Chap.2

Movement
Latin animus means “consciousness”

Sea squirt

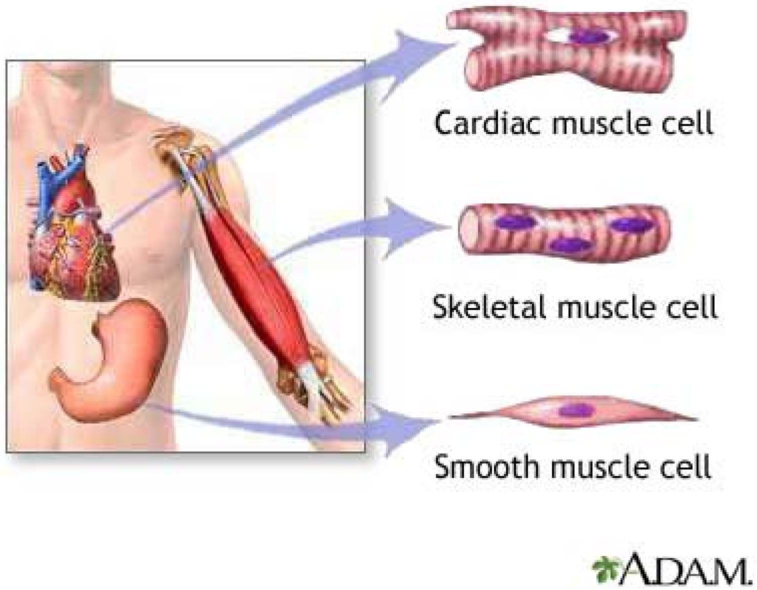
swimming immature larvae has primitive devices comparable to brain
immotile mature form consumes its own brain

For stationary life forms no brain is necessary

http://www.horizons-2000.org/2.%20Ideas%20and%20Meaning/Topics/NeuroPsychology.htm

Robot
http://video.google.co.kr/videoplay?docid=4476811361193228548&ei=Z5fsSIzCHZrUgAPKl7TkCw&q=robot&hl=ko

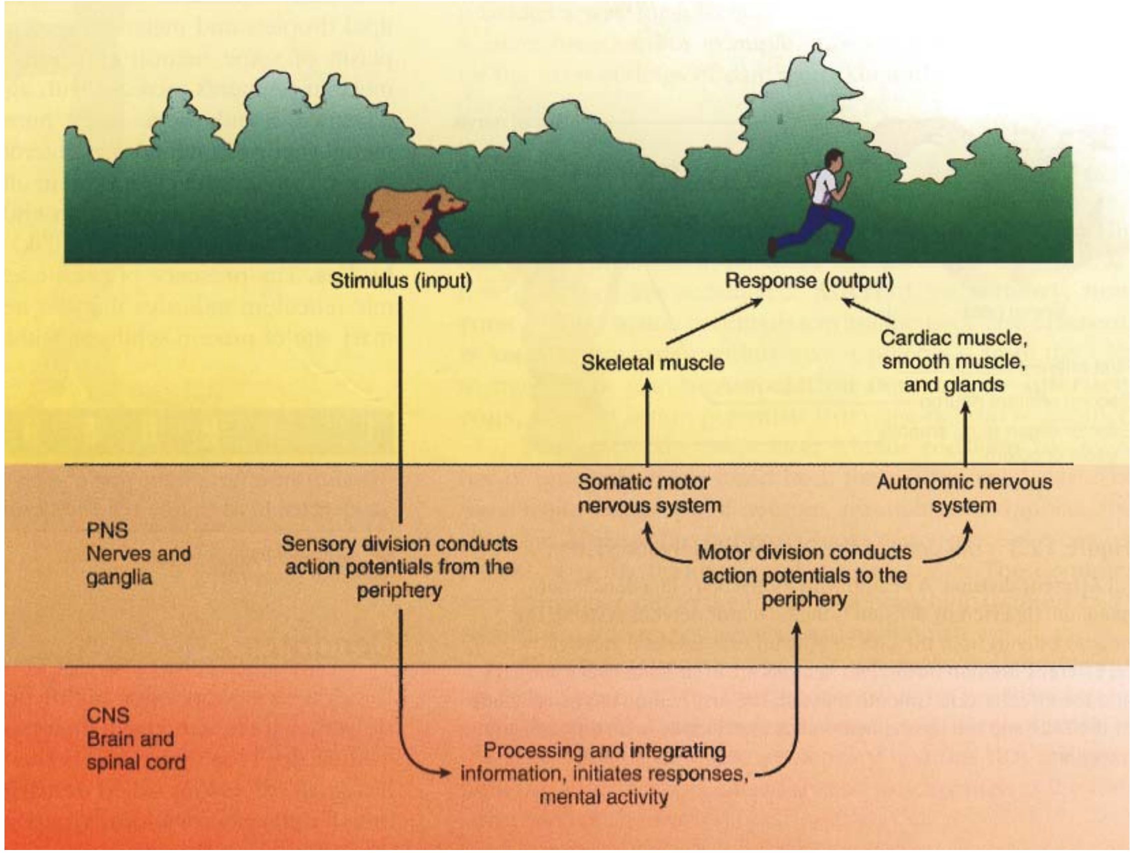
Robot muscle
http://kr.youtube.com/watch?v=k9f-W6Xi_Wo



Neural Reflexes: Overview

Organization of the nervous system

- •Stimulus
- •Sensory receptor
- •Sensory (afferent) neuron
- •CNS integration
- •Efferent (motor) neuron
- •Effector (target tissue)
- •Response (movement)
- •Feedback to CNS



Achievement of movement

Signal from the brain to spinal cord

Autonomous function of spinal cord: reflexes

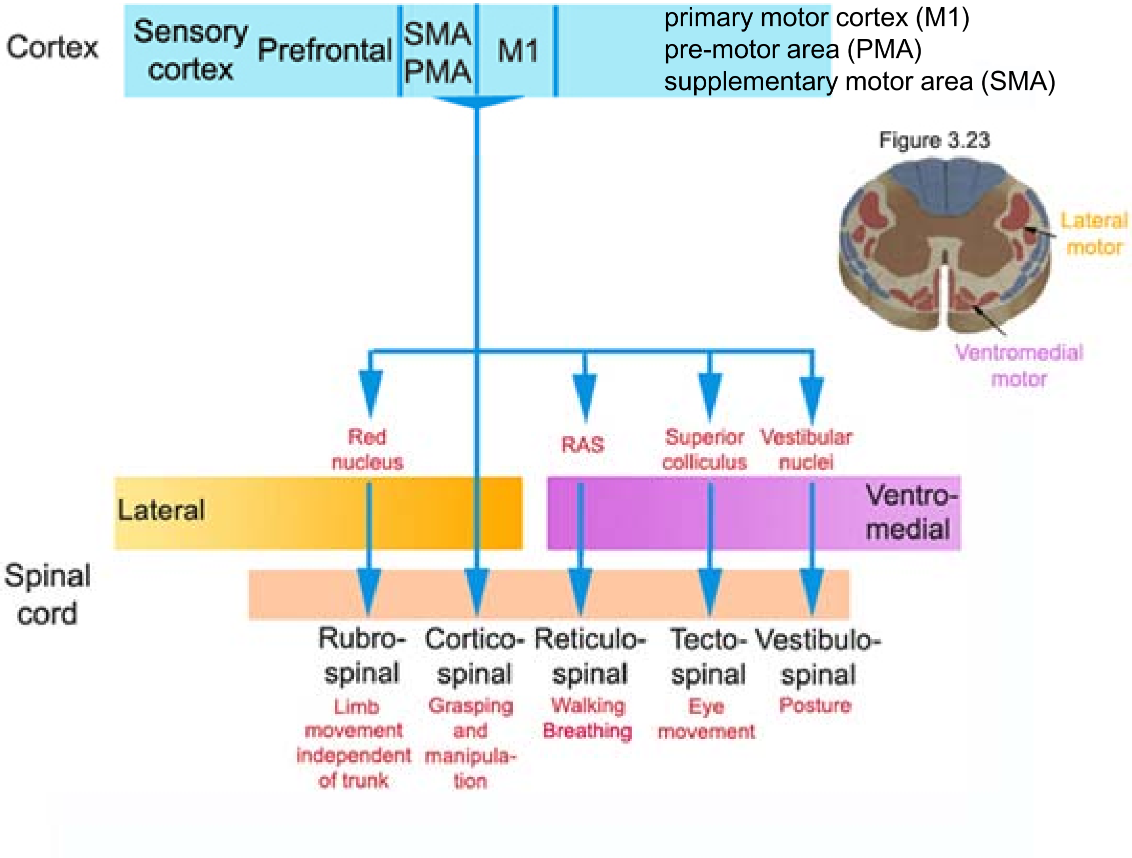
- stretch reflex

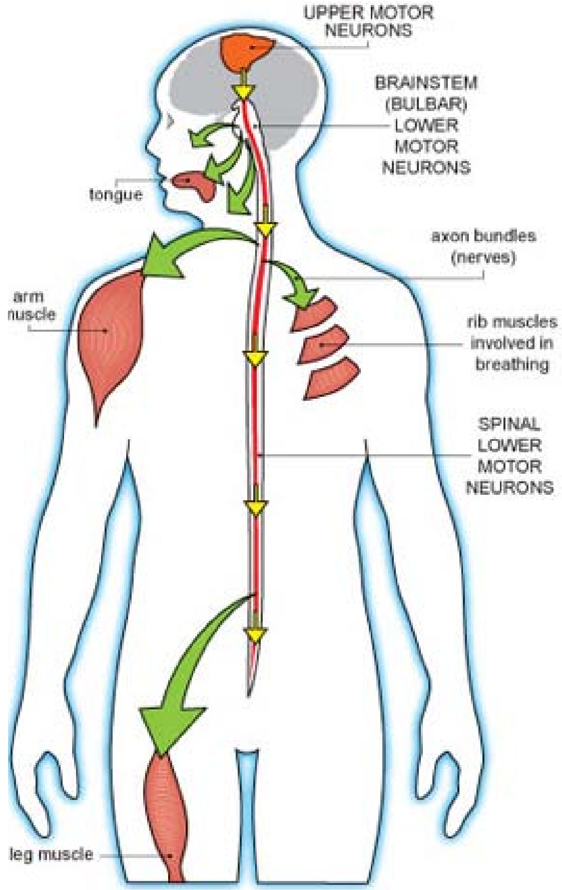
Semiautomatic movements

- signals from brain stem
- 4 motorways from the brain stem
  - one responsible for semireflex rhythmic subconscious movements: swimming
  - the second coordinates movement with visual and sensory information
  - the third for balance
  - the fourth mediates the moving of individual limbs

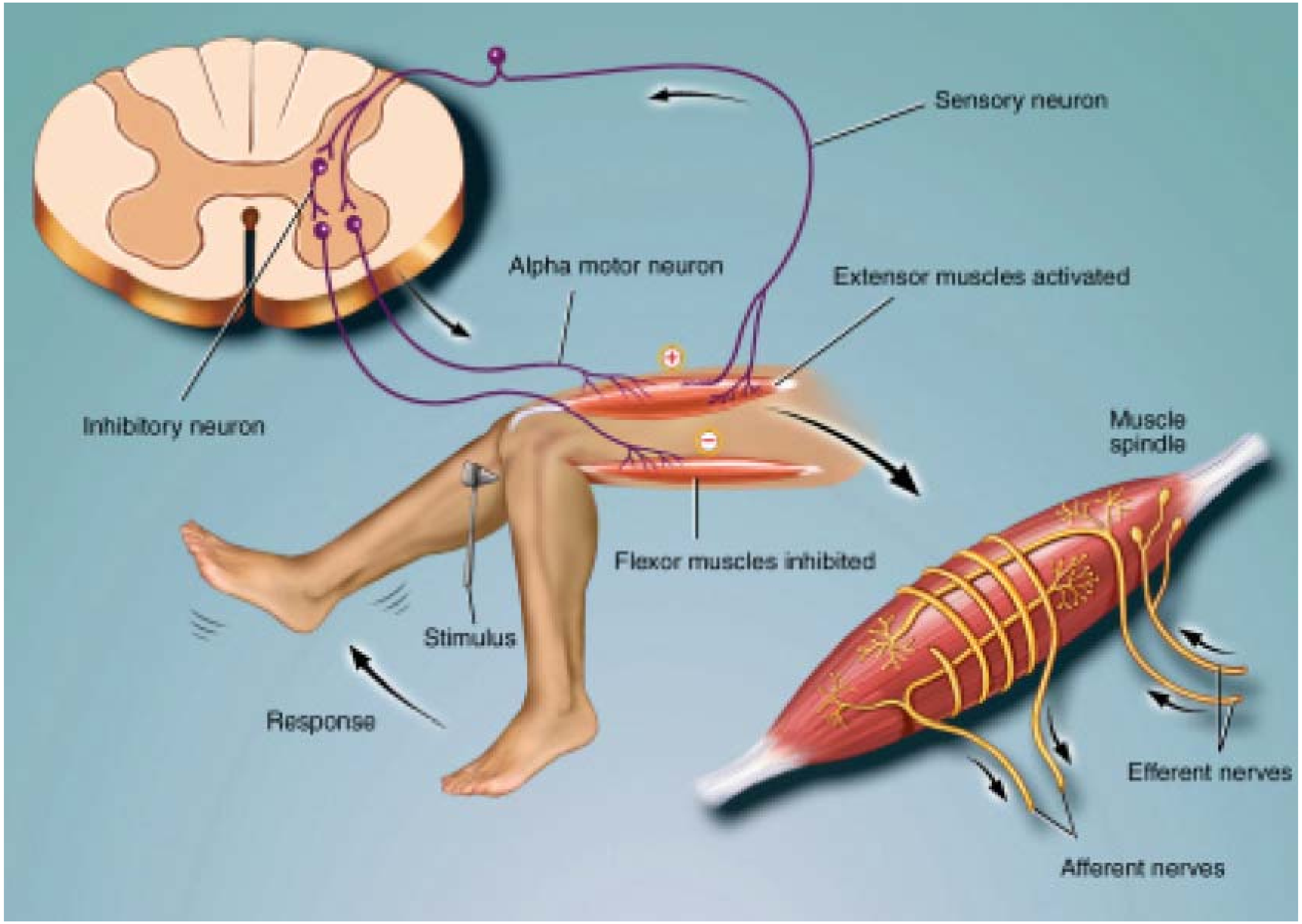
finger movement: from the motor cortex

4 motorways from the brain stem

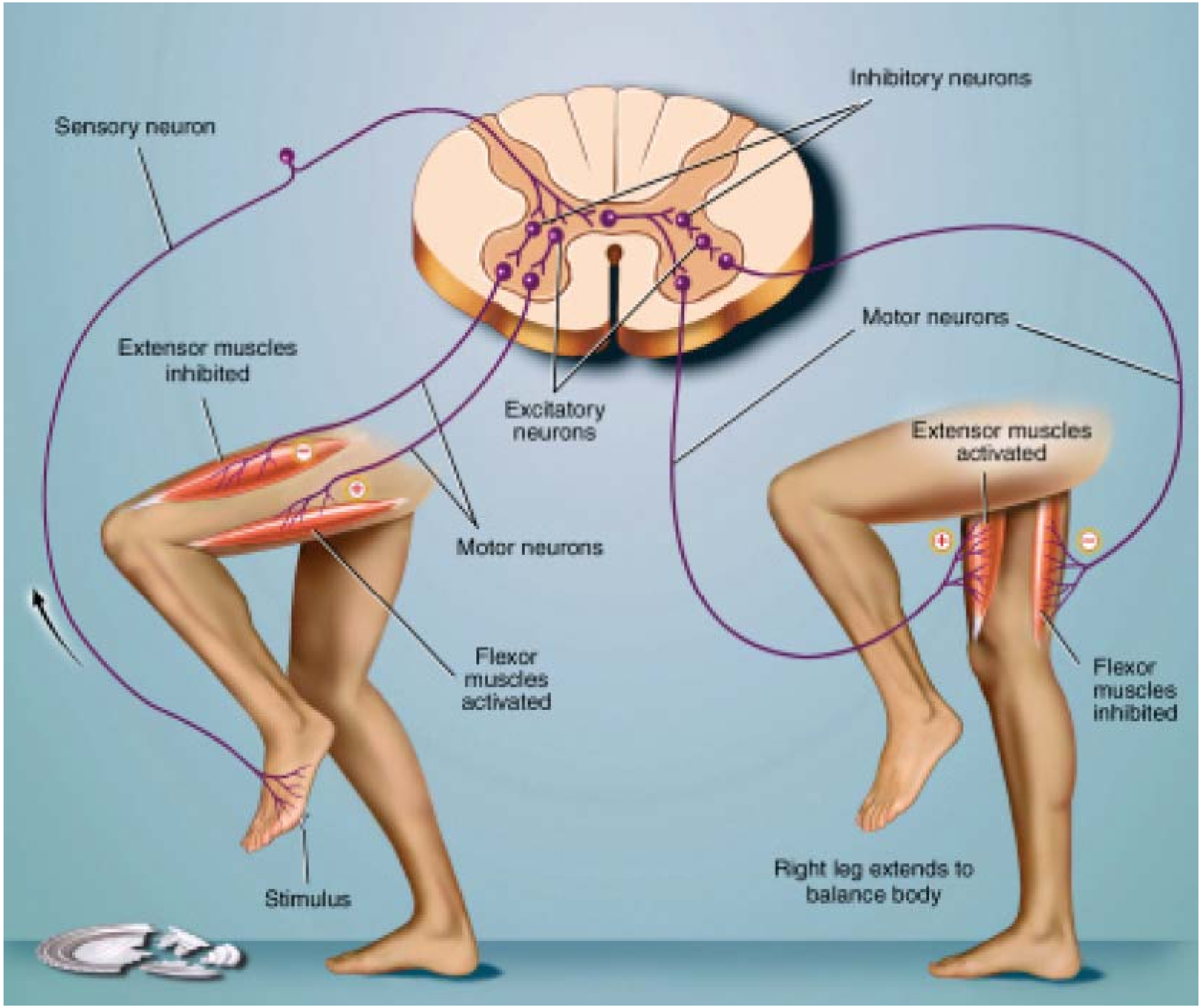


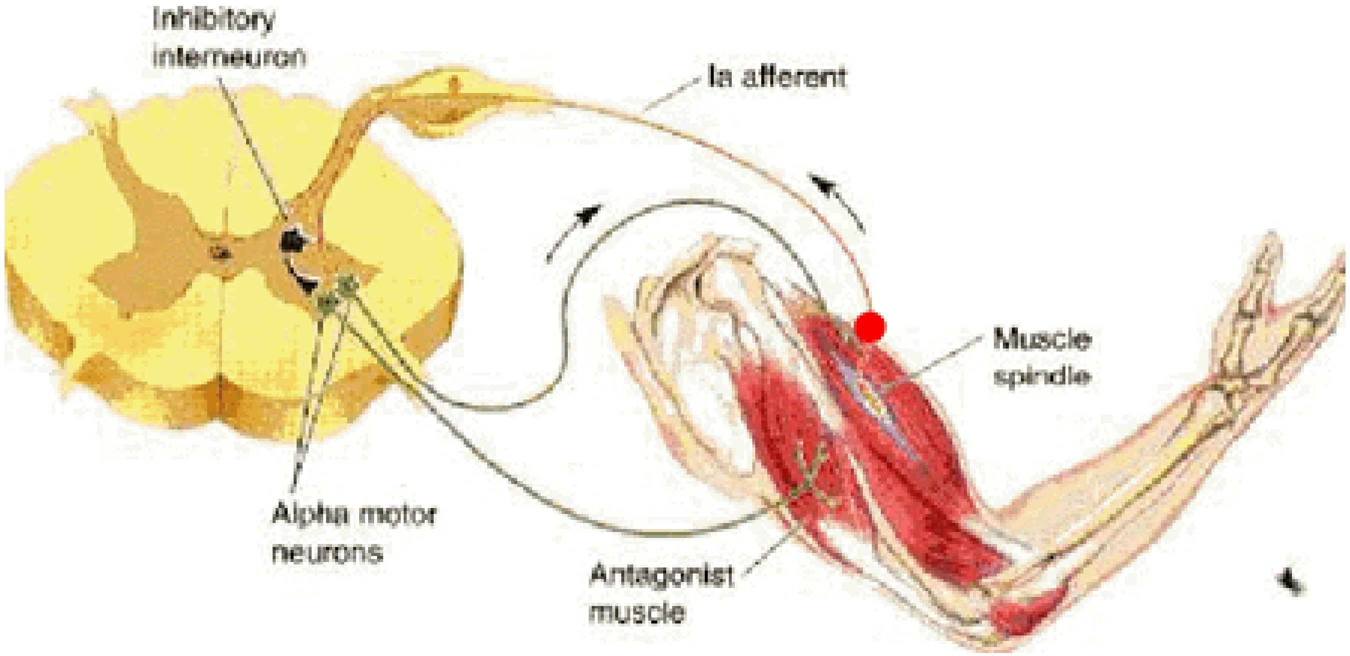


reflexes


Sensory neuron
Alpha motor neuron
Extensor muscles activated
Inhibitory neuron
Muscle spindle
Flexor muscles inhibited
Stimulus
Response
Efferent nerves
Afferent nerves

flexion withdrawal





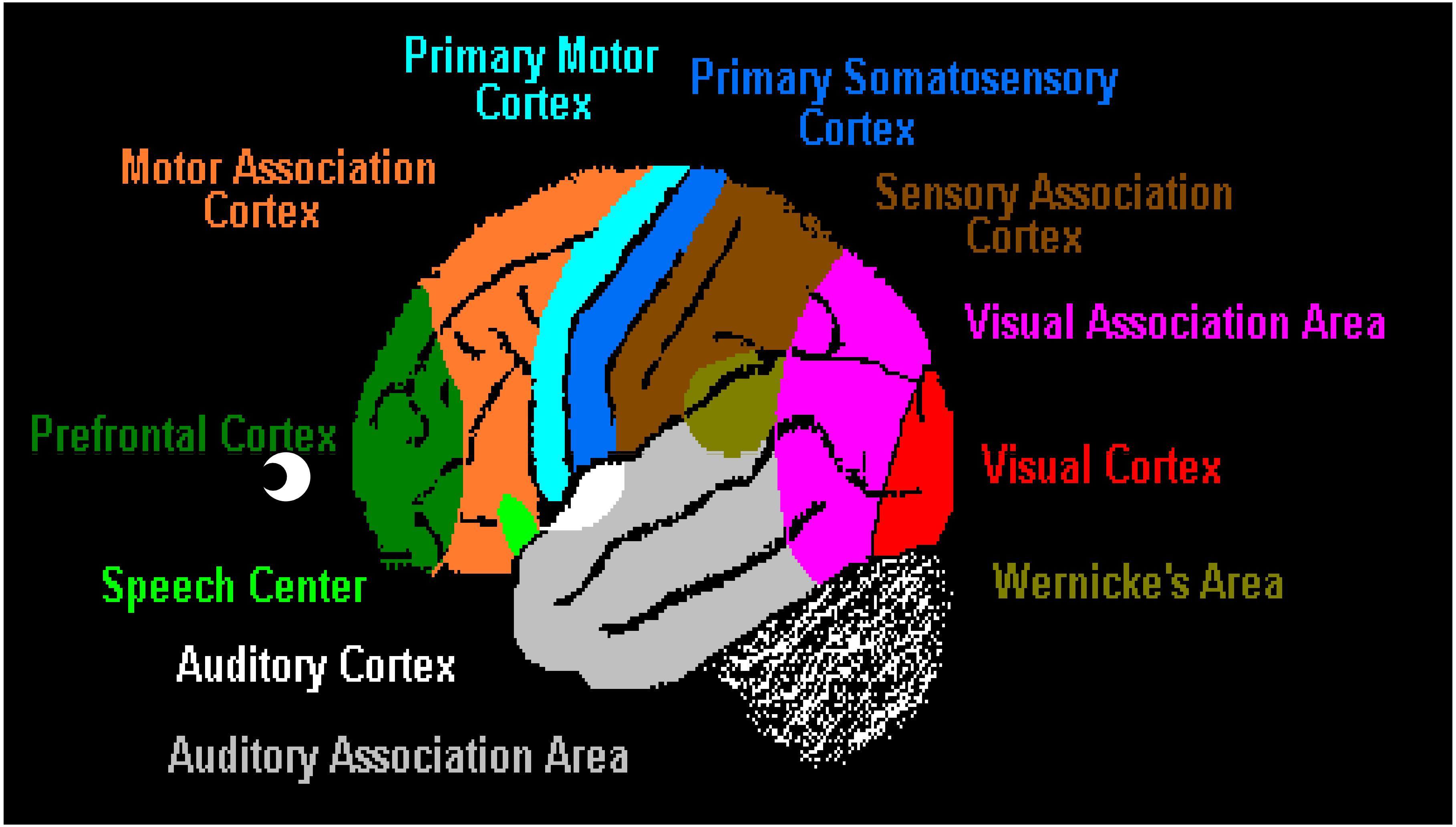
Inhibitory interneuron
Ia afferent
Muscle spindle
Alpha motor neurons
Antagonist muscle

Motor cortex

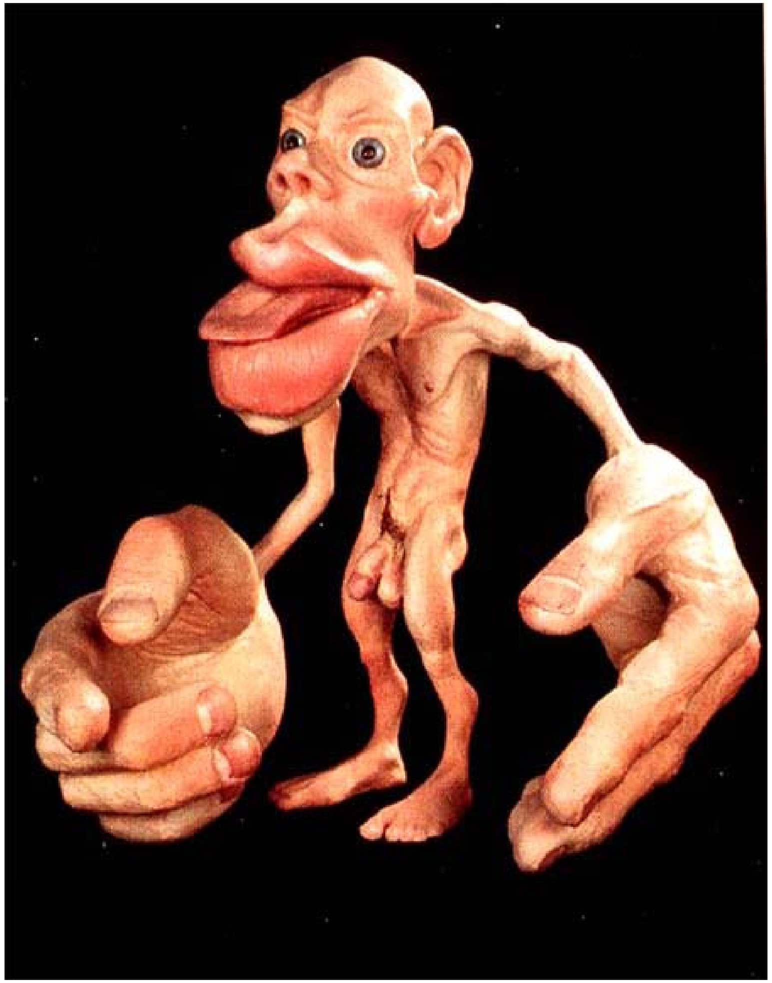
Plays a critical role in the control of movement
- Direct control of some of the muscles controlling the hands
- Hierarchical influence over the other four movement motorways

Movement center of the brain but no monopoly
- Involvement of basal ganglia and cerebellum

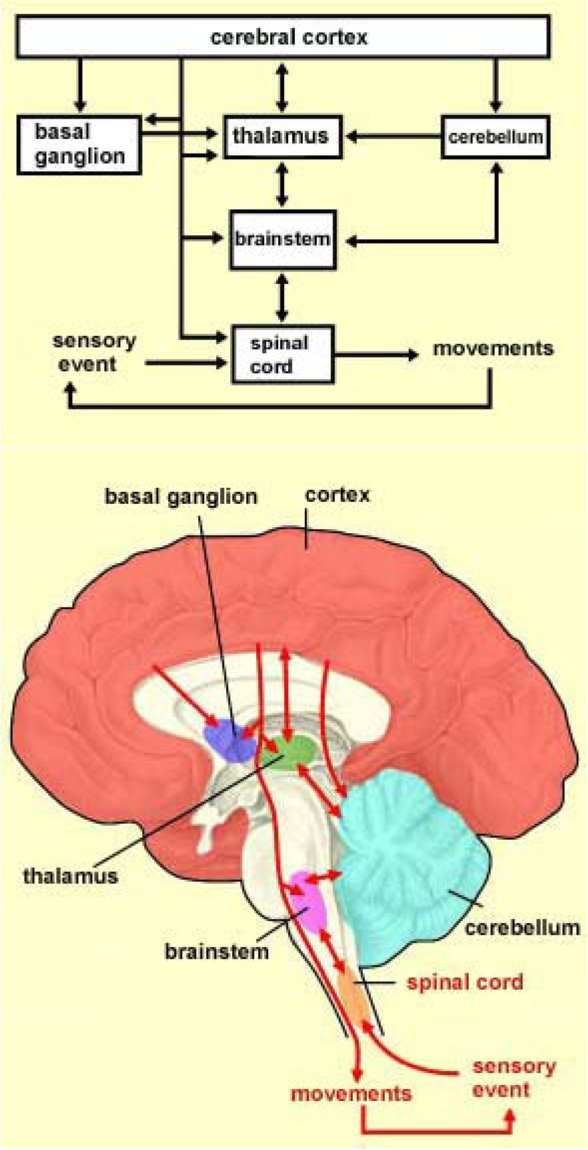
Sensory and motor areas



More sensitive areas require more cortex

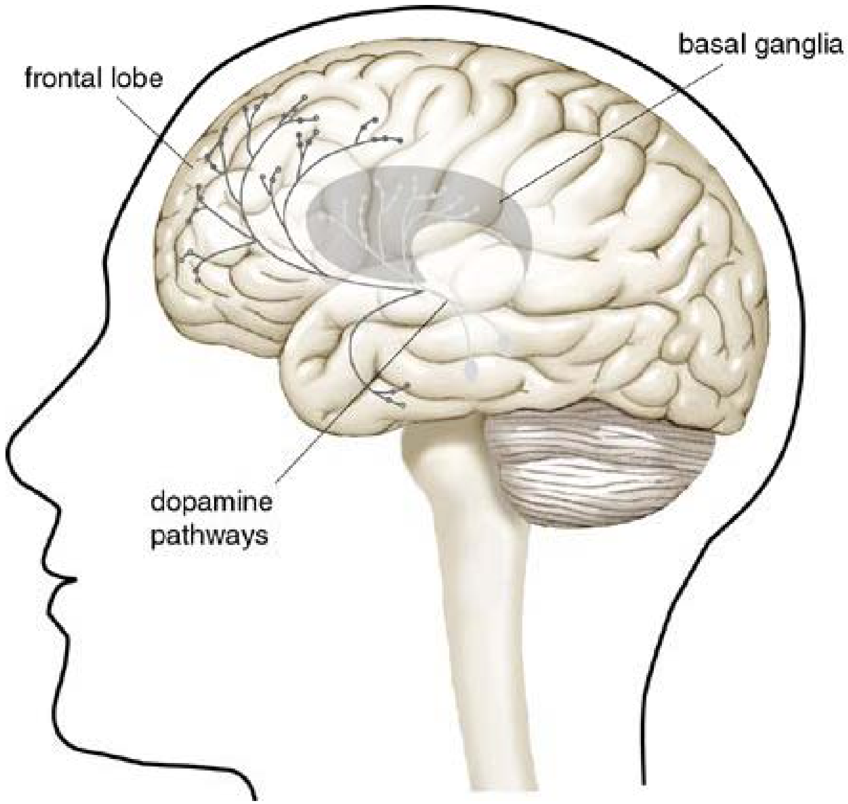


Basal ganglia and cerebellum in movement

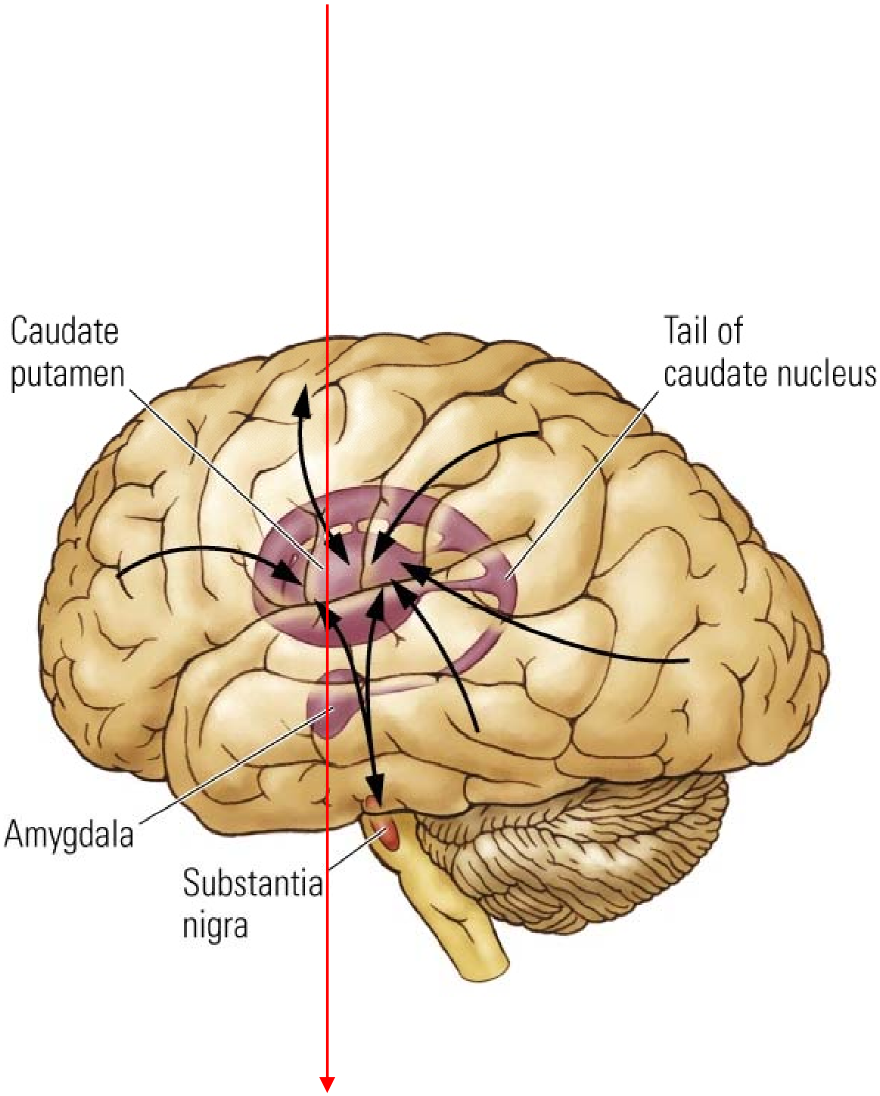


Basal ganglia

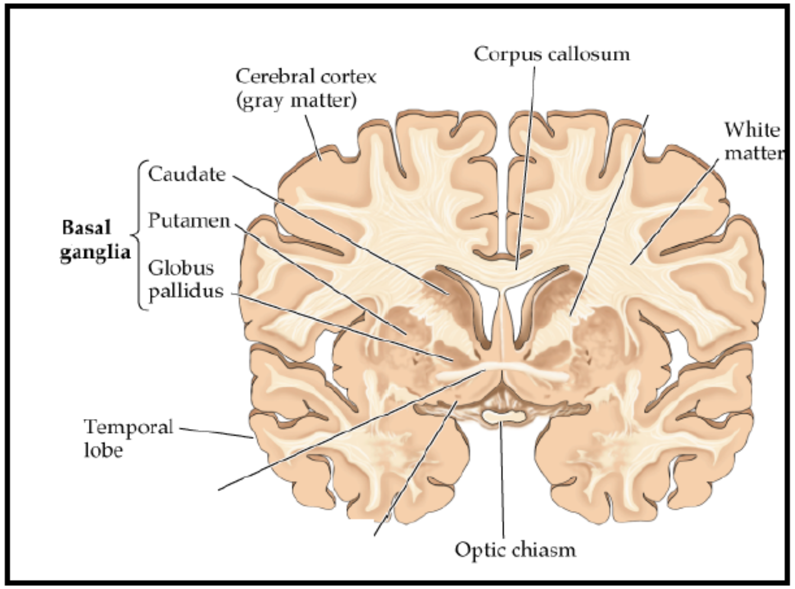
Responsible for ballistic movements (subconscious)
A group of various interconnected brain regions



<table>
<tr><th>Functional Division</th><th>Constituent Parts</th><th>Developmental Division</th><th colspan="2">Primary Division</th></tr>
<tr><td>Neocortex (신피질)</td><td>Cerebral cortex (대뇌피질)
Frontal Lobes
Temporal Lobes
Parietal Lobes
Occipital Lobes
Corpus Callosum (뇌량)</td><td rowspan="4">Telencephalon</td><td rowspan="4">Cerebral Hemispheres</td><td rowspan="6">Forebrain</td></tr>
<tr><td rowspan="3">Limbic system(변연계)
Cingulate Cortex
Amygdala
Hippocampus
Septum</td><td>Amygdala (편도체)</td></tr>
<tr><td>Hippocampus (해마)</td></tr>
<tr><td>Basal ganglia (기저핵)
Caudate Nucleus
Putamen
Globus Pallidus</td></tr>
<tr><td rowspan="2">Diencephalon (간뇌)</td><td>Thalamus (시상)</td><td rowspan="2">Diencephalon</td><td rowspan="2">Diencephalon</td></tr>
<tr><td>Hypothalamus (시상하부)</td></tr>
<tr><td rowspan="4">Brainstem (뇌간)</td><td>Midbrain
Superior Colliculus
Inferior Colliculus</td><td>Mesencephalon</td><td rowspan="4">Brainstem</td><td>Midbrain</td></tr>
<tr><td>Cerebellum (소뇌)</td><td rowspan="2">Metencephalon</td><td rowspan="4">Hindbrain</td></tr>
<tr><td>Pons (교뇌)</td></tr>
<tr><td>Medulla Oblongata (연수)</td><td>Myelencephalon</td></tr>
<tr><td>Spinal Cord (척수)</td><td>Spinal Cord</td><td></td><td>Spinal Cord</td></tr>
</table>

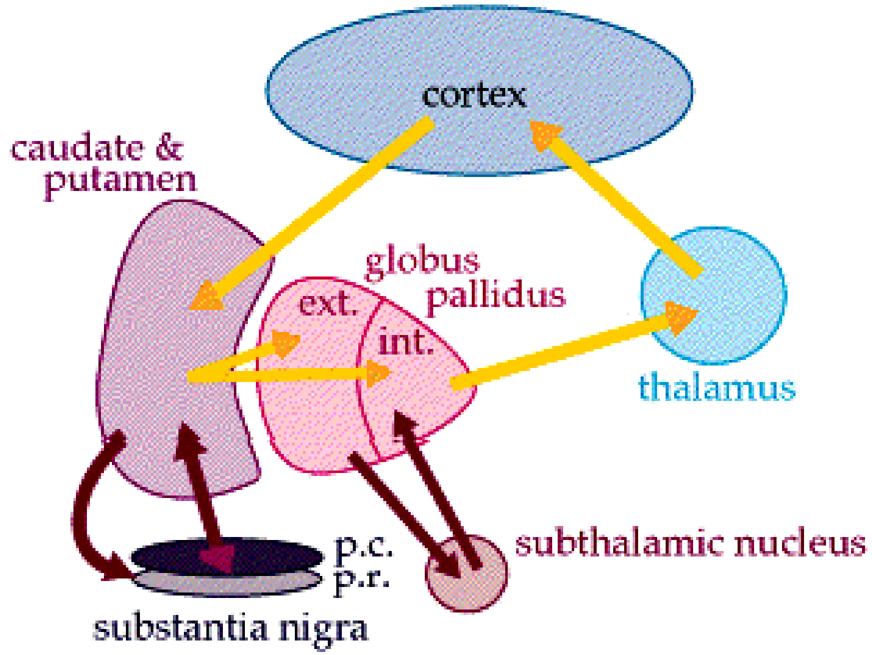


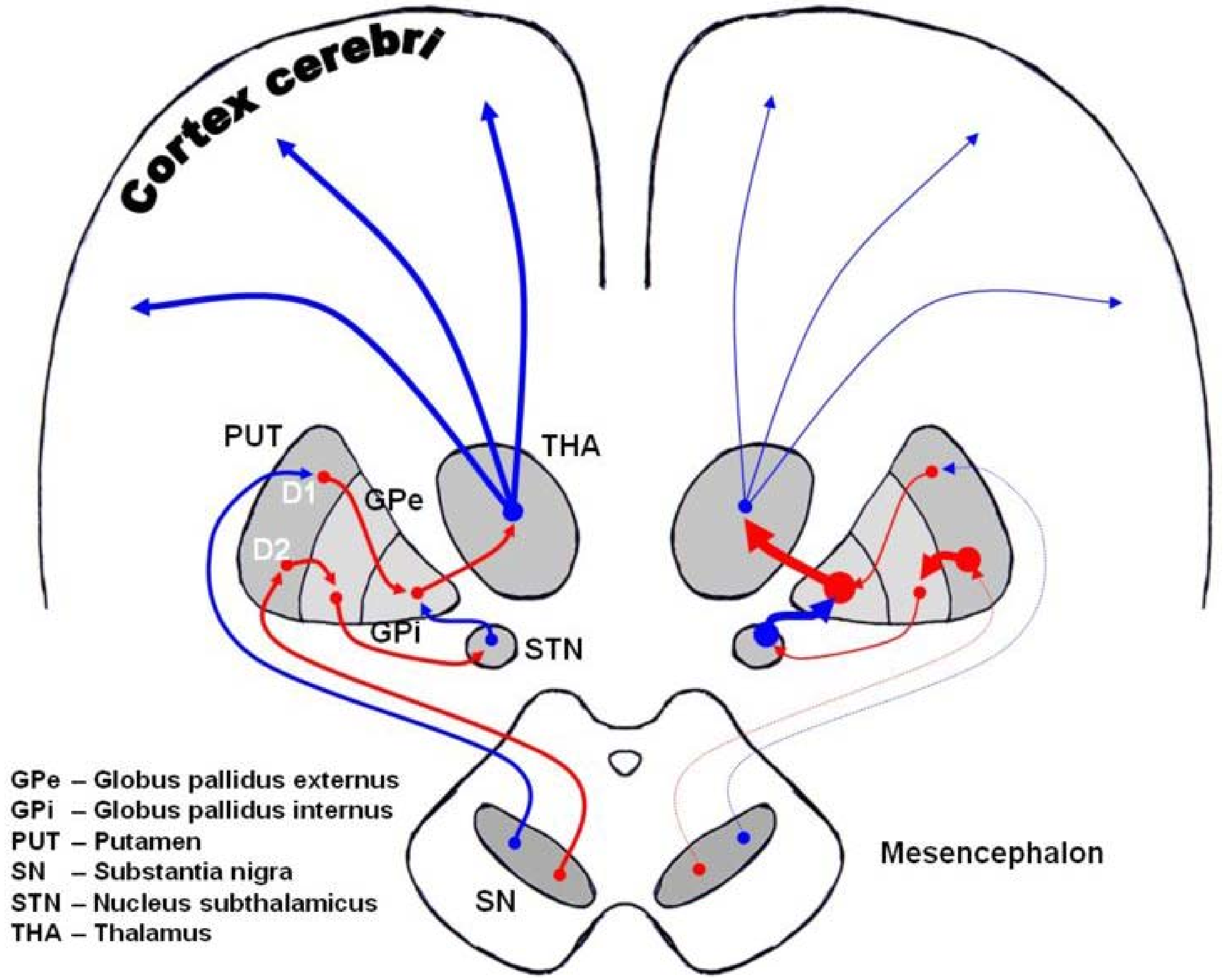
Basal Ganglia Cross Section



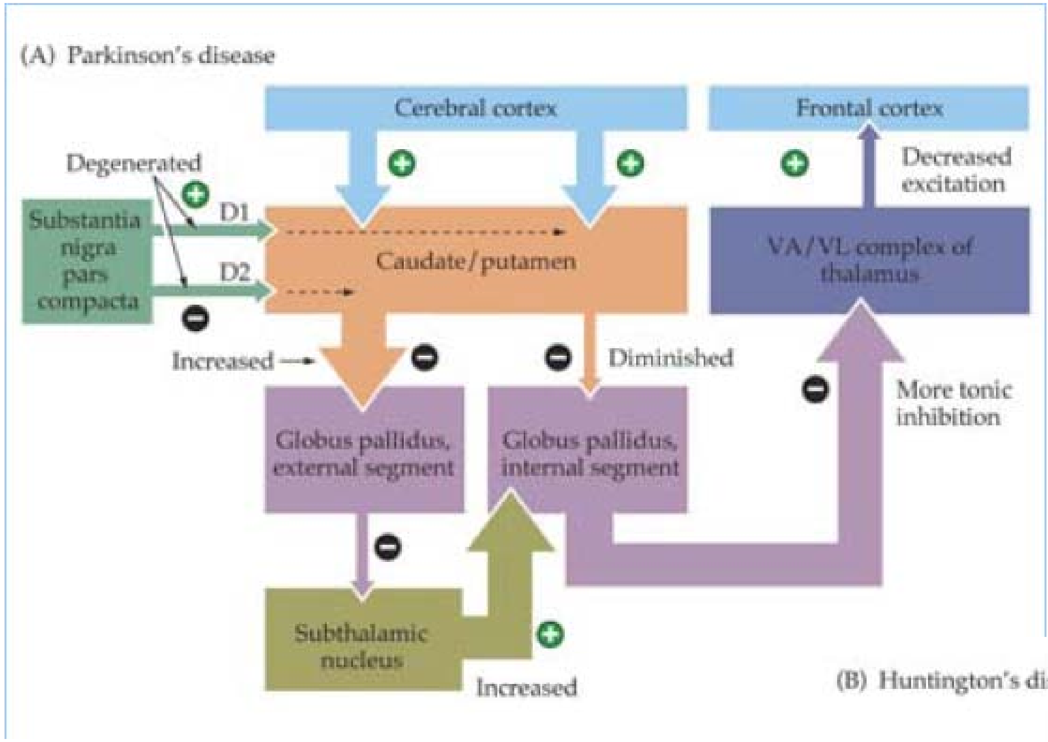
basal ganglia: a collection of nuclei deep to the white matter of cerebral cortex
caudate + putamen + nucleus accumbens + globus pallidus + substantia nigra + subthalamic nucleus + (claustrum + amygdala)
the claustrum and the amygdala, however, do not really deal with movement, nor are they interconnected with the rest of the basal ganglia

Striatum: caudate + putamen + nucleus accumbens
corpus striatum: striatum + globus pallidus
lenticular nucleus: putamen + globus pallidus

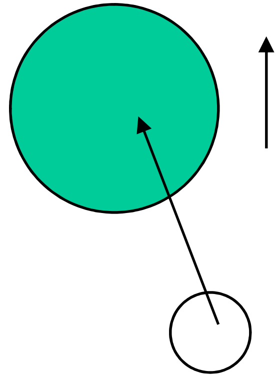


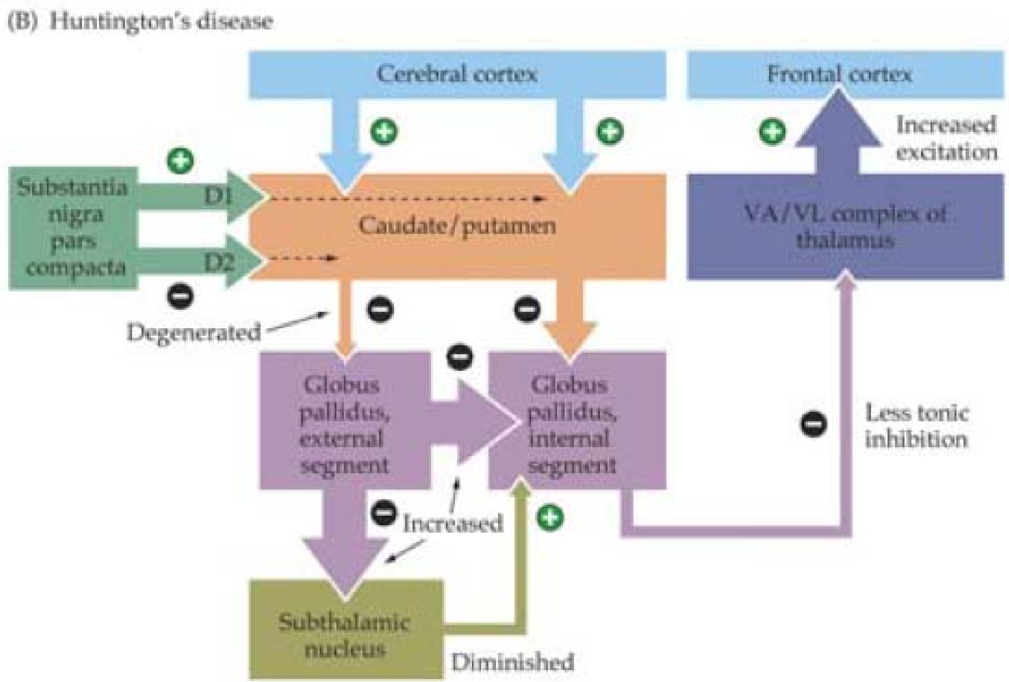


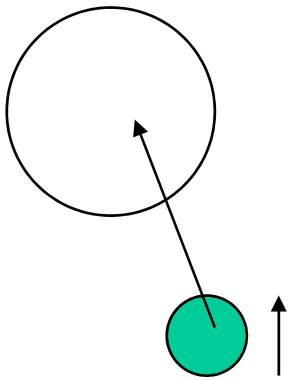
The image shows dopaminergic pathways of the human brain in normal condition (left) and Parkinsons Disease (right). Red Arrows indicate suppression of the target, blue arrows indicate stimulation of target structure



striatum



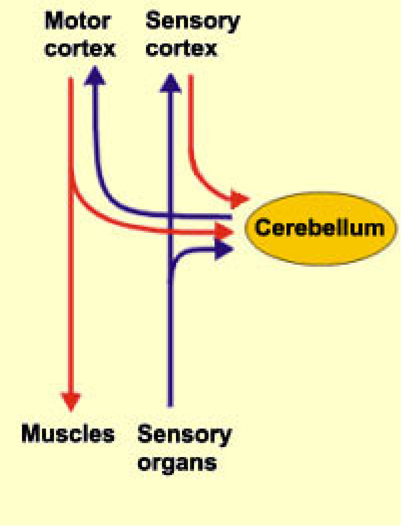


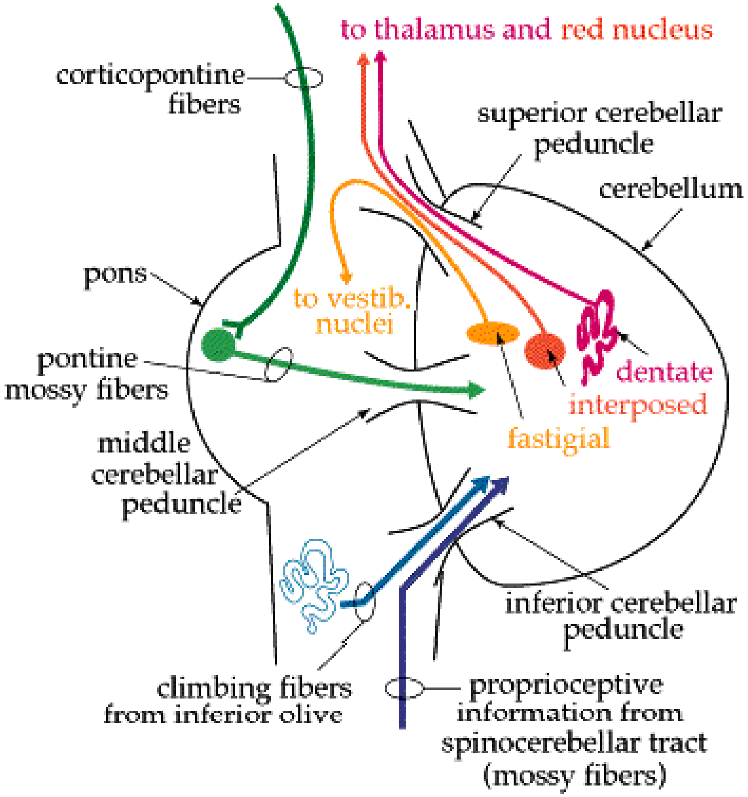


substantia nigra

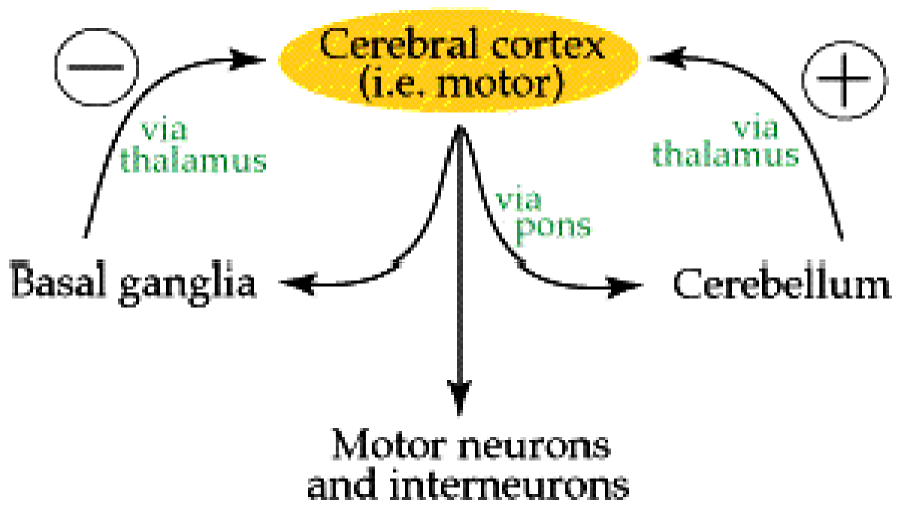
Cerebellum (Little brain)

Important for automated movements triggered by outside events
unconscious movements
Sensory motor coordination: skilled movements
improve with exercise to become almost subconscious



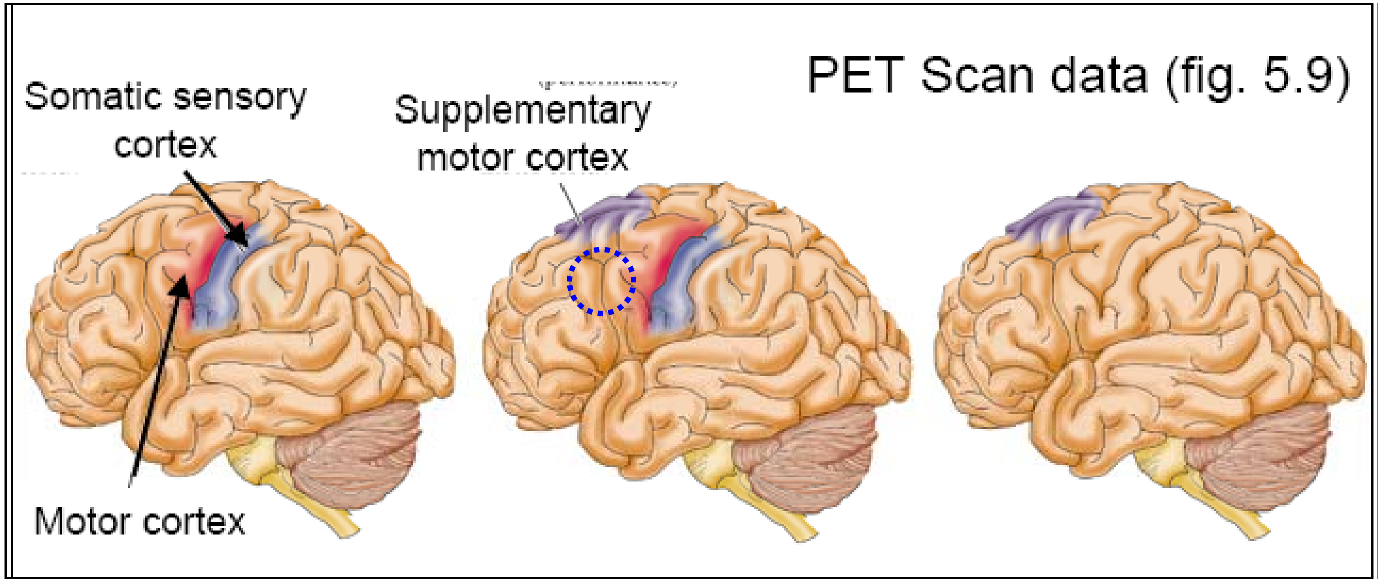


Coordinated control of different brain areas



Supplementary Motor Cortex:

Brain image studies indicate it is important in planning complex movements



Simple finger flexion: Motor Cortex and Somatic Sensory Cortex are active

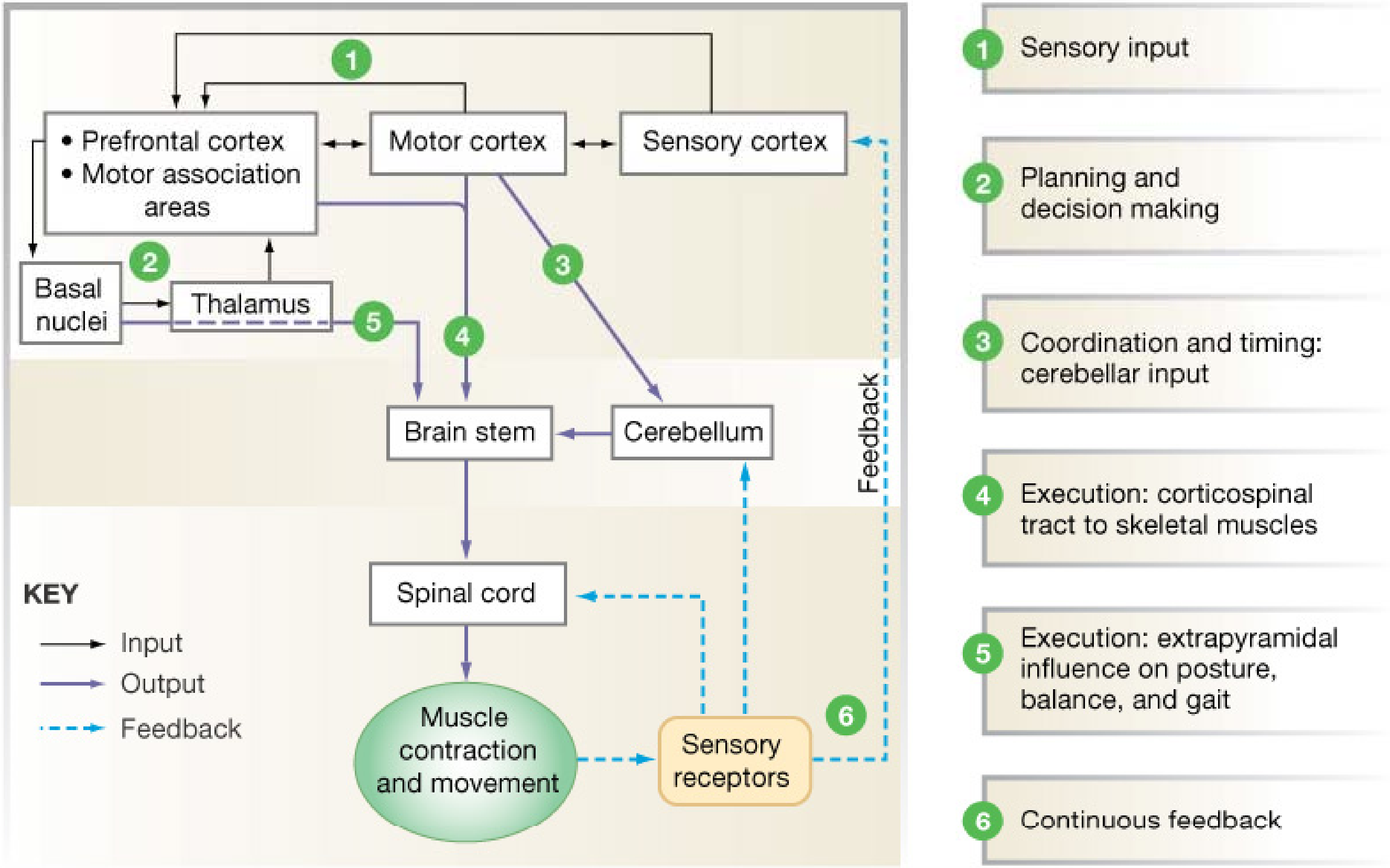
Finger movement sequence: Supplementary motor cortex is also active

Mental rehearsal of finger movement sequence: Only supplemental motor cortex is active

Voluntary Movement: “Conscious”

- Cortex at top of several CNS integration sites
- Can be initiated with no external stimuli
- Parts can become involuntary: muscle memory

Voluntary Movement: “Conscious”



Somatosensory system

The **somatosensory system** includes multiple types of sensation from the body - light touch, pain, pressure, temperature, and joint and muscle position sense (also called proprioception).

These modalities are lumped into three different pathways in the spinal cord and have different targets in the brain.

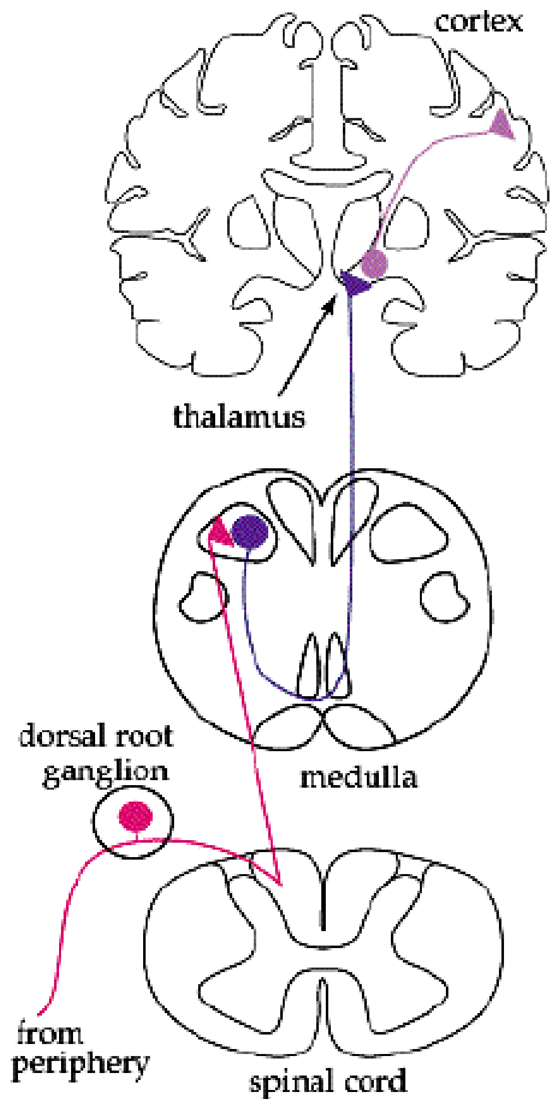
Discriminative touch, which includes touch, pressure, and vibration perception, and enables us to "read" raised letters with our fingertips, or describe the shape and texture of an object without seeing it.

Pain and temperature, which is just what it sounds like, and also includes the sensations of itch and tickle.

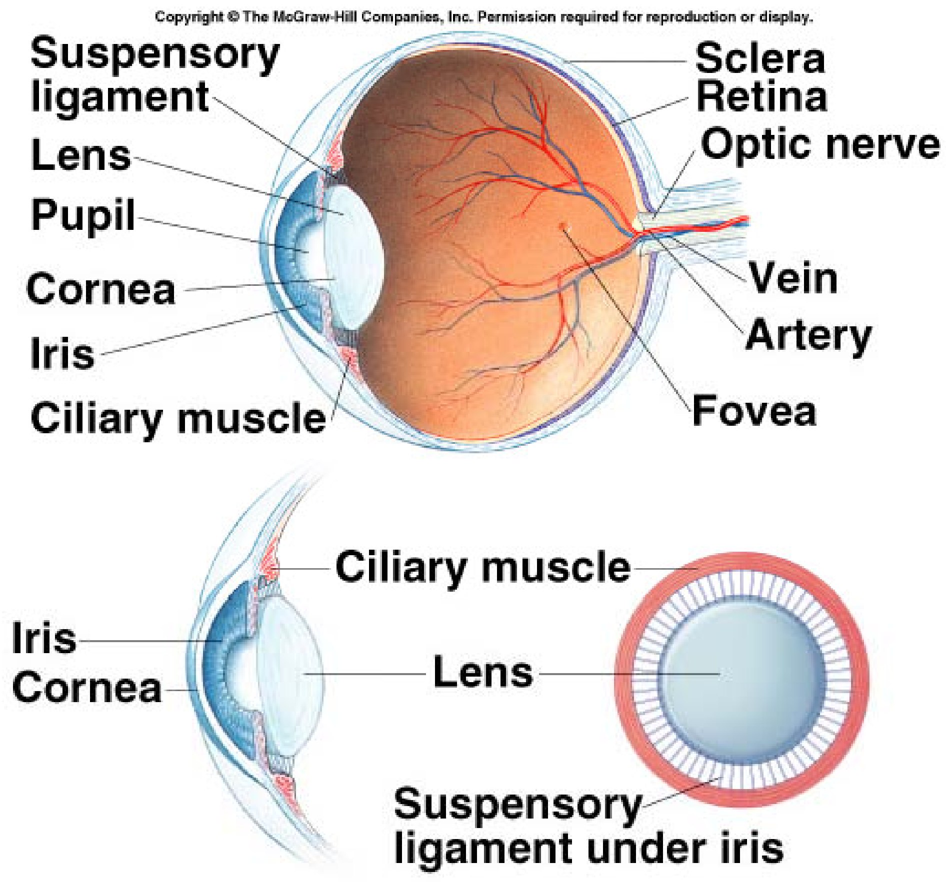
Proprioception, and includes receptors for what happens below the body surface: muscle stretch, joint position, tendon tension, etc. This modality primarily targets the **cerebellum**, which needs minute-by-minute feedback on what the muscles are doing.

These modalities differ in their receptors, pathways, and targets, and also in the level of crossing. Any sensory system going to the cerebral cortex will have to cross over at some point, because the cerebral cortex operates on a contralateral (opposite side) basis. The discriminative touch system crosses high - in the medulla. The pain system crosses low - in the spinal cord. The proprioceptive system is going to the cerebellum, which (surprise!) works ipsilaterally (same side). Therefore this system doesn't cross.

Discriminative touch pathway

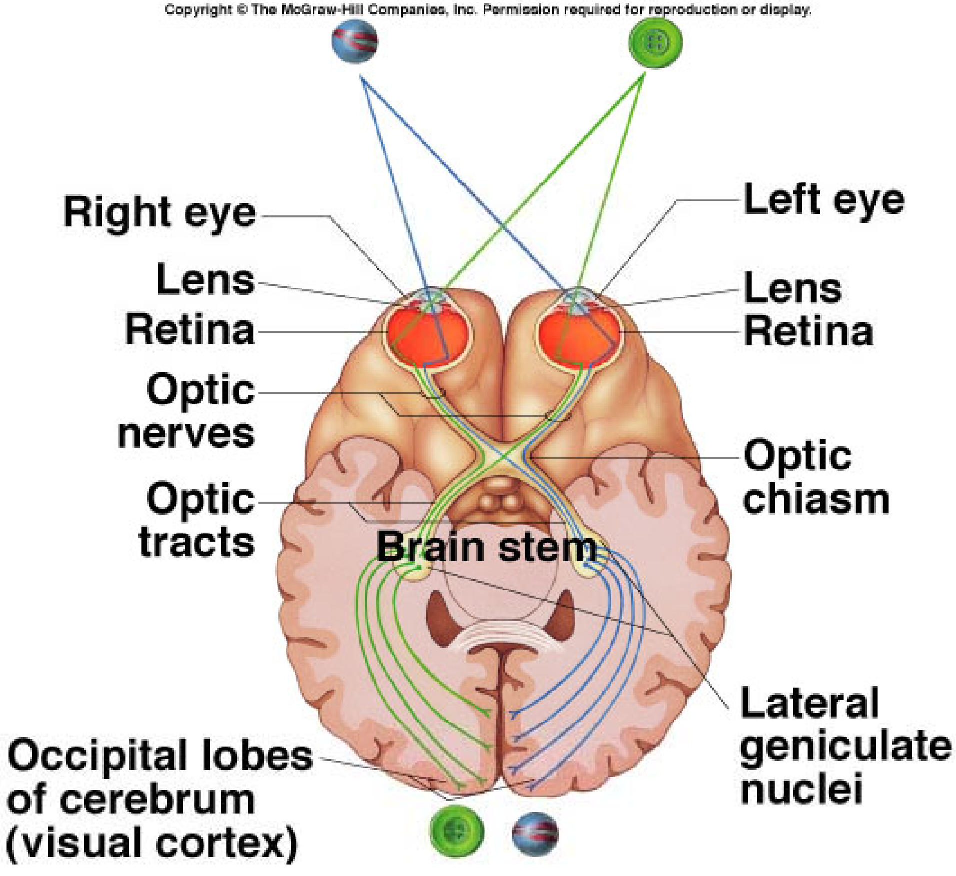


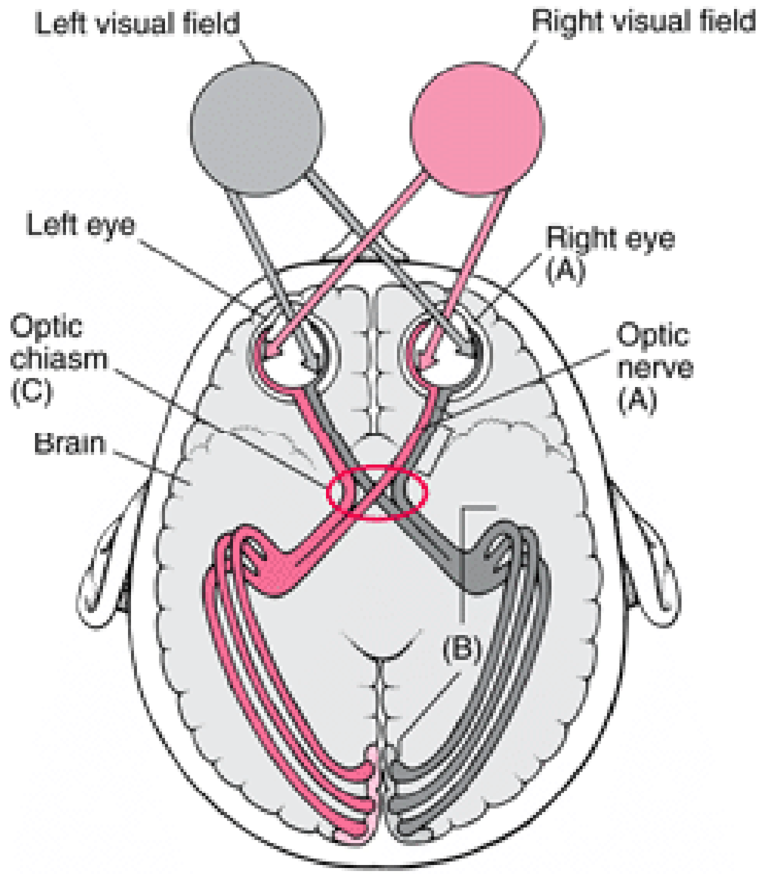
Human Eye

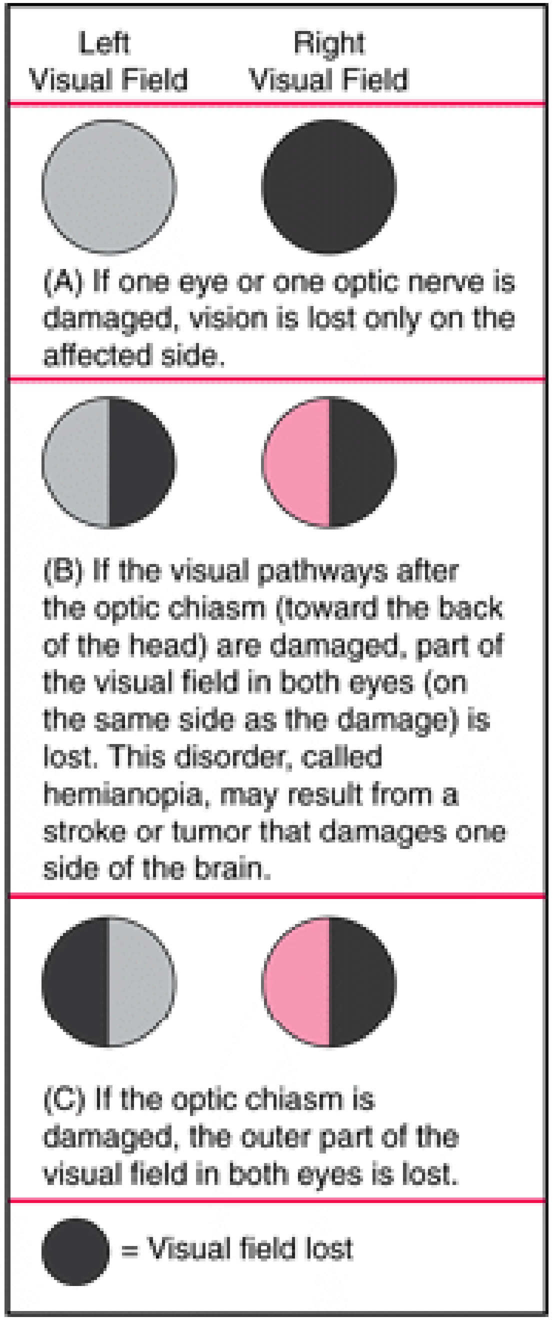


http://optics.snu.ac.kr/on-line/bong/eye1.html

Pathway of Visual Information

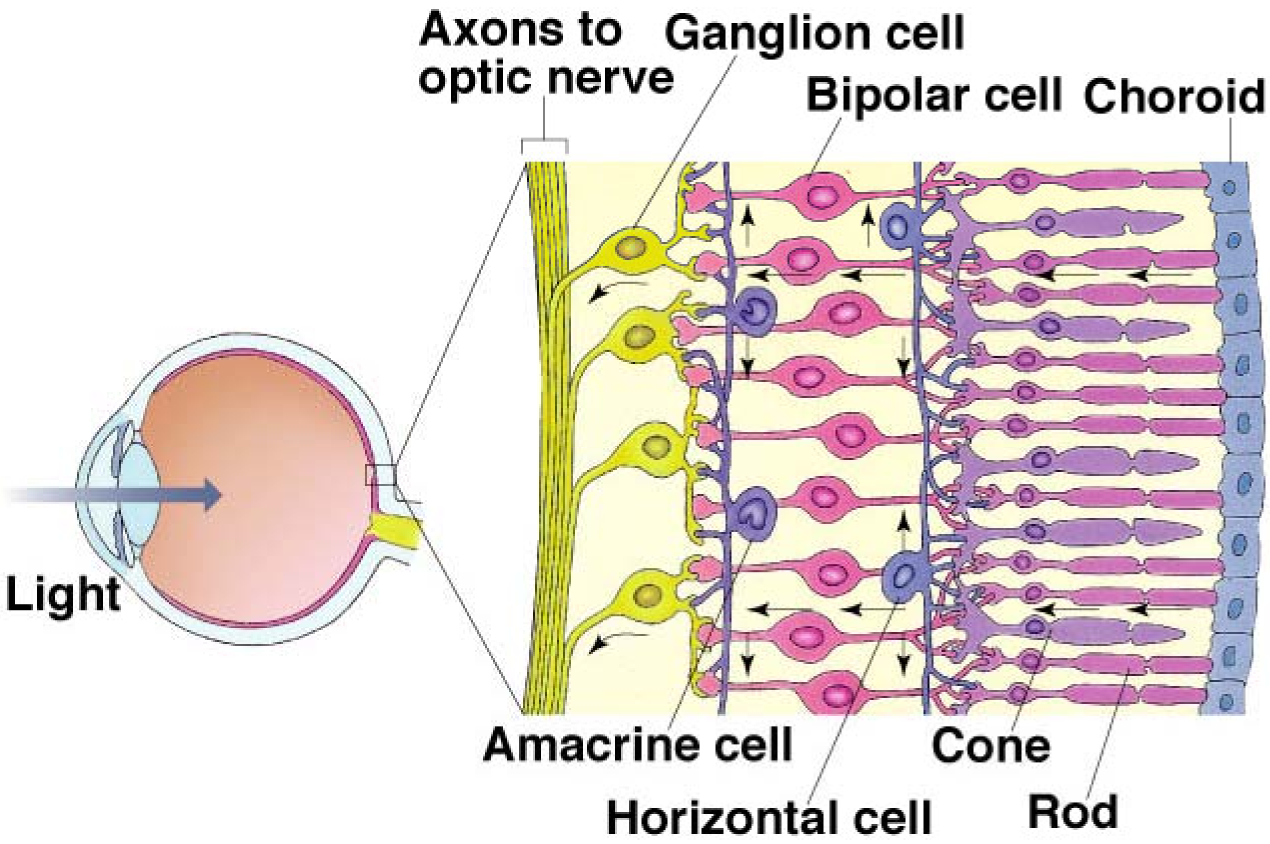






http://www.merck.com/mmhe/sec20/ch225/ch225b.html

Structure of the Retina



- **rods -** 130,000,000
- **cones -** 7,000,000: concentrated in fovea

Receptive field

Spatial summation occurs due to the convergence of photoreceptors onto ganglion cells. This convergence of photoreceptors form a receptive field thus stimulating different photoreceptor within this receptive field would result in one signal. Receptive field sizes vary with eccentricity (figure 26), and helps explain the reason why critical area varies with eccentricity (Shapley and Enroth-Cugell, 1984). Clearly, the size of spatial summation (functional receptive field), will limit resolution capabilities as outlined earlier.

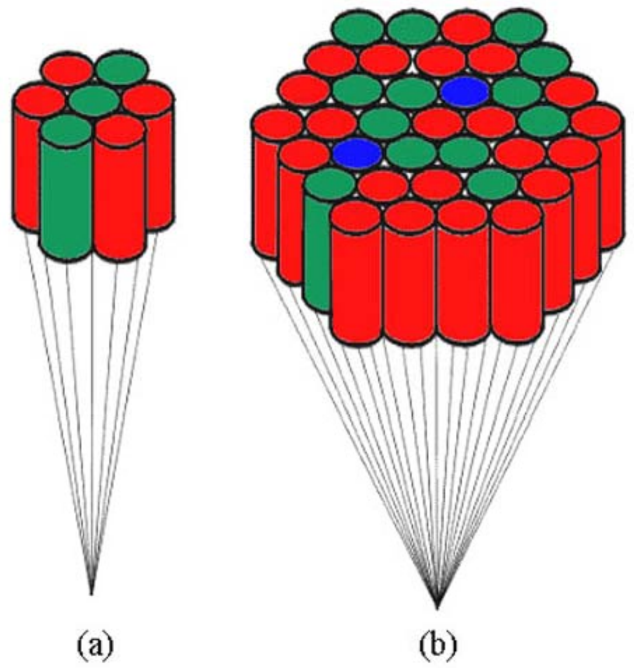
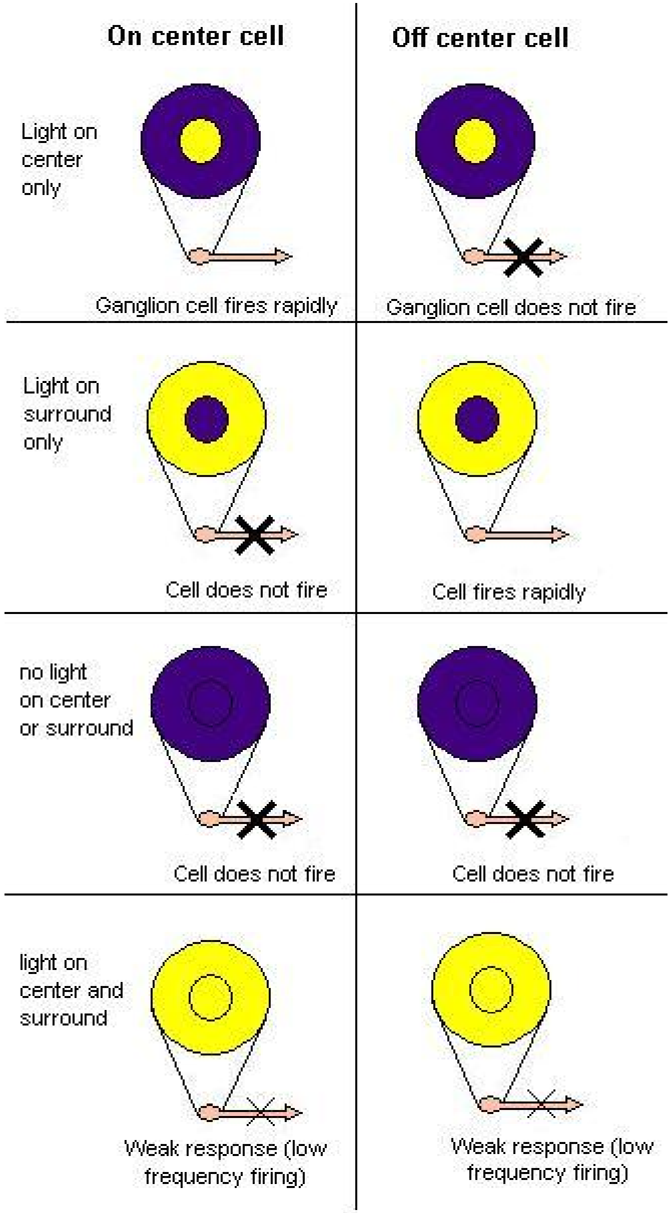


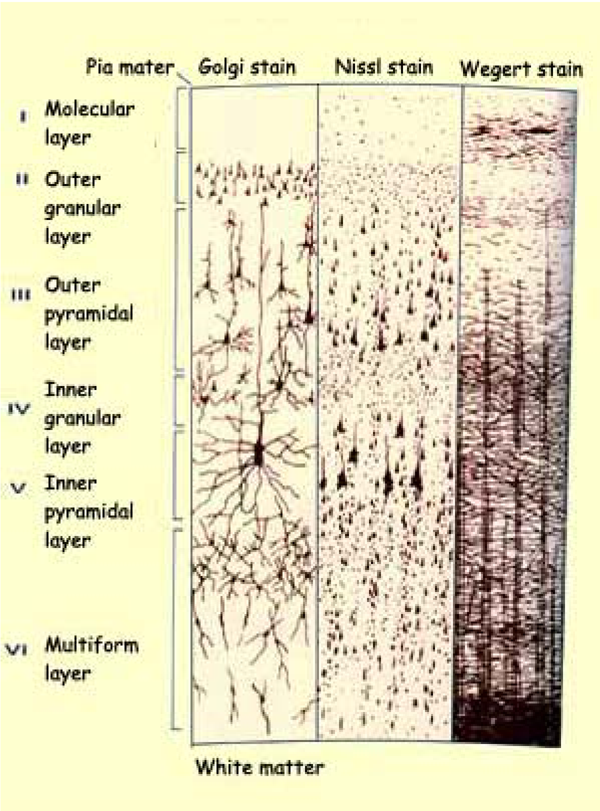
Figure 26. Schematic illustration of the size of receptive fields in (a) the parafoveal region (7^o eccentricity) and in (b) the peripheral retina (35^o eccentricity).

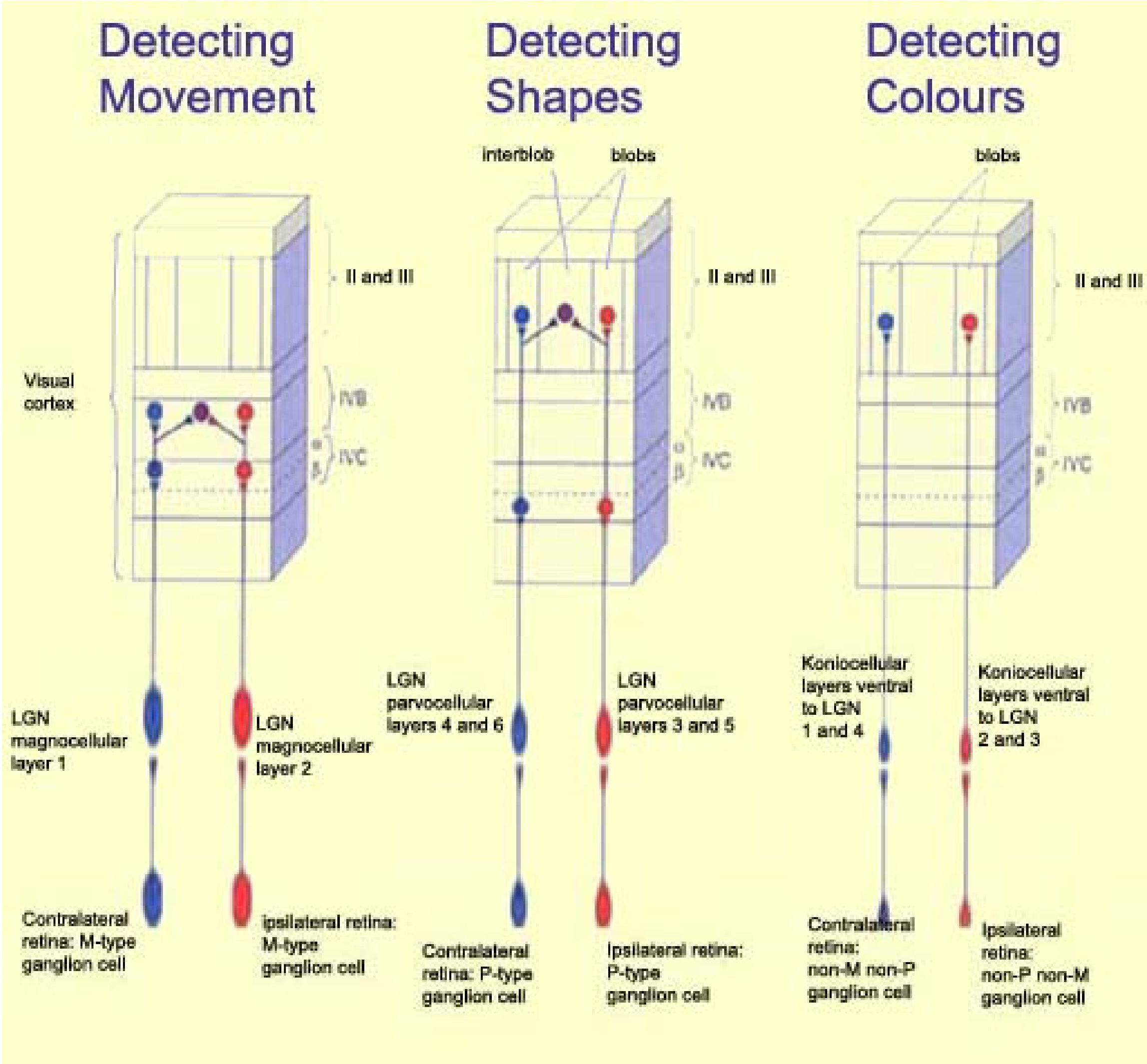
http://webvision.med.utah.edu/KallSpatial.html



http://www.answers.com/topic/receptive-field-jpg-1

Visual cortex





How is light registered in the brain?

Conversion of light energy into electrical impulses
Two light sensitive cells
- rod: mediated by rhodopsin
- cone: sensitive to color
  - wavelength dependent excitation of red, green, or blue cells

Images are relayed into the brain with an enormous bias
- retina is more concerned with states of change
  - such as contrasting edges or movement

Nerve fibers exiting via the blind spot to the thalamus and then to visual cortex
What happen in the visual cortex?

Patients with visual problems

1. A woman damaged in the visual cortex
   deficient in detecting moving objects
2. George Riddoch
   see movement but not shape or color
3. See form and movement but not experience color
   deficit of cones or damage to visual cortex
4. See movement and color but not form: agnosia
   see objects but not identify
   vary in its severity and time dependent
   Is it because there is a gradual process of integrating patterns?

Vision of form, movement, and color occur independently of each other
They are processed simultaneously but in different parts of the brain
How and where they are integrated?

A hypothesis of grand central station

- convergence of different pathways
- but there should be a area which, when damaged,
  - leads to complete loss of vision

A hypothesis of interactive parallel brain regions

- connections between brain regions are not directed to converge
  - into an executive center
- but are likely to take the form of balanced dialogues between them

<u>Seeing and recognition</u>

Is it possible to separate visual event from

- the intervention of consciousness into the visual process?
- activation of parts of brain under visual process
  - is reproduced under unconsciousness condition

Blind sight

Separation of visual process from conscious awareness

- patients who cannot see but guess objects: blind sight
- meaning that the brain is still functioning
  - but the consciousness is lost of actually seeing the object

- balance between brain regions
  - signals to cortex for processing
  - signals intercepting the incoming information

Rupture in the balanced circuitry: suggested by Zeki

- dialogue between brain regions are not operational

However, blind sight is conditional: physical entity and properties of the object

Prosopagnosia: face blindness

the reverse of blind sight: awareness without recognition

but improved by psychological linkage

consciousness depends on more than one factor

Perceptions are unified wholes

depending on personal characters

Why the electrical signal in the visual cortex is experienced as vision?
Learn through experience?
Linked to movement?

A mixing of senses: synesthesia

- see musical notes in colors
- mostly in childhood or schizophrenia or hallucination
- probably a problem of association cortex
  - a malfunctioning of physiology rather than anatomy

Arousal

Constant dialogue with the outside world
Different levels of arousal
- sleep, arousal, and higher arousal

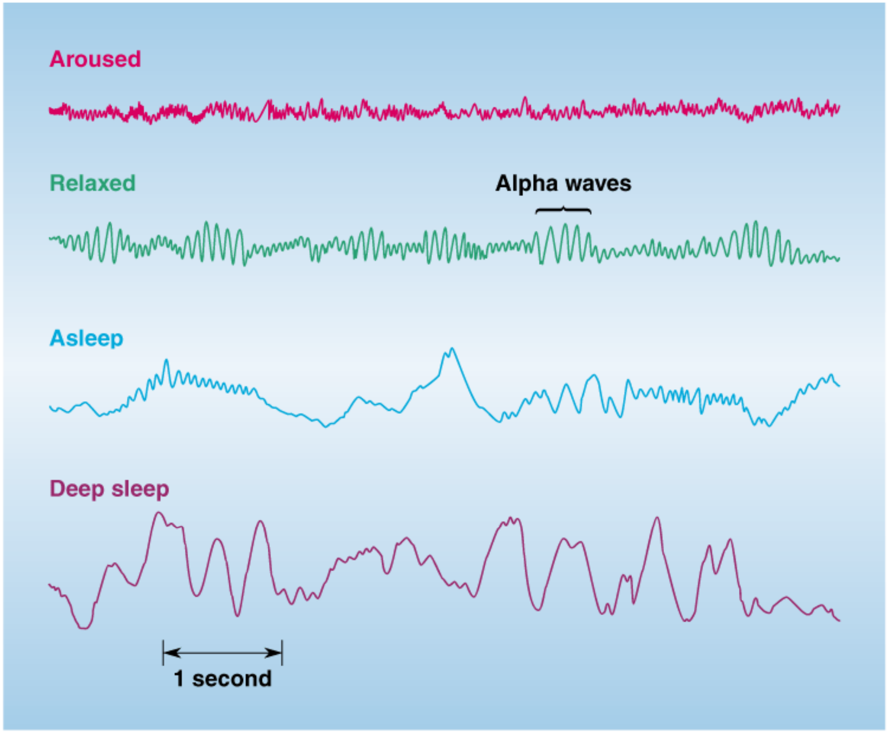
Measuring arousal states
- 1875 Richard Caton: electrical activity in the brain
- 1929 Hans Berger: electrical current in the human brain

Electroencephalography

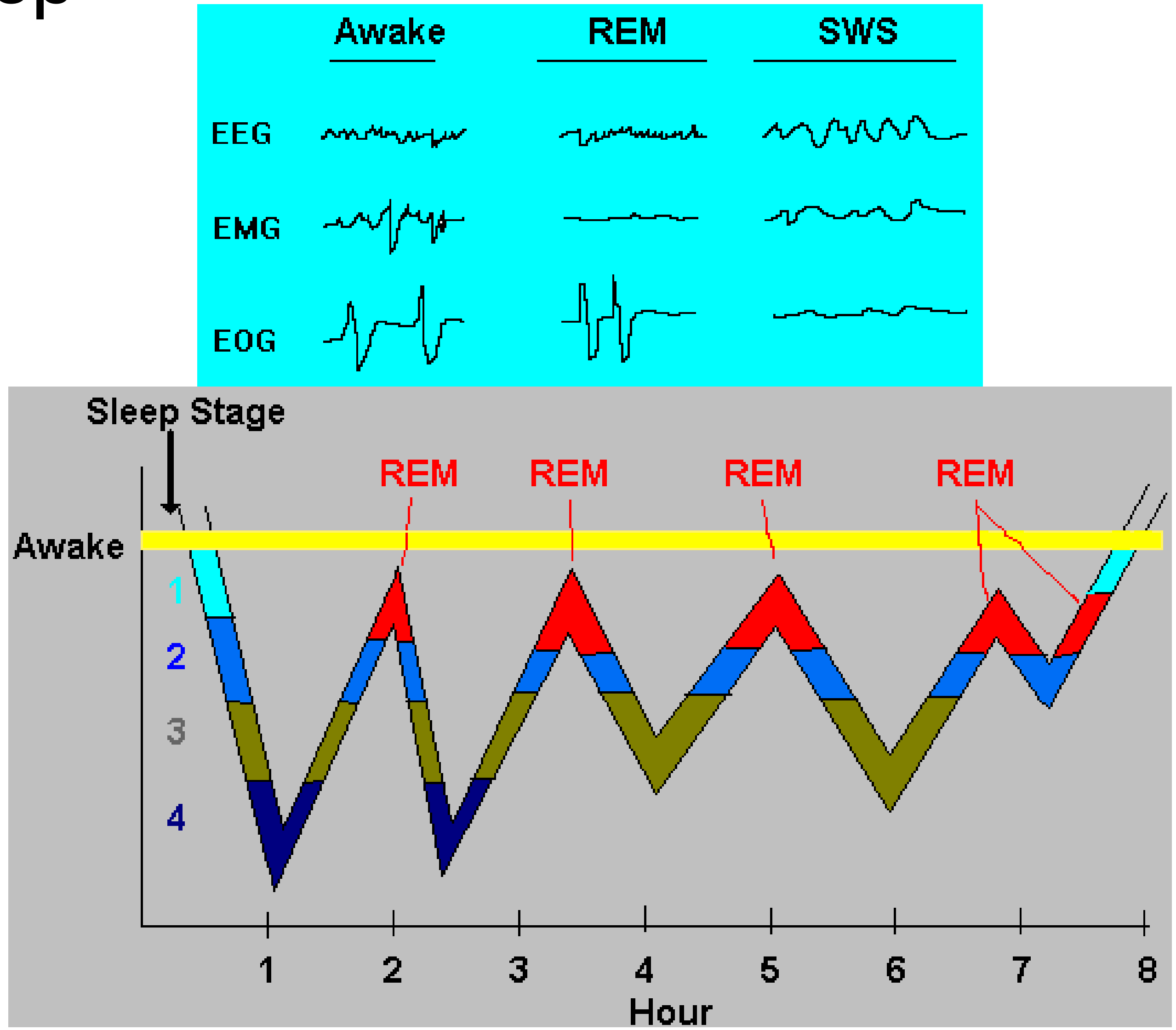
<u>electrical potentials amplified from scalp</u>
-high temporal resolution
-low spatial resolution
-cortical tissue only

Electroencephalograghy (EEG) recording

► Typical EEGs



Sleep



http://www.univ.trieste.it/~brain/NeuroBiol/Neuroscienze%20per%20tutti/sleep.html

Dreaming during REM sleep
Why do we dream?

Play around?
Any benefit?

compensation of REM sleep
REM sleep decrease during childhood
consolidation or resolving of experiences: but fetus also dream
A type of consciousness resulting from a less vigorous
dialogue between brain regions

underdeveloped brain
prevailing chemicals in the brain: schizophrenic
failure of processing large amounts of sensory input during asleep

high protein synthesis during sleep
in nonhuman animals: pineal gland is important for sleeping
melatonin secretion
in human controlled by a variety of factors

Pain

Diurnal variation of pain

the pain nerve system does not change

therefore some other factor

Acupuncture: probably mediated by natural chemicals

Intrinsic pain reliever: enkephalin