McMaster University

Inspiring Innovation and Discovery

KIN 3E03 /Life Sciences 3K03

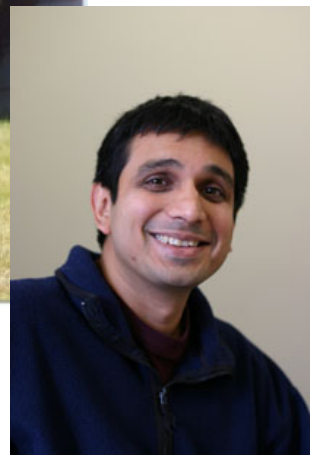
Neural control of human movement

Dr. Ramesh Balasubramaniam

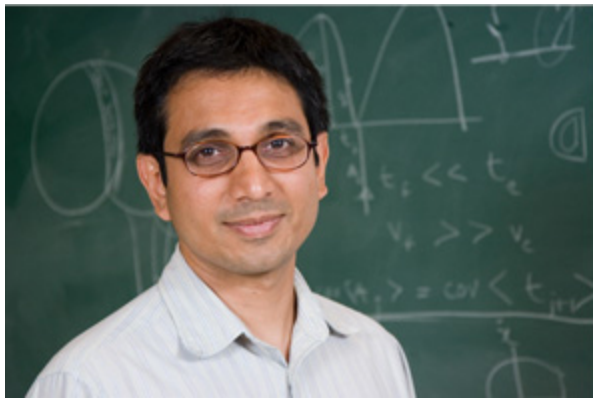
Fall 2012

Course details

- **Professor:** Dr. Ramesh Balasubramaniam
- **Email:** *ramesh@mcmaster.ca*
- **Phone:** 905.525.9140 ext 21208
- **Meeting times:** M-Th 3:30-4:20; Tu 4:30-5:20
- **Location:** TSH 120 (all classes).
- **Office hours:** Tuesday 2:30-4pm.
  (or by appointment)
  @ IWC# Rm 203.
- **Course web site:** http://avenue.mcmaster.ca
- **Teaching Assistants:** TBA



……. Before & After



Dr. Ramesh Balasubramaniam, PhD
Neuroscientist
& Respectable citizen.


LED ZEPPELIN

What is this course about?

- This is a basic course that examines the scientific study of human movement.
- The course explores the relationships between brain and motor behaviour.
- Theories and methods that investigate the fundamental mechanisms and principles involved in the control of human movement are studied in detail from (1) Neurophysiological (2) Cognitive and (3) Dynamical perspectives.

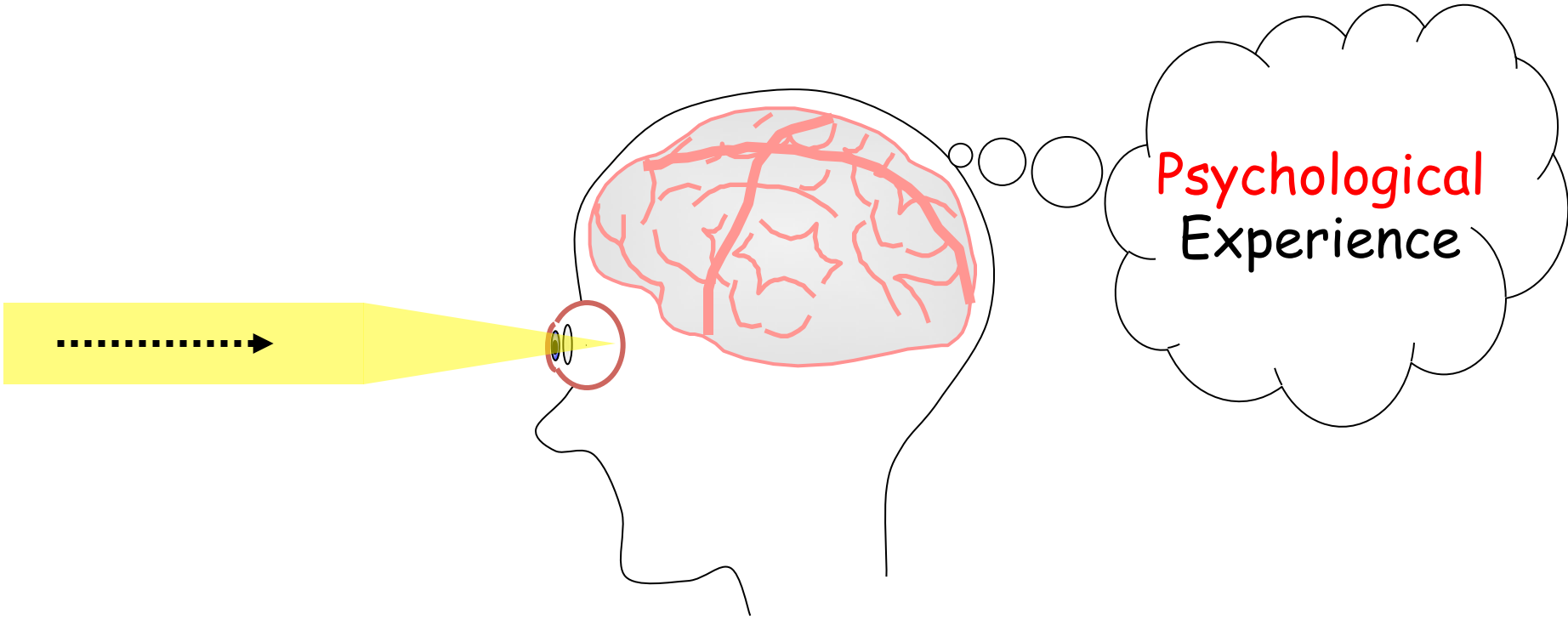
- The mid-terms, each worth 30% of the total grade, will be held on
- Thursday, October 4, 2012 (Exam 1)
- Tuesday, October 30, 2012 (Exam 2)
- Monday, November 26, 2012 (Exam 3)
- All exams will consist of multiple choice, fill-in-the-blank and short answer questions.
- The final paper will be due on Dec 4. 10%
- Topic and instructions in due course.

Why study motor control?

- Understand the brain and its relationship to behaviour.
- Integrate physiological and psychological mechanisms of brain function.
- Learn about motor disorders by studying cases of patients with brain damage.
- Applications in sport, rehabilitation and robotics.

Why do we have a brain?

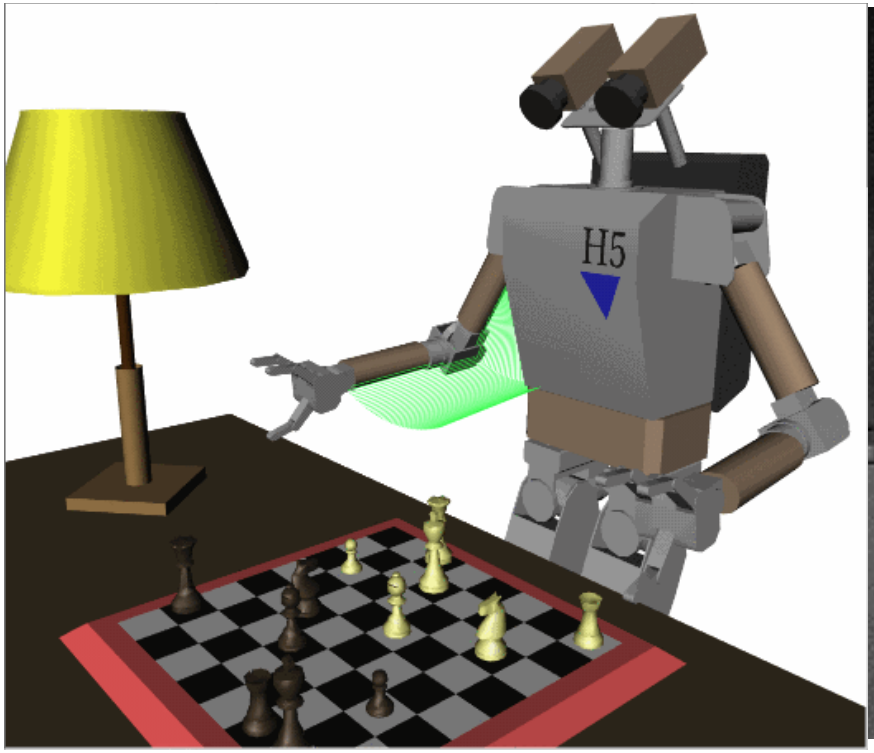
- To generate purposeful movements.
- Movement is the only way
  - Of interacting with the world.
  - Of communicating (speech, writing, gestures)

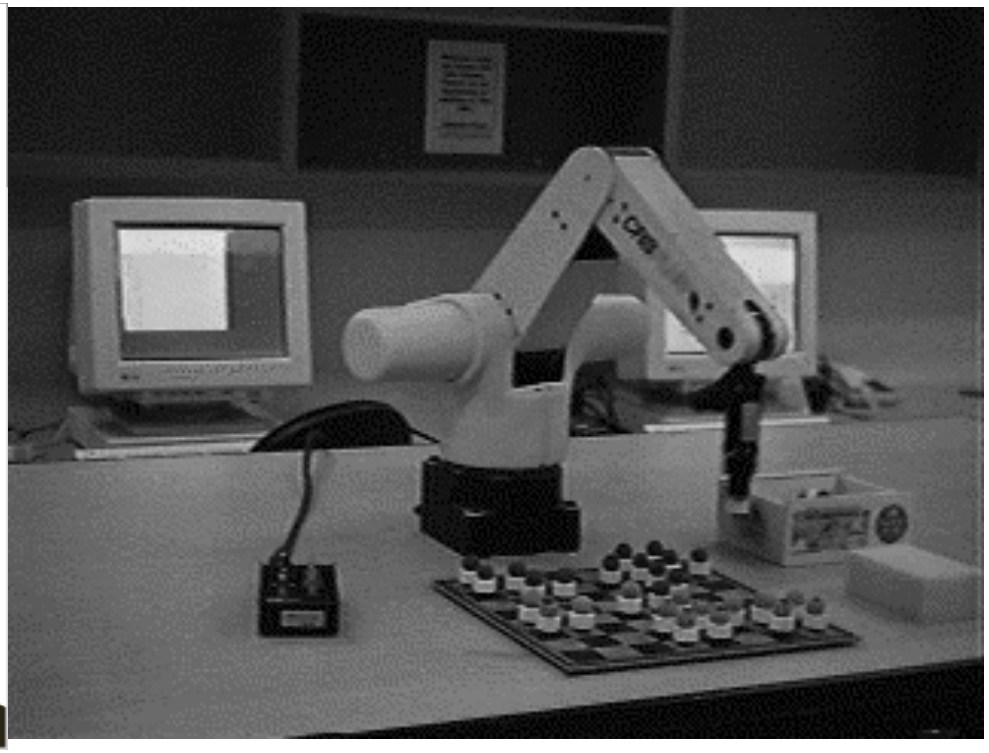

Psychological
Experience

Human motor control

- Everything we do is by moving our bodies.
- Perception in the service of action.

- What is the difference between the human brain and an artificial brain like a robot?

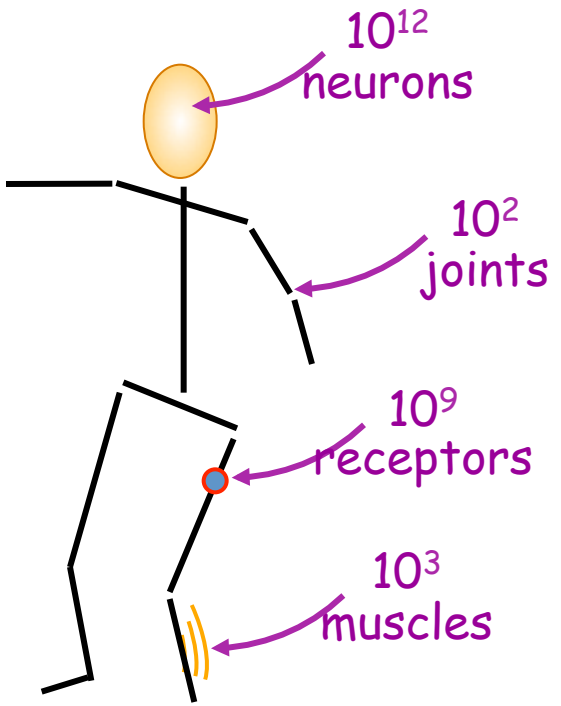




Chess playing computers: Yes
But can a robot move chess pieces?

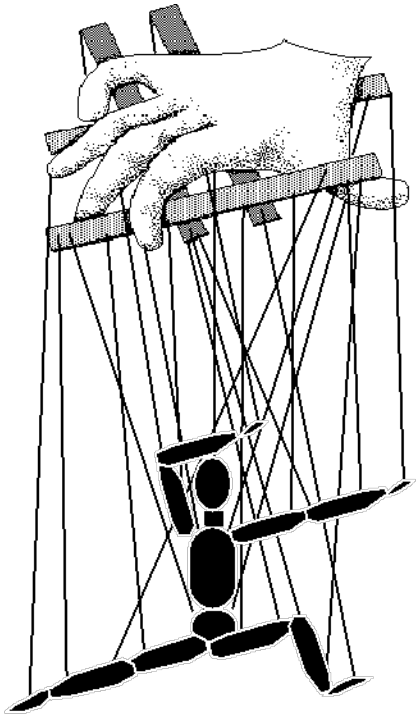
Why is the study of movement such a big deal?

- The problem is not so simple.
- We still are only scratching the surface.
- The problem of graceful degradation.



Compression from many to few dimensions

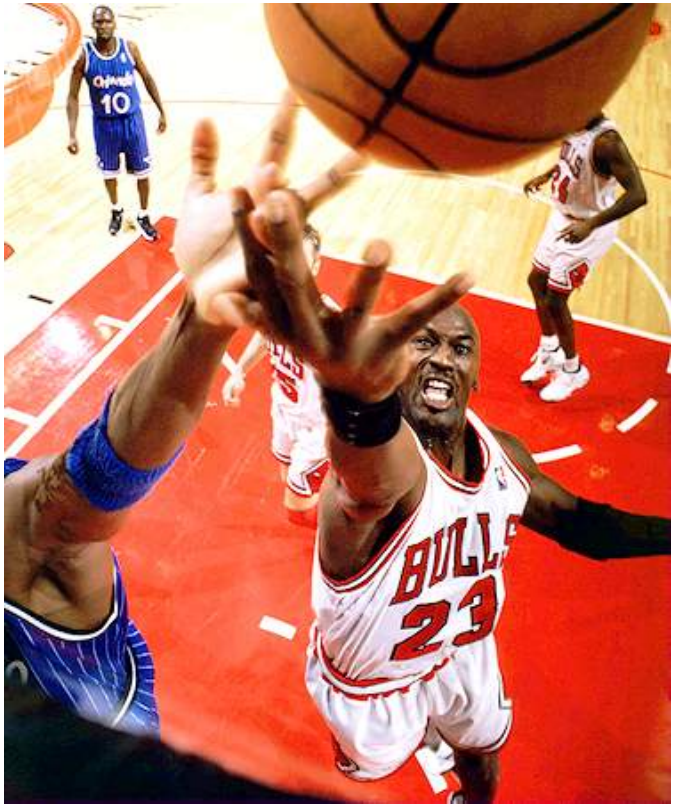
THE BRAIN' s PROBLEM:
How to control a large number of degrees of freedom or moving parts?



The degrees of freedom problem.

Specific topics

- Balance and coordinated reaching



Grasping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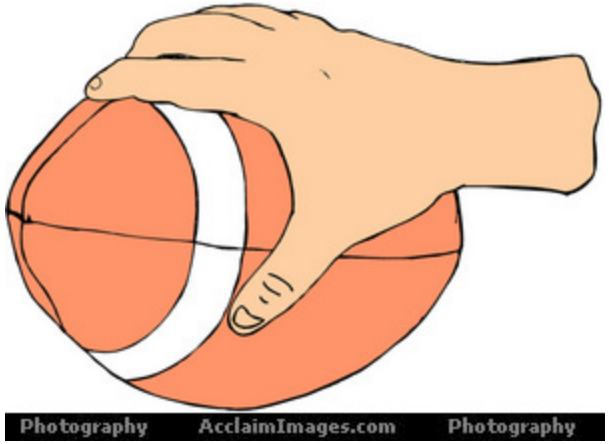
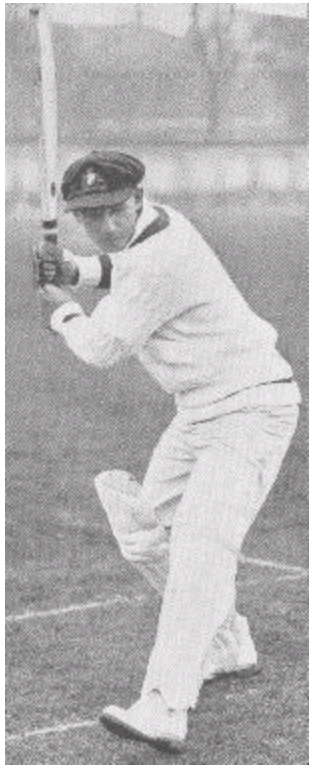

Photography AcclaimImages.com Photography

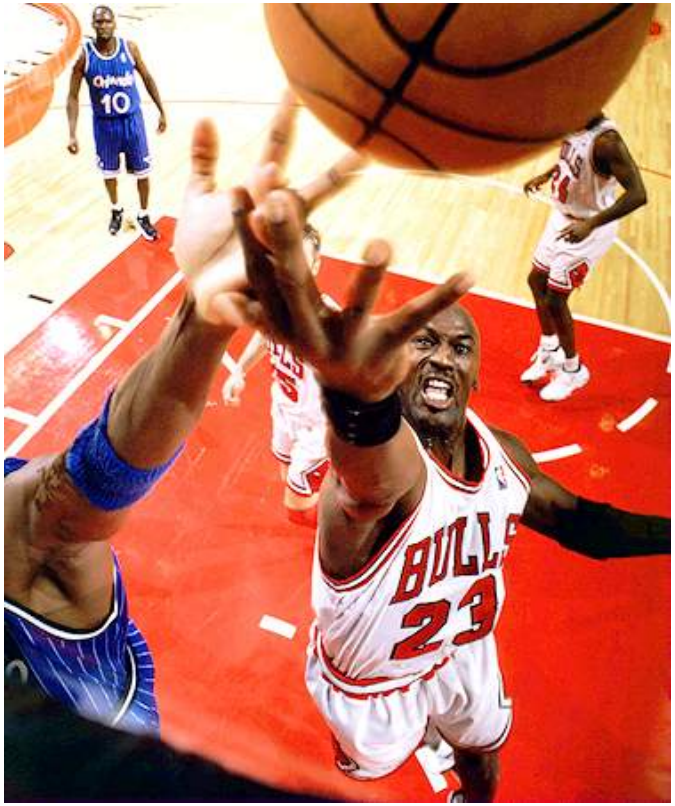

AcclaimImages.com

Interceptive actions



Timing & social coordination

Is there a brain state for every behaviour?



One more time…

- Relate brain structure to brain function
- How does the brain solve the Degrees of freedom problem?
- What kind of computations does the brain perform to make successful movements?
- How does the brain learn these complex movement patterns?

Bernstein's problem

- Most physical tasks can be done in an infinite number of ways.
- This is possible due to redundant numbers of degrees of freedom.

Touch the tip of your nose with your finger

- How did the inefficient options get eliminated?
- Problem of selecting the path (or optimal trajectory) is mathematically underdetermined.
- Understanding how this is done…..This is the crux of the degrees of freedom problem.

Patient video

Aspects of the DF problem.

- How to co-ordinate?

Coordination: to bring two any two moving parts of the body into a relationship.

How does the brain solve this problem.

Motor equivalence

- There is more than one proper solution to the degrees of freedom problem
- Consider the use of multiple effectors
- The problem of handwriting: Depending on how & with what body part(s) we are writing, (anatomically they can vary greatly) we see common characteristics. This is referred to as motor equivalence

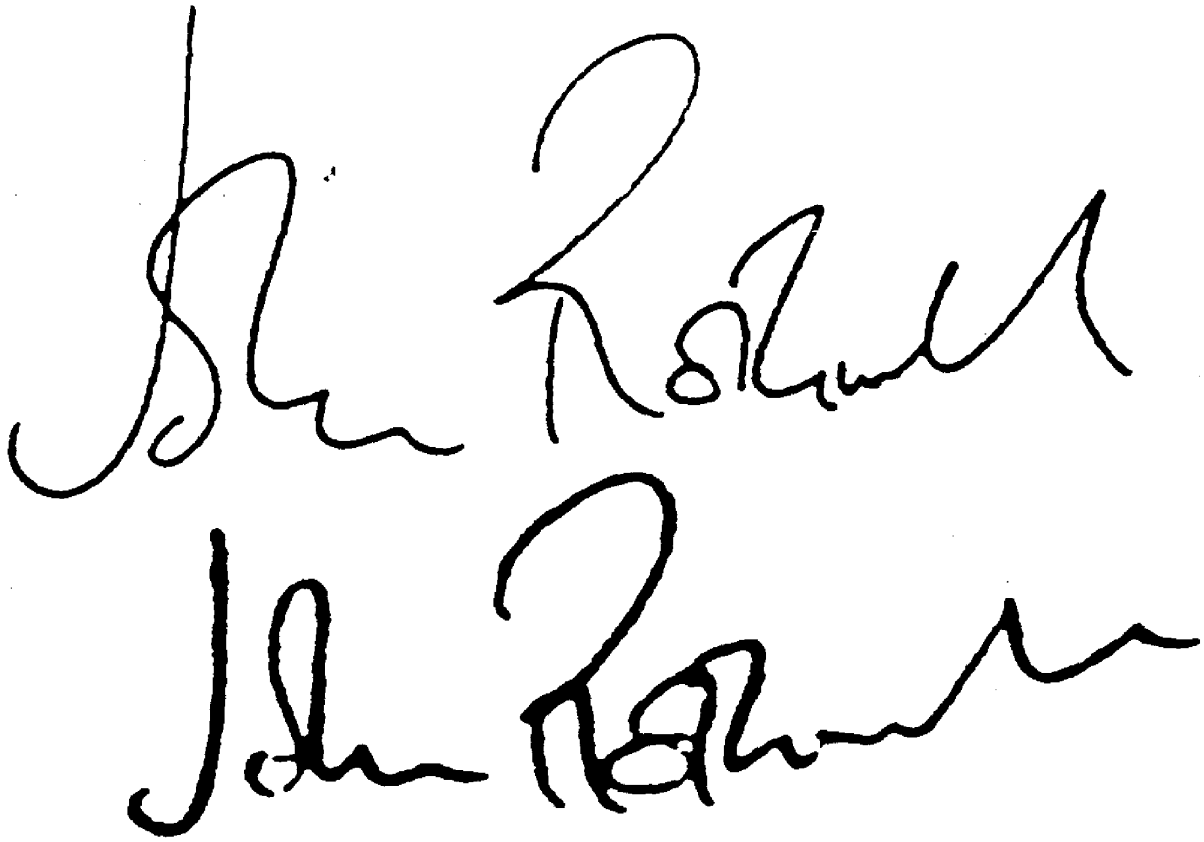


Figure 1.1 Two specimens of the author's handwriting. The signature at the top was written with a small fine pen and measured only 2 cm from start to finish; the signature at the bottom was written with a large felt-tip pen on a full sheet of A4 and measured 20 cm from start to finish. The large writing was performed mainly using the wrist, elbow and shoulder whereas the small writing mainly used the small muscles of the hand itself. Despite the differences in the muscles used, the character of the handwriting remains unmistakably the same.

Serial order problem

- The word TULIP
- Motor planning is in sequences (cannot be explained by a Stimulus-response chaining).
- This phenomenon is called co-articulation.

Important definitions

- Coordination: The patterning of body & limb motions relative to the patterning of environmental objects & events.

- Bernstein's DOF problem: Most physical tasks can be done in an infinite number of ways. This is possible due to redundant numbers of degrees of freedom. TOUCH YOUR NOSE

- Motor equivalence: Use of multiple effector sets (body parts) to achieve the same goal. HANDWRITING EXAMPLE

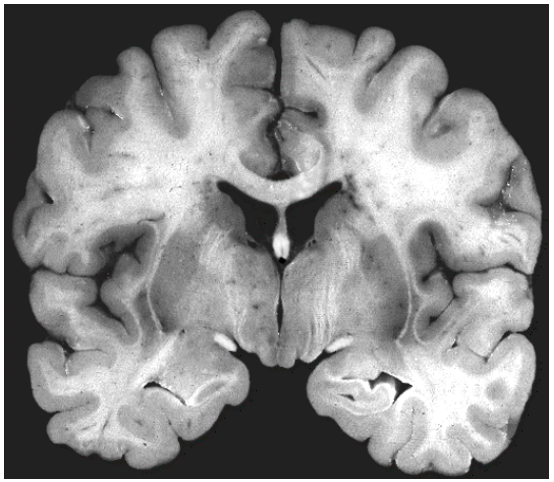
- Serial order problem: How does the brain figure out in which order to do things? TULIP

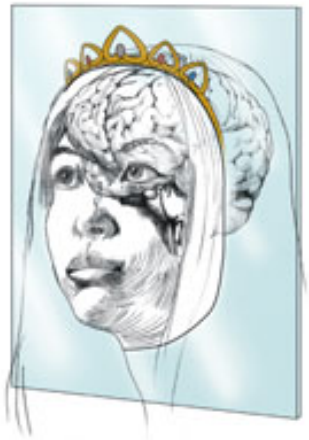
Da Brain

- Brain = 100 billion neurons
- Synapses = It has been estimated that there are 1 quadrillion synapses in the human brain. That's 10^{15} or 1,000,000,000,000,000 synapses!
- Number of connections = 100 billion X $10^{15.}$
- Number of possible behaviours -> ∞

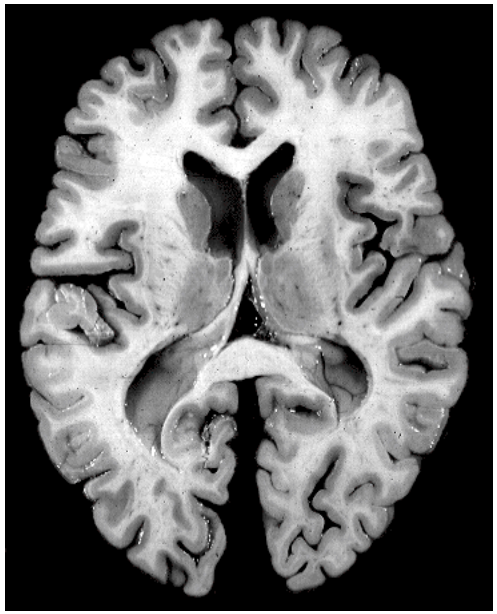
Tools: Directions

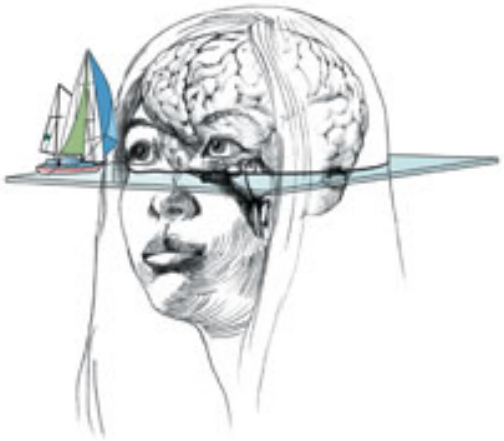
Coronal



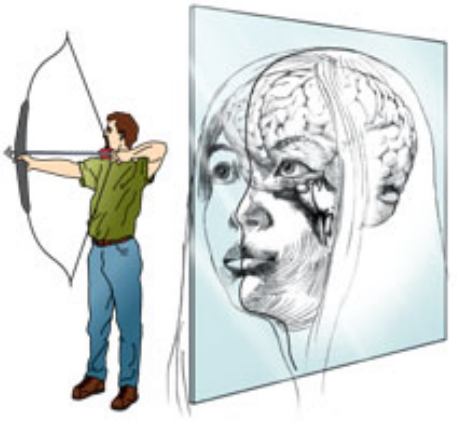


Horizontal

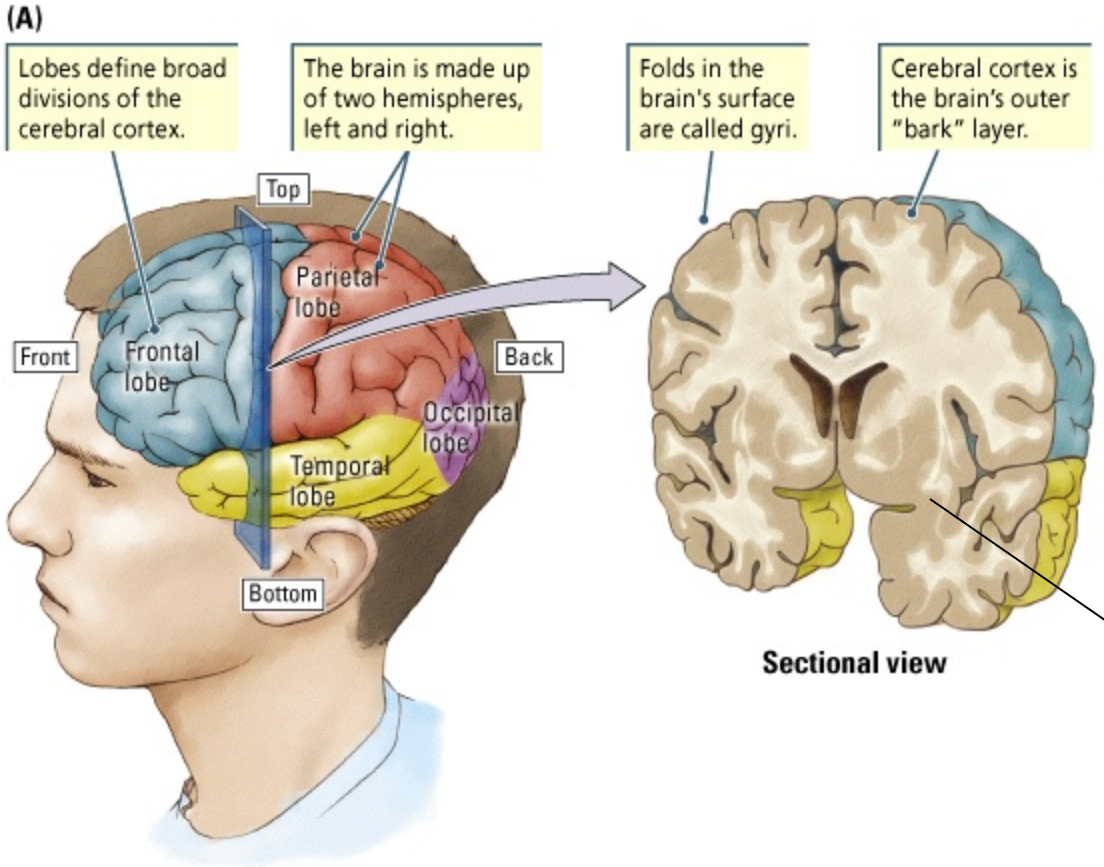




Sagittal



I'd rather have a bottle in front of me, than a ….



Frontalobotomy

What kind of section is this?

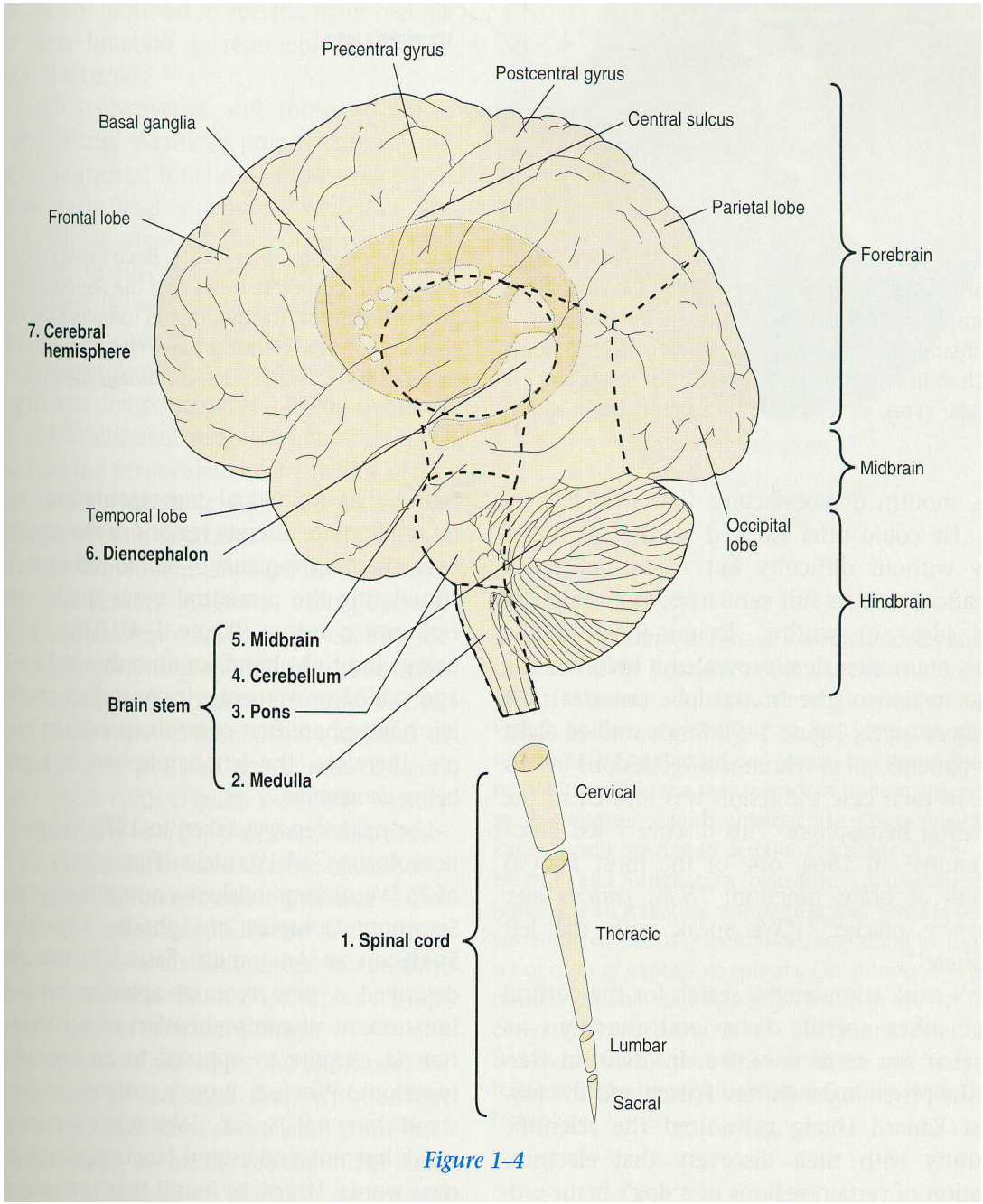


Figure 1–4

The evolved brain

Neo-Mammalian brain

Paleo-mammalian brain

Reptilian brain

Netherbrain

BRAIN + spinal cord =
Central Nervous system

Hierarchy of CNS organization: the problem for motor control

- Spinal cord: seat of reflexes.
- Brain stem: seat of arousal, tuning & basic emotions (Limbic system)
- Cerebral cortex: the big cheese

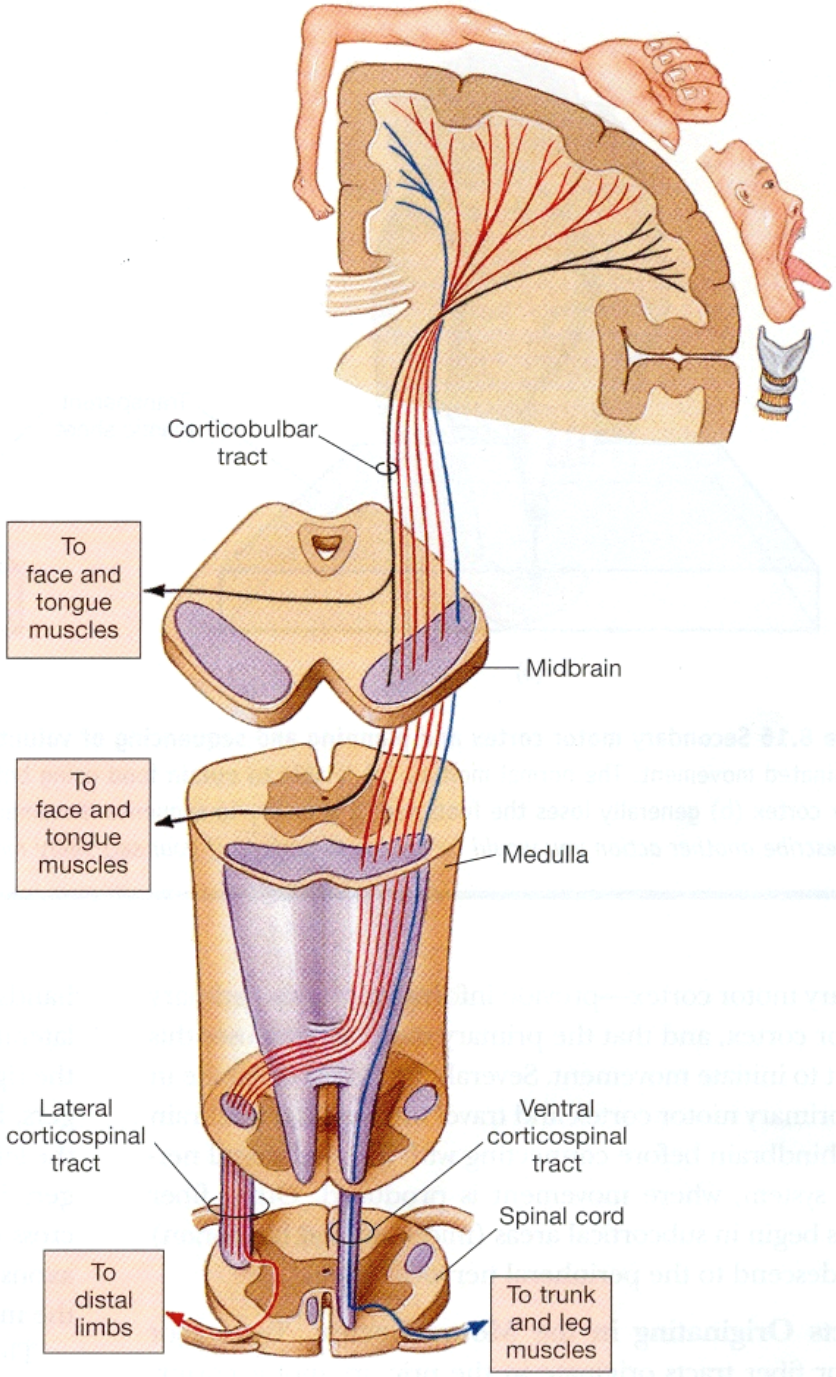
→ Subcortical / supraspinal areas

→ Higher level Cortical areas

Recap

- Problems
  - Degrees of Freedom
  - Motor equivalence
  - Serial order

Brain Structure: CNS, reflexes



CORTEX

MIDBRAIN

& BRAIN STEM

SPINAL CORD
Final common pathway

Unit of Action: Reflex

- Reflex arc: Receptor, conductor & effector (Discovered by Sir Charles Sherrington).
- Stimulus --→ Response (knee jerk)
- Is chaining of reflexes the way movements are organized?
- NO. for the following reasons.

Basic unit of behaviour

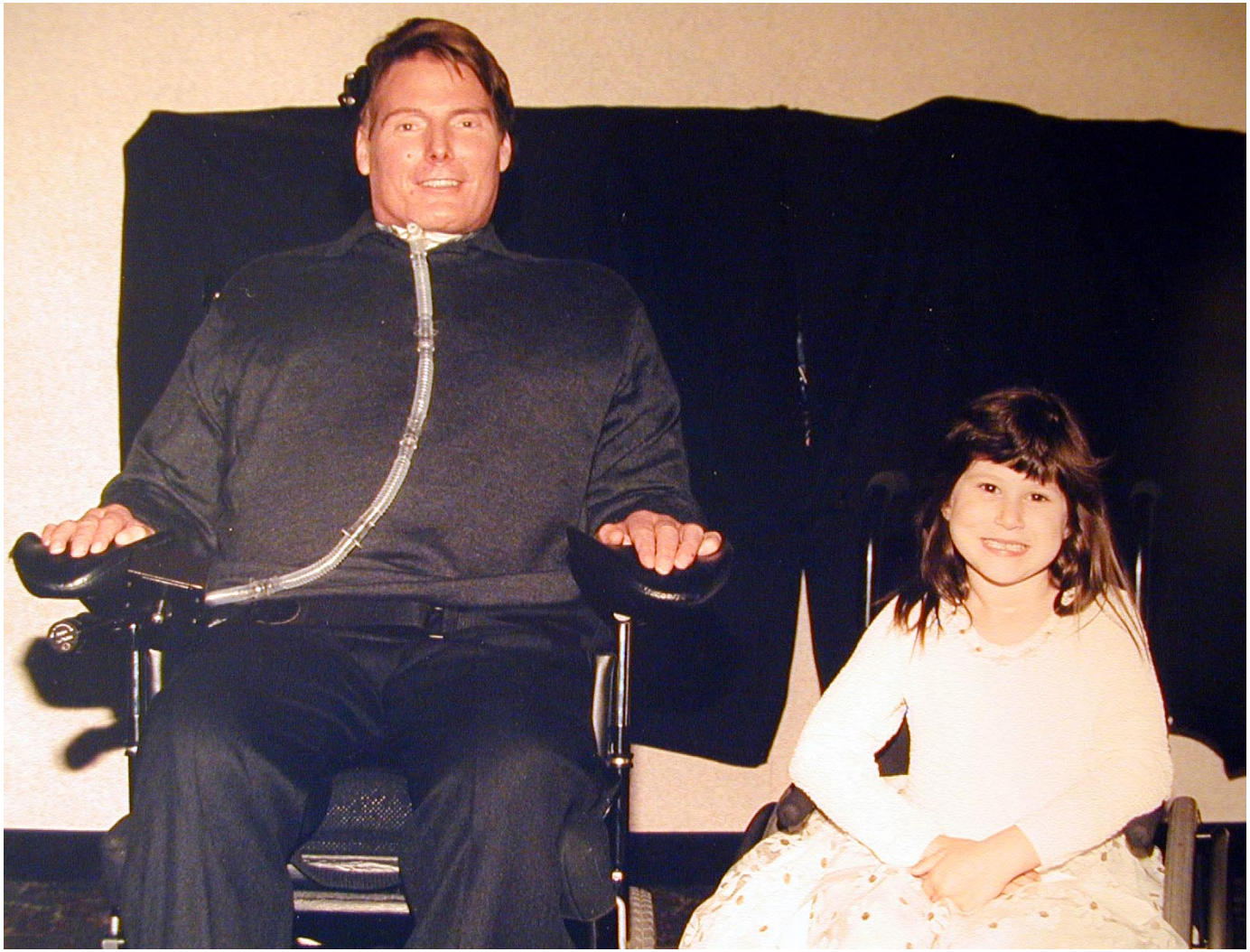
- Reflex? No
- 1. must be activated by an outside agent
- 2. what happens when there is no stimulus?
- 3. fast movements where there is no feedback like typing (or piano playing).
- 4. you can overwrite reflexes depending on context
- 5. Production of novel movements.

Spinal cord damage

- Spinal cord injury (SCI) occurs when a traumatic event results in damage to cells within the spinal cord or severs the nerve tracts that relay signals up and down the spinal cord.

- Most common are Lacerations (severing or tearing of some nerve fibers, such as damage caused by a gun shot wound /football injury/car accident).

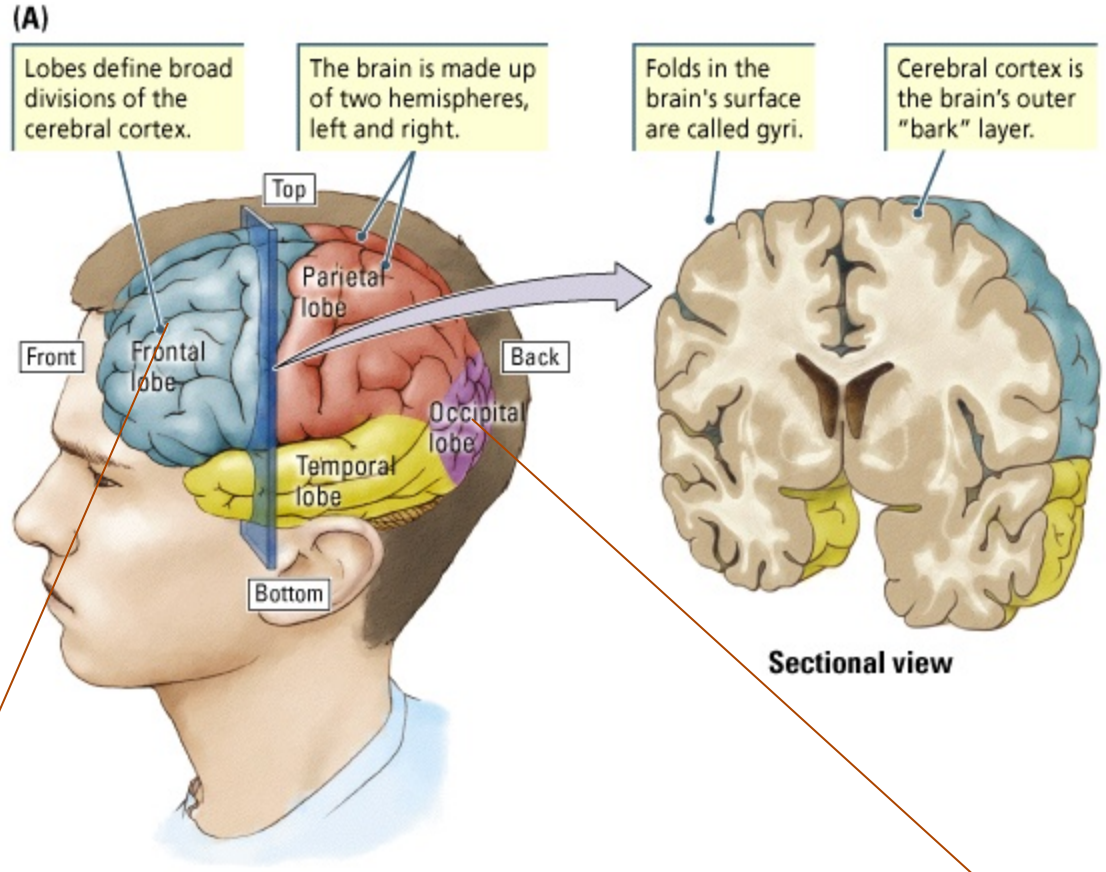
- Severe SCI often causes paralysis (loss of control over voluntary movement and muscles of the body) and loss of sensation and reflex function below the point of injury, including autonomic activity such as breathing and other activities such as bowel and bladder control.



Deafferentation & Neuropathy

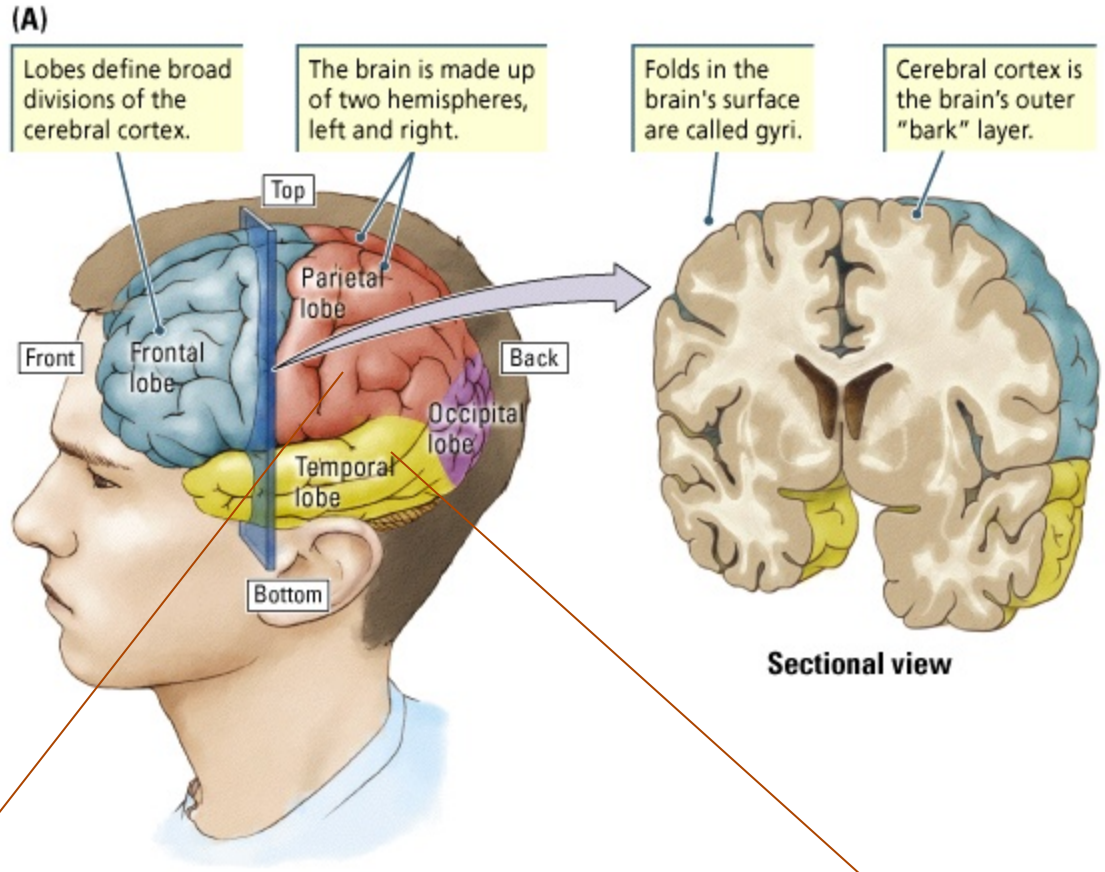
- Only afferent pathways are affected (no feedback going to the brain) Relies on vision
- Can come from accidents or even diabetes
- The role of proprioception: case study of Ian Waterman.

http://www.bbc.co.uk/music/dancersbody/body/proprioception.shtml



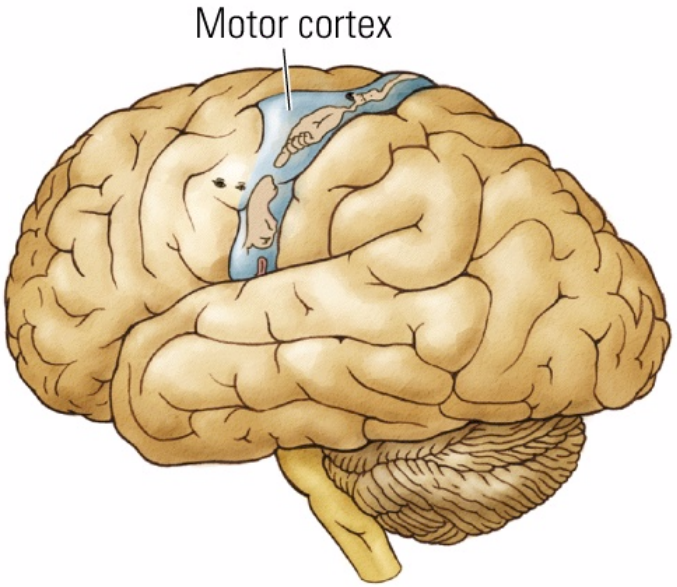
FRONTAL LOBE: contains MOTOR CORTEX
Planning, reasoning,
movement (map of the body)
some aspects of speech (like TULIP)

OCCIPITAL LOBE:
Seat of the visual cortex
Deals with visual information



PARIETAL LOBE:
Handles skin based proprioceptive information (heat, cold, pressure & pain)
Works closely with the motor areas.

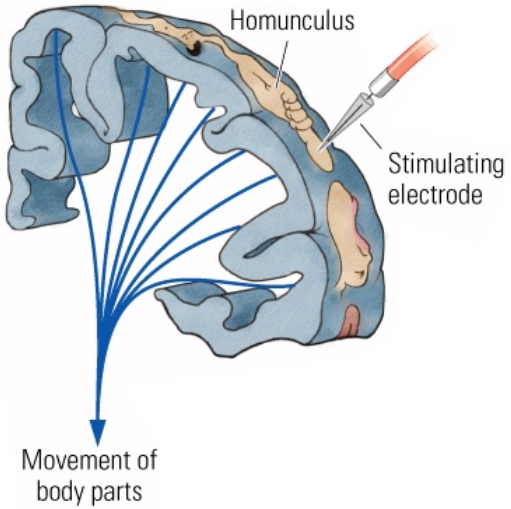
TEMPORAL LOBE
Speech, hearing and Language

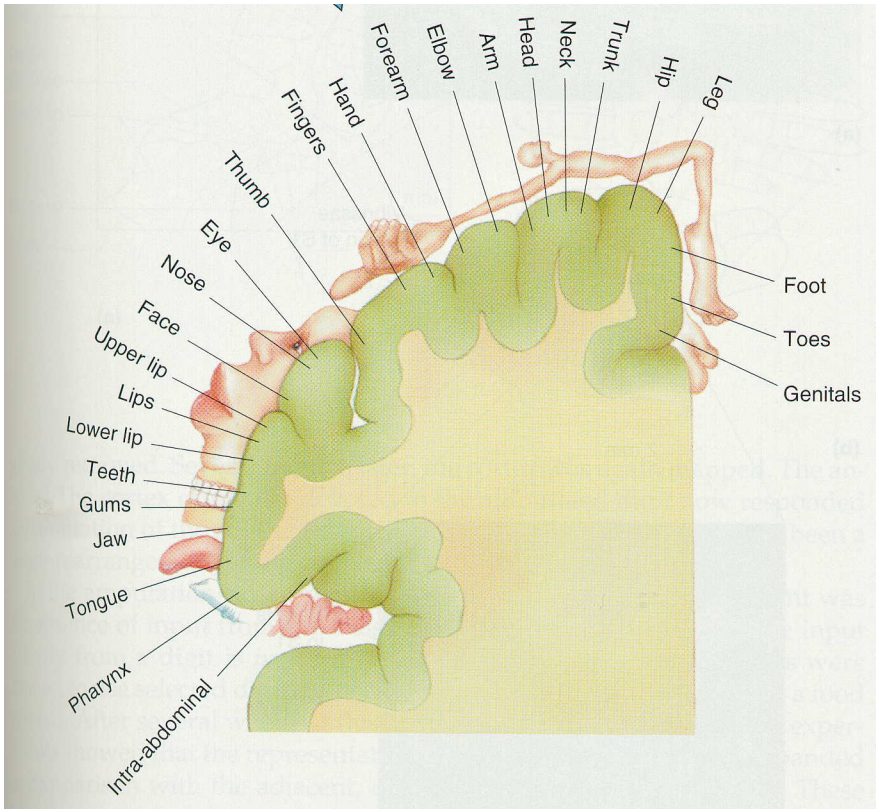


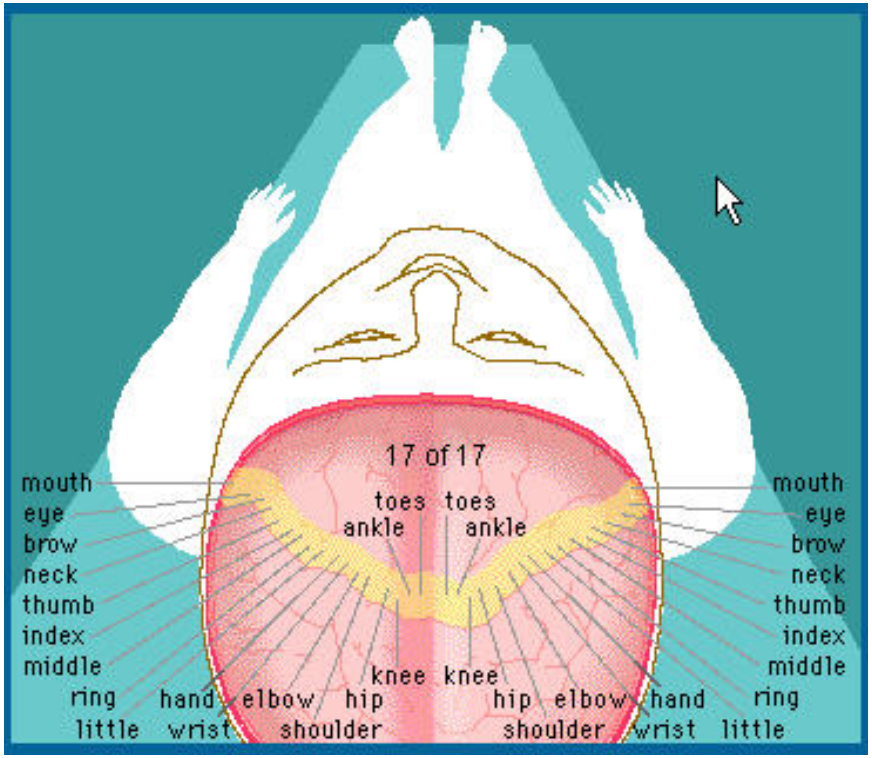
Great Canadian Discovery

- **Organization of motor cortex reveals a map of the body**

- **Wilder Penfield aka Docteur Penfield**







This is what we would look like if we used the image from the motor cortex

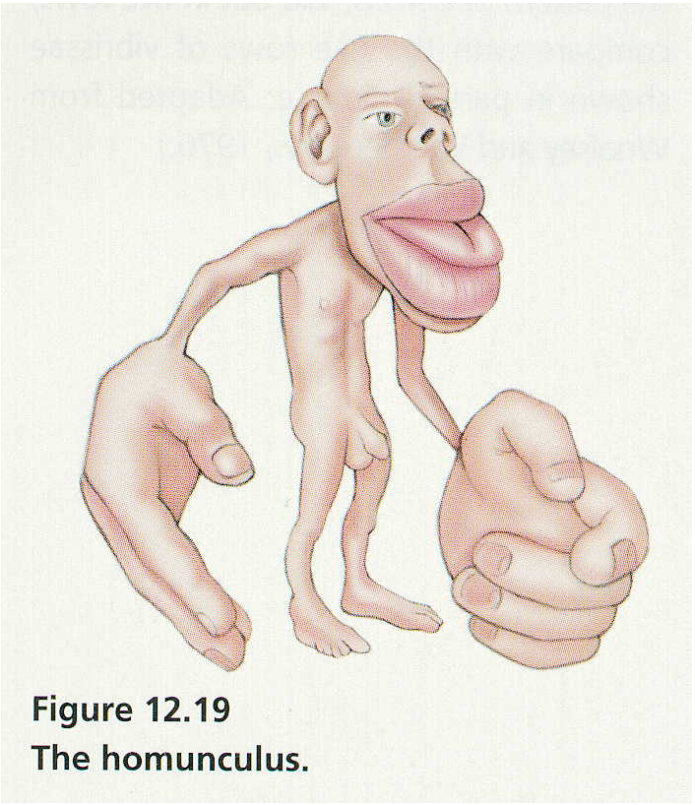
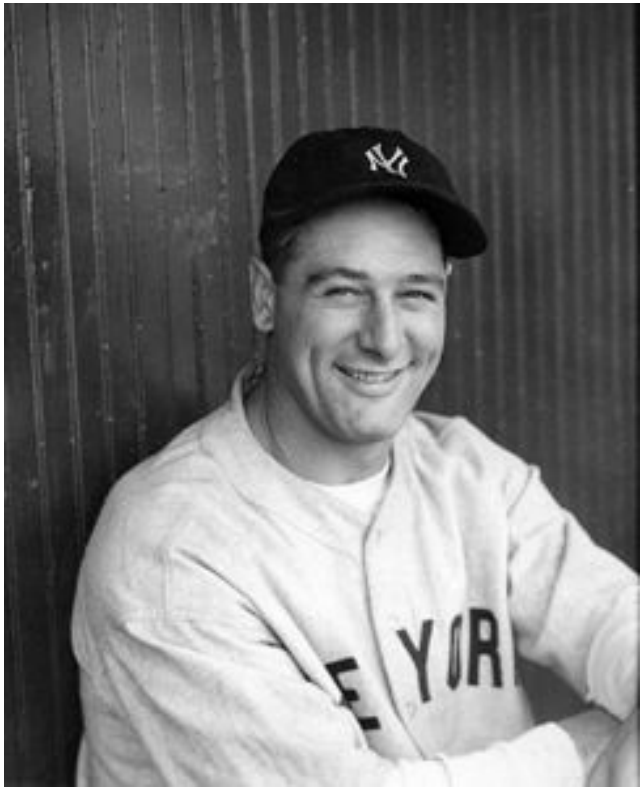


Figure 12.19
The homunculus.

SCI, deafferentation & Neuropathy

- Only afferent pathways are affected (no feedback going to the brain)
- Can come from accidents or even diabetes
- The role of proprioception: case study of Ian Waterman.

http://www.bbc.co.uk/music/dancersbody/body/proprioception.shtml



What is common between the two?

Amyotrophic Lateral Sclerosis (ALS)

- "Lou Gehrig's disease" - motorneurons of the brainstem and spinal cord are destroyed and their target muscles wither away
- First symptoms are muscle weakness and atrophy
- Within 3-5 years, the ability to walk, speak, swallow, (and sometimes breathe) is gone
- Patient retains cognitive function (keenly aware of what is happening)
- 10 % are hereditary, autosomal dominant; although not all people with defective gene inherit the disorder
- 20% of familial ALS have a mutation in the gene for the enzyme *superoxide dismutase (protects body from free radicals that cause damage to DNA and proteins w/in cells)*

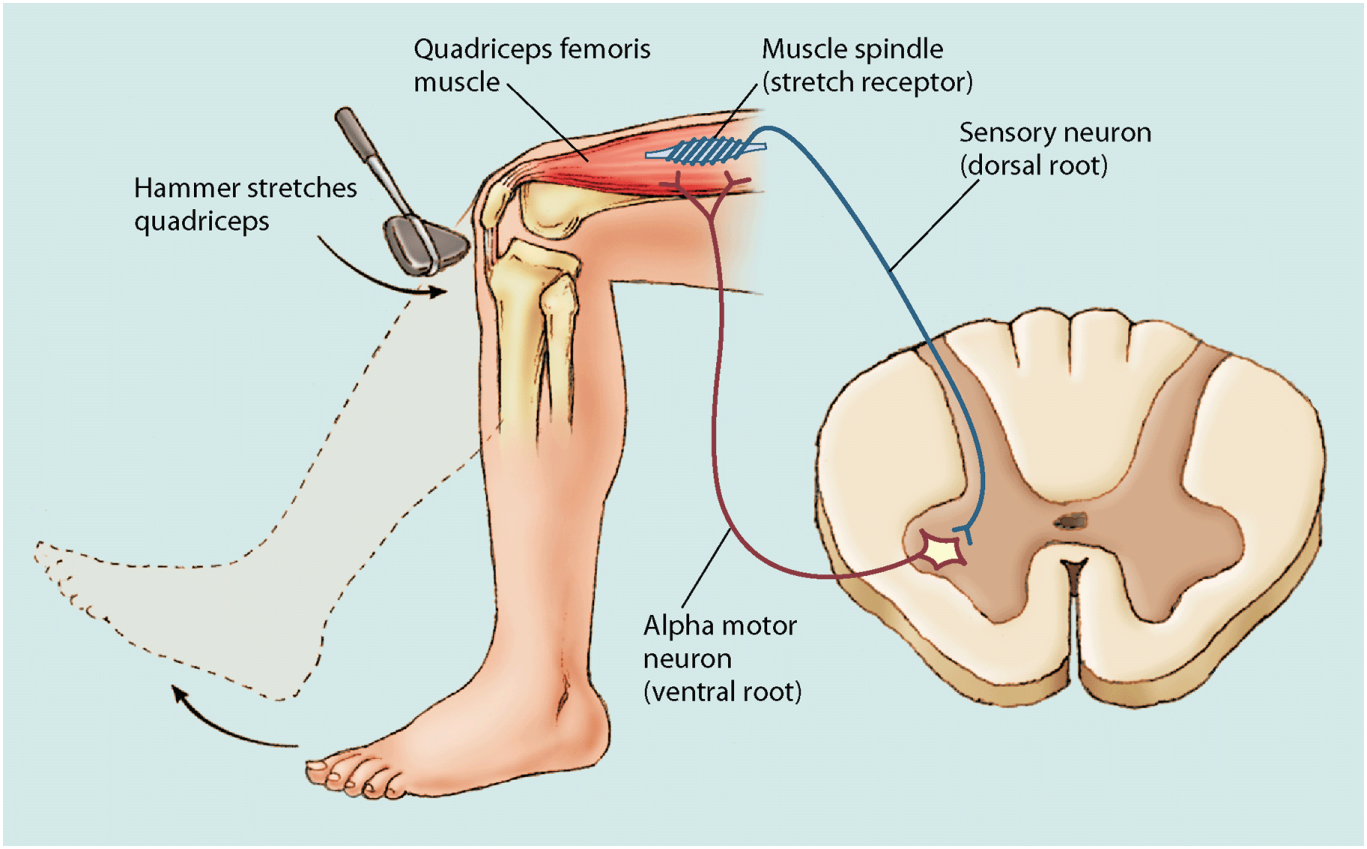
Neuromuscular diseases

- Destruction of motor neurons

(from polio virus for e.g)

- Plegia – paralysis
- Paresis – weakness
- Strategies for recovery.
  - Stem cells
  - Transplantation of glial cells (ensheathing cells) promoting regeneration
  - “regeneration-friendly” peripheral nerves

THE SIMPLE STRETCH REFLEX.

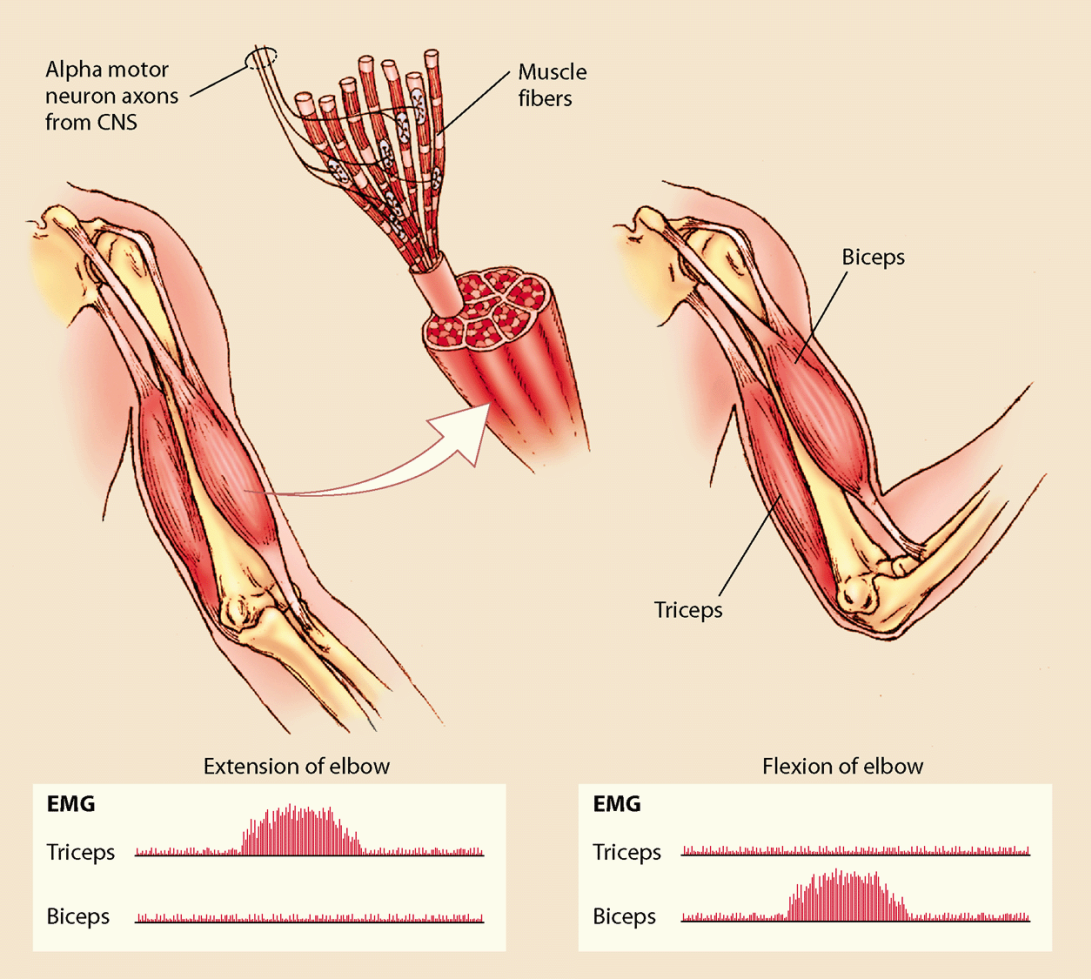


Doctor Taps your knee
Quadriceps extend
Stretch receptor tells spinal cord (dorsal root)
Spinal cord activates alpha motor neuron (ventral root)

Dorsum – The back

Ventral – The front (belly side)

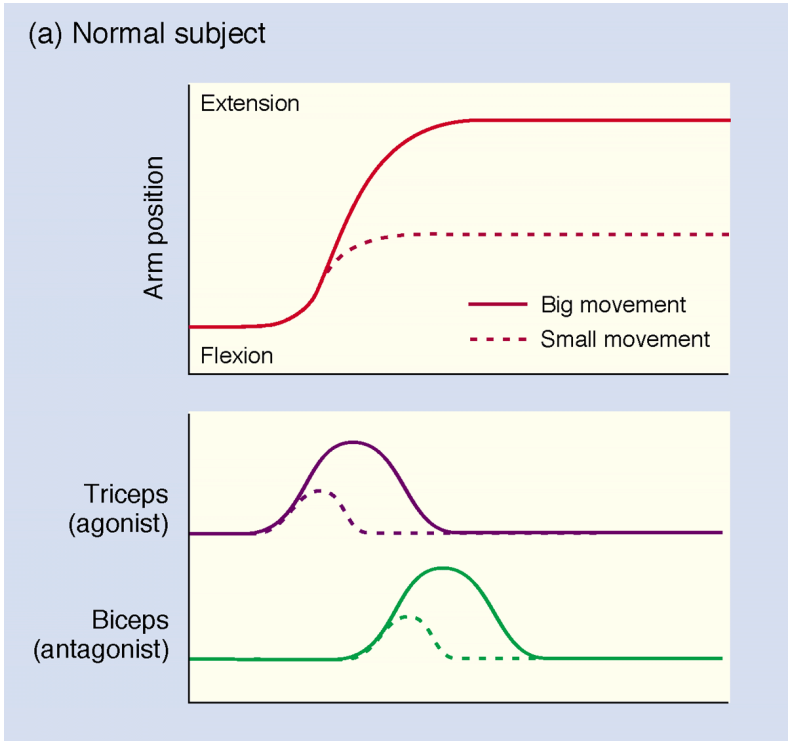
SIMPLE VOLUNTARY MOVEMENT

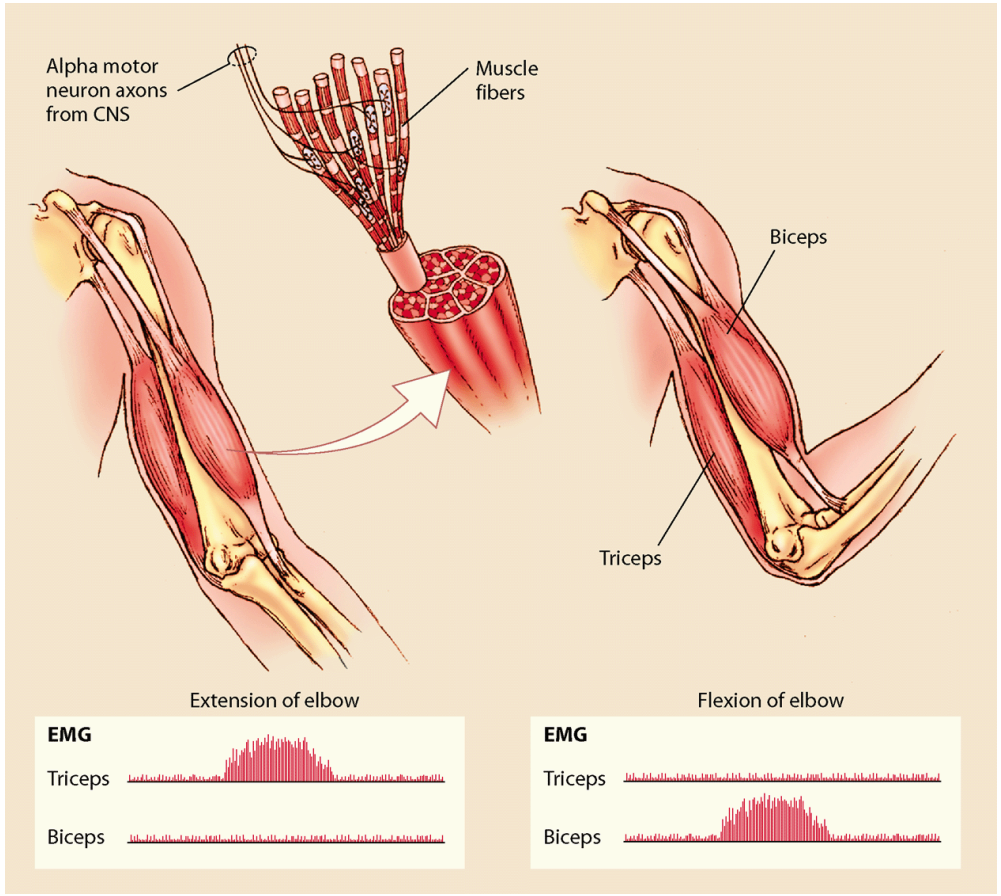


Muscles activated by alpha motor neurons

Alpha motor neuron activation causes muscle fibers to contract (increase stiffeness by Acetyl-choline production).

Thus movement production is done by lengthening and shortening of agonist-antagonist pairs.


(a) Normal subject
Extension
Arm position
Flexion
Big movement
Small movement
Triceps
(agonist)
Biceps
(antagonist)


Alpha motor
neuron axons
from CNS
Muscle
fibers
Biceps
Triceps
Extension of elbow
Flexion of elbow
EMG
Triceps
Biceps
EMG
Triceps
Biceps

Motor command

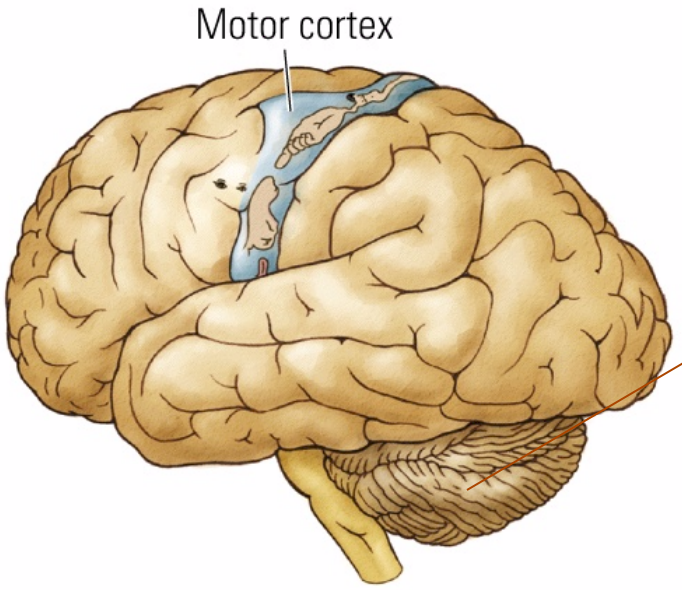
- Signal sent from motor cortex to the periphery
- Goes through the spinal cord before it reaches the muscle + motor neurons
- Can be modified/fine tuned by other parts of the brain.

The midbrain

- Controls many sensory and motor functions including eye movement and the coordination of visual and auditory reflexes (vestibulo-ocular reflex): what is that?
- Pursuit tracking
- Automatic processes that are not reflexes (once you've learned to ride a bicycle).

Cerebellum

- Between the cortex and brainstem sits the most important organ of movement.
- Locus of time, motor learning, posture.
- While voluntary movement is largely cortical, most learned physical activity is cerebellar.
- Builds models of the world (Dyslexia & Autism). Plays a large role in prediction



CEREBELLUM (cerebellar cortex)

Similar circuits in fish, mice & humans

The cerebellum

1) The cerebellum handles a lot of information. It gets 200 million inputs all the time. In comparison the optic nerve has around 1 million fibres (when the eyes are open)
2) Purkinje cells: input-output operators of the cerebellum.
3) Talks to both sensory and motor cortical areas.
4) Hemispheres project ipsilaterally.

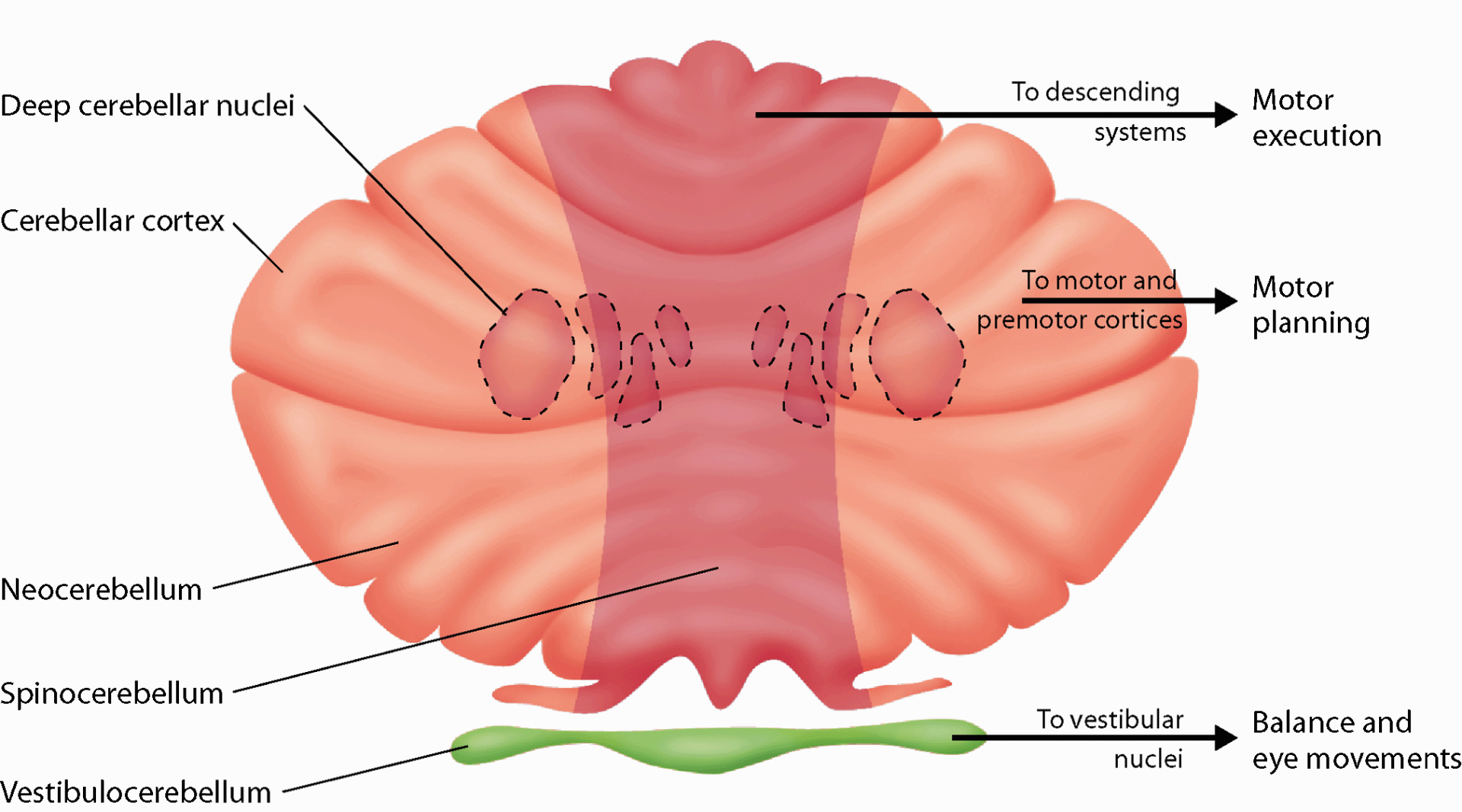
Recap

- Role of reflexes, spinal cord damage
- Deafferentation
- Basic neurophysiology: Brain, spinal cord.
- Cortex, descending motor systems, cerebellum
- Motor homonculus – somatotopic map
- Cerebellar disorders
- Motor cortex

Multiple sclerosis vs ALS

- Due to loss of myelination -> loss in information transmission
- Weakness

Cerebellum

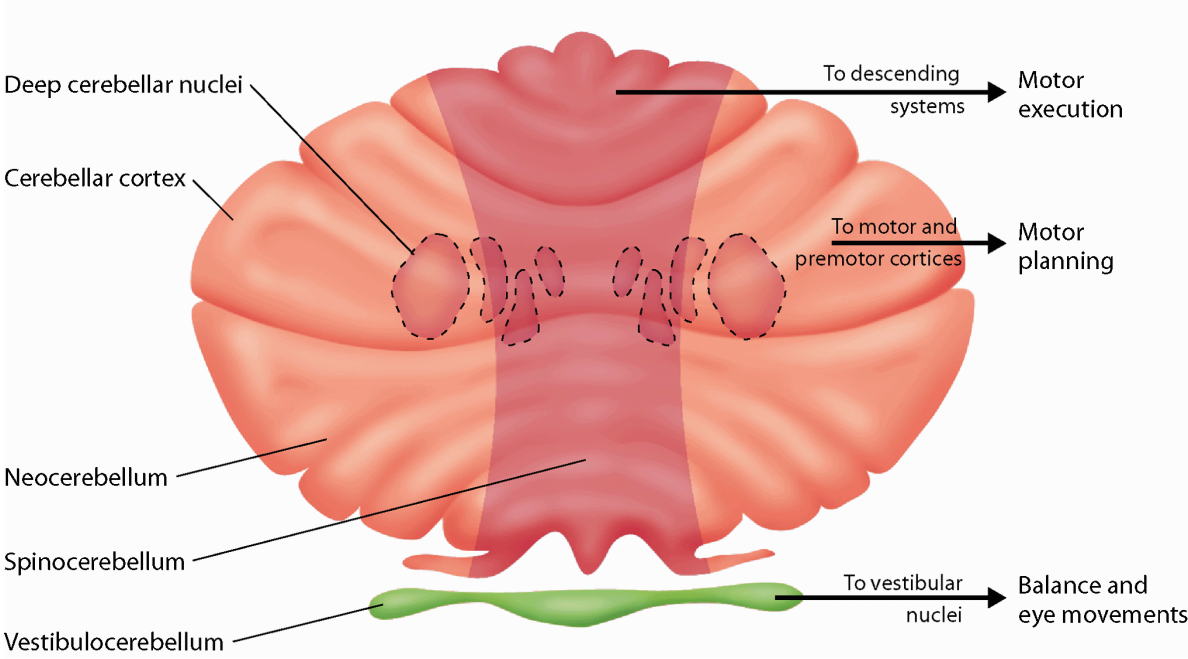

Deep cerebellar nuclei
Cerebellar cortex
Neocerebellum
Spinocerebellum
Vestibulocerebellum
To descending systems
Motor execution
To motor and premotor cortices
Motor planning
To vestibular nuclei
Balance and eye movements

Vestibulocerebellum:

•Equilibrium & stability
•Vestibular system

Spinocerebellum:

•Receives sensory information from the spinal cord
•Important for smooth control of movement.
•Especially of trunk coordination.
•Chronic alcohol abuse destroys this area.
•Have you ever been pulled over for drunk driving?



Neocerebellum

Does not receive input from spinal cord
But gets heavy projections from cortex
Efference copies get sent here
Internal models of the world
Lesions cause ataxia (clumsiness)

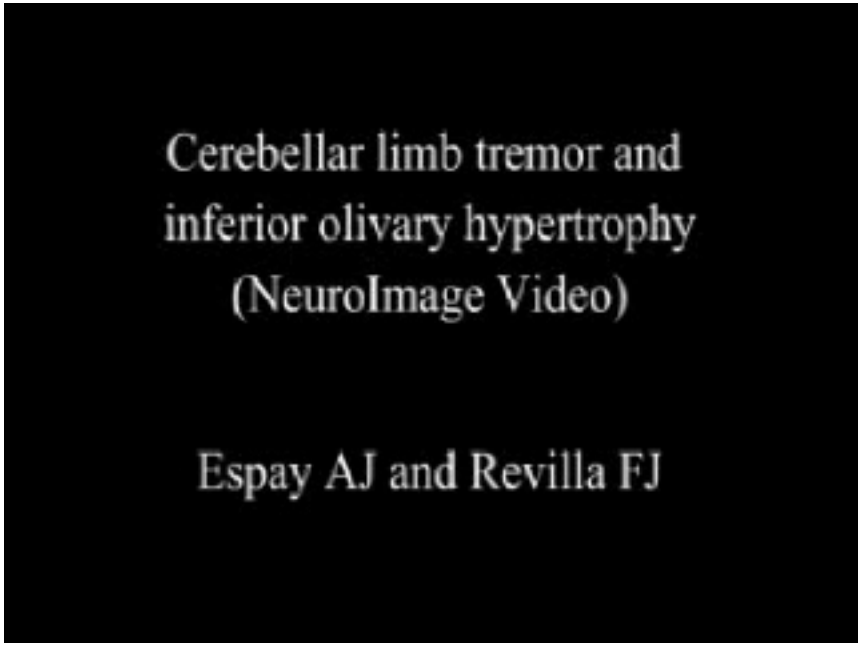
Video of cerebellar patient

- What happens when there is damage to the cerebellum?

- Prediction, timing, sensorimotor skill
- More about this when we go into details about motor disorders.

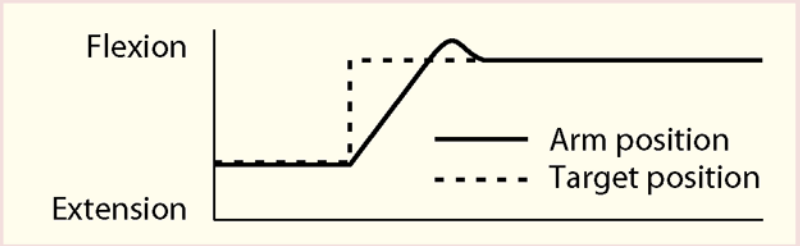
Cerebellar ataxia (left-unilateral)

Cerebellar atrophy (degeneration)

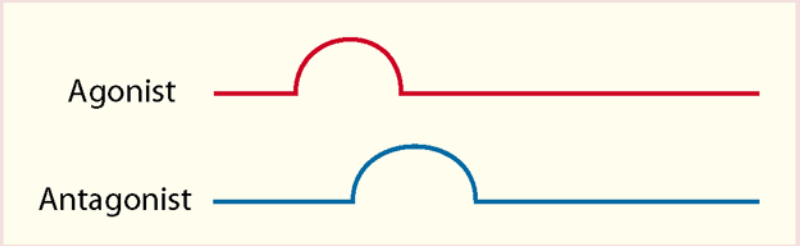


(a) Normal subject

Arm position

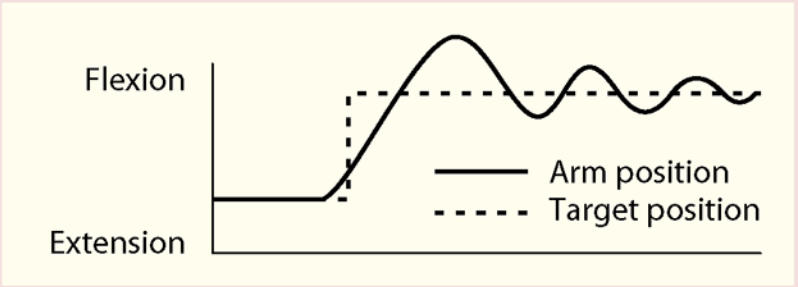


EMG

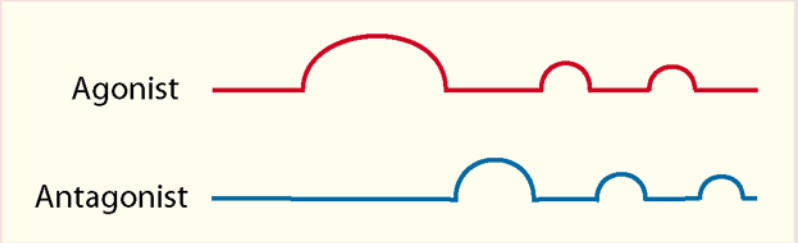


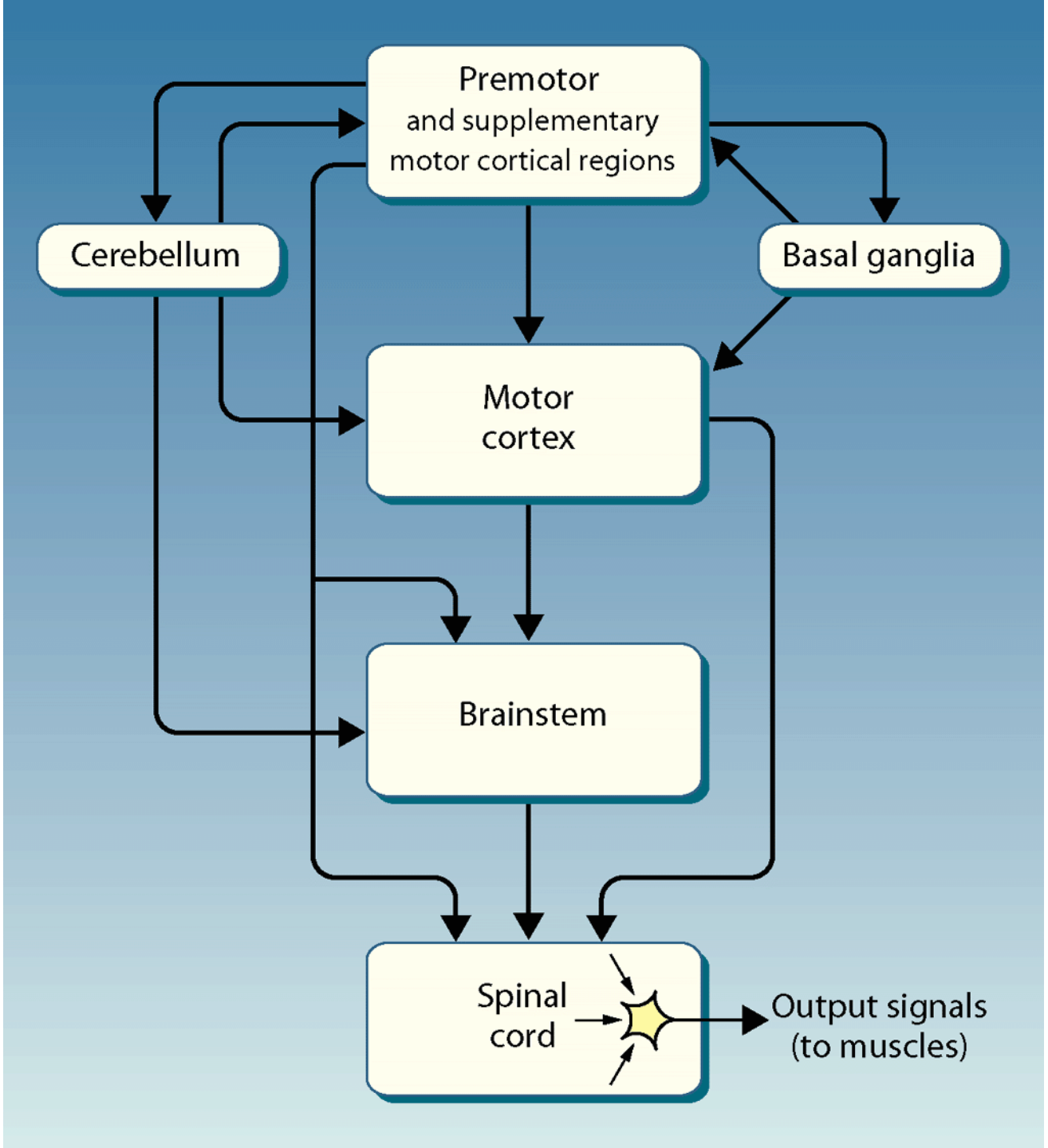
(b) Cerebellar patient

Arm position



EMG




Premotor
and supplementary
motor cortical regions
Cerebellum
Basal ganglia
Motor
cortex
Brainstem
Spinal
cord
Output signals
(to muscles)

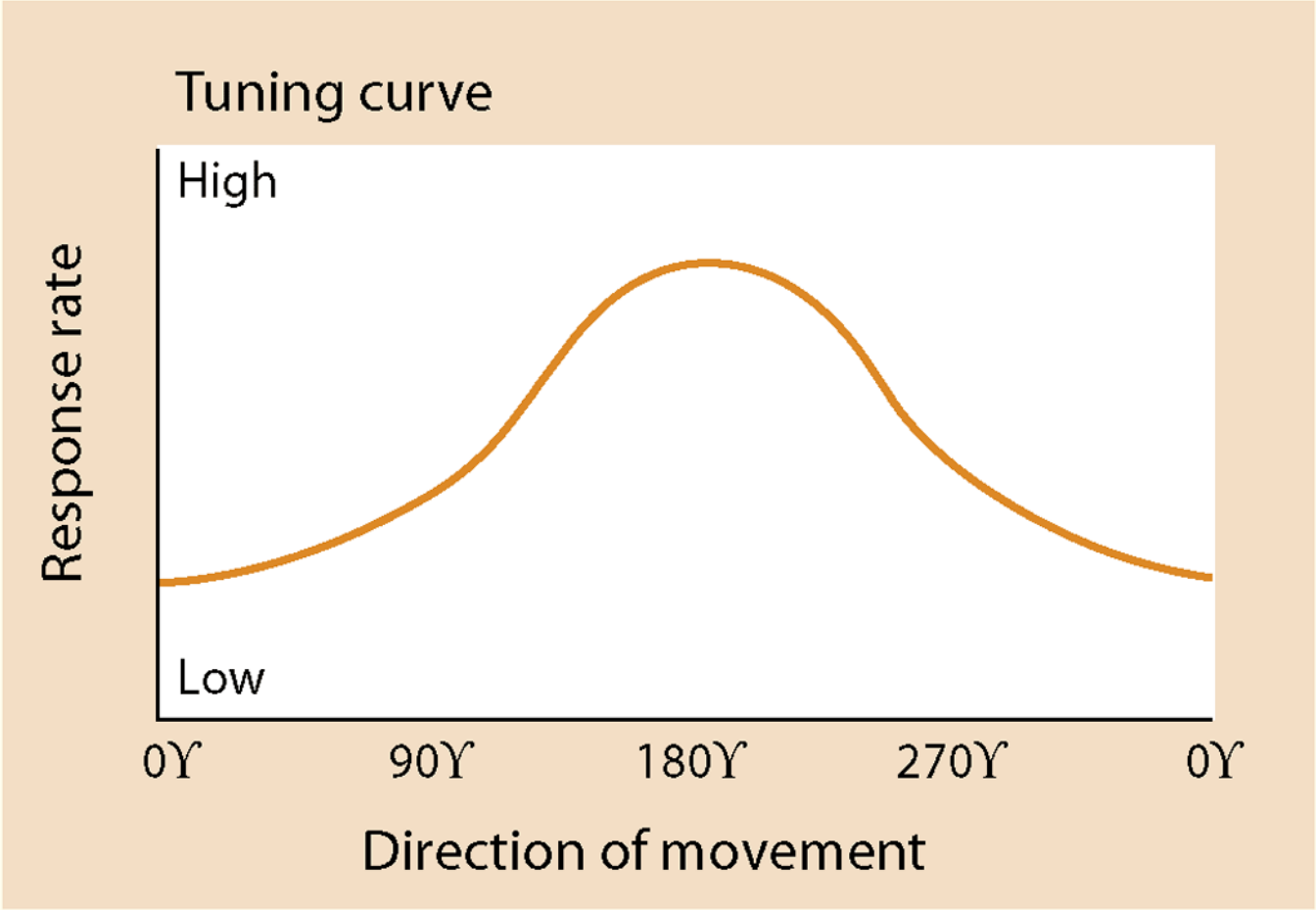
One more time …

- Movement fundamentals
- Hierarchy in the CNS
- Spinal cord damage, Deafferentation, ALS
- Midbrain
- Cerebellum

Recap: Motor cortex

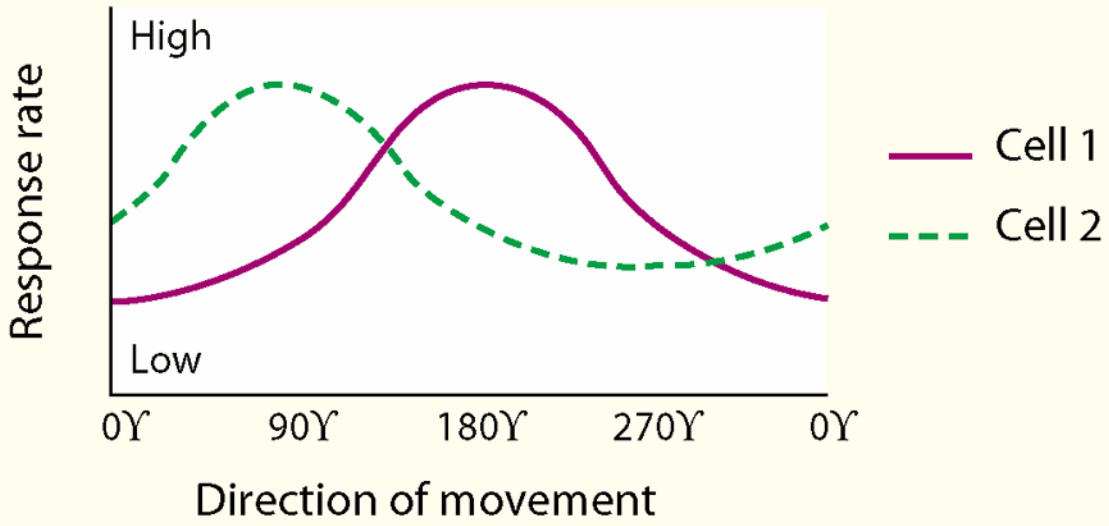
- Somatotopic map (also called homunculus)
- Each part of the cortex uniquely corresponds to a part of the body
- Neurons in the motor cortex have a specific tuning curve

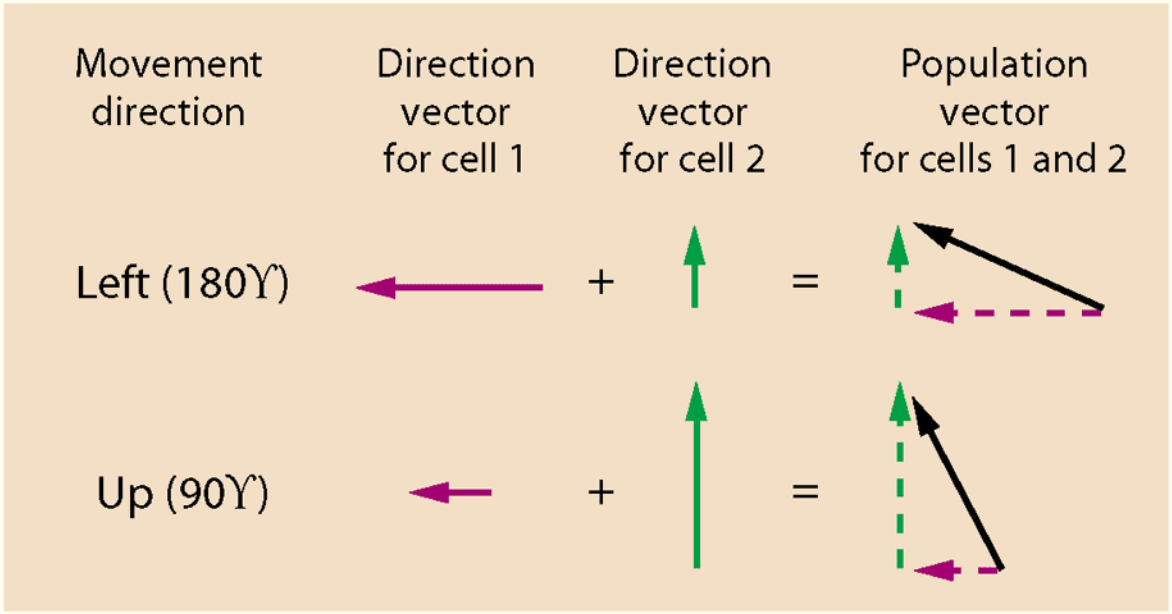
(b)



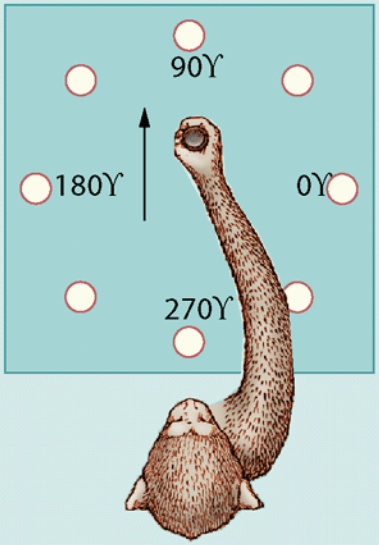
Adapted from Georgopoulos, A.P., Neurophysiology of Reaching, in Jeannerod, M. (Ed.), Attention and Performance XIII: Motor Representation and Control. Hillsdale, NJ: Lawrence Erlbaum Associates, 1990, pp. 227–263

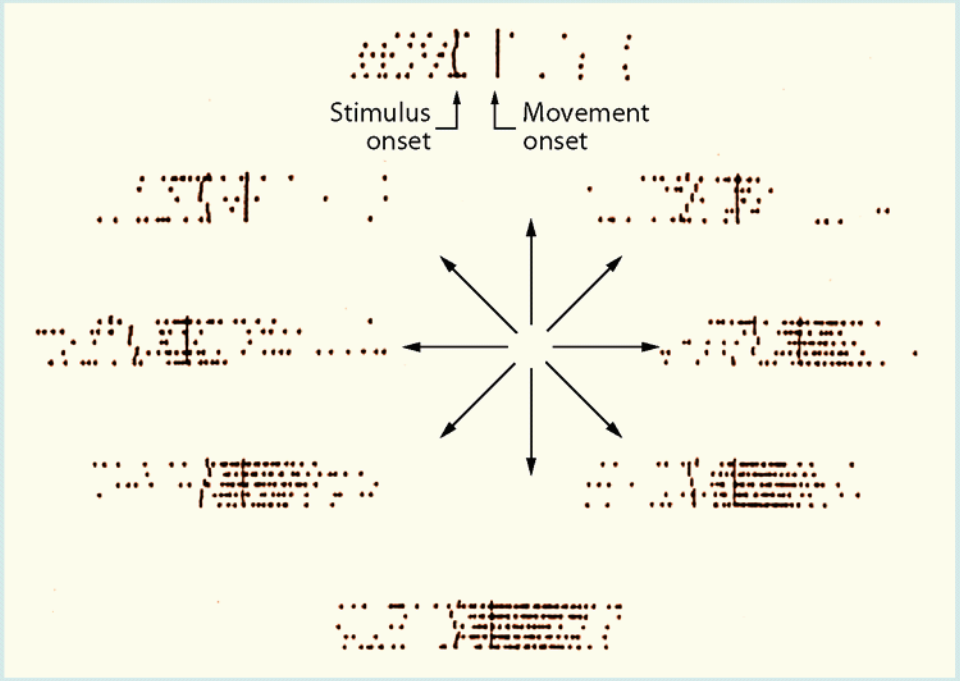
(c)


High
Low
Response rate
0Υ
90Υ
180Υ
270Υ
0Υ
Direction of movement
Cell 1
Cell 2

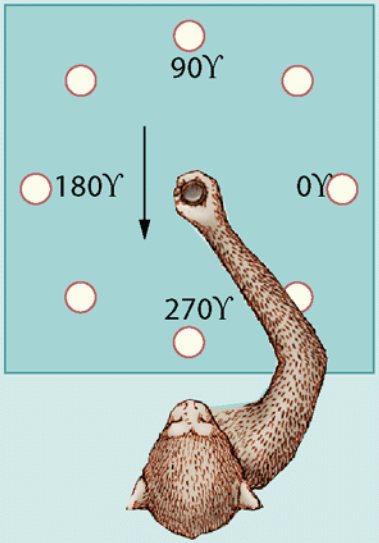

Movement direction
Direction vector for cell 1
Direction vector for cell 2
Population vector for cells 1 and 2
Left (180Υ)
+
=
Up (90Υ)
+
=

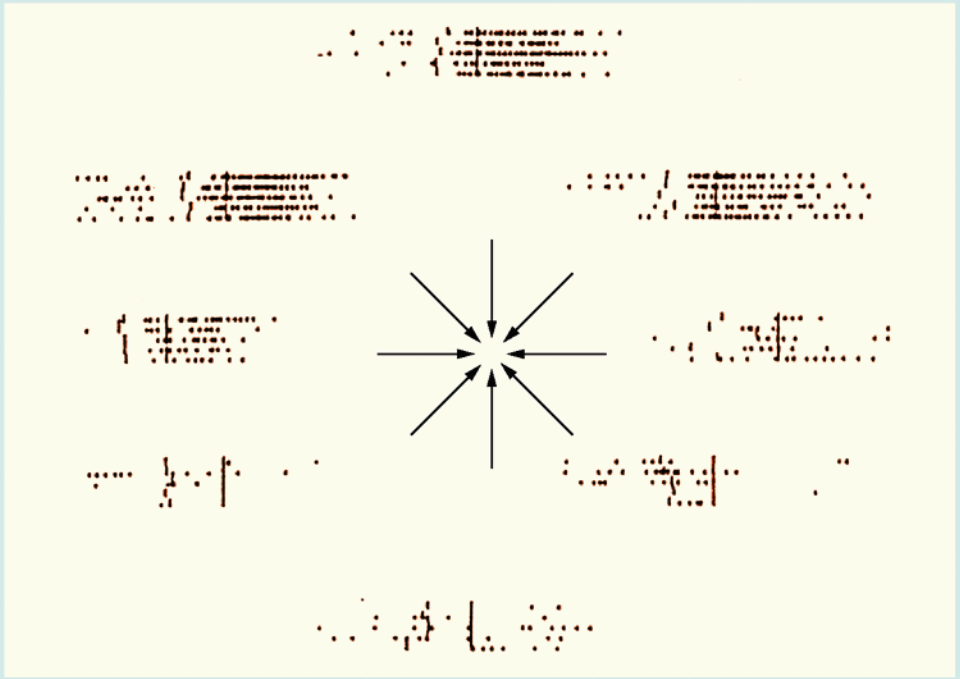
(a)

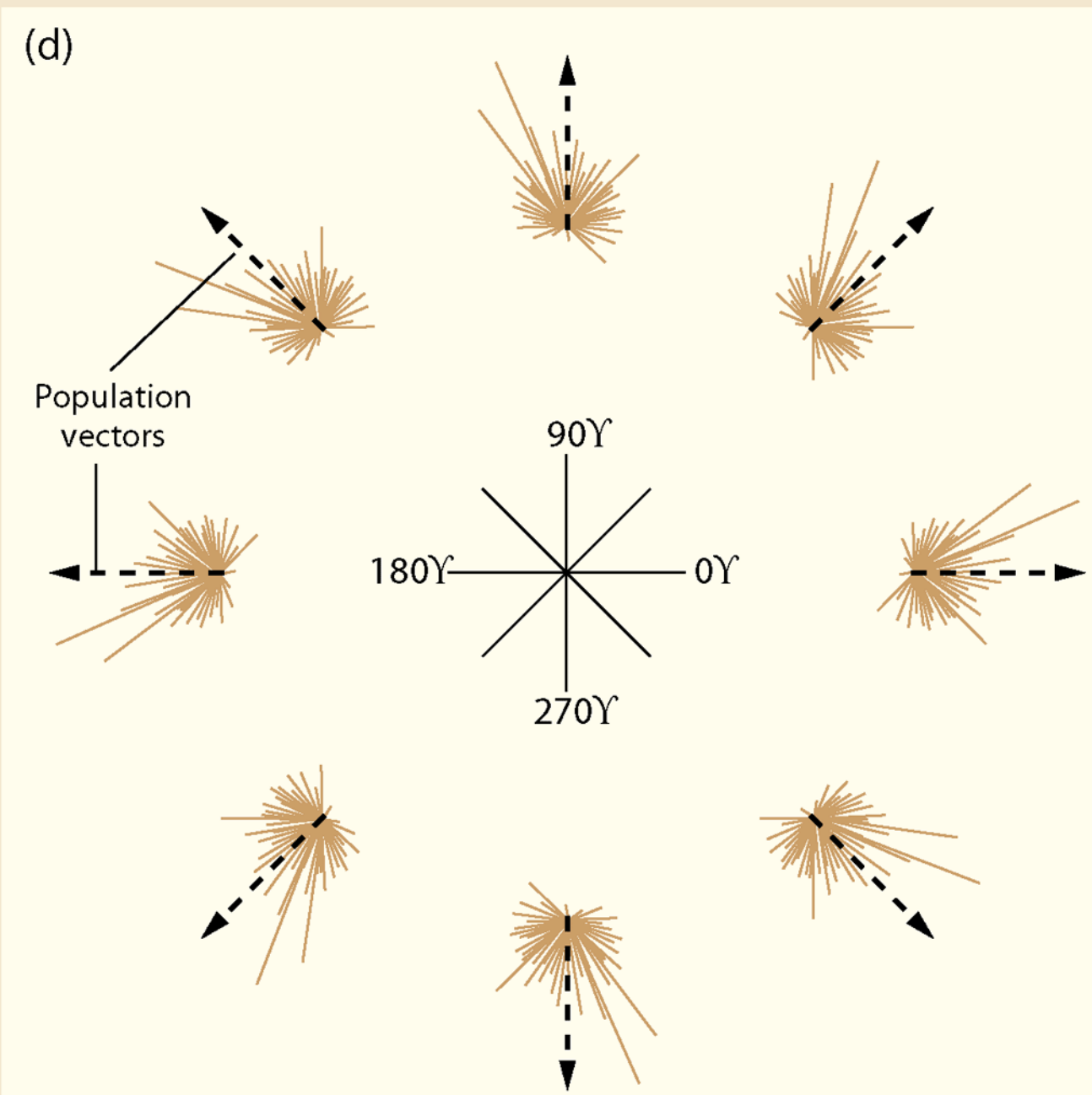


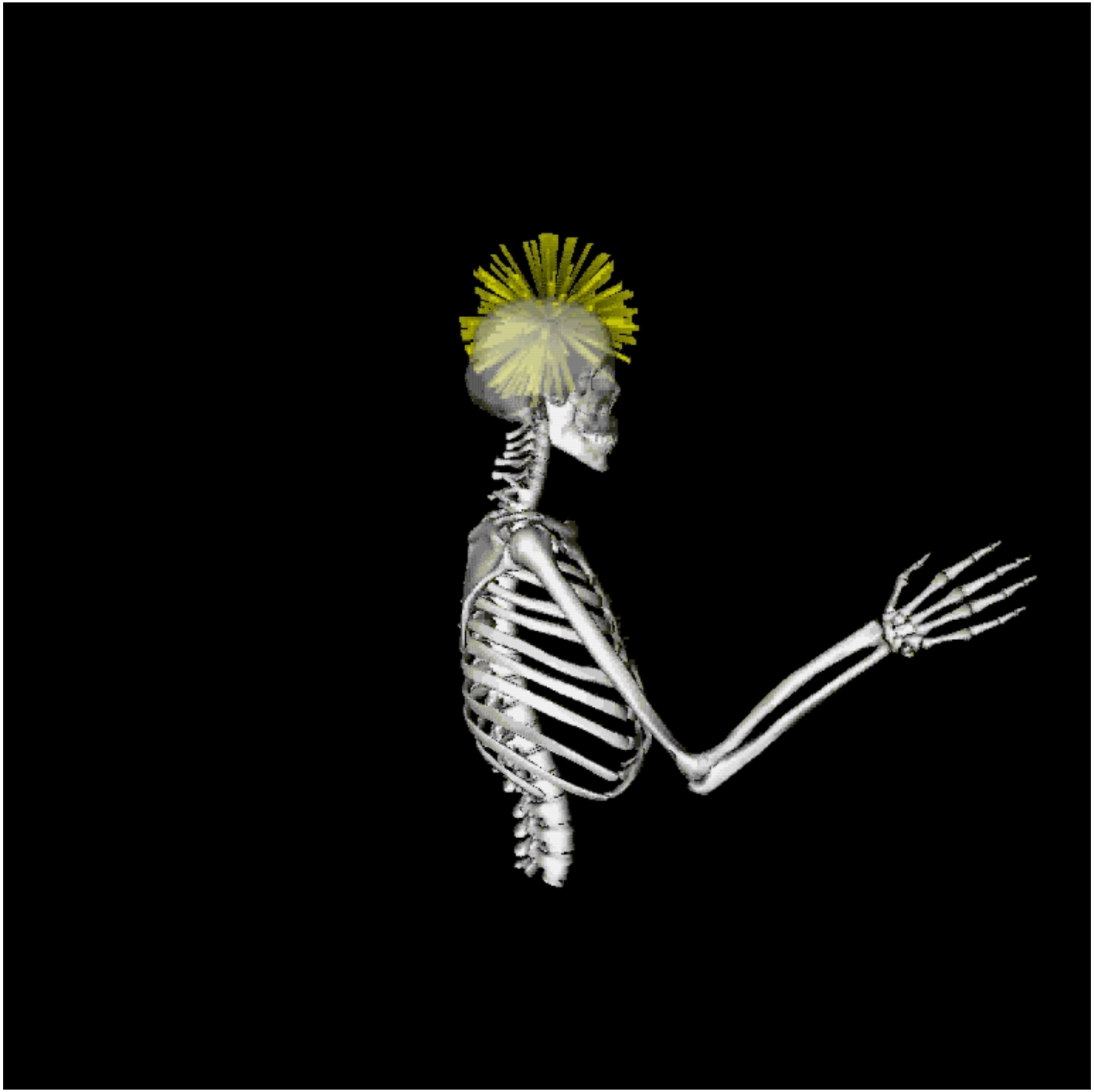


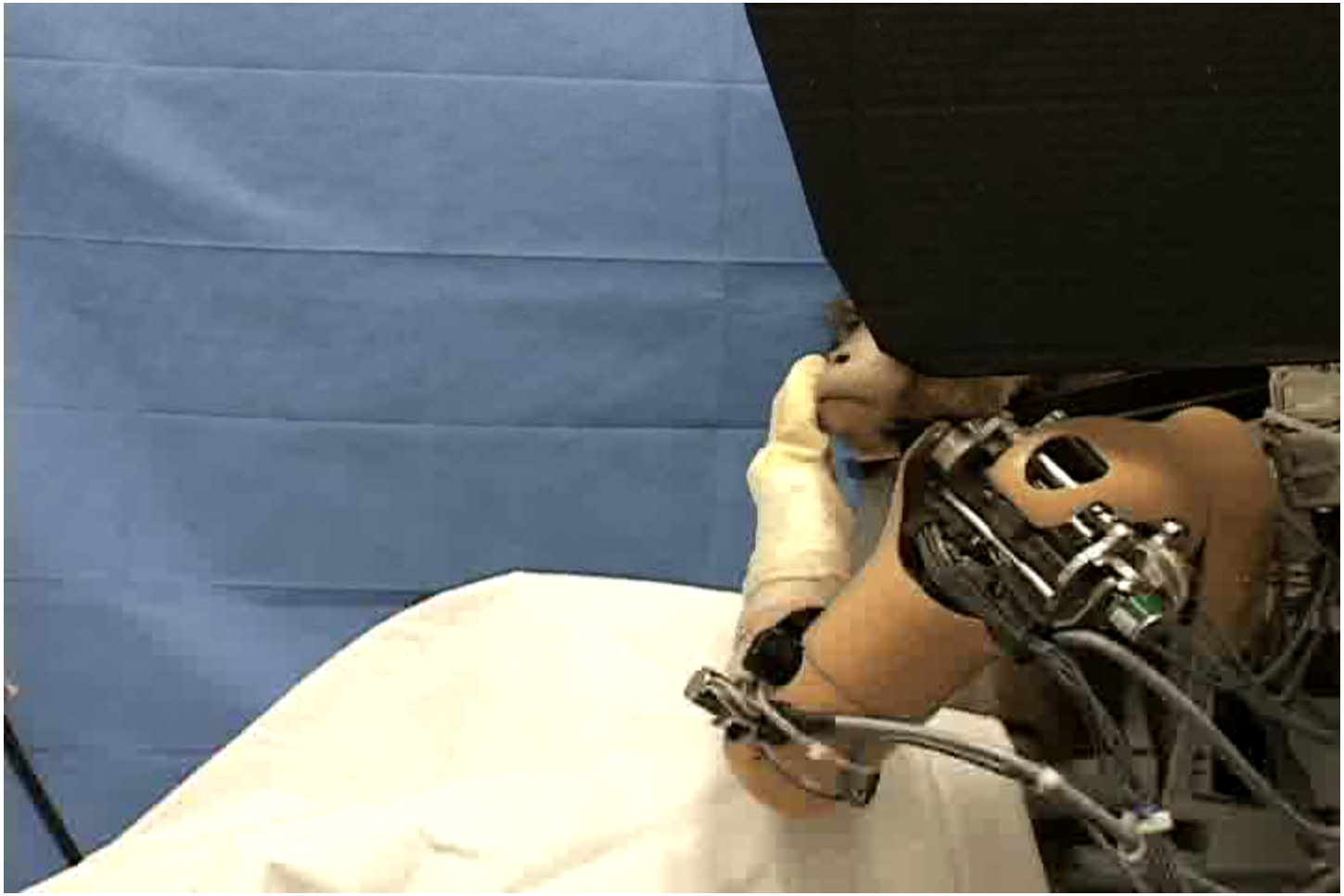
(b)






(d)
Population vectors
90°
180°
0°
270°



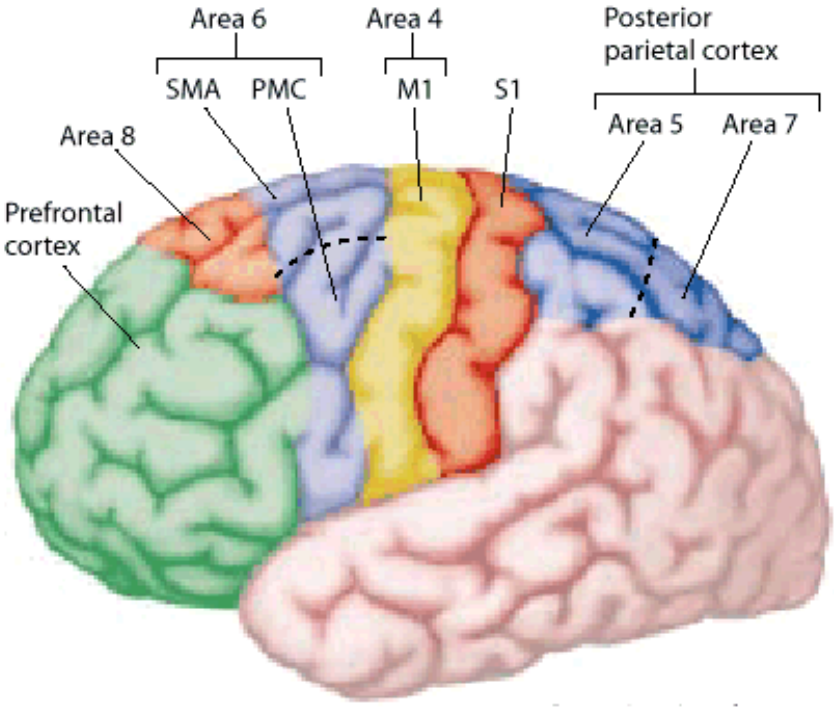


Cortical Motor System

<u>Primary motor cortex</u>

Execution of movement

- Somatopically organized
- Massive descending projections to spinal cord
- Damage => pronounced weakness in affected body parts
- Stimulation => simple mov't in small muscle groups



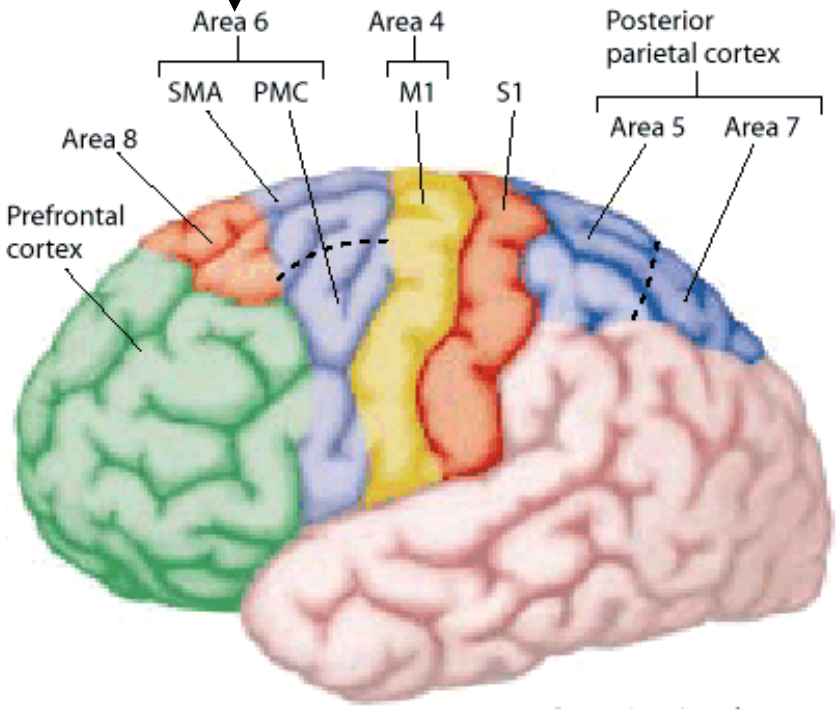
Cortical Motor System

M1 and S1 are parallel. Stimulate area in M1 you see an stimulus in muscle. IF you stimulate a muscle then you will see it in S1.

Pre-motor cortex

Movement planning/sequencing

- Many projections to M1
- But also many projections directly into pyramidal tract
- Damage => more complex motor coordination deficits
- Stimulation => more complex mov't
- Two distinct somatotopically organized subregions
  - SMA — supplementary motor area
    May be more involved in internally generated movement
  - Pre-motor areas
    - May be more involved in externally guided movement



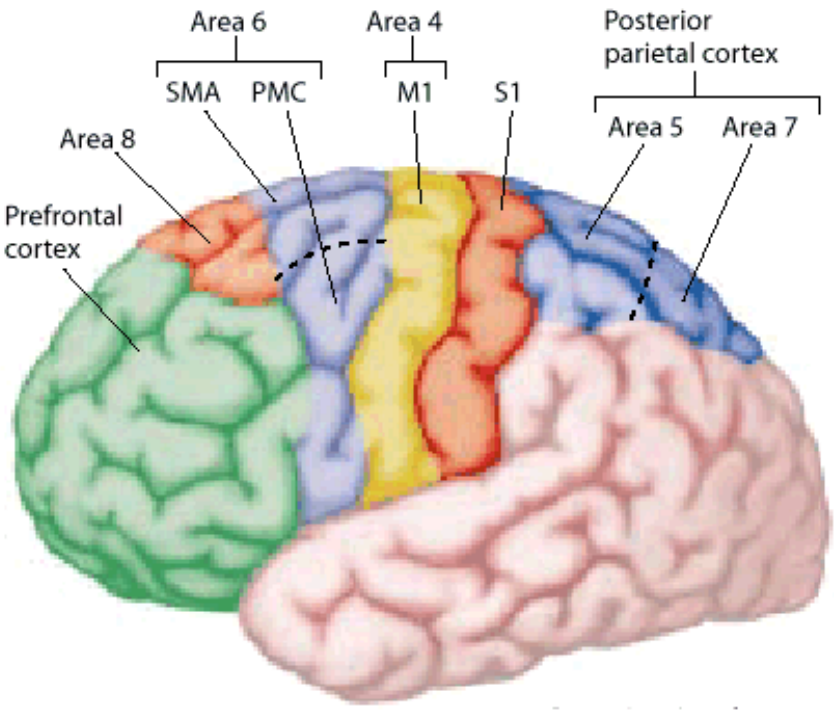
Cortical Motor System

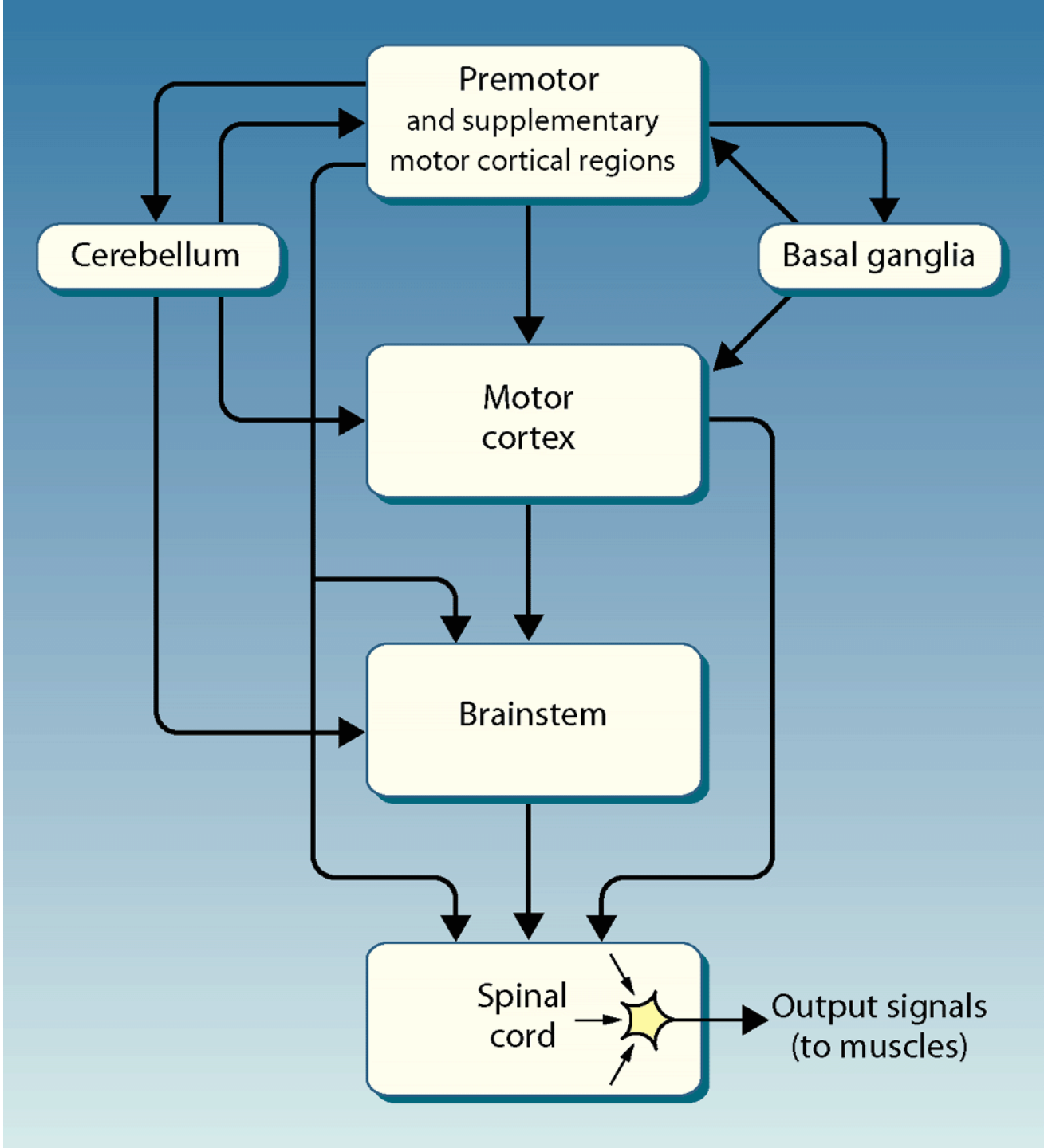
Posterior parietal cortex (PPC)

Sensory guidance of movement

- Many projections to pre-motor cortex
- But also many projections directly into pyramidal tract
- Damage can cause deficits in visually guided reaching (Balint's syndrom) and/or optic ataxia
- Likely part of the dorsal visual stream

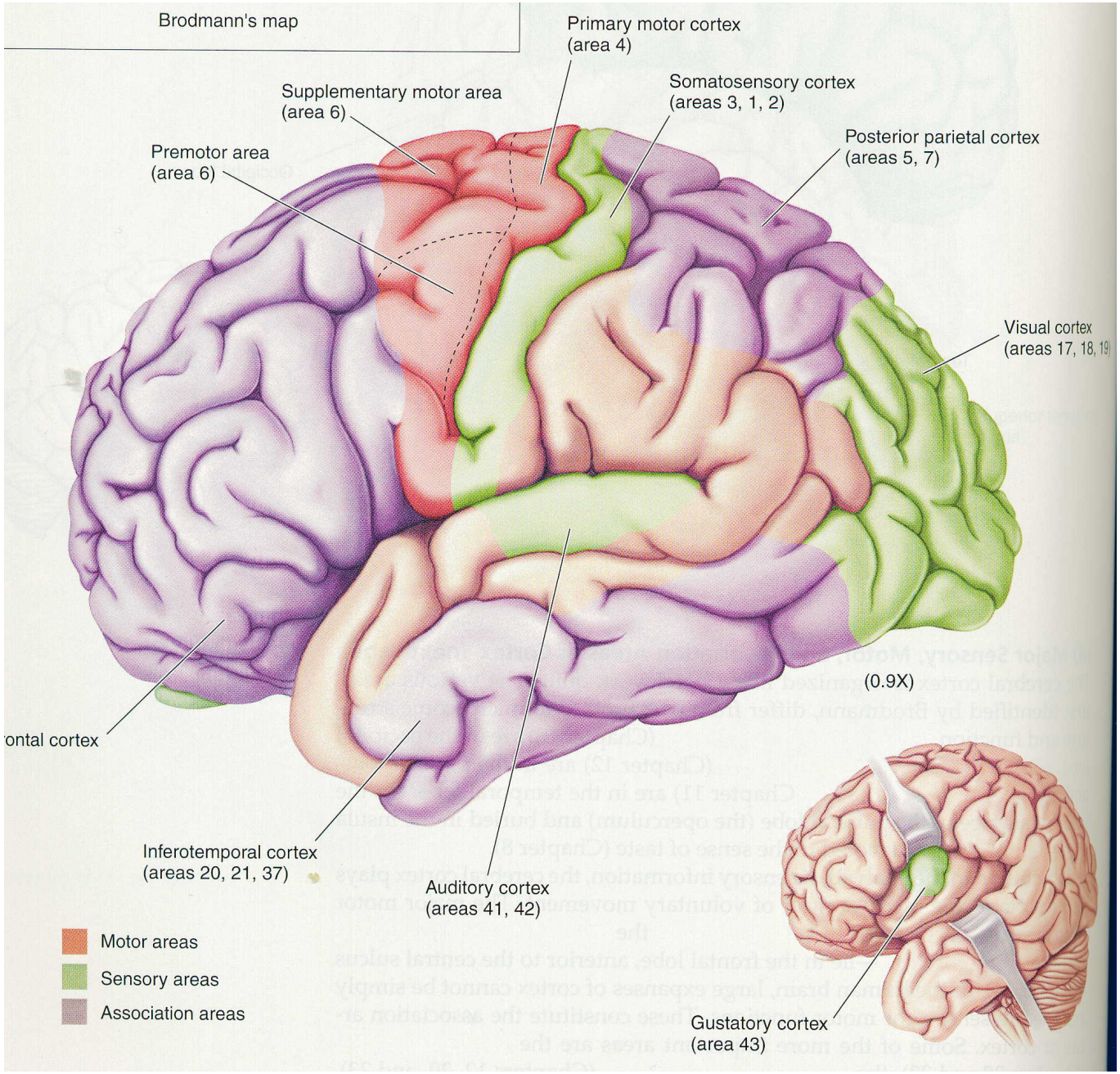
(we will talk about this in the next few lectures)

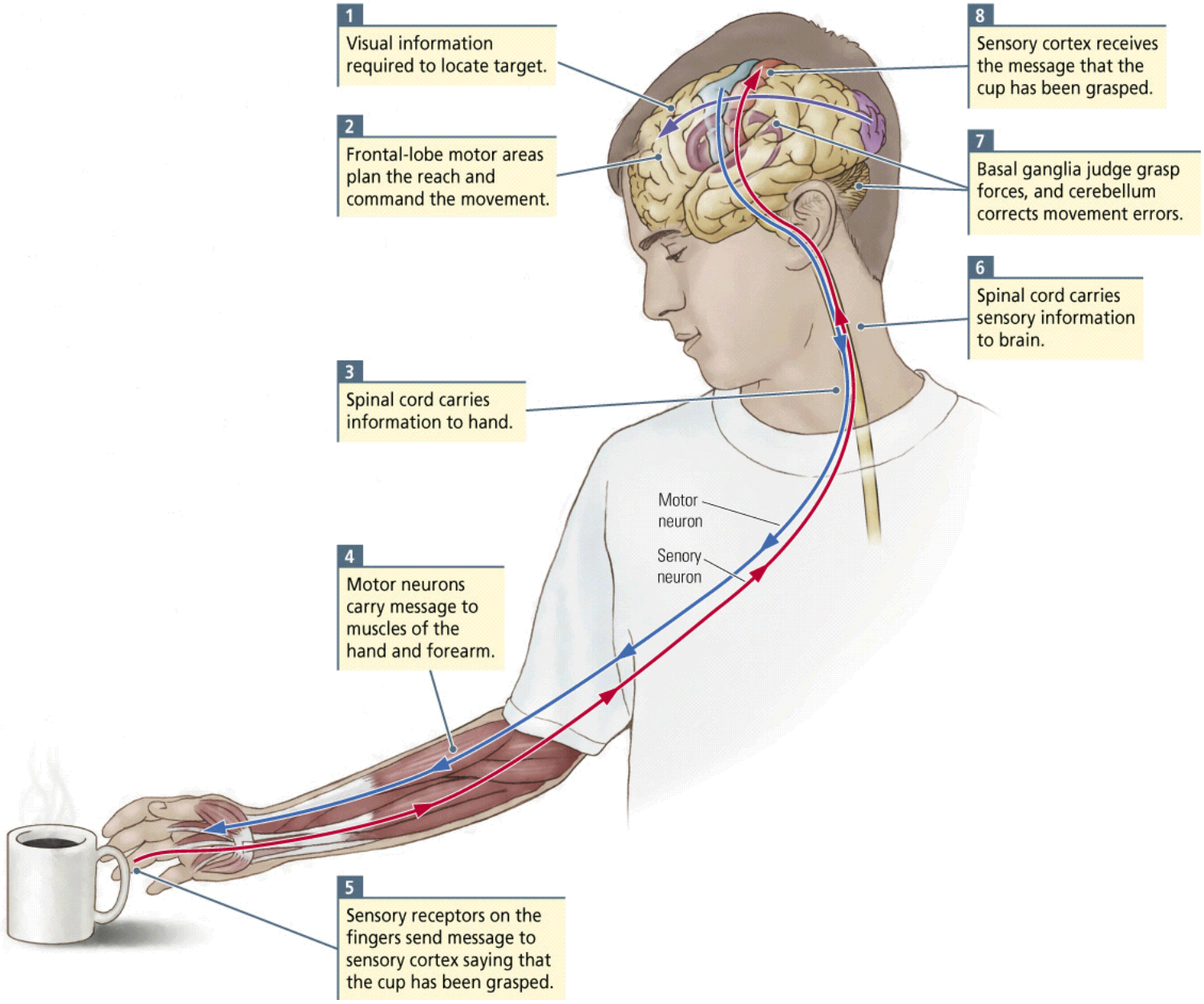



Premotor
and supplementary
motor cortical regions
Cerebellum
Basal ganglia
Motor
cortex
Brainstem
Spinal
cord
Output signals
(to muscles)

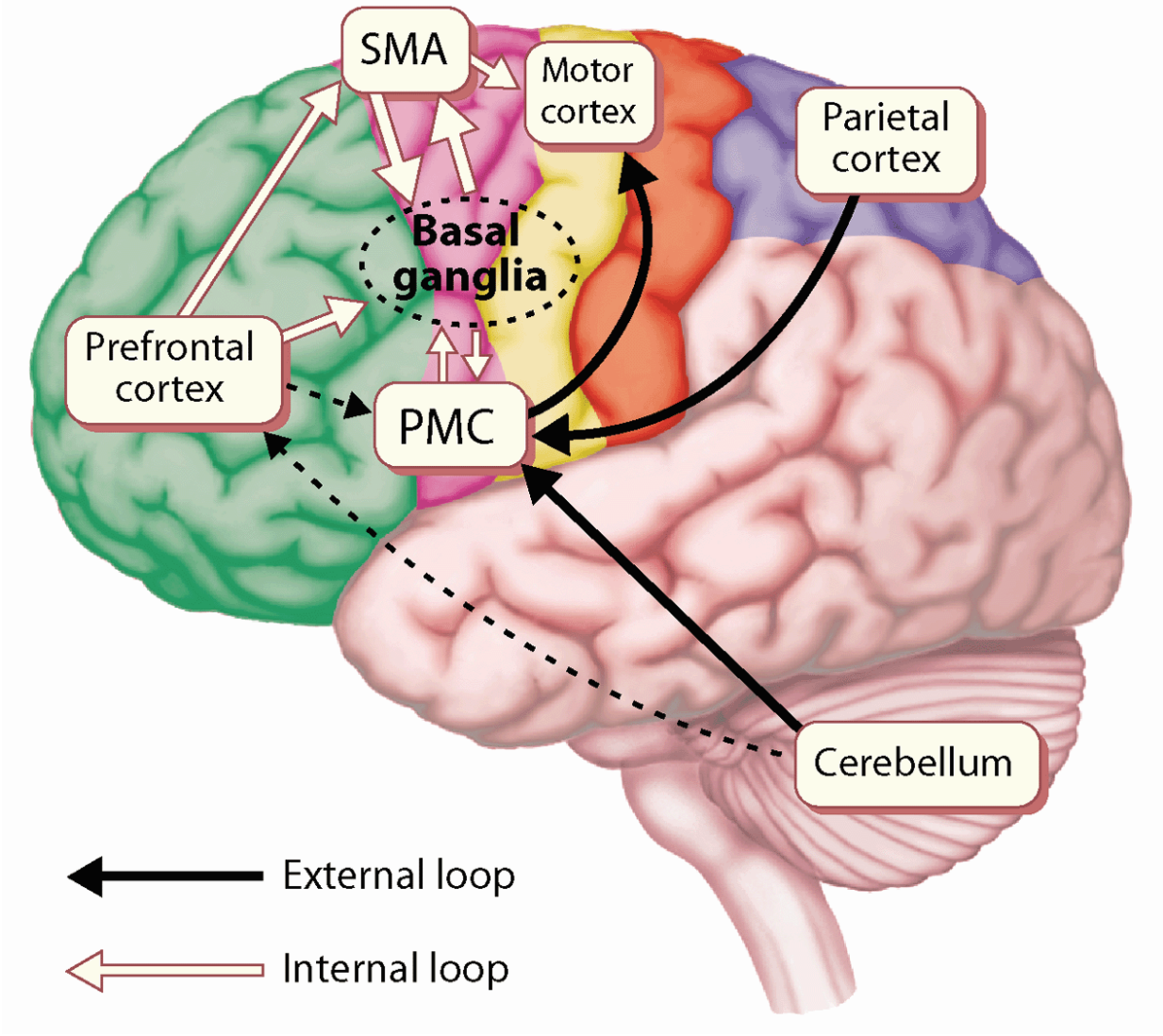
Recap

- Cortex, descending motor systems, cerebellum
- Motor homonculus – somatotopic map
- Motor cortex: population codes sensitive to direction
- Cerebellum and efference copies
- Other motor areas of the brain
- Cortical motor systems: M1, SMA/PMC, Posterior Parietal cortex


Brodmann's map
Primary motor cortex
(area 4)
Supplementary motor area
(area 6)
Somatosensory cortex
(areas 3, 1, 2)
Premotor area
(area 6)
Posterior parietal cortex
(areas 5, 7)
Visual cortex
(areas 17, 18, 19)
(0.9X)
ontal cortex
Inferotemporal cortex
(areas 20, 21, 37)
Auditory cortex
(areas 41, 42)
Motor areas
Sensory areas
Association areas
Gustatory cortex
(area 43)


1
Visual information required to locate target.
2
Frontal-lobe motor areas plan the reach and command the movement.
3
Spinal cord carries information to hand.
4
Motor neurons carry message to muscles of the hand and forearm.
5
Sensory receptors on the fingers send message to sensory cortex saying that the cup has been grasped.
6
Spinal cord carries sensory information to brain.
7
Basal ganglia judge grasp forces, and cerebellum corrects movement errors.
8
Sensory cortex receives the message that the cup has been grasped.
Motor neuron
Senory neuron

Different movements have different cortical activations



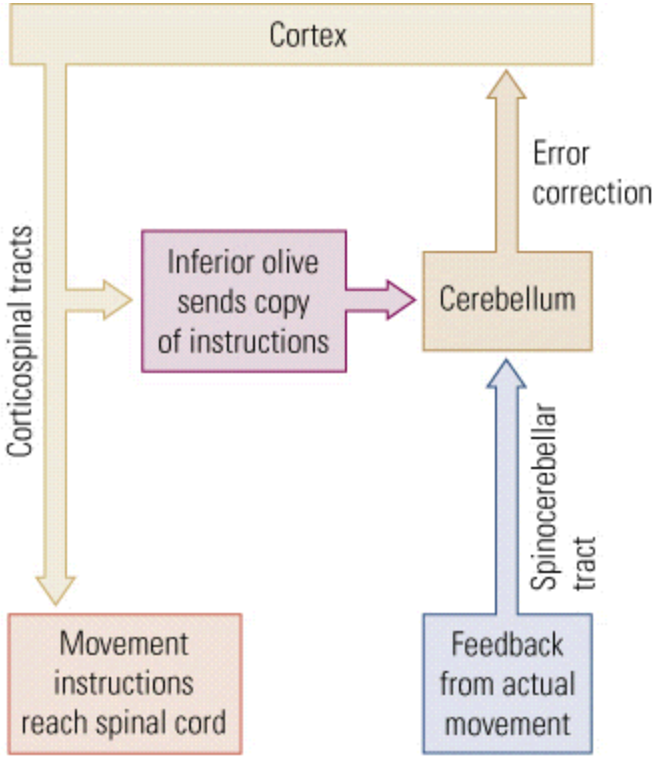
Externally guided movements

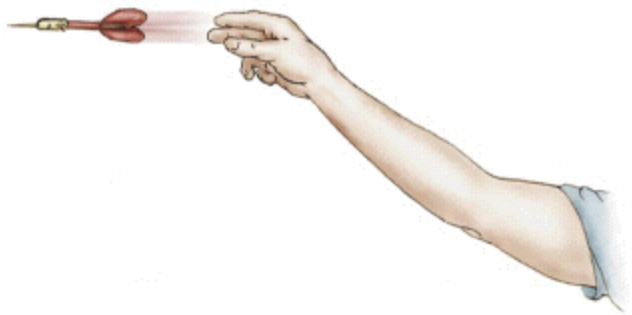
Novel movements that are visually guided

Internally guided movements

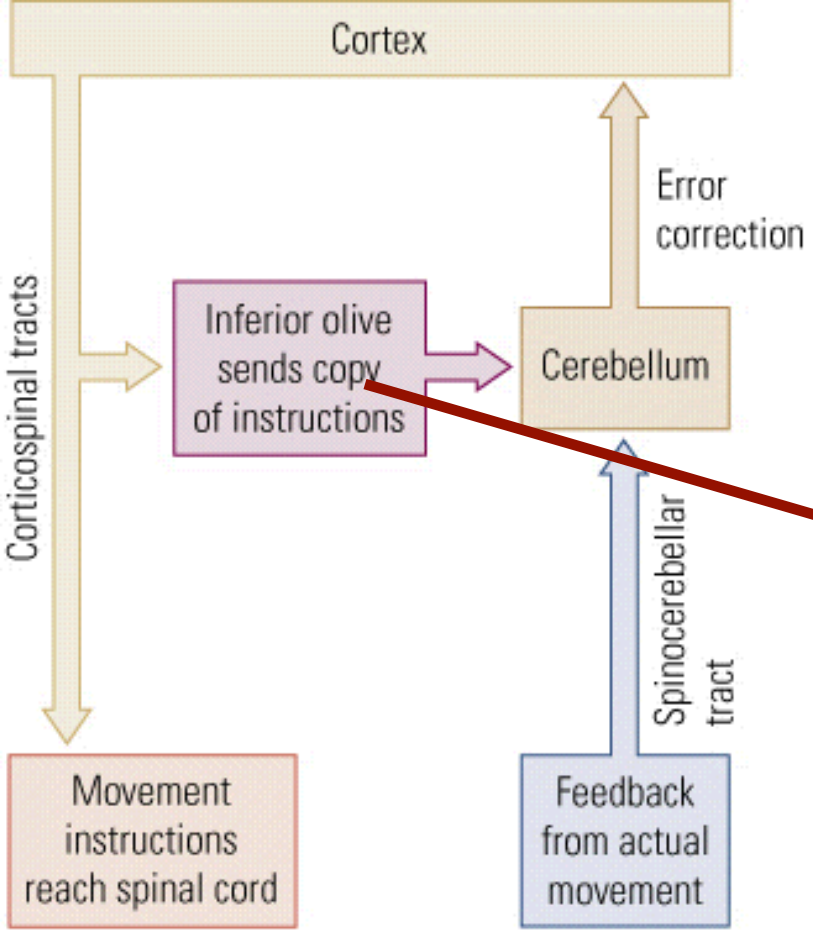
Well-learned self guided movements

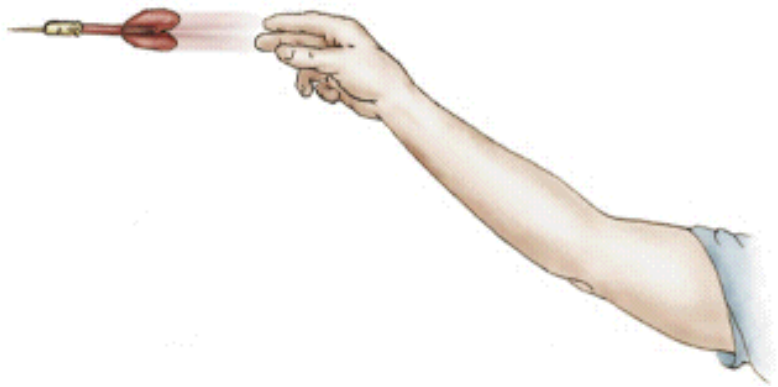
Detection of self movement





- It is almost nap time. Do you know where your limbs are?
- How do you know that your arm moved?

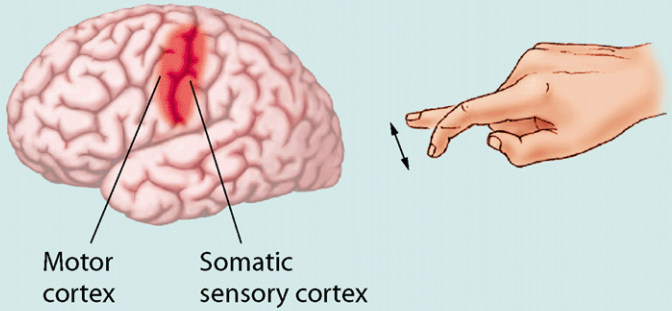




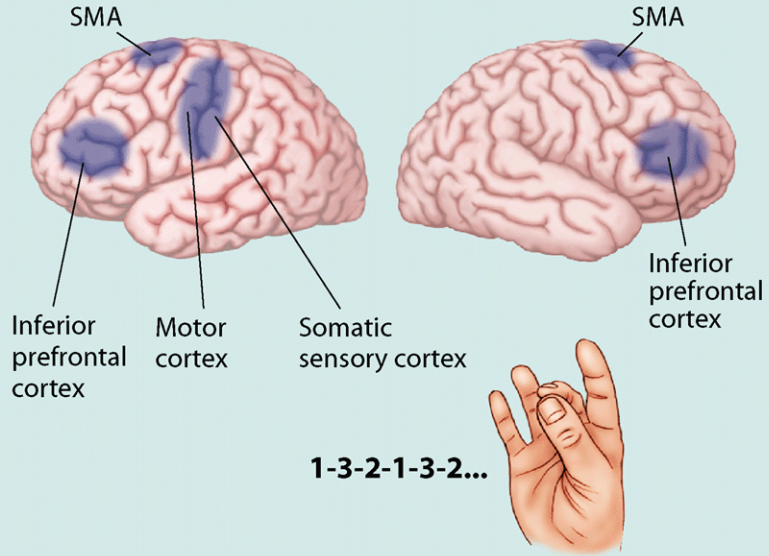
EFFERENCE COPY
or
COROLLARY DISCHARGE

Why you cannot tickle yourself?

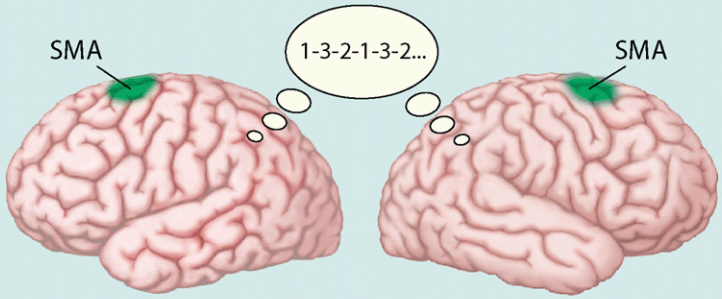
Simple flexion performed with right index finger

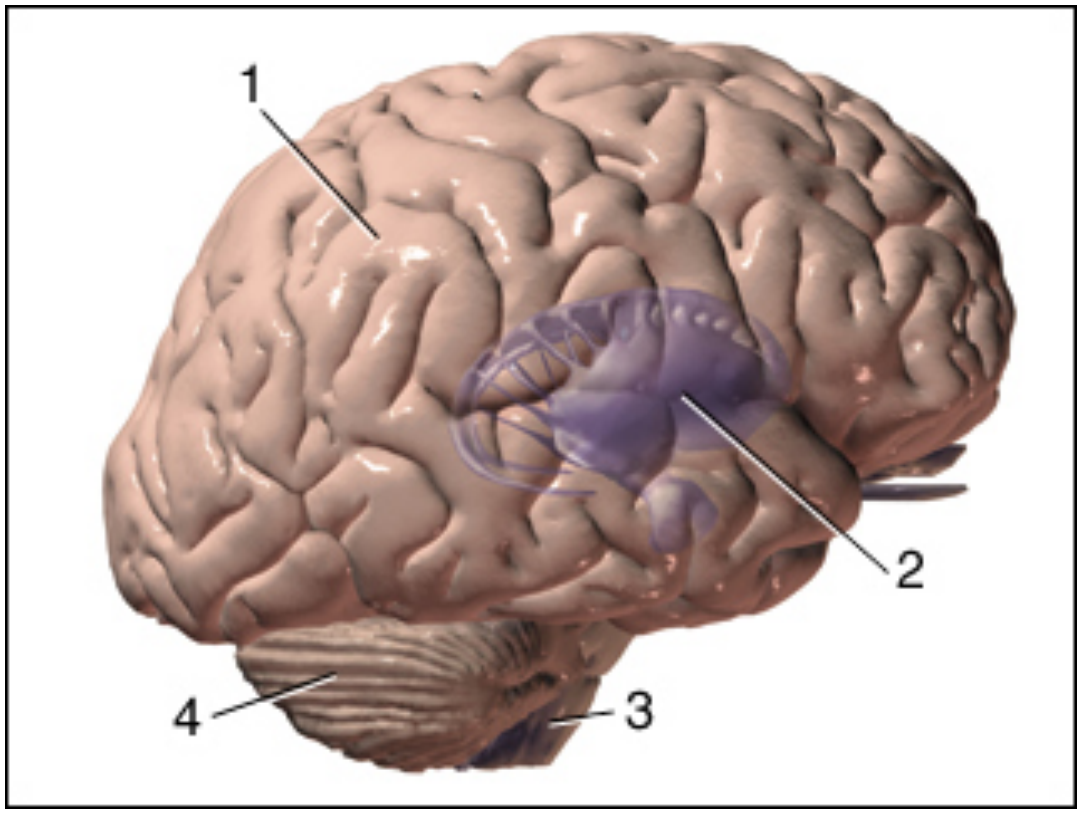


Movement sequence performed with fingers of right hand



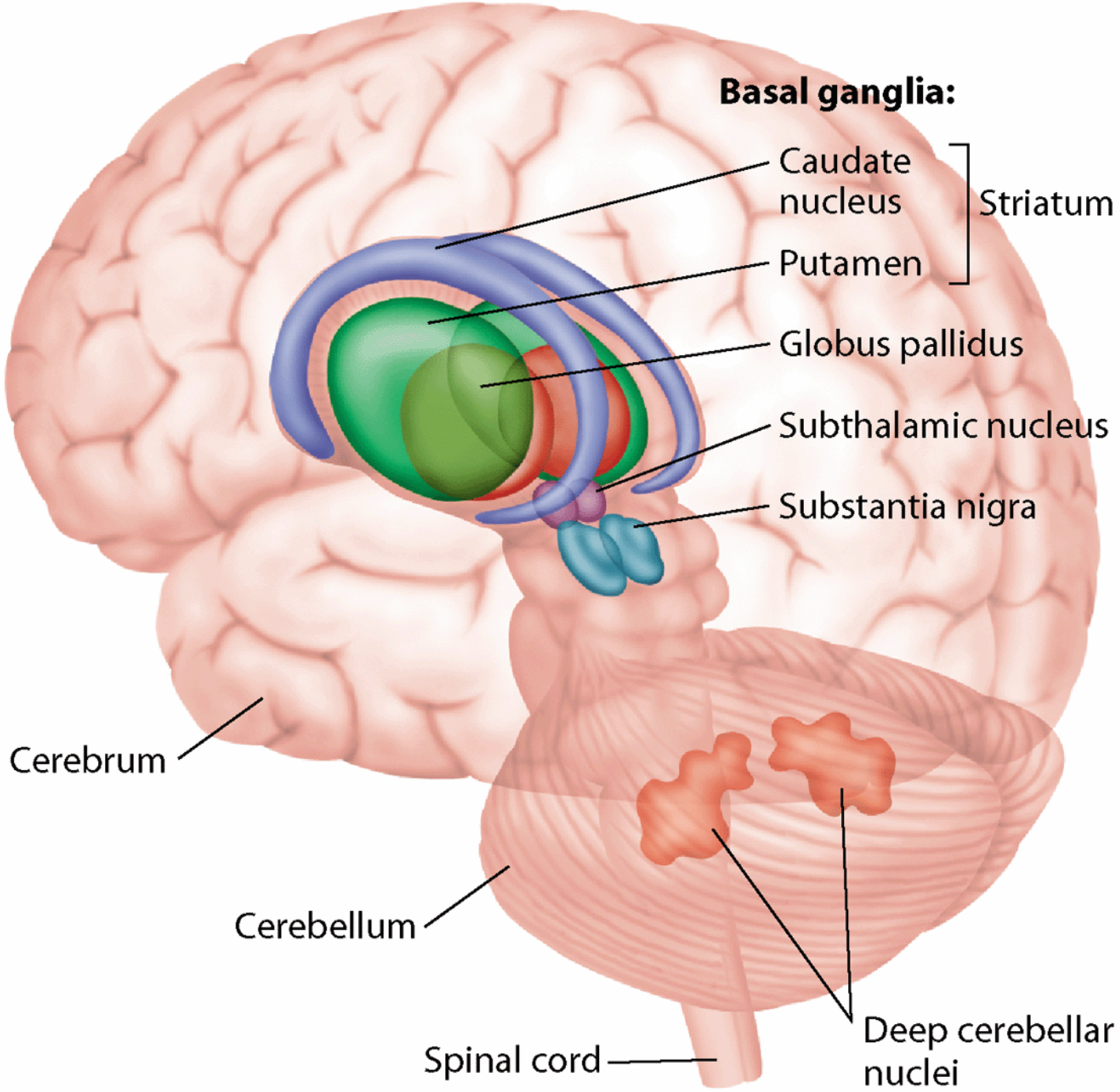
Movement sequence imagined with fingers of right hand





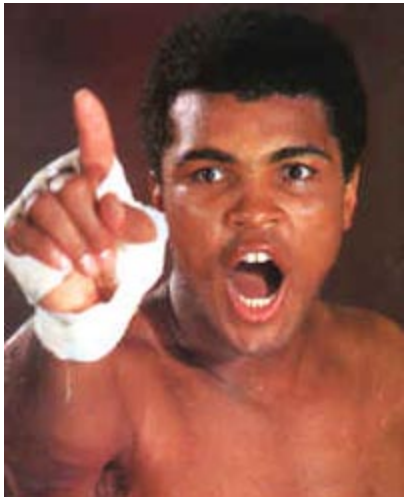
1. Cerebral cortex
2. Basal ganglia
3. Brain stem
4. Cerebellum

REVIEW OF KEY BRAIN AREAS


Basal ganglia:
Caudate nucleus
Striatum
Putamen
Globus pallidus
Subthalamic nucleus
Substantia nigra
Cerebrum
Cerebellum
Spinal cord
Deep cerebellar nuclei

Basal ganglia

- Controls force production
- Fine tunes movements like cerebellum
- Produces a neurotransmitter that inhibits acetylcholine (called dopamine)
- Also involved in making movements smooth
- Damage to BG causes Parkinson's disease.



What is common between these people?

Video of Parkinson's patient

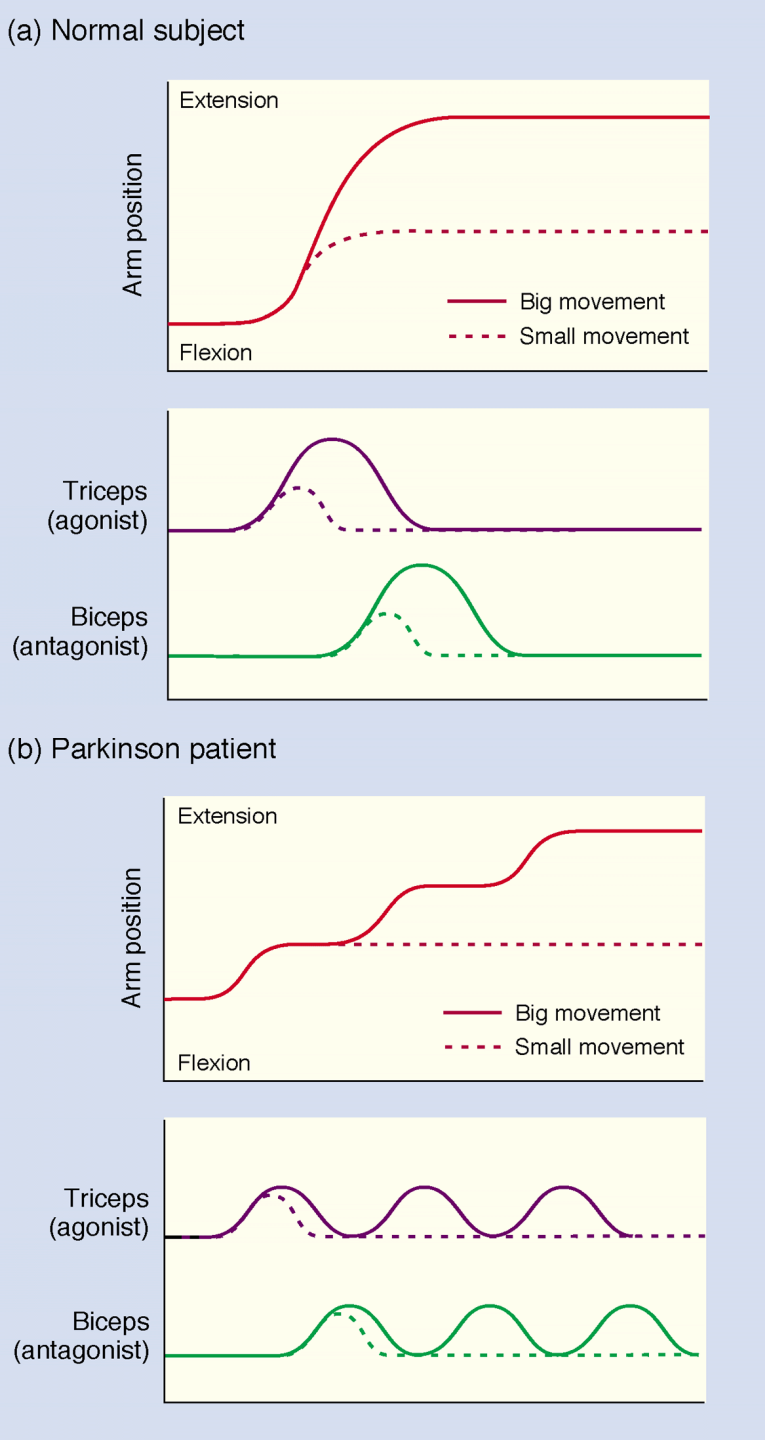
- Smoothness of movement is compromised
- Rigidity, tremor and slowness

Rigidity & Tremor at rest

Shuffling gait, Bradykinesia (slowness)

Trajectory formation in a Parkinson's patient

Note the pattern of EMG activity
Note the shakiness/ tremor envelope



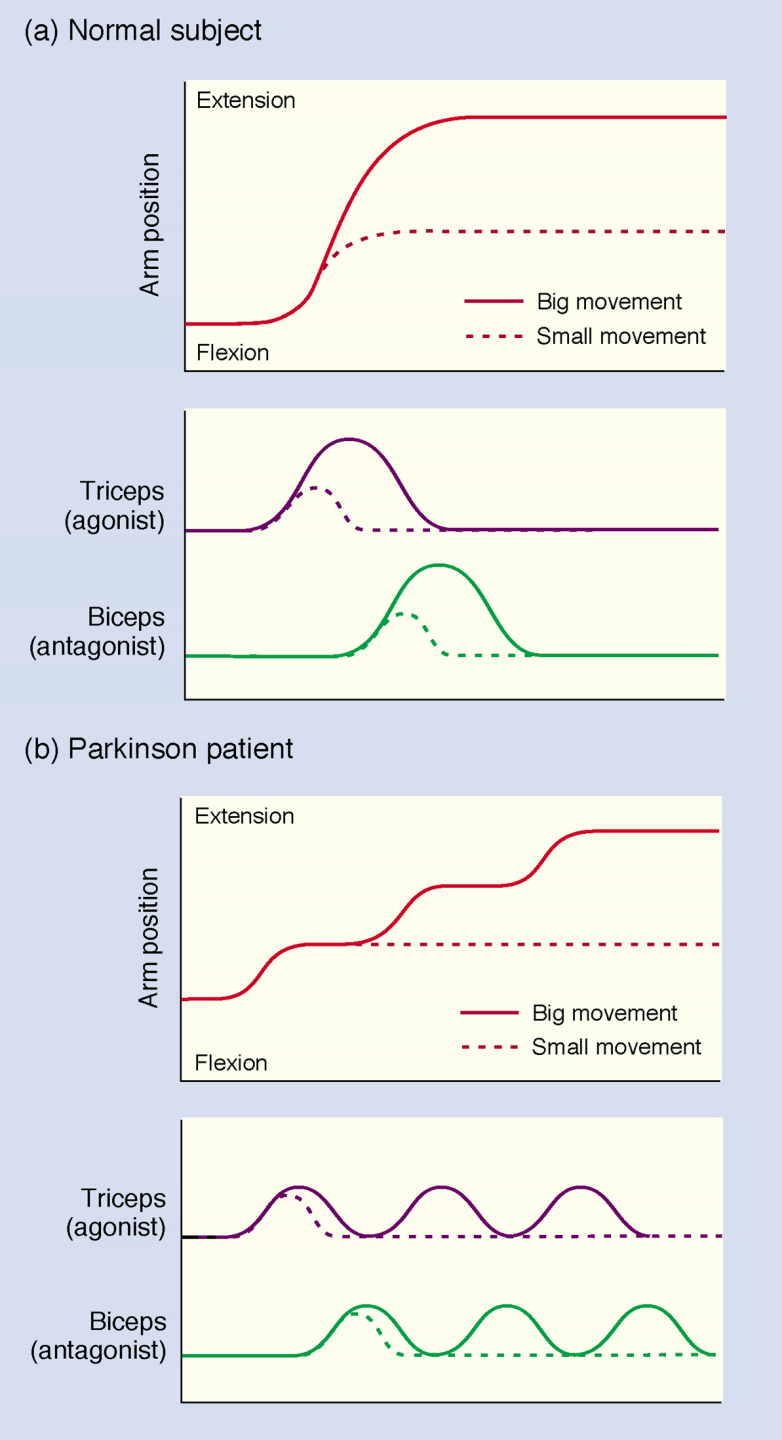
Recap: Basal ganglia disorders

- Parkinson's disease (PD)
- "shaking palsy" – 1817, James Parkinson
- ~ 1/4 million people nationwide suffer from PD
- Strikes men slightly more than women and Found most often in patients over 50 with ~10% of patients afflicted with "young-onset" PD under 40
- Dopamine and acetylcholine balance is lost (Not enough dopamine)

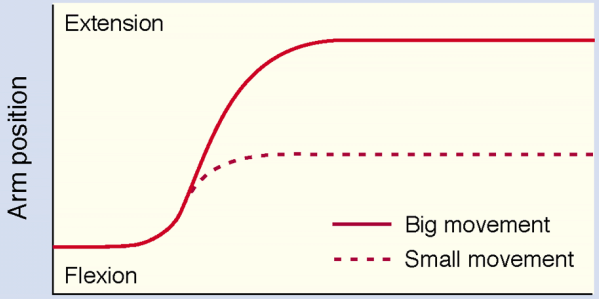
PD symptoms

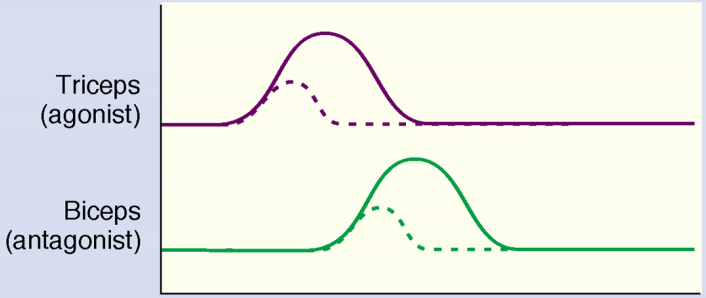
- Tremor at rest
- Slow movements
- Shuffling rather than walking
- Impaired implicit motor/cognitive memories (postural corrections, non-verbal communication)

- Dementia – 20-60% of individuals
  - *Cognitive and motoric slowing*
  - *Executive dysfunction and poor memory retrieval*

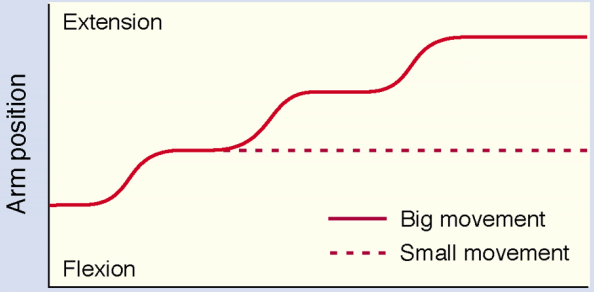


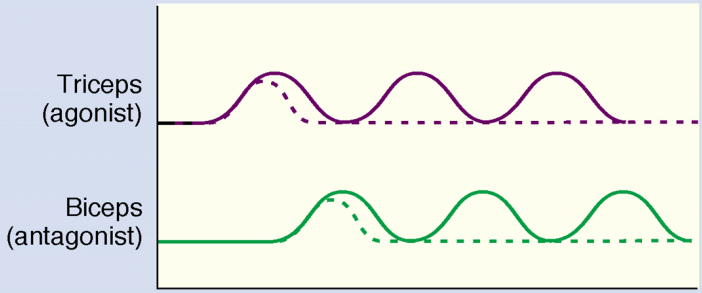
(a) Normal subject

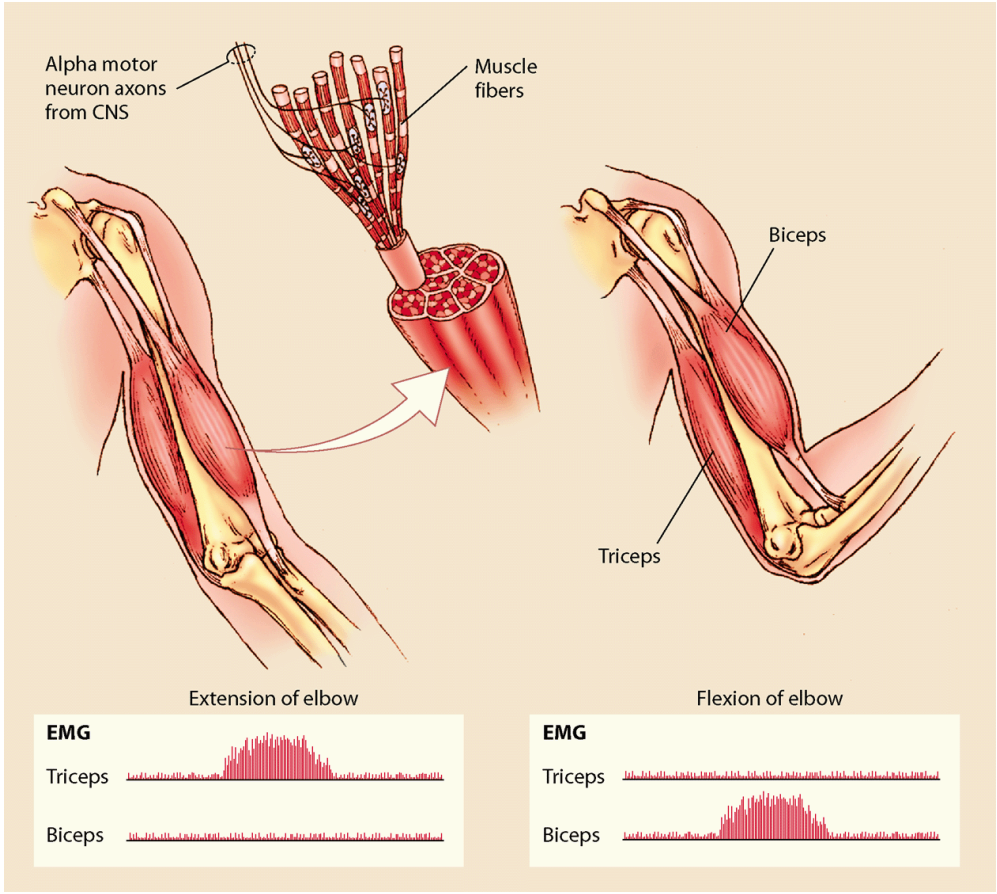




(b) Parkinson patient



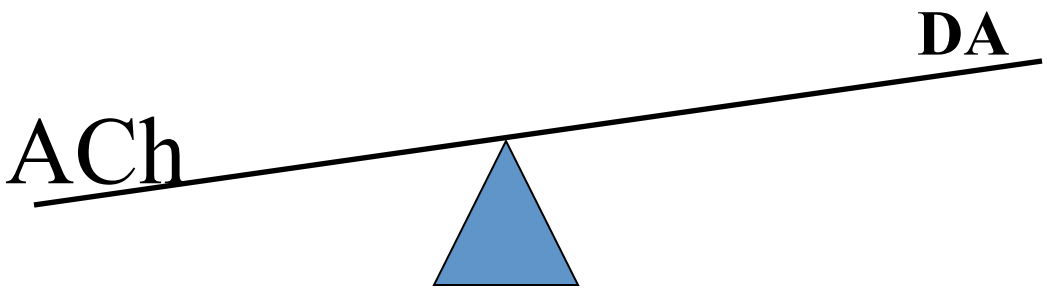




What causes this?

- Not enough dopamine
- So, acetylcholine builds up
- Muscles become stiff and contract too much.
- Creates rigidity, tremor and slowness.

- **Imbalance** primarily between the excitatory neurotransmitter Acetylcholine and inhibitory neurotransmitter Dopamine in the Basal Ganglia



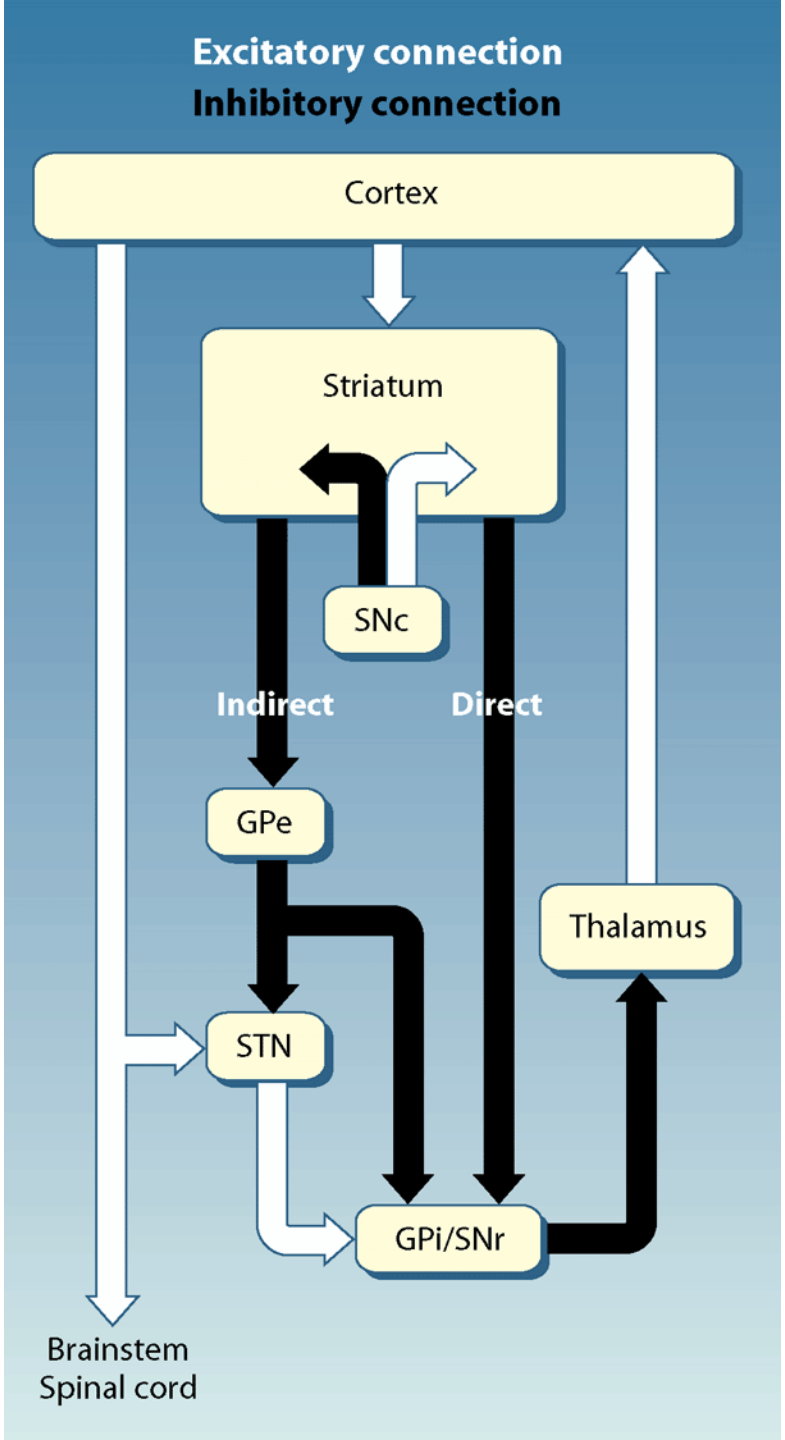
L-Dopa: delays the breakdown of naturally occurring dopamine, allowing accumulation in surviving nerve cells.

Recap

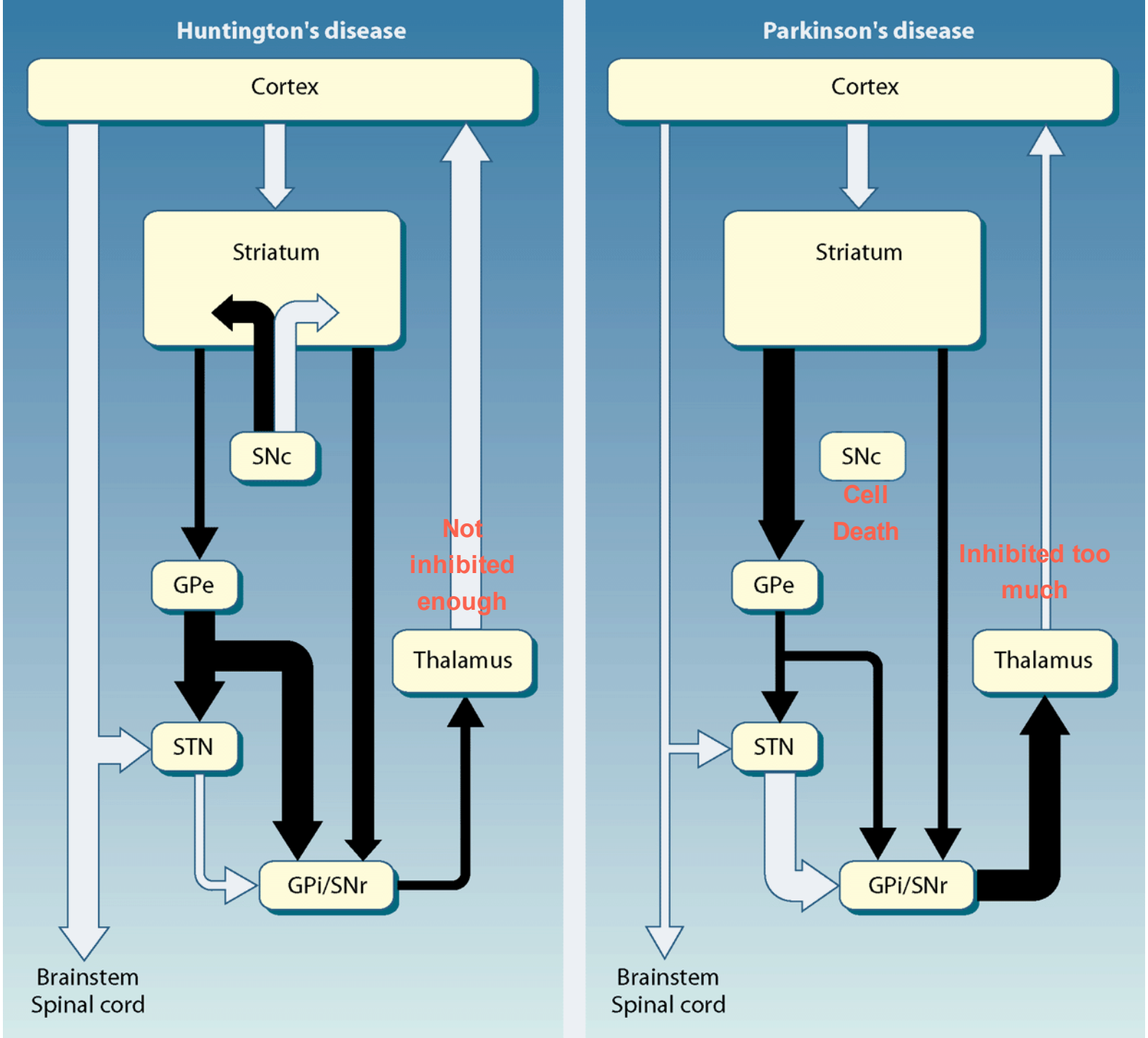
- Motor command
- Cerebellar function & efference copies
- Basal Ganglia
- Parkinson's disease.
- Dopamine – Ach balance
- L-dopa therapies

SNc = substansa nigra

STN = Subthalmic Nucleus
GP = Globus Pallidus
(i = internis, e = externis)



Adapted from Wichmann, T., and DeLong, M.R., Functional and pathophysiological models of the basal ganglia, Current Opinion in Neurobiology 6 (1996): 751–758



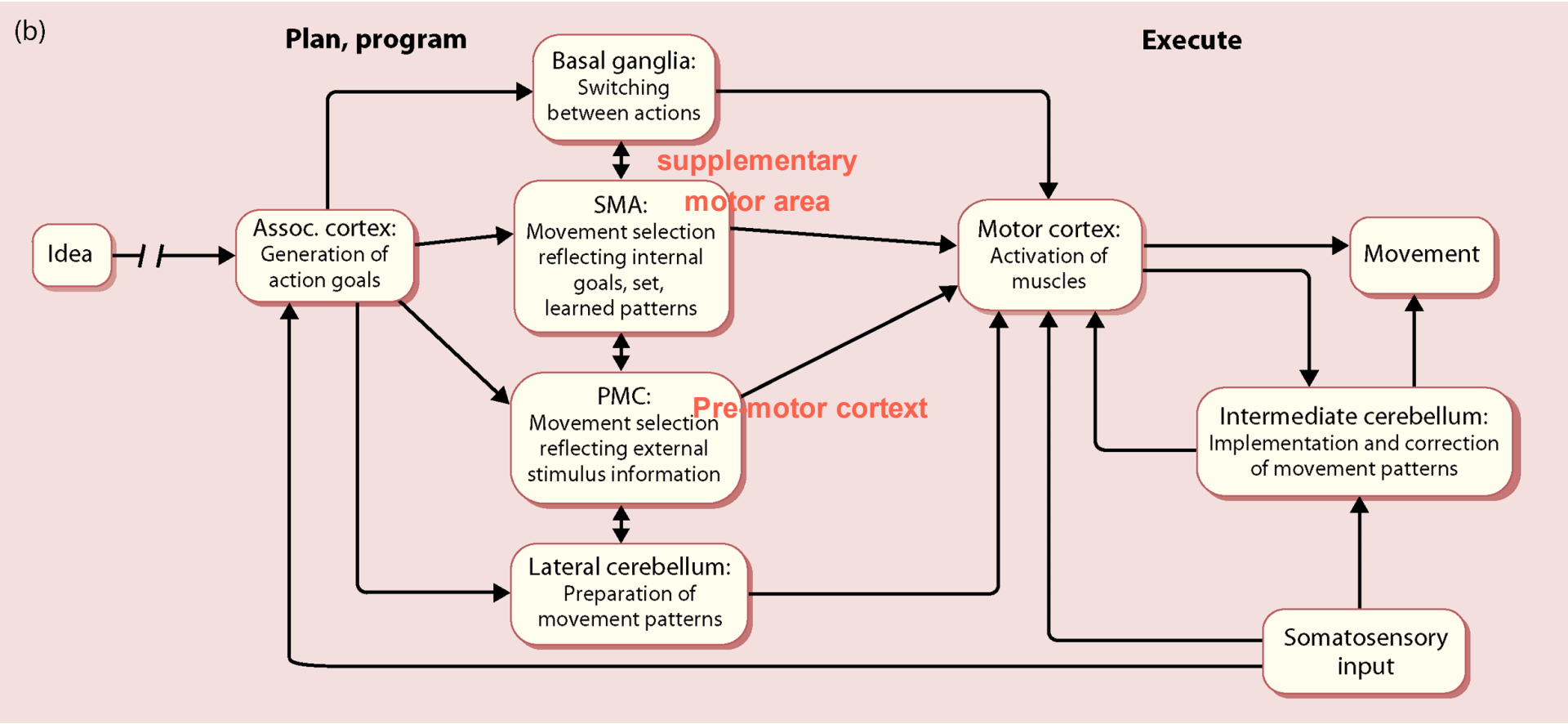
Adapted from Wichmann, T., and DeLong, M.R., Functional and pathophysiological models of the basal ganglia, Current Opinion in Neurobiology 6 (1996): 751–758

Video of Huntington's patient

is genetically passed on.

Notice the involuntary tics.

Structure of motor actions



Discovery of Mirror Neurons

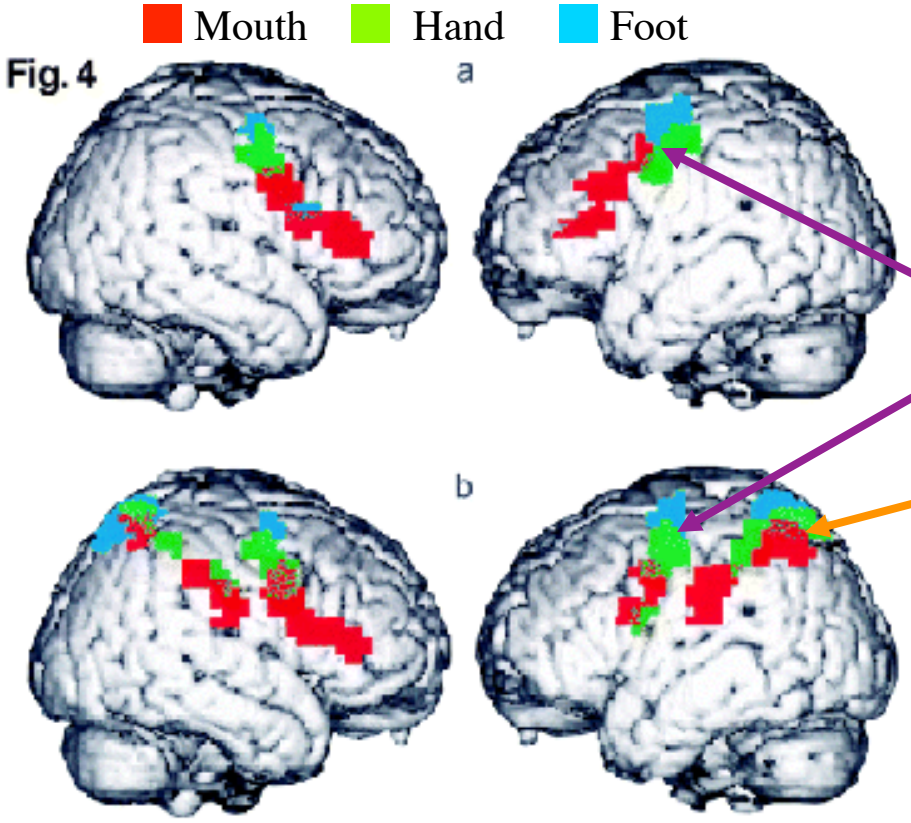
- **Mirror neurons**: The cells that selectively discharge when a person executes particular actions as well as when the person observes an other individual executing the same action (discovered by Rizzolatti in Italy).

USEFUL FOR

- Action recognition
- Understanding (assigning meaning to other's actions)
- Associative memory for actions
- Imitation based learning.

Human See, Human Do

Evidence of mirror neurons in humans from fMRI studies



Viewed non-object-related actions
- chewing, reaching, kicking

Motor areas

Parietal areas

Viewed object-related actions
-biting an apple, grabbing a cup, kicking a ball

Found in both frontal (motor) and parietal cortical areas.

Mechanisms of action

- Observation & Imitation (mirror neurons)
- Found in ventral pre-motor cortex, Superior temporal sulcus and Inferior Parietal lobe.
- Role of transformation of object dimensions in visual space into motor specific signals.

NOW……..

Mirror Neurons video

Recap: Vision and Action

- Discovery of Mirror Neurons
- How does visual information reach the motor cortex?
- What are the basic functions of vision and space perception?
- How is sensory information used in action?
- How is the parietal lobe involved in actions?

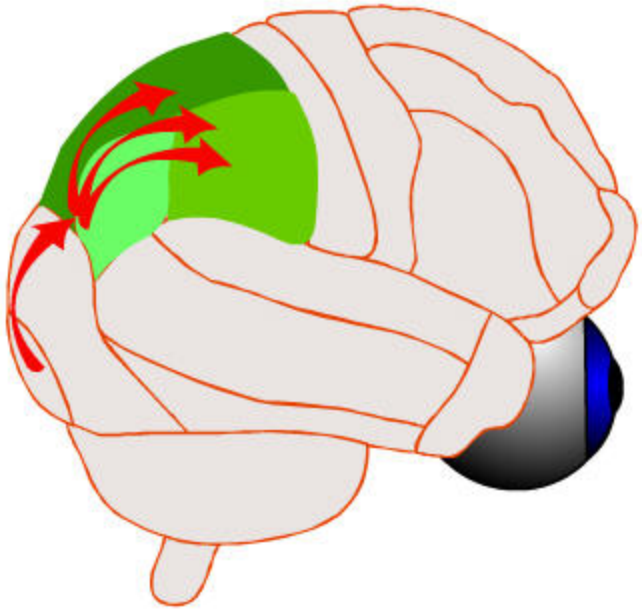
PARIETAL CORTEX FUNCTION

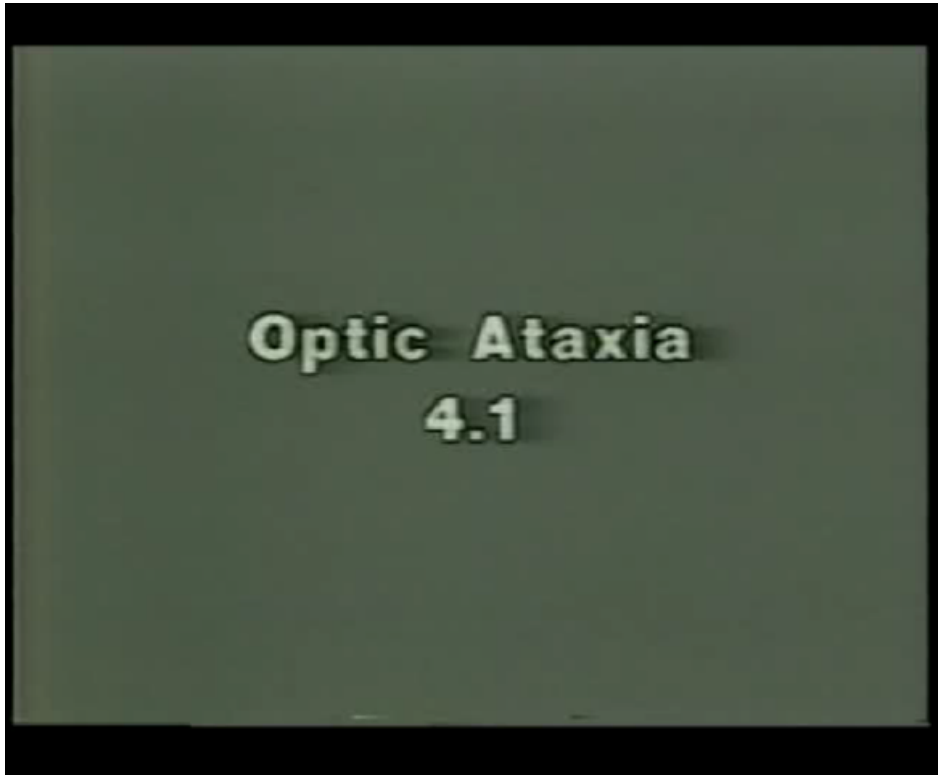
The posterior cortex contains multiple representations of space.

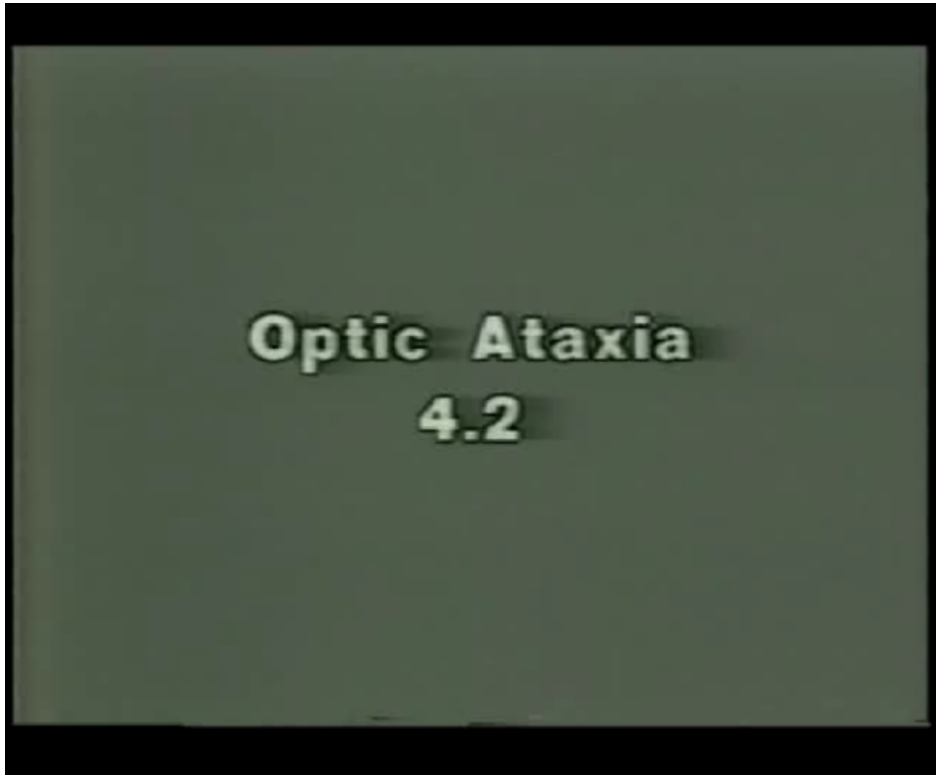
These representations are used to guide a variety of movements: saccades, grasps, reaches, and feeding.

These representations are mapped in egocentric frames of reference of several forms: retinotopic, head centered, and body centered.

Some regions map space that is near while others map space that is far.

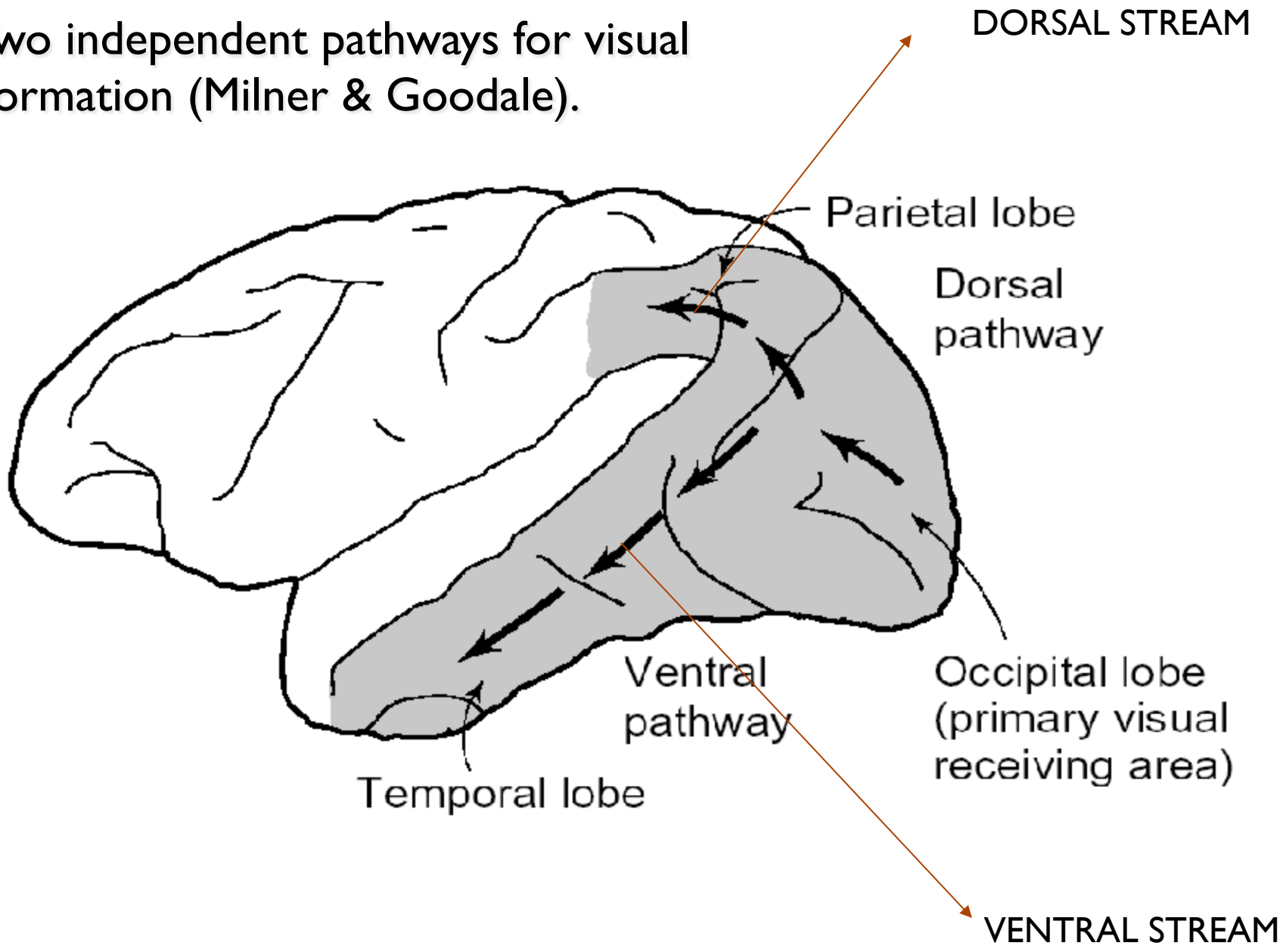






- can see and localize object but cannot convert information into movement.
- cannot reach for it.
- depending on where the damage in the parital lobe occurs will determine if they more difficulty with the left or right side of the body.

- Two independent pathways for visual information (Milner & Goodale).



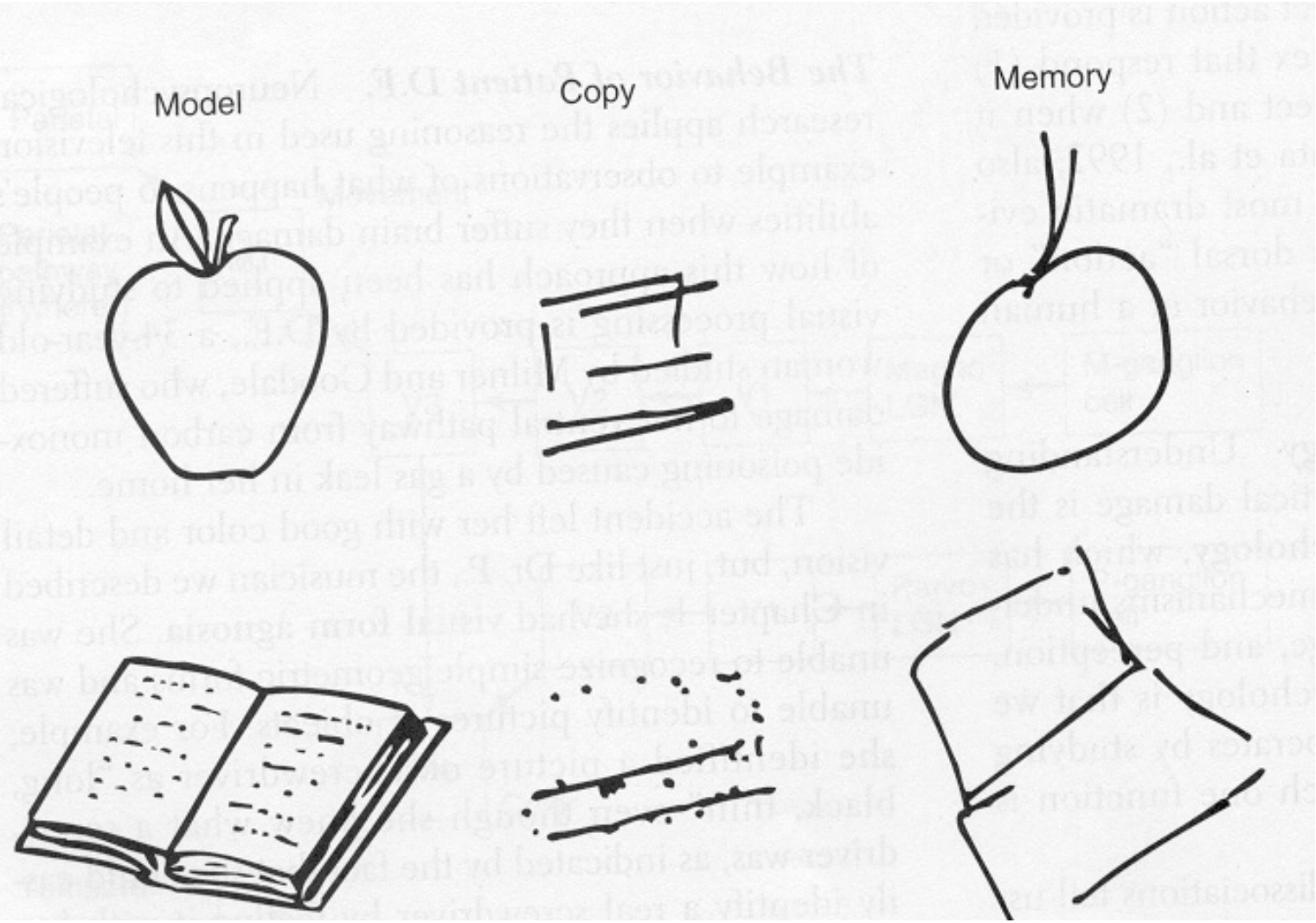
DORSAL STREAM

- DORSAL STREAM: Dorsal stream from visual cortex toward parietal lobe (roughly toward the top of the brain).
- Sometimes called the "where" pathway (as in location and/or motion) or the "how" pathway (as in how do I take action about the stimulus).

VENTRAL STREAM

- Ventral stream from visual cortex toward temporal lobe (roughly toward the bottom of the brain).
- Lesions disrupt object discrimination but vision for action is ok. Sometimes called the "what" pathway implying its role in conscious recognition.

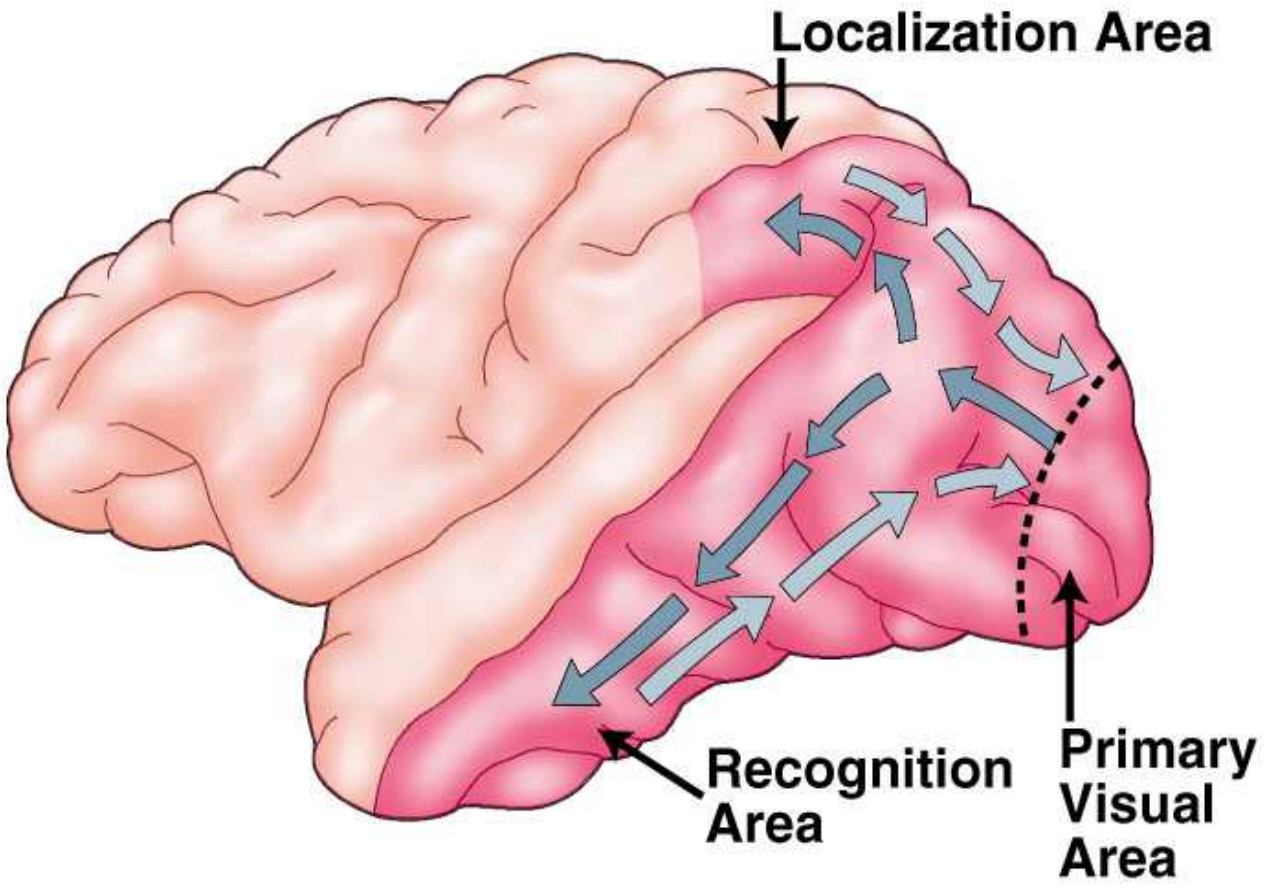
Form agnosia: Milner & Goodale's patient DF



DF could not recognize or draw an apple or a book by looking at them, but could draw them from memory or recognize the held objects.

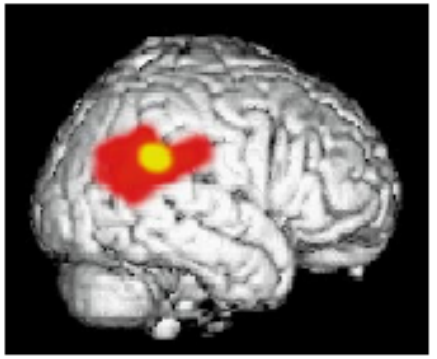
Visual pathways in action:

HOW ? WHERE? DORSAL



WHAT? VENTRAL

Right Parietal lobe lesions



- Problems with personal space (left and right) and neglect (ATTENTION DEFICITS)
- Distorted "personal space" in patients with right parietal lobe lesions ("hemi-neglect")
- Profound indifference to objects and events in the left side of the world, sometimes including the left side of their own body, but not blindness per se (forced attention leads to perception)

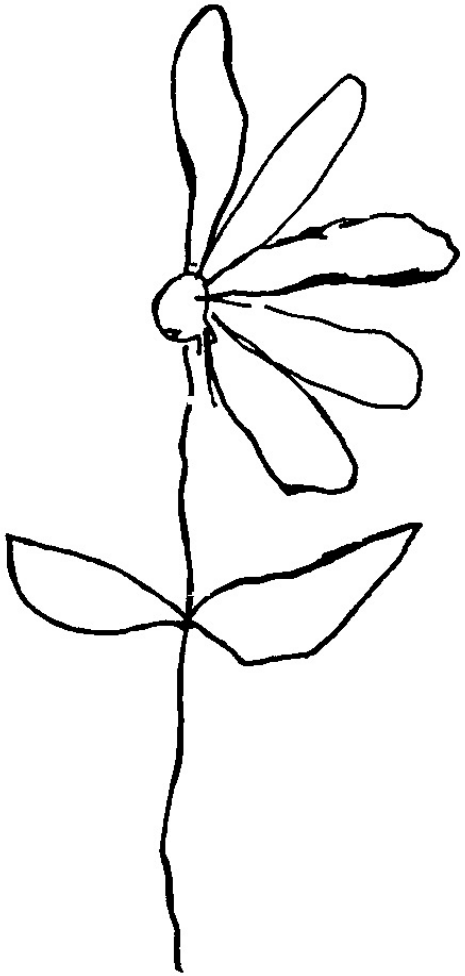
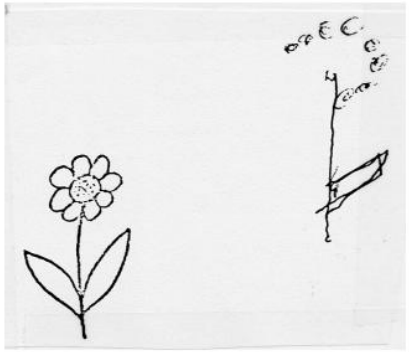
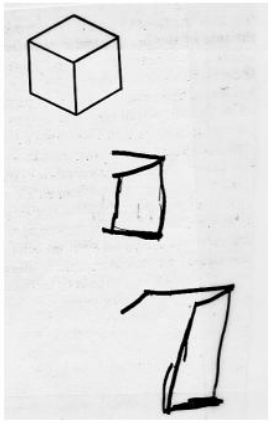


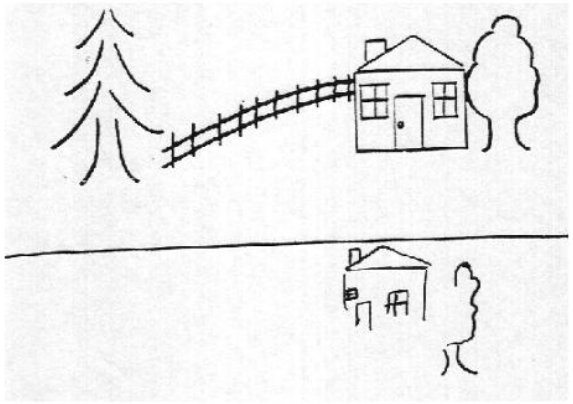
Figure 6.1 *Drawing made by a neglect patient. Notice that the left half of the flower is missing.*

Many neglect patients will also draw only half the flower when drawing from memory—even with their eyes closed. This implies that the patient has also lost the ability to "scan" the left side of the internal mental picture of the flower.

Neglect within and between objects







•Ellen, a stroke patient, before the mishap, was described as "Martha Stewart perfect". (her clothes and makeup)

Afterward, still true for right half of face (lipstick, mascara, rouge, etc) and hair (styled), but hair not combed on left and "it was almost as though someone had used a wet towel to erase all of the makeup on the left side".

•While eating she ignores food on the left side of the plate.

•When looking in a mirror at an object placed near the left of her face (which seems on the right in the mirror), when asked to reach for it with her right hand tries to reach through the mirror. By changing the mirror's orientation, an object seen to the right behind her head she successfully reaches on the first try.

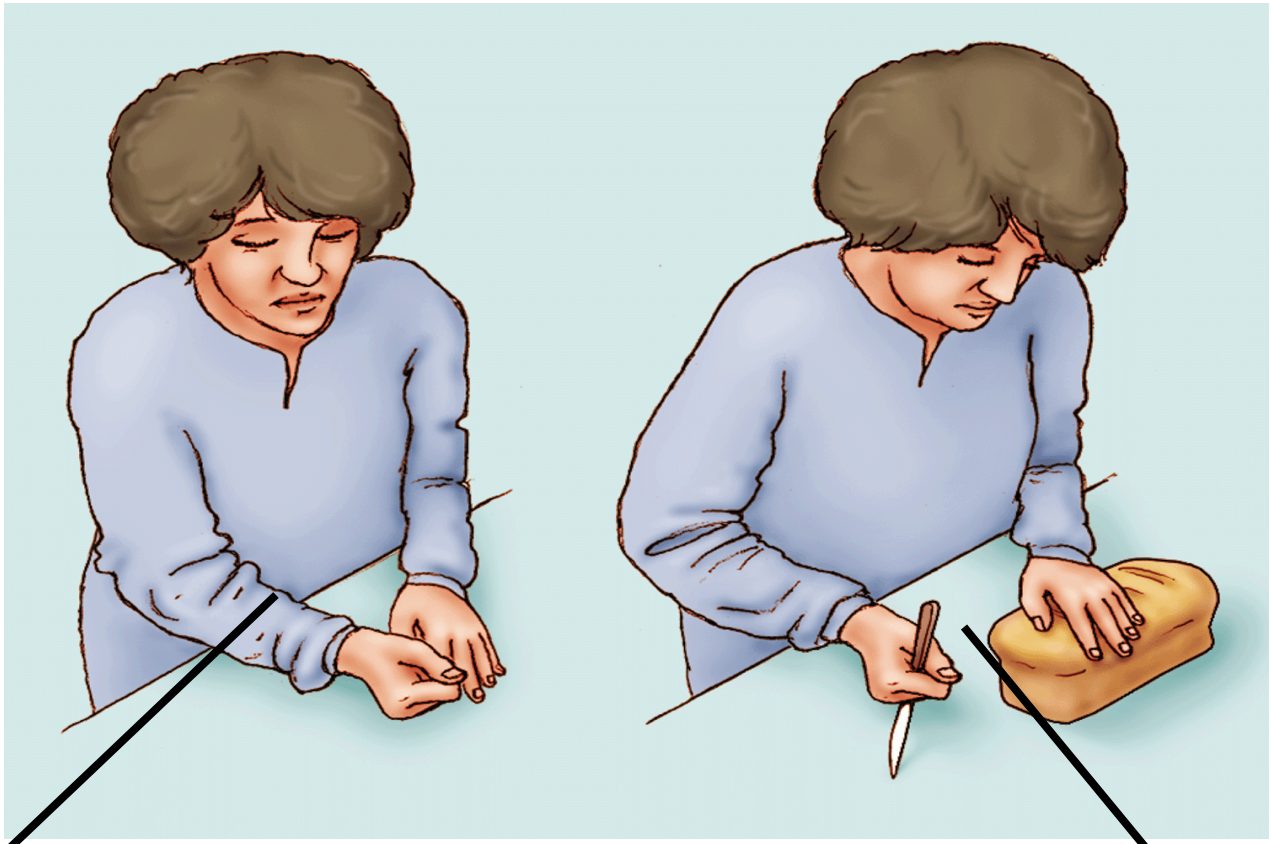
What is going on with left parietal lesions?

- Right hemisphere has a particular role in spatial representations (but this is not mirrored in the left side)
- Left parietal lobe is involved in attention but not in the same way.

Parietal movement disorders

- Apraxia- loss or impairment of the ability to execute complex coordinated movements without impairment of the muscles or senses. Comes from left parietal lobe damage

- (1) Ideo-motor apraxia– inability to carry out simple motor activity in response to verbal command (e.g. "smile"), even when they can do this spontaneously. Also cannot imitate actions.



Show me how you would slice bread.

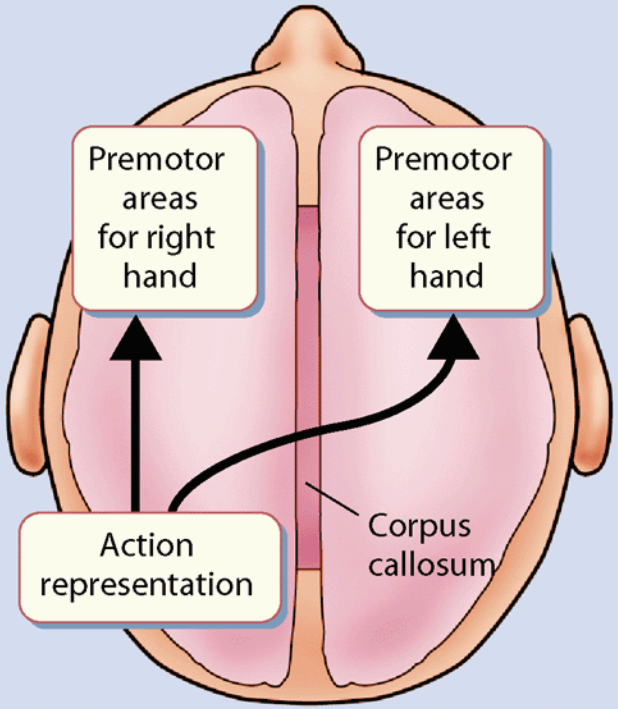
Patient makes a fist and pounds table

When bread and knife are present then the patient improves but is not very good with the task

(2) IDEATIONAL APRAXIA

- Impairment in carrying out sequence of movements that are components of a behavioural script, while being able to carry out each one alone (e.g., use of a tool appropriately) SERIAL ORDER PROBLEM.

- Problems with attention demanding tasks
- Can also be caused by frontal lobe damage especially in the pre-motor areas.



•Premotor cortical (PMC) areas of the contralateral hemisphere are essential for skilled movements

•PMC receives input from the parietal cortex where action represention are stored.

•Parietal lesions can thus cause ideational apraxia in both contralesional and ipsilesional limbs.

One more time…

- Vision and action
- Mirror neurons and action
- Two visual pathways: dorsal and ventral
- Right parietal damage: hemi-neglect
- Left parietal damage: apraxia

Midterm
1hour
50 multiple choice
15 fill in the blank
1-2 diagram
Few Definitions

T28

Overview of concepts