Νευροφυσιολογία και Αισθήσεις

Διάλεξη 14

Κίνηση από το ΚΝΣ

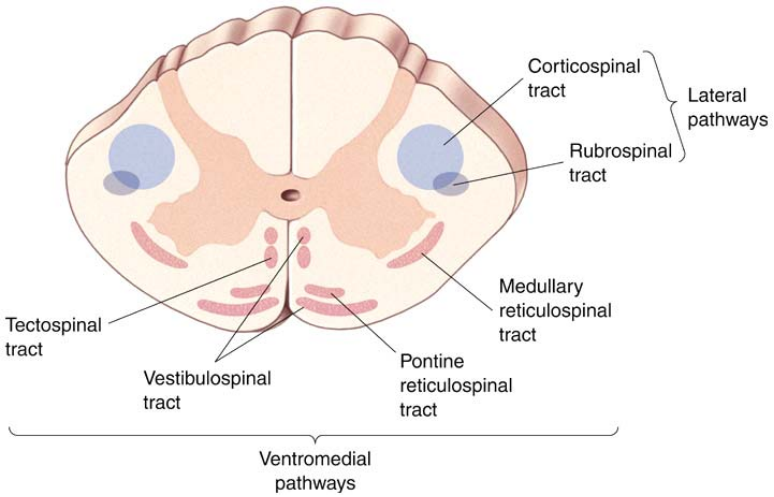
(CNS Control of Movement)

Introduction

- **The brain influences activity of the spinal cord**
  - Voluntary movements
- **Hierarchy of controls**
  - Highest level: Strategy (goal of the movement)
  - Middle level: Tactics (series of muscle contractions)
  - Lowest level: Execution (activation of neurons and muscles)
- **Sensorimotor system**
  - Sensory information: Used by motor system

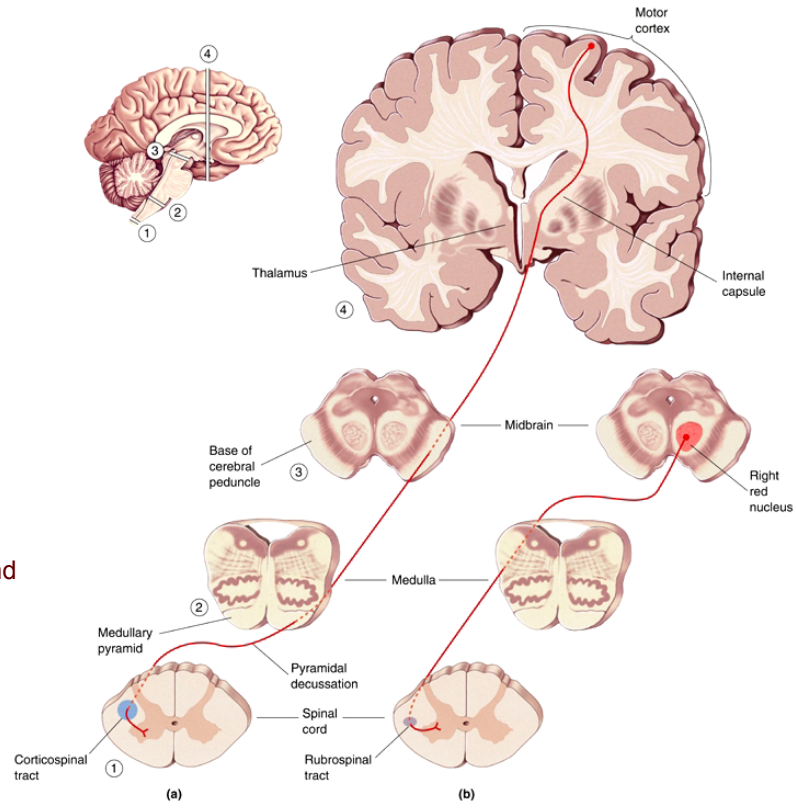
Descending Spinal Tracts

- **Axons from brain descend along two major pathways**
  - Lateral Pathways
  - Ventromedial Pathways



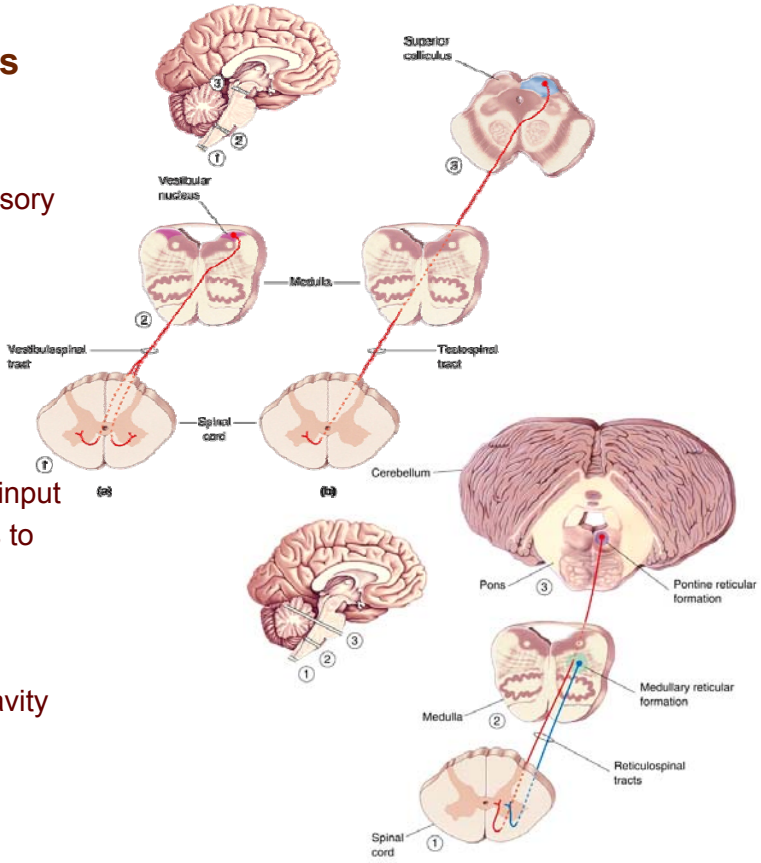
Descending Spinal Tracts

- **The Lateral Pathways**
  - Voluntary movement → under direct cortical control
  - Components
    - Corticospinal tract or Pyramidal tract
    - Rubrospinal tract
  - The Effects of Lateral Pathway Lesions
    - Experimental lesions in corticospinal and rubrospinal tracts
      - Loss of fractionated movement of arms and hands
    - Stroke in corticospinal tract or primary cortex
      - Paralysis on contralateral side
      - Significant recovery

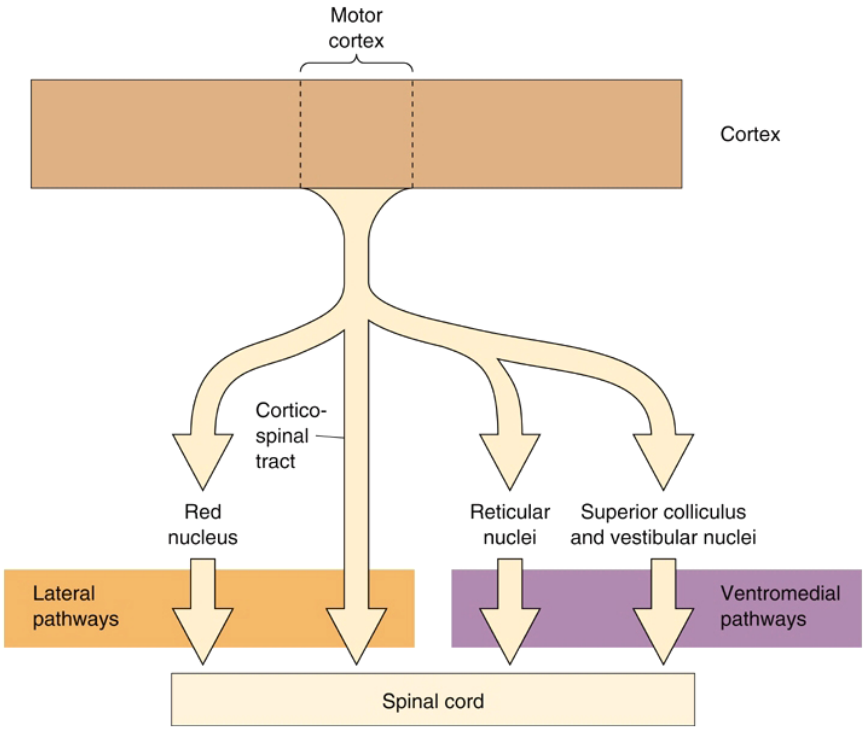


Descending Spinal Tracts

- **The Ventromedial Pathways**
  - Posture and locomotion
    - Under brain stem control
    - Receive and integrate sensory information
  - The Vestibulospinal tract
    - Vestibular input
    - Balance of the head and keeping the eyes steady
  - The Tectospinal tract
    - Retinal and Visual Cortex input
    - Head and eye movements to follow input
  - The Pontine and Medullary Recticulospinal tract
    - Enhance or reduce antigravity reflexes

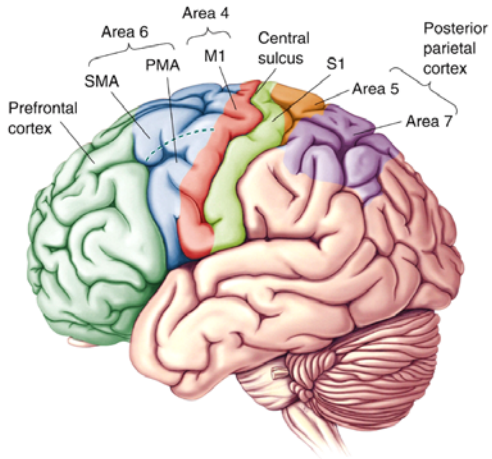


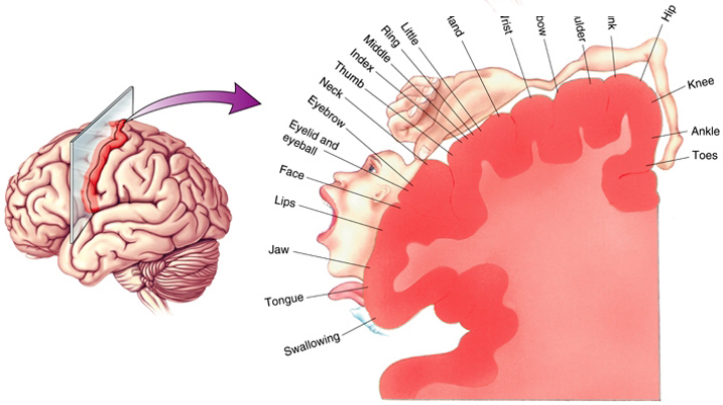
Descending Spinal Tracts



The Planning of Movement by the Cerebral Cortex

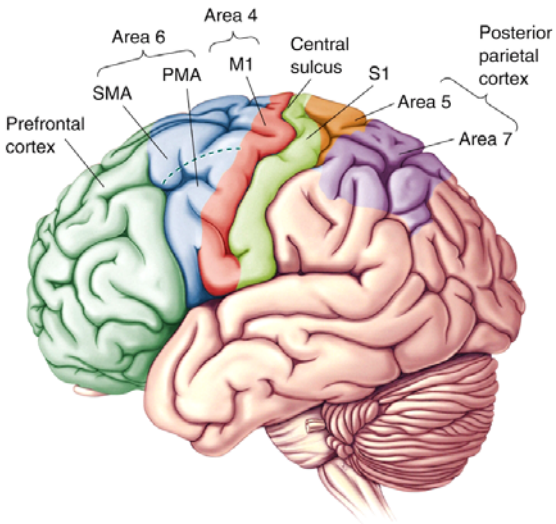
- **Motor Cortex**
  - Somatotopic organization
  - Area 4 and area 6 of the frontal lobe
- **Area 4 = "Primary motor cortex" or "M1"**
- **Area 6 = "Higher motor area"**
  - Two areas of similar functions
  - Motor maps in PMA and SMA
    - Premotor area (PMA) → proximal motor units
    - Supplementary motor area (SMA) → distal motor units





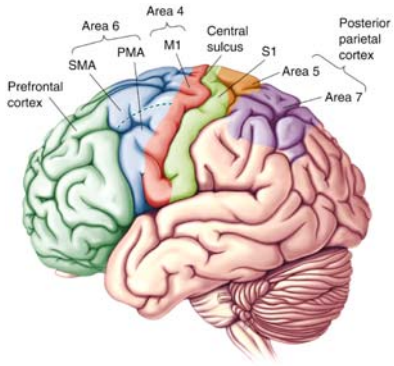
The Planning of Movement by the Cerebral Cortex

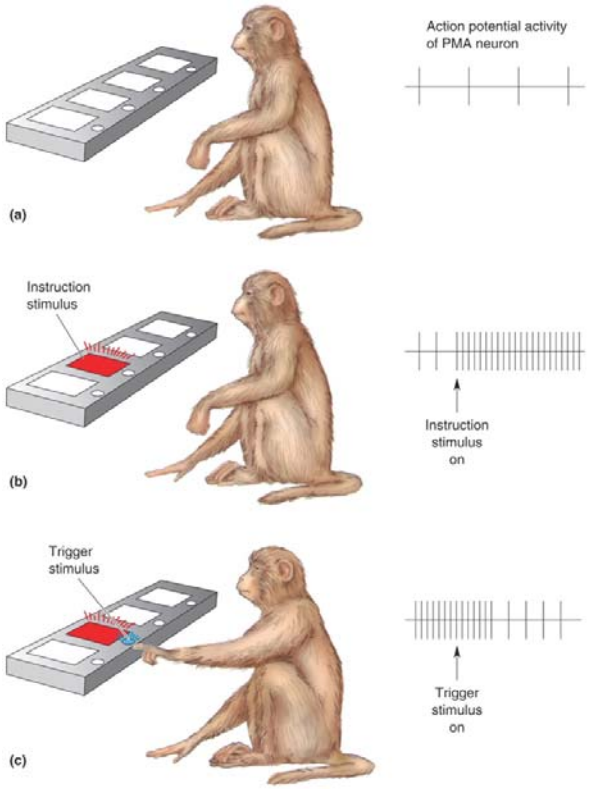
- **The Contributions of Posterior Parietal and Prefrontal Cortex**
  - Represent highest levels of motor control
    - Decisions made about actions and their outcome
  - Posterior Parietal
    - Perception of body and space image
    - Area 5: Inputs from area S1
    - Area 7: Inputs from higher-order visual cortical areas such as MT
  - Anterior frontal lobes
    - Abstract thought, decision making and anticipating consequences of action
    - Area 6: Actions converted into signals specifying how actions will be performed
    - Monitoring cortical activation accompanying voluntary movement (PET)
      - Results supported view of higher order motor planning
      - Area 6 was active even during mentally rehearsing a motion



The Planning of Movement by the Cerebral Cortex

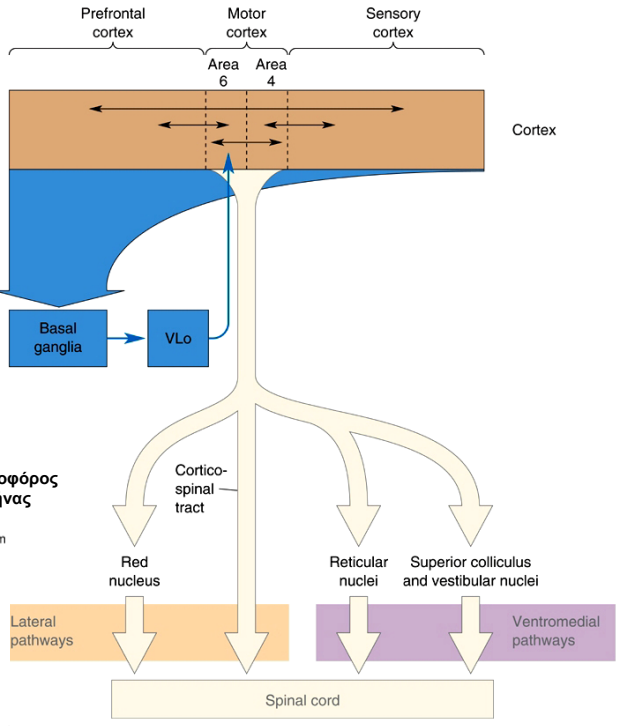
- **Neuronal Correlates of Motor Planning**
  - Activity in motor areas of awake, behaving animals
    - Area 6 important for planning movement
    - "ready"- Parietal and frontal lobes
    - "set"- Supplementary and premotor areas
    - "go"- subcortical input Area 6
  - Lesions in area 6
    - Inability to perform complex motor tasks = apraxia
    - Ability to coordinate to sides of the body is impaired

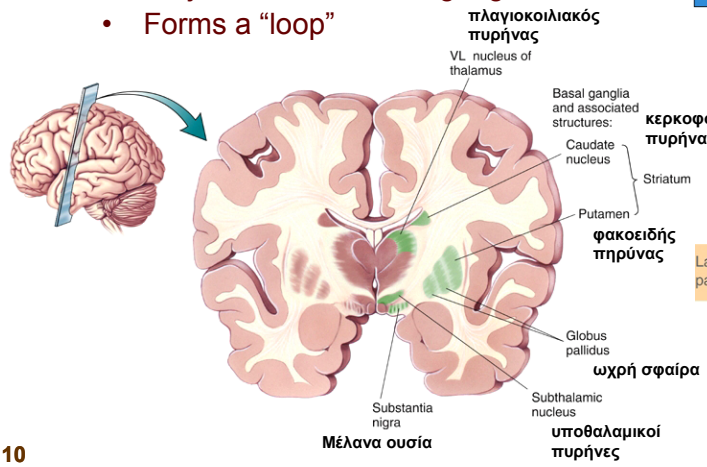




The Basal Ganglia

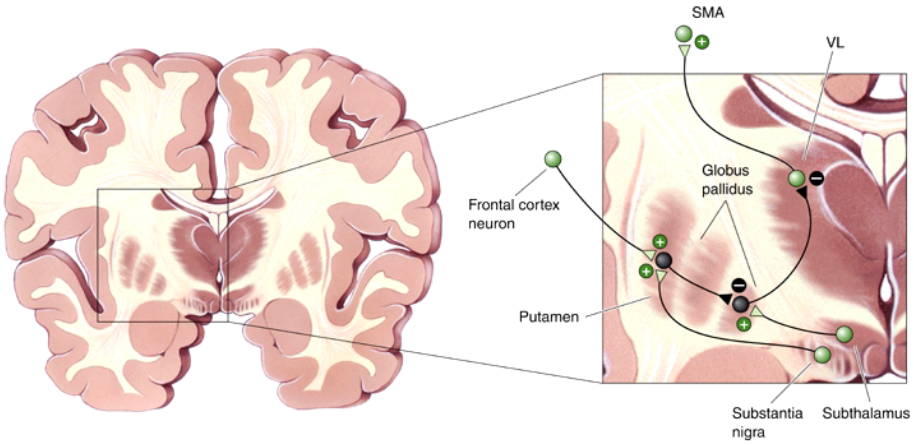
- **Basal ganglia**
  - Project to the ventral lateral (VLo) nucleus
  - Provides major input to area 6
  - Large number of parallel circuits
  - Also involved in memory and cognitive function
- **Cortex**
  - Projects back to basal ganglia
  - Forms a "loop"





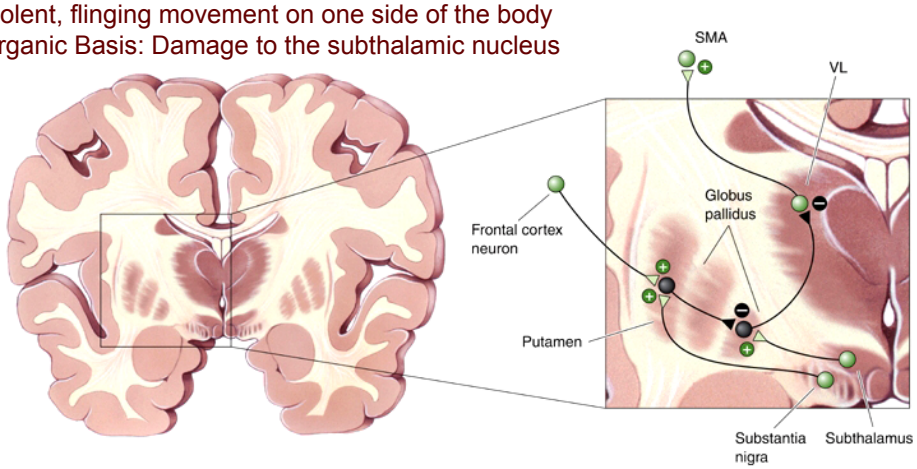
The Basal Ganglia

- **The Motor Loop: Selection and initiation of willed movements**
  - Origin of direct path: Excitatory connection from the cortex to cells in putamen
  - Cortical activation
    - Excites putamen neurons
    - Inhibits globus pallidus neurons
    - Release cells in VLo from inhibition
  - Activity in VLo boosts activity in SMA



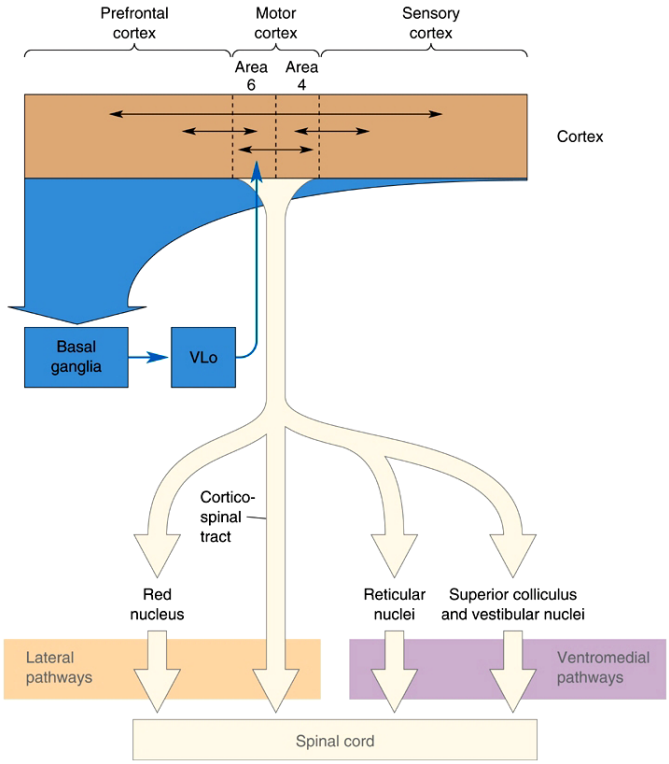
The Basal Ganglia

- **Basal Ganglia Disorders**
  - Hypokinesia and hyperkinesia
  - Parkinson's disease
    - Symptoms: Bradykinesia, akinesia, rigidity and tremors of hand and jaw
    - Organic basis: Degeneration of substantia nigra inputs to striatum
    - Dopa treatment: Facilitates production of dopamine to increase SMA activity
  - Huntington's disease
    - Symptoms: Hyperkinesia, dyskinesia, dementia, impaired cognitive disability, personality disorder
    - Organic Basis: Profound loss of neurons in basal ganglia and other areas of brain
  - Hemiballismus
    - Violent, flinging movement on one side of the body
    - Organic Basis: Damage to the subthalamic nucleus



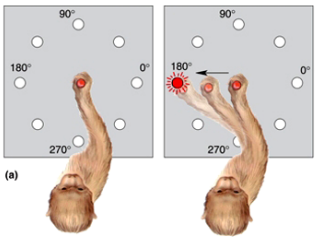
Initiation of Movement by the Primary Motor Cortex

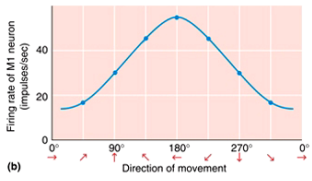
- **Electrical stimulation of area 4**
  - Contraction of small group of muscle fibers
- **The Input-Output Organization of M1**
  - Betz cells: Pyramidal cells in cortical layer 5
  - Two sources of input to Betz cells
    - Cortical areas
    - Thalamus

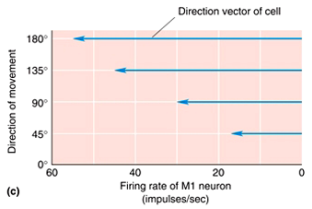


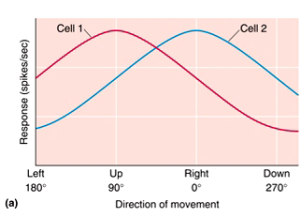
Initiation of Movement by the Primary Motor Cortex

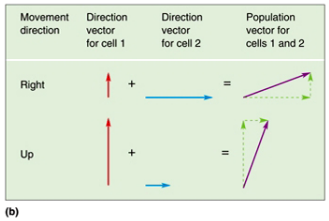
- **The Coding of Movement in M1**
  - Activity from several neurons in M1 encodes force and direction of movement
  - Movement direction encoded by collective activity of neurons
    - Motor cortex: Active for every movement
    - Activity of each cell: Represents a single “vote”
    - Direction of movement: Determined by a tally (and averaging)
  - The Malleable Motor Map
    - Experimental evidence from rats
      - Microstimulation of M1 cortex normally elicits whisker movement→ cut nerve that supplies whisker muscles→ Microstimulation now causes forelimb movement
    - Decoding M1 activity
      - Helps patients with severe damage to their motor pathways







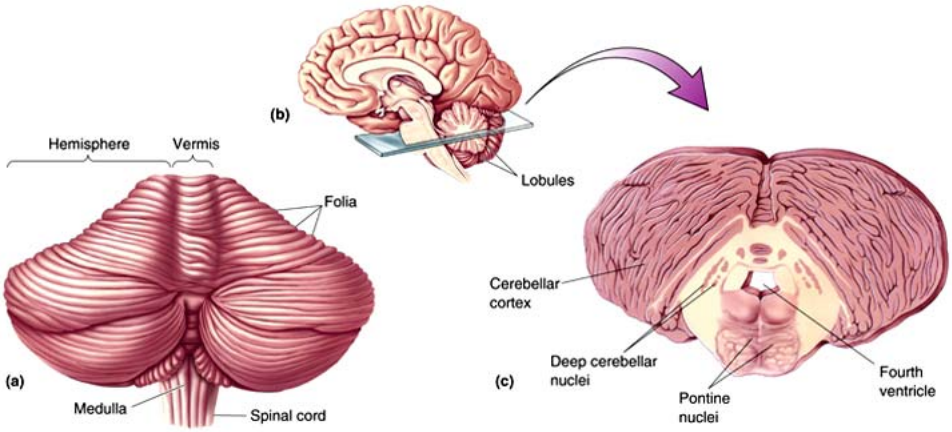




Biomedical Imaging and Applied Optics Laboratory

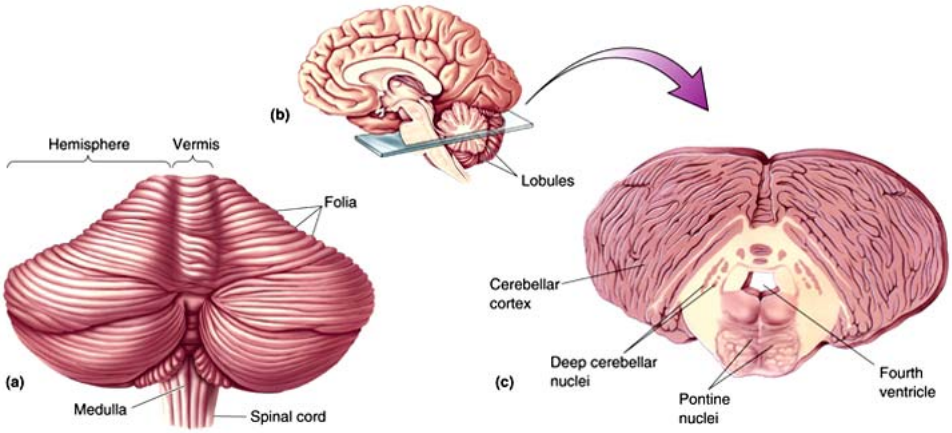
The Cerebellum

- **Function**
  - Coordination of sequence of muscle contractions
  - Ataxia
    - Uncoordinated and inaccurate movements
    - Caused by cerebellar lesions
    - Symptoms
      - Dysynergia (decomposition of synergistic joint movement)
      - Dysmetric (innacuracy)
      - Like alcohol intoxication



The Cerebellum

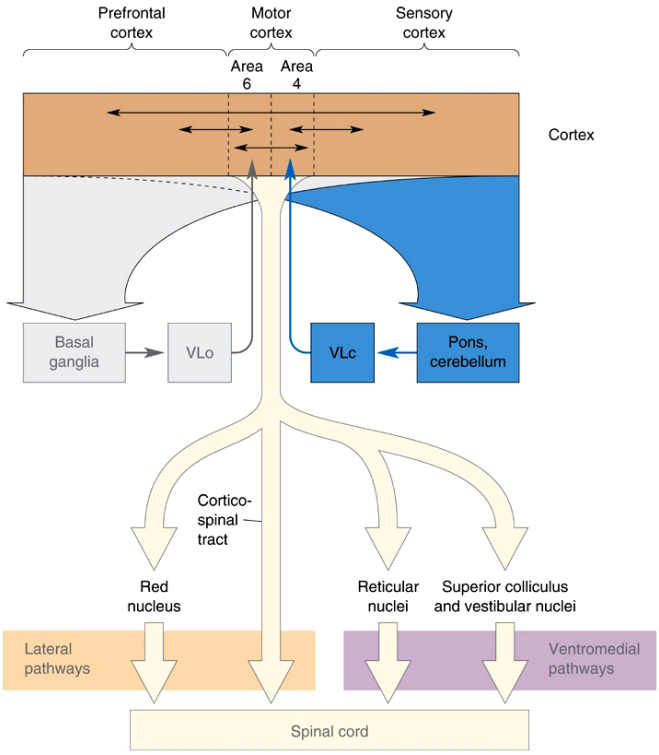
- **Anatomy of the Cerebellum**
  - Folia and lobules
    - Increased area→ 50% of CNS neurons
  - Deep cerebellar nuclei
    - Relay cerebellar cortical output to brain stem structures
  - Vermis
    - Contributes to ventromedial pathways
  - Cerebellar hemispheres
    - Contributes to lateral pathways



Biomedical Imaging and Applied Optics Laboratory

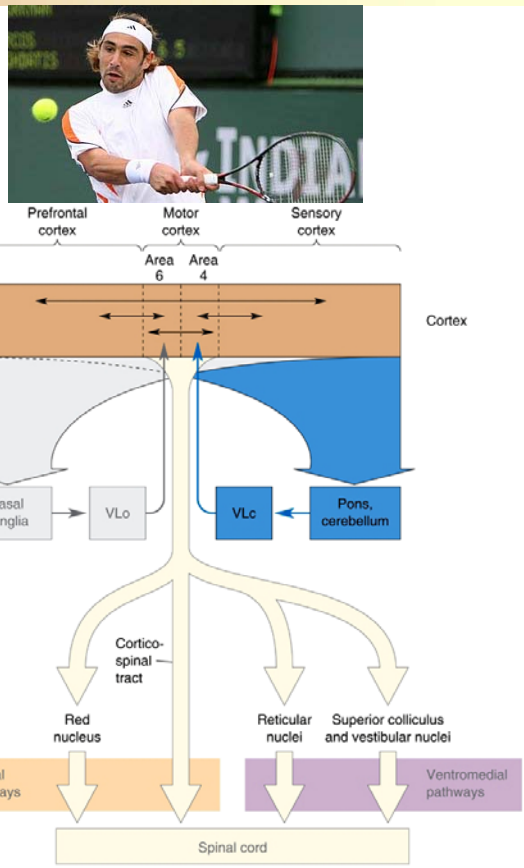
The Cerebellum

- **The Motor Loop Through the Lateral Cerebellum**
  - Pontine nuclei (γεφυριδικός πυρήνας)
    - Axons from layer V pyramidal cells in the sensorimotor cortex form massive projections to pons
  - Corticopontocerebellar projection
    - 20 times larger than pyramidal tract
  - Function
    - Execution of planned, voluntary, multijoint movements
  - Programming the Cerebellum
    - Cerebellum- “brain inside”
      - Process of learning a new skill
      - New motor program created to ensure smooth movement



Conclusion

- **Bagdatis Example**
  - Walking: Ventromedial pathways
  - Ready to serve
    - Neocortex, ventromedial pathways
  - Serve strategy
    - Sensory information engages parietal and prefrontal cortex and area 6
  - Throw and hit
    - Increased basal ganglia activity (initiation)
    - SMA activity → M1 activation
    - Corticopontocerebellar pathways → Cerebellum
    - Cortical input to reticular formation → Release of antigravity muscles
    - Lateral pathway → engages motor neurons → action



Επόμενη Διάλεξη …

Διάλεξη 15

Χημεία του Εγκεφάλου και της Συμπεριφοράς

(Chemical Control of the Brain and Behavior)