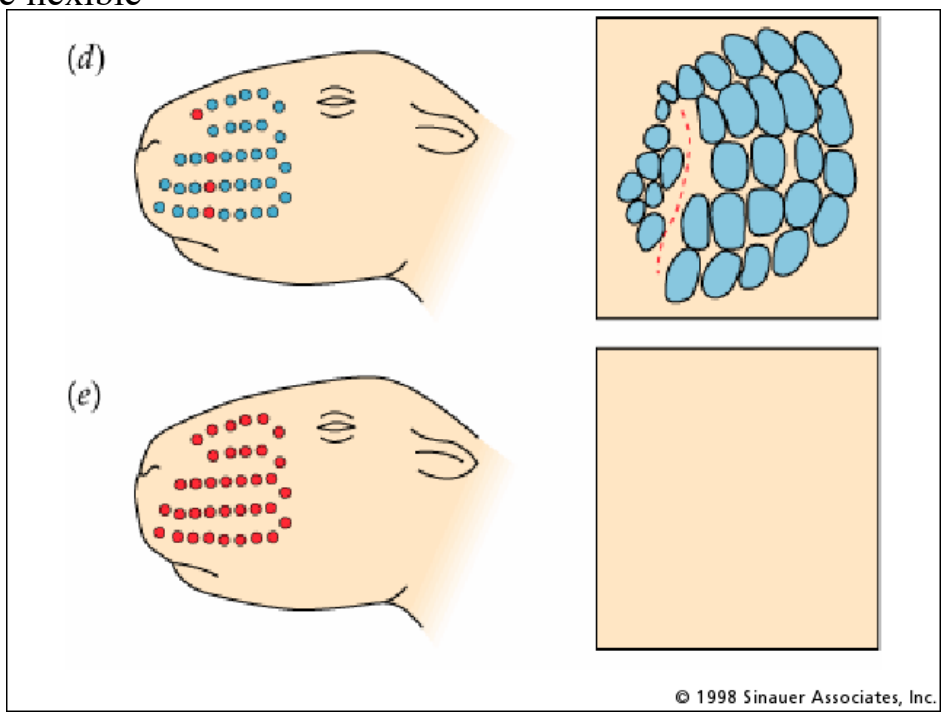


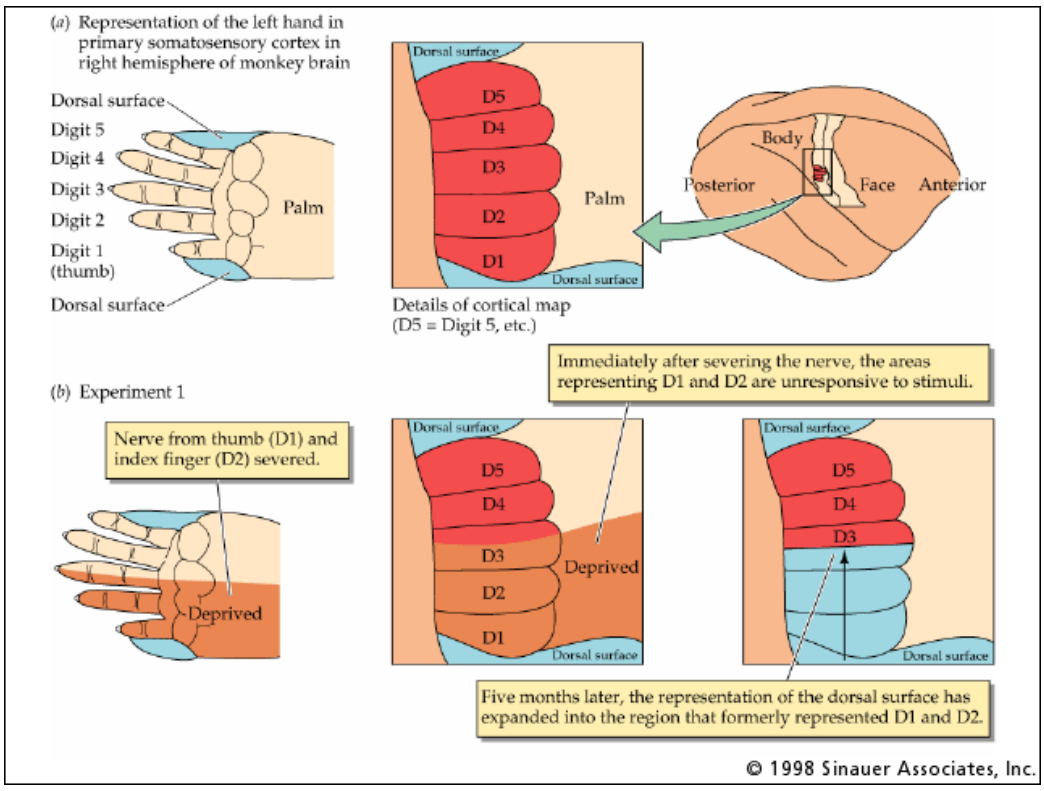


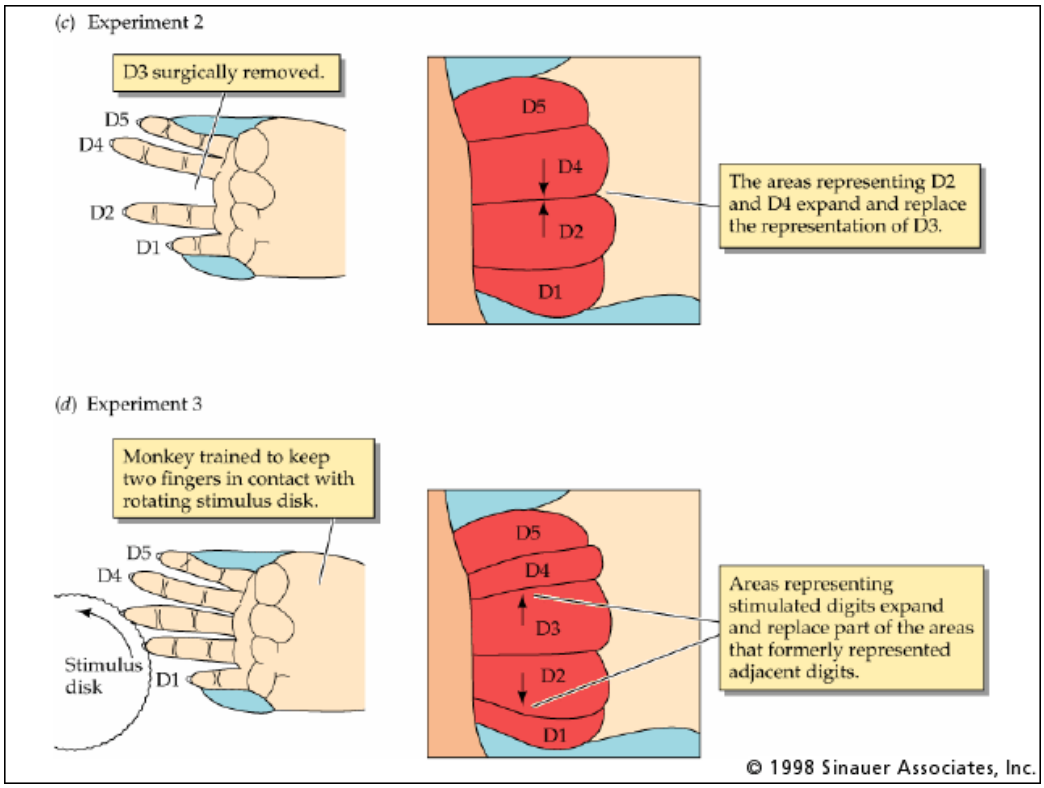
Cortical barrels in mice/rats
One for each whisker



Cortical Plasticity – brain modified by experience
Maps are flexible







Pain –

Unpleasant, but adaptive
prevents injury
pain-induced behavior, such as vocalization, may warn others about potential noxious stimuli

Suppression of pain (analgesia) is also adaptive
fear, stress, and painful stimuli can induce analgesia
analgesia prevents recuperative behaviors (tending to wounds); facilitates escape from threat

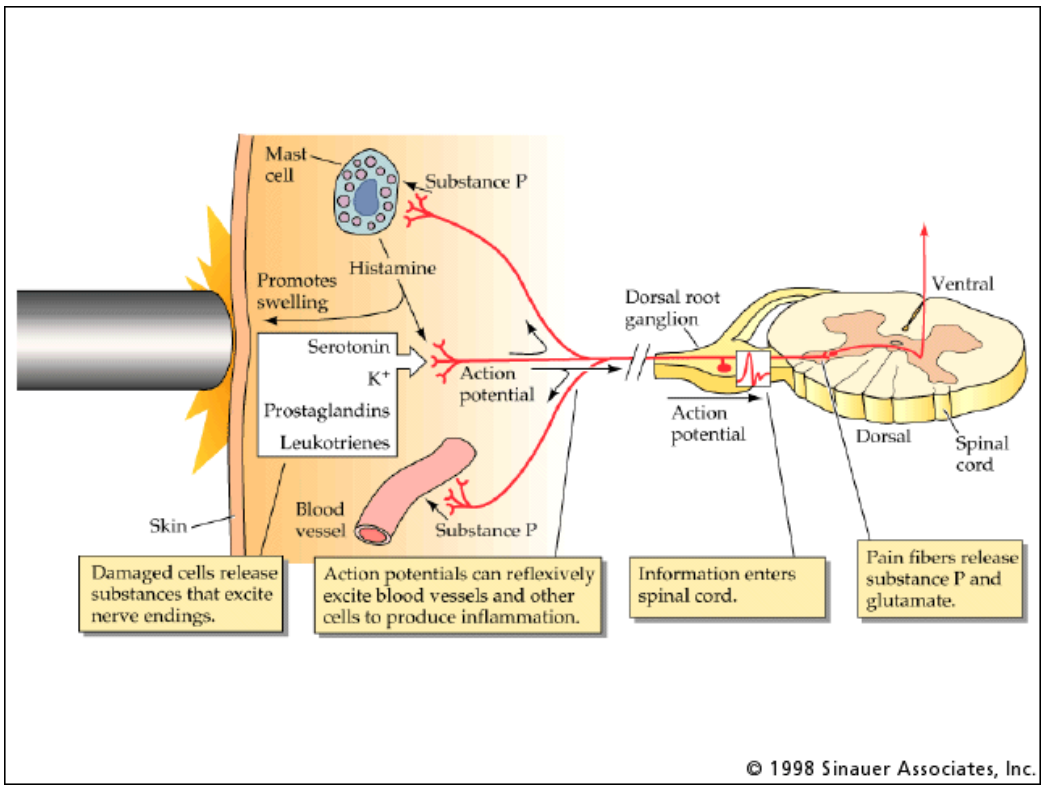
Transduction of Pain --

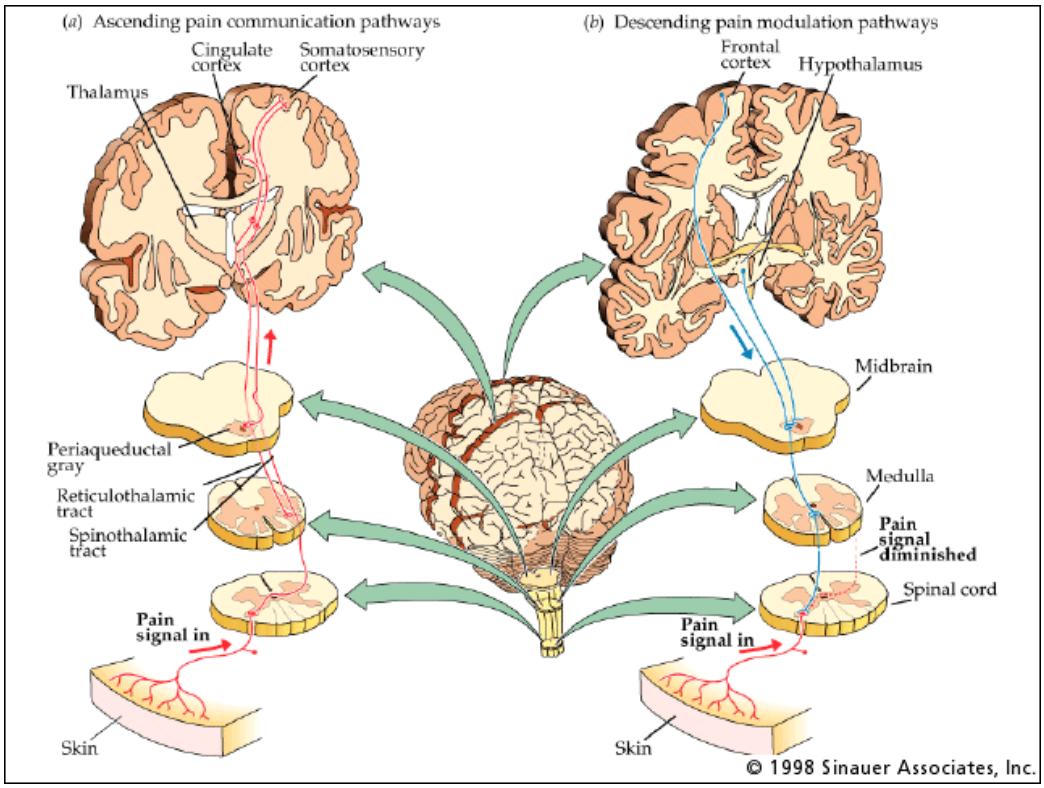
Peripheral tissue damage

Chemical substances activate nerve terminals or make endings more sensitive

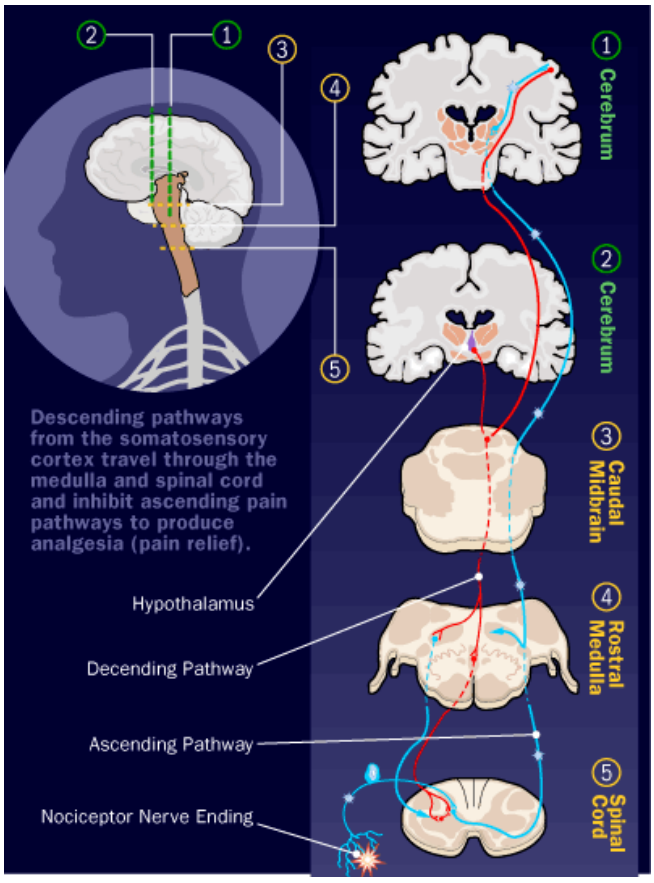
substance P
histamine
prostaglandins

Some pain relievers act here - aspirin blocks prostaglandin synthesis





Another view of system



Pain is context-dependent
Beecher showed less pain in soldiers than civilians

Topical pain killers
stop Aps from firing

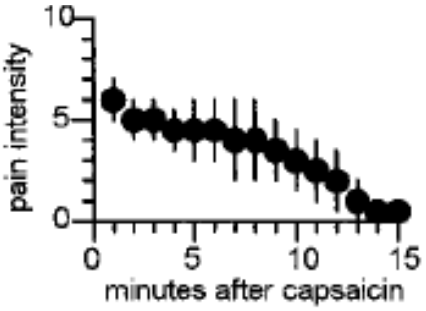
Opiates kill pain
opium (from poppy plants), morphine, and heroin Bind to opiate receptors in *brain*
endogenous opiate transmitters

Endorphins -- natural pain suppression
opiates to modulate pain transmission -- descending modulation
Opiate neurons in PAG activate 5-HT neurons in medullla
medulla neurons shut down spinal neurons - close gate

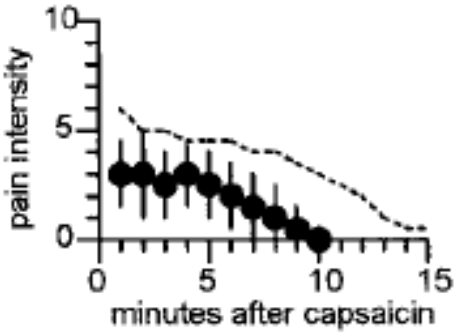
Cutaneous Stimulation Can Gate Pain
Stub toe....you rub it
Vibration or electrical stimulation seems to have similar effect on pain
Gate Control Theory
"A fibers" (non-pain touch) can excite inhibitory neurons to shut off pain

Fear and Stress Attenuate Pain
Measure pain via "tail-flick"
Shocked rats have higher thresholds to tail-flick
opioid-dependent

How do we know?
block opiates – NALOXONE eliminates effect

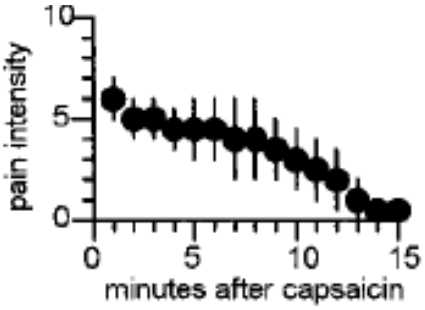


left hand

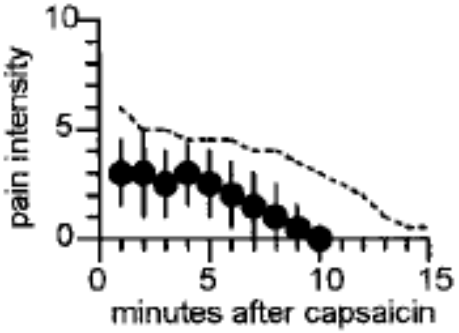


PLACEBO **left hand**

How do placebos work?

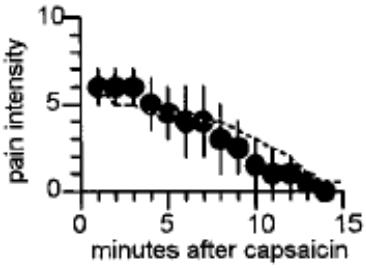


left hand



PLACEBO **left hand**

+ NALOXONE



PLACEBO **left hand**

Summary

1. Touch senses communicate variety of information well-characterized neural pathways.

2. Neural processing of sensory information is plastic.

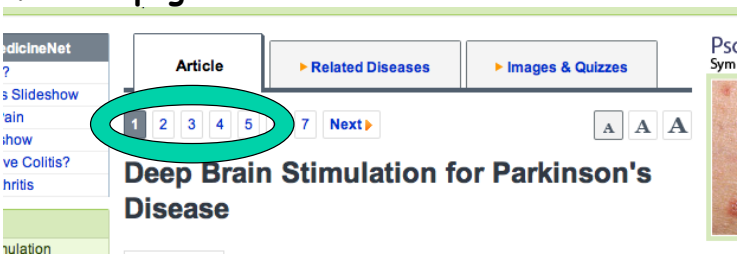
3. Strong top-down influences on sensory processing, including pain.

Midterm Exam – Wednesday at 2 to 3:20

Cumulative from beginning of class
50 Multiple Choice Questions
likely to be table/graph etc
Includes Non-Textbook Reading
2 Essays from the list of study questions

Reading Assignment: Text 8:1 – 8:3
http://www.medicinenet.com/deep_brain_stimulation/article.htm

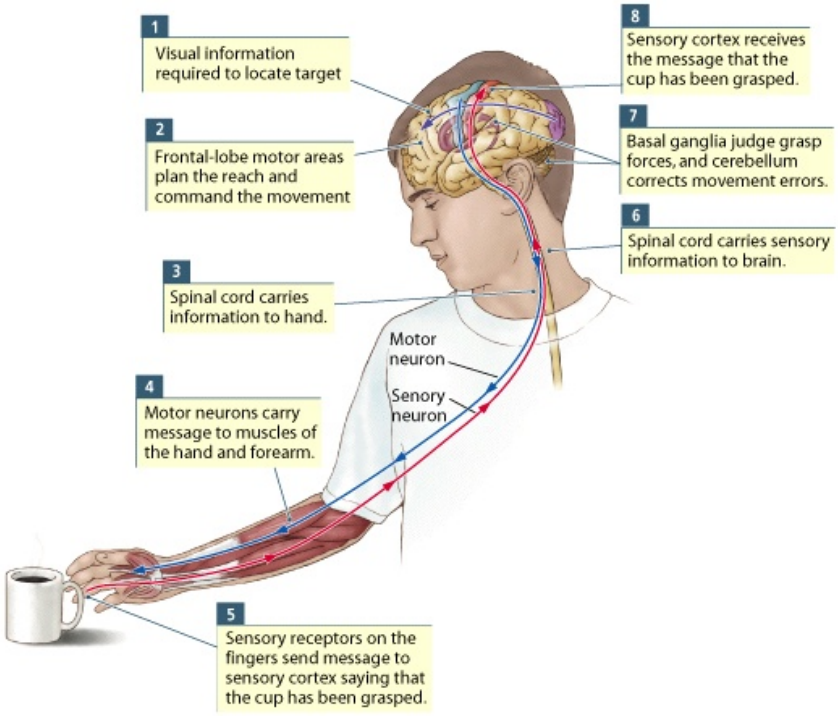
– first 5 pages



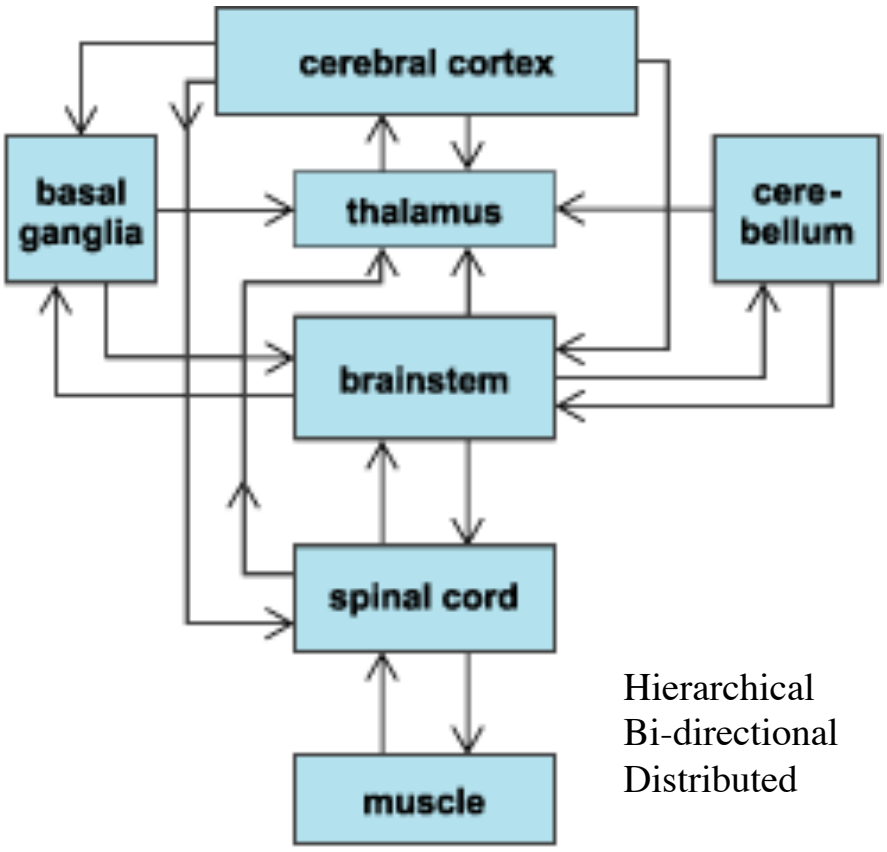
Study Questions

1. **Describe the interaction of sensory neurons, interneurons and motor components in simple reflexes (i.e., knee-jerk). What additional factors contribute to more complex motor programs?**

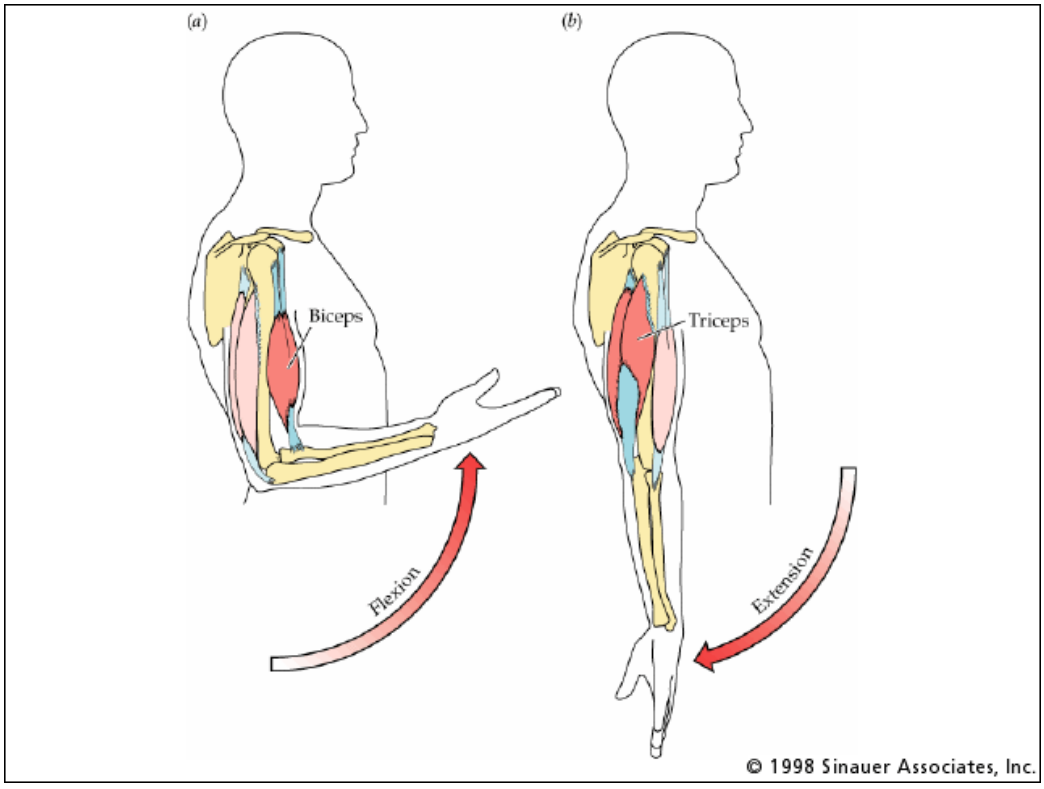
2. **What is Parkinson's disease? What treatments are there for it and what are their strengths/weaknesses?**



1. Simple reflexes - sneezing, startle, knee jerk
2. Posture/postural changes - sitting, lying, sitting
3. Locomotion - walking, swimming, flying
4. Sensory orientation - head turning, sniffing, tasting
5. Species-typical action patterns - ingestion, courtship, escape & defense, grooming
6. Acquired skills - painting, speech, tool use



Hierarchical
Bi-directional
Distributed



Spinal Motoneurons
Ventral Root

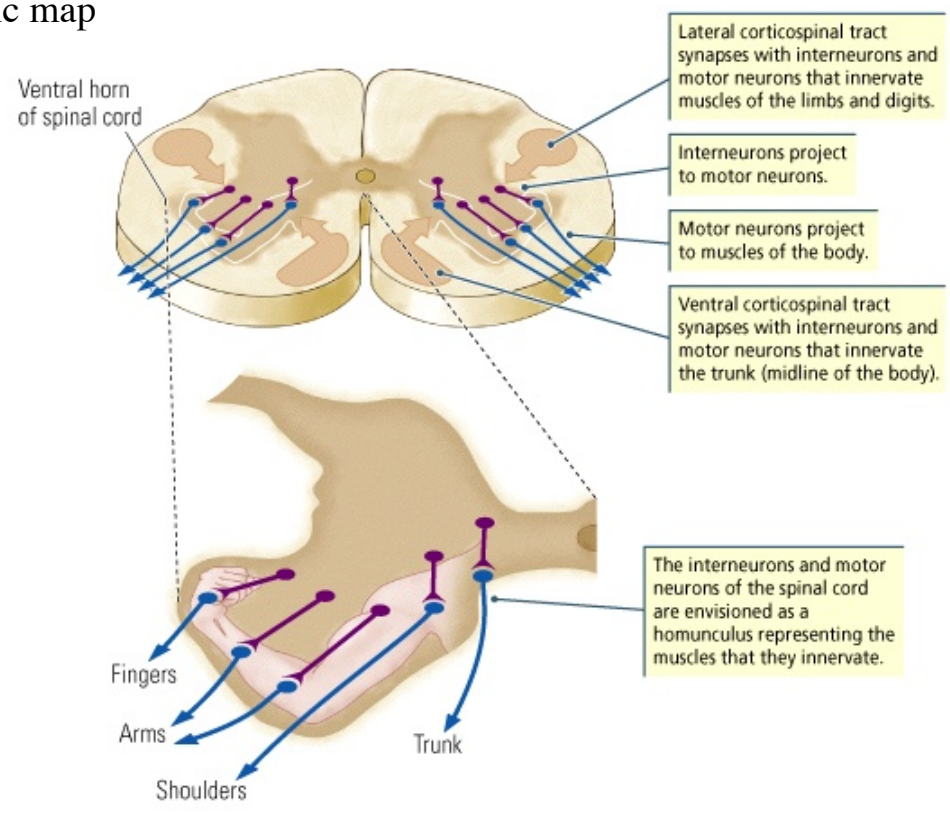
ACh is NT

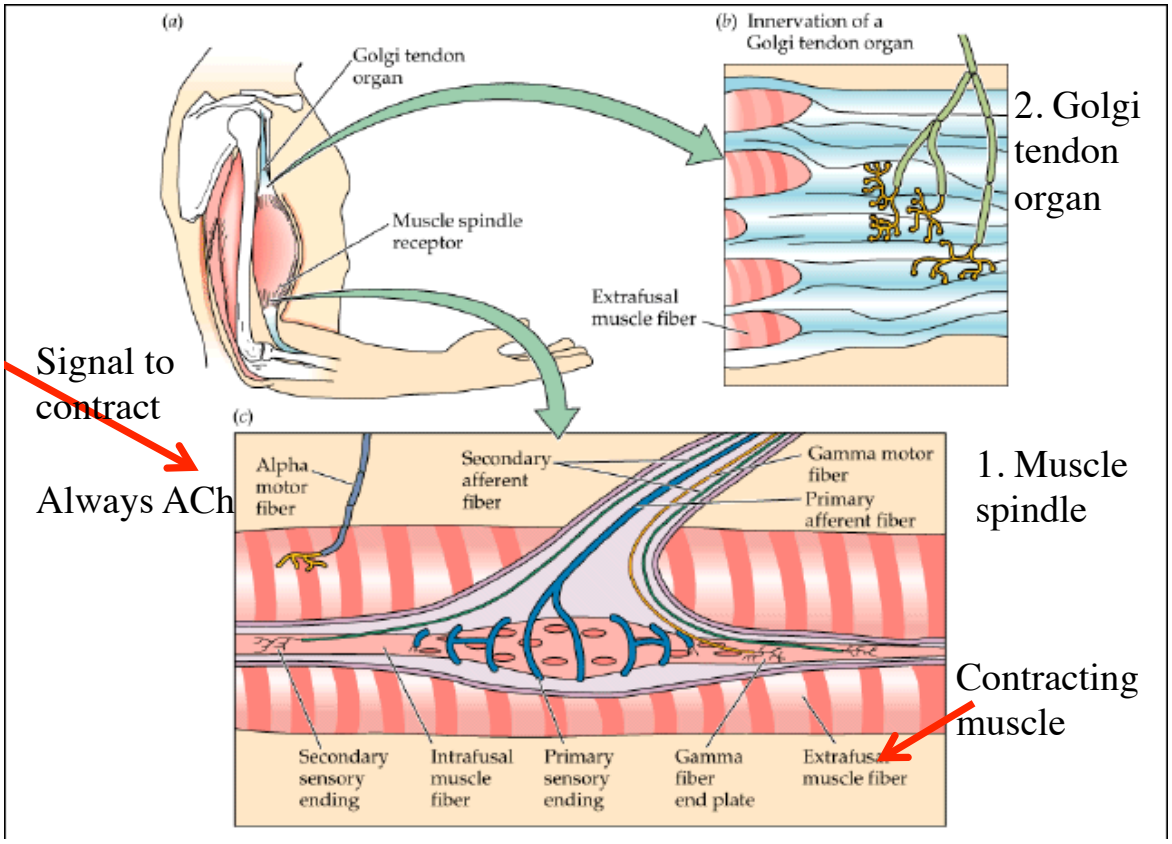
Motor unit = single axon and all muscle fibers it innervates
Different kinds of MNs
Big, wide axons = fast muscles (fatigue fast), powerful
Small = slow muscles (fatigue less), posture

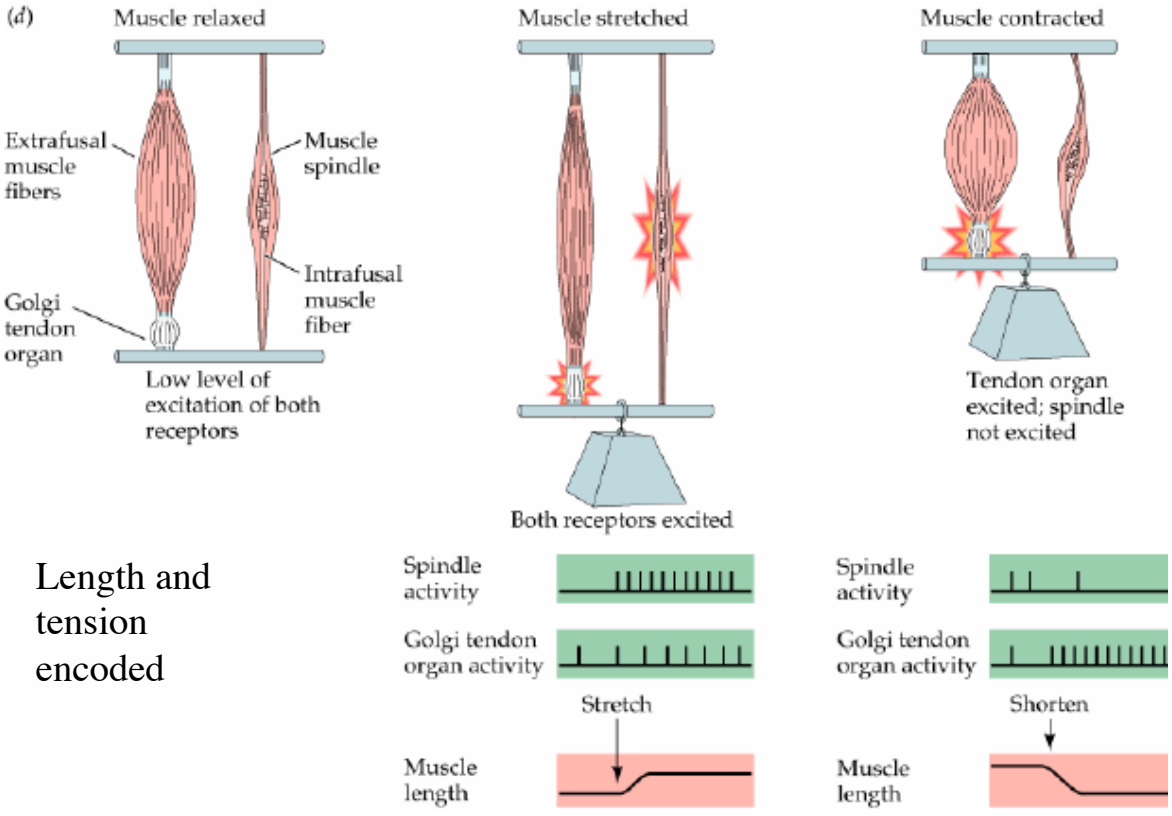
Innervation ratio
High- fine control
Low - gross control

Mapping in spinal cord

Somatotopic map




(a)
Golgi tendon organ
Muscle spindle receptor
Extrafusal muscle fiber
(b) Innervation of a Golgi tendon organ
2. Golgi tendon organ
Signal to contract
Always ACh
(c)
Alpha motor fiber
Secondary afferent fiber
Gamma motor fiber
Primary afferent fiber
1. Muscle spindle
Contracting muscle
Secondary sensory ending
Intrafusal muscle fiber
Primary sensory ending
Gamma fiber end plate
Extrafusal muscle fiber


(d)
Muscle relaxed
Extrafusal muscle fibers
Muscle spindle
Intrafusal muscle fiber
Golgi tendon organ
Low level of excitation of both receptors
Muscle stretched
Both receptors excited
Muscle contracted
Tendon organ excited; spindle not excited
Length and tension encoded
Spindle activity
Golgi tendon organ activity
Stretch
Muscle length
Spindle activity
Golgi tendon organ activity
Shorten
Muscle length

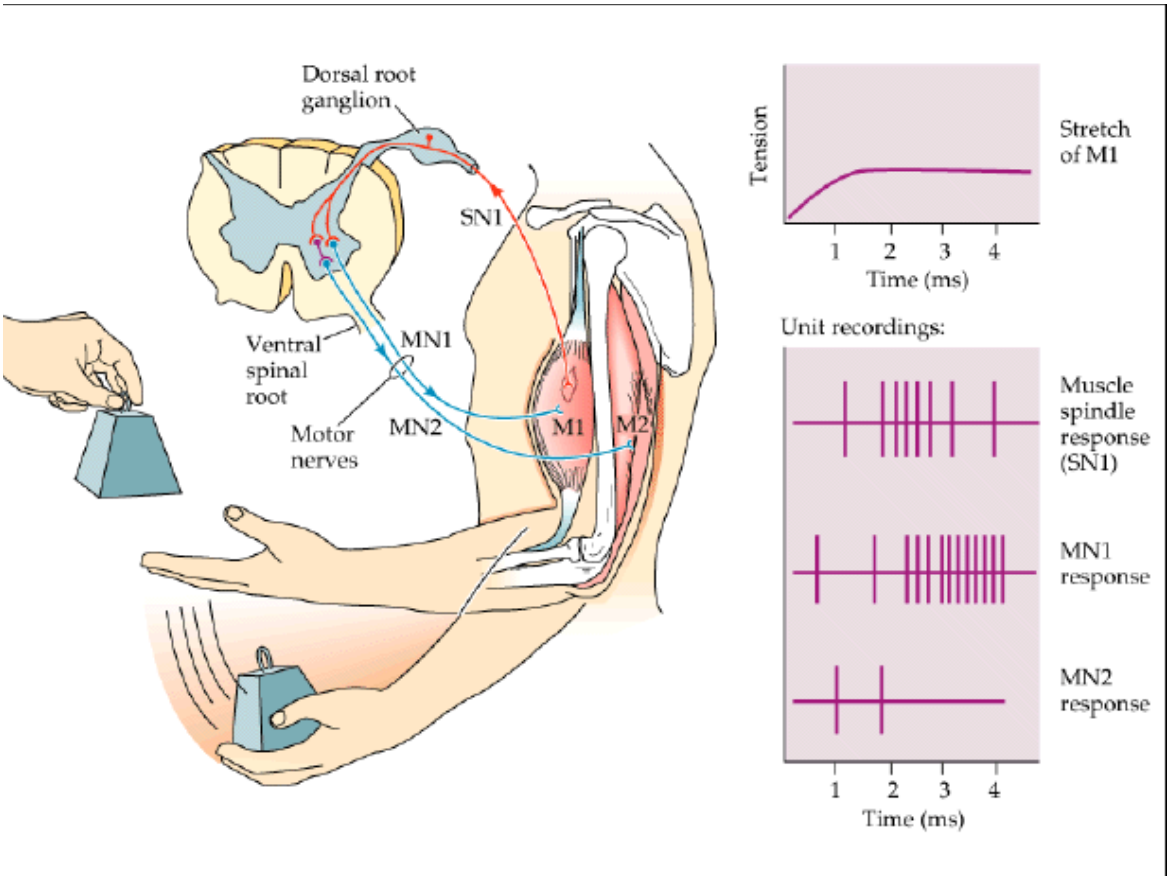
Reflexes: fixed response to stimulus,
fast, rigid and inflexible

Stretch reflex
Stretch of paw = stretch of muscle
Spindles excited, AP to dorsal root
EPSPs to motoneuron controlling muscle
Contracts muscle

Also, relaxation of antagonist muscle ÷ counteracts effects of its paired muscle
Sensory neuron to dorsal root
Stimulates short inhibitory interneuron
Short interneuron inhibits antagonistic motoneuron

Can occur in "spinal animal"
includes stretch reflex, urinaation, have erection, walking movements

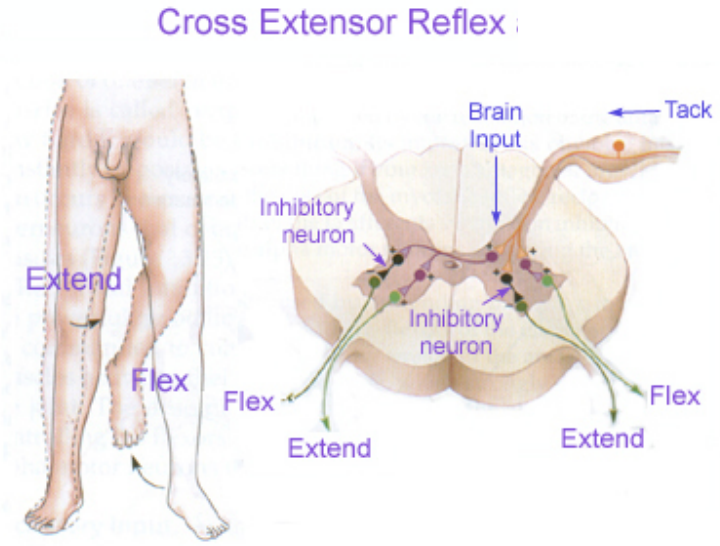
Brain normally controls these reflexes



Other reflexes more complex

Flexion reflex is multisynaptic

Both legs



Spinal animals

stimulation of dorsal root

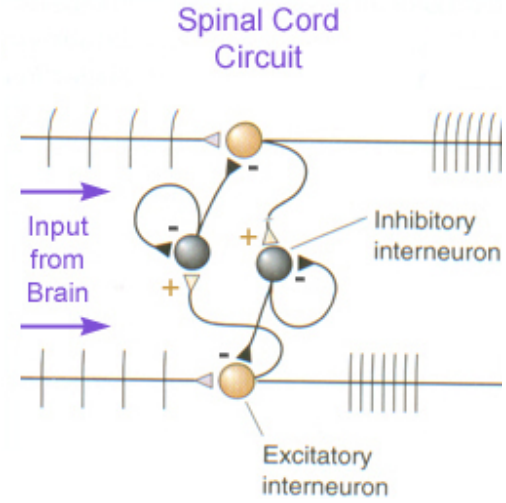
coordinated activity of limbs

all gaits on treadmill

Reflex chain? Each act is stimulus for the next

Removing sensory info didn't eliminate

Central Pattern Generators



CPG = neural circuit responsible for rhythmic pattern of behavior

Multiple connected cells

Inhibitory connections

Self-test question

What is contained in a muscle spindle?

A. Muscle fiber

B. Motor efferents

C. Sensory afferents

D. All choices above (A, B, C)

E. Choices A and B only

Self-test question

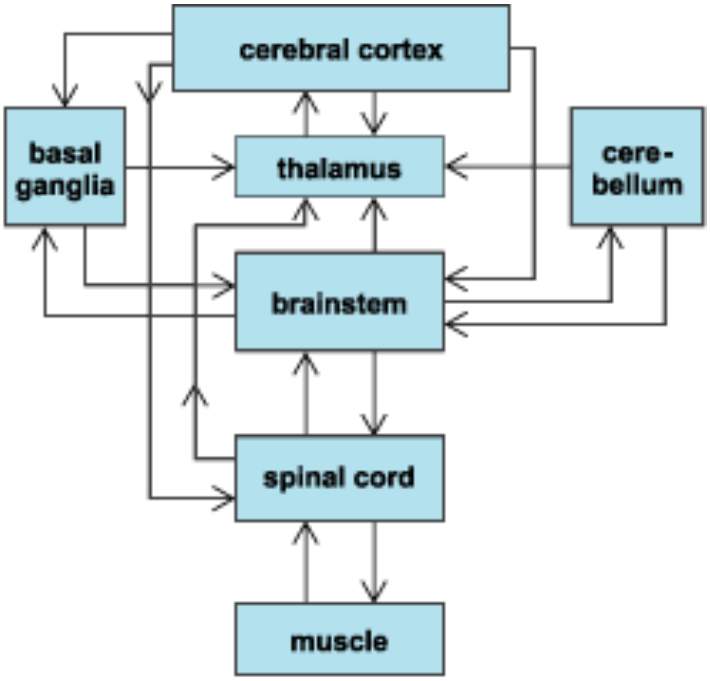
What critical factor will allow flexors and extensors to operate in a complementary fashion in a reflex action?

A. An extra inhibitory interneuron

B. An extra excitatory interneuron

C. Release of different neurotransmitters at the neuro-muscular junction

D. Any of the above

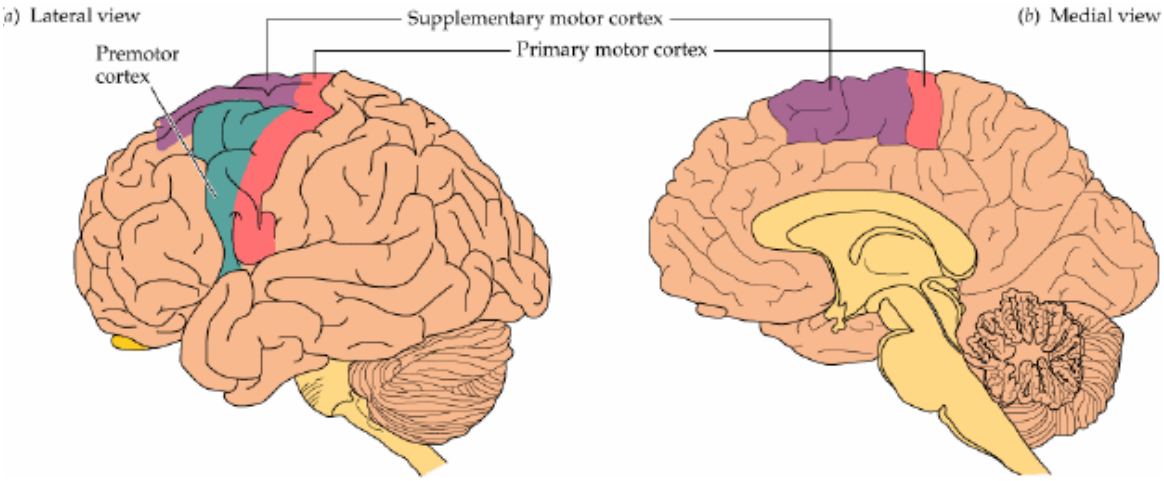

cerebral cortex
basal ganglia
thalamus
cere-bellum
brainstem
spinal cord
muscle


Shanahan
"You slept with her, didn't you?"

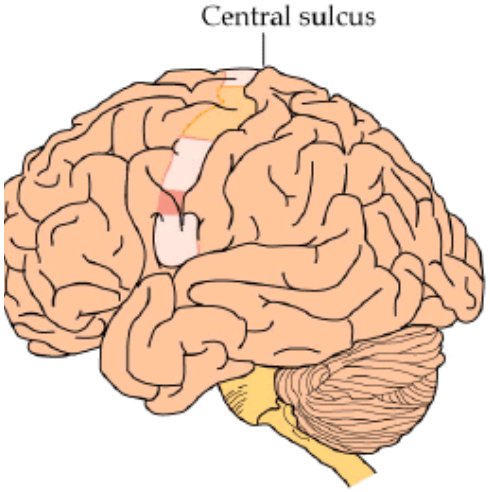
Unit autonomy -- unit can do its own thing
Descending pathways from brain initiate/gate/modulate these circuits

1. Praying Mantis
   Head inhibits autonomous thorax copulation
   Female's bite disinhibits unit

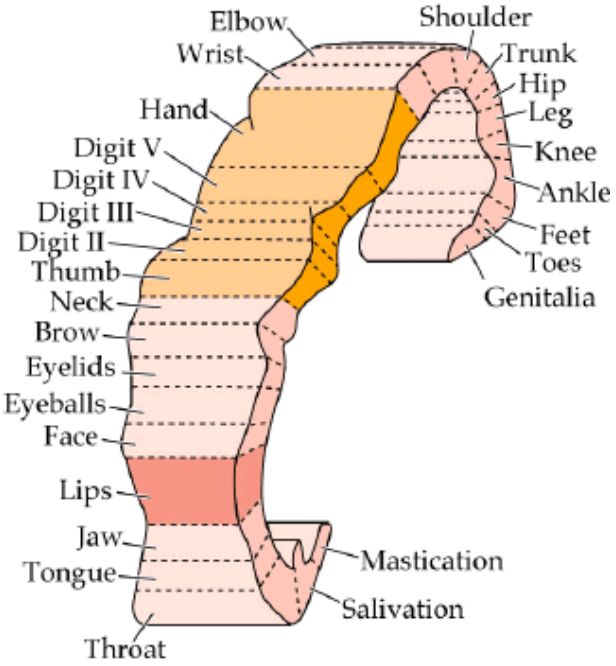
2. Lordosis reflex – female rodent mating reflex
   Spinal autonomy
   Hormones *disinhibit* hypothalamus signal (removal of descending inhibition)



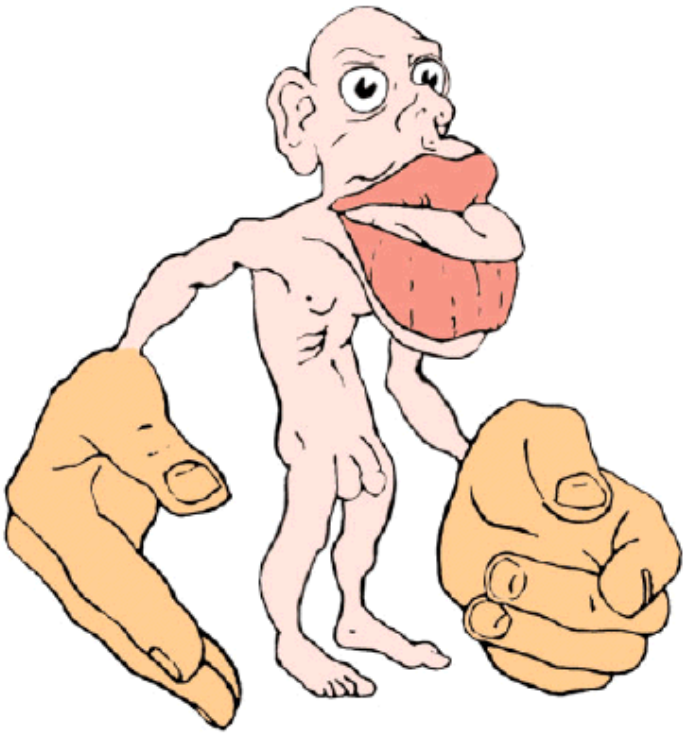
) Lateral view of brain showing location of primary motor cortex



(*b*) Representation of the body in primary motor cortex

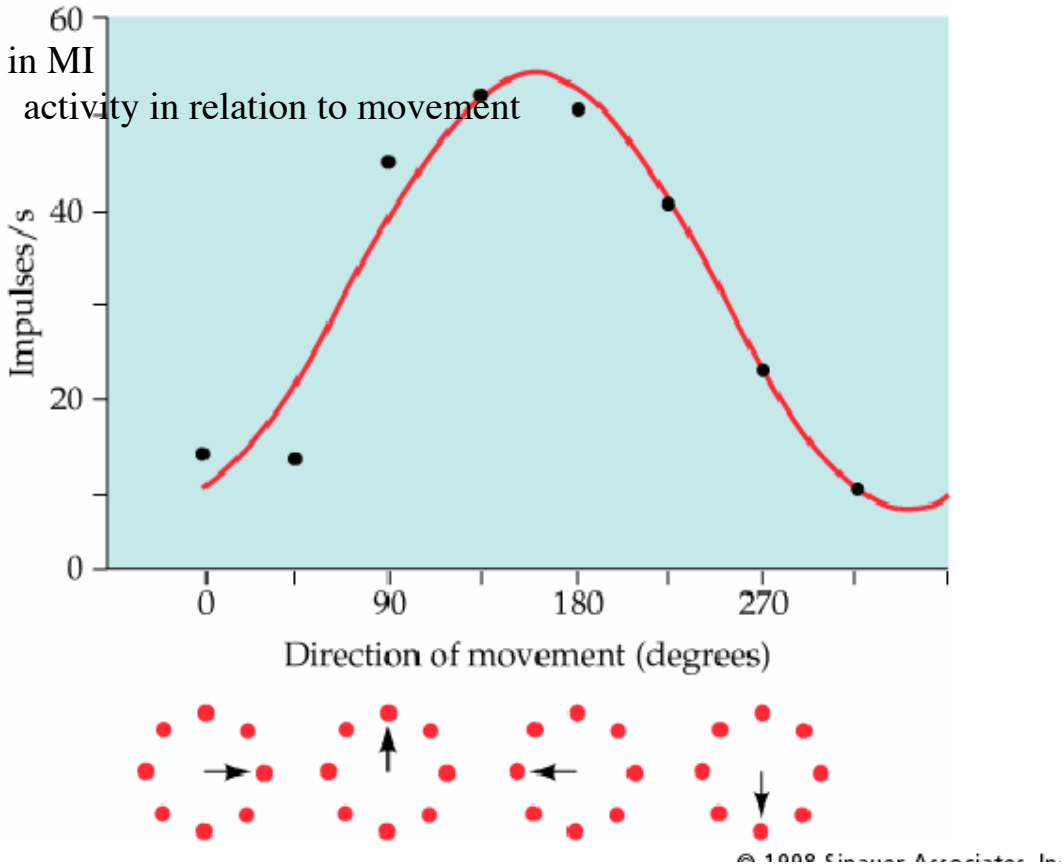


(*c*) Motor homunculus



Cell's in MI

activity in relation to movement



The Journal of Neuroscience, August 1988, 8(8): 2928–2937

Primate Motor Cortex and Free Arm Movements to Visual Targets in Three-Dimensional Space. II. Coding of the Direction of Movement by a Neuronal Population

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Figure 1. An example of population coding of movement direction. The *blue lines* represent the vectorial contributions of individual cells in the population ($N = 475$). The movement direction is in *yellow* and the direction of the population vector in *red*.

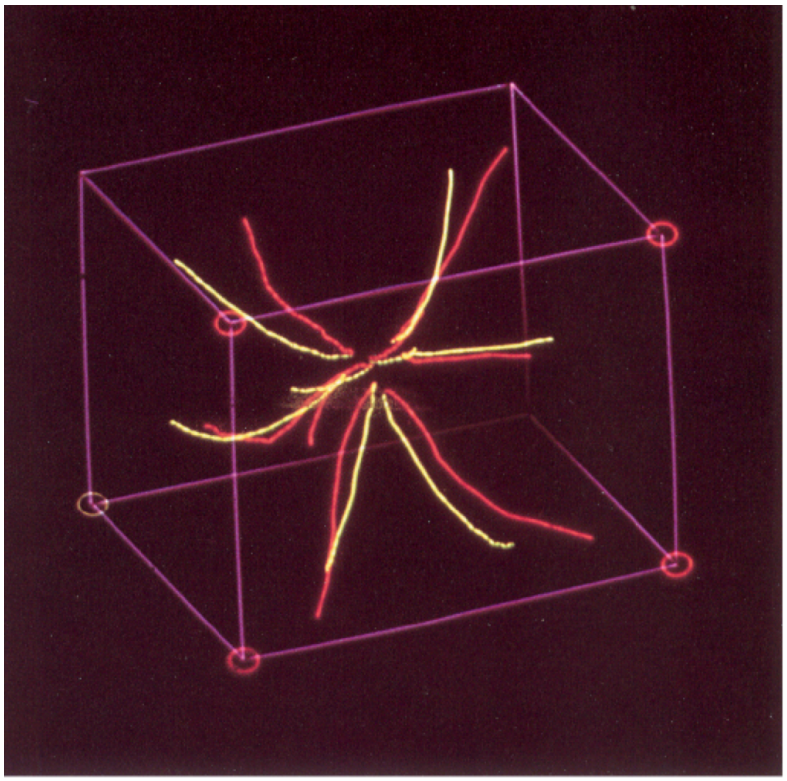


Figure 5. Normalized actual (*yellow*) and "neural" (*orange*) trajectories. See text for details.

Matthew Nagle, left paralyzed when he was stabbed five years ago, and the circle he drew on a computer screen by using only his thoughts.

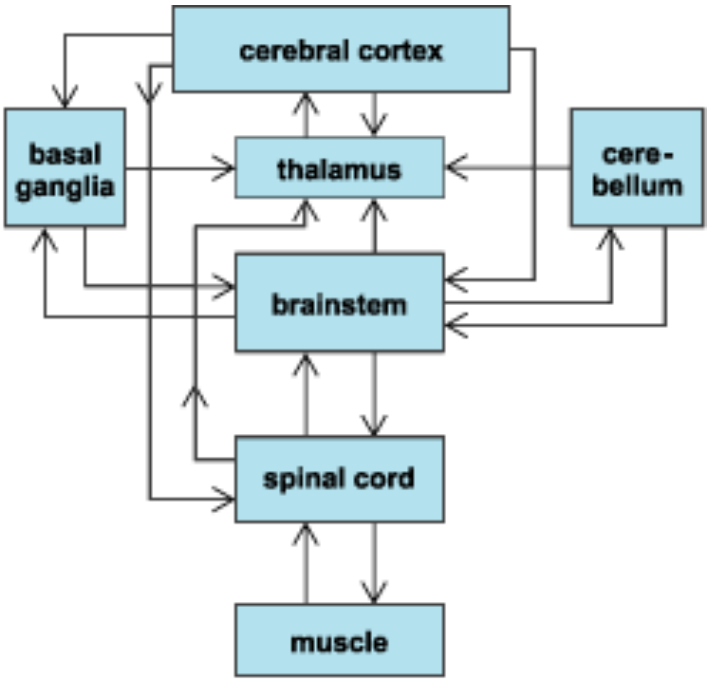

sky NEWS

microelectrode arrays connect brain cells to electronic circuitry -- square grids just 16 square millimeters large with

Same as recording electrodes seen earlier

96 electrodes penetrate the brain's surface by about one-16th of an inch.

Scan brain to determine placement in left motor cortex



Cerebellum (read text)

Ipsilateral control
Finger-to-nose test
Highly sensitive to alcohol

Critical for ballistic movements
Fine learned skills – golf swing etc

Parkinson's Disease

death of substantia nigra neurons

Loss of DA projections to basal ganglia

Period of compensation

Symptoms

apraxia - impairment in executing movements (starting and stopping)

shuffle, resting tremor, rigidity

not problem with muscles, MNs etc

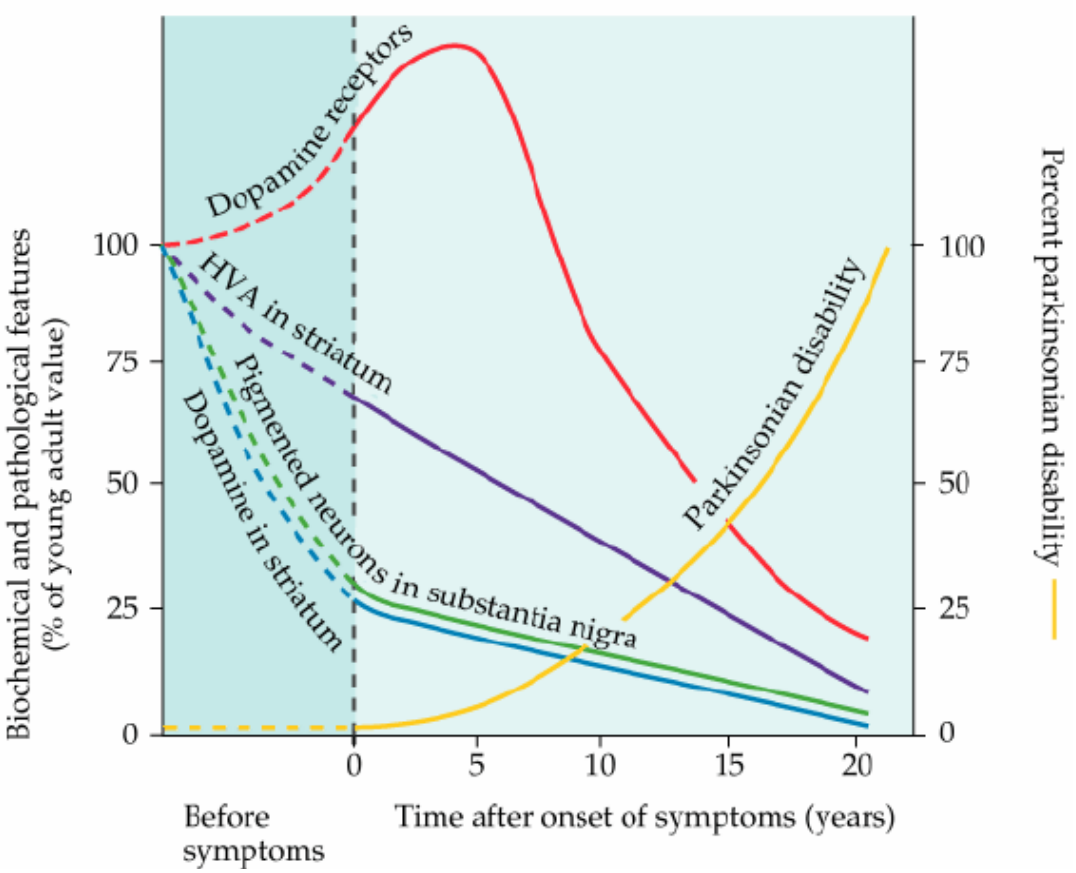
Some treatments

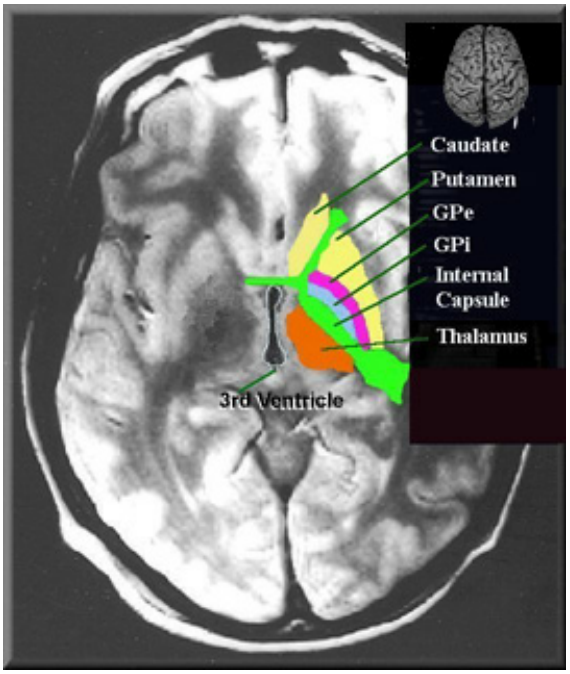
L-DOPA

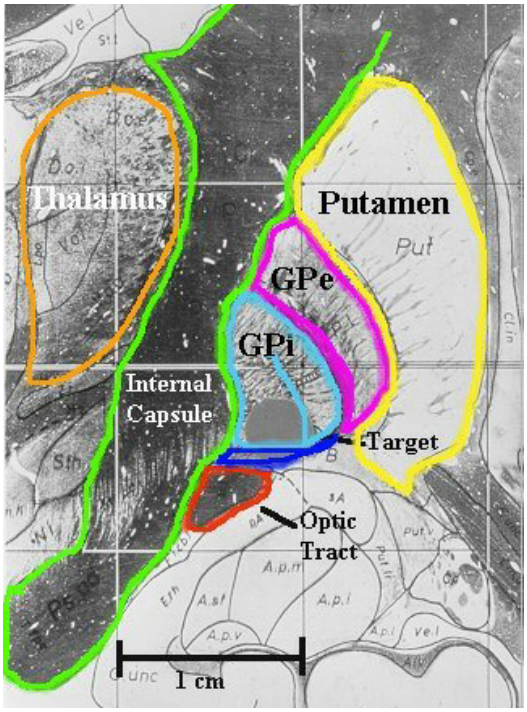
fetal cells transplant –replacement therapy (controversial)

pallidotomies

shuffling aided by lines on ground







GPi normally inhibited by DA
Activity increases with loss of DA transmission

Imbalance contributes to symptoms
- Pallidotomy is purposeful destruction of this structure
- Thalamic lesions also used
- Permanent interventions
- Age/stage of condition important considerations

Deep brain stimulation
- neurons not destroyed
- no drugs
- electrical stimulation to interfere with function

Andrew – Deep Brain Stimulation Video

Self-test question

Damage to which structure is INCORRECTLY associated with which condition

A. Motor cortex – weak reflexes

B. Spinal cord -- paralysis

C. Substantia nigra -- tremor

D. Cerebellum -- ataxia

E. All are correctly paired

Summary

Movements are the ultimate output of the nervous system

Hierarchical and distributed system

Autonomous circuitry in spinal cord to planned movements initiated in cortex

Intimate connection of sensory and motor aspects

Movement quality monitored/modulated by BG and cerebellum