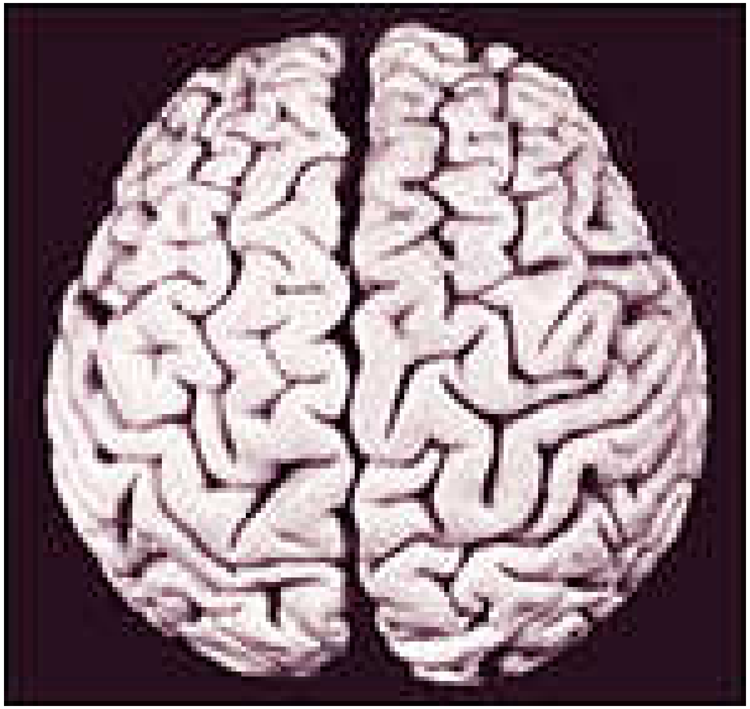
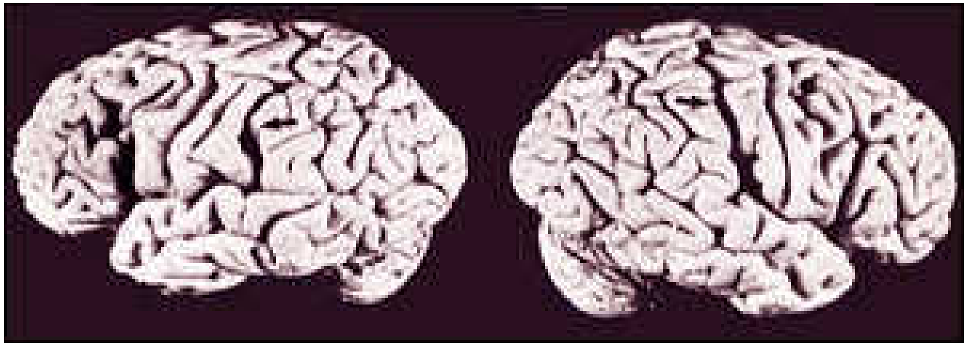
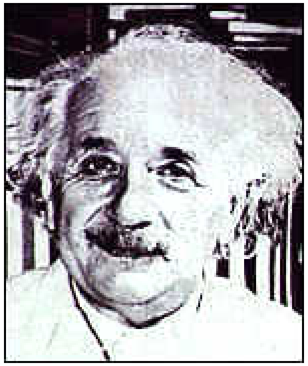
Hemispheric Specialization, Recovery of Function, and Plasticity

Lecture 5

Two Cerebral Hemispheres

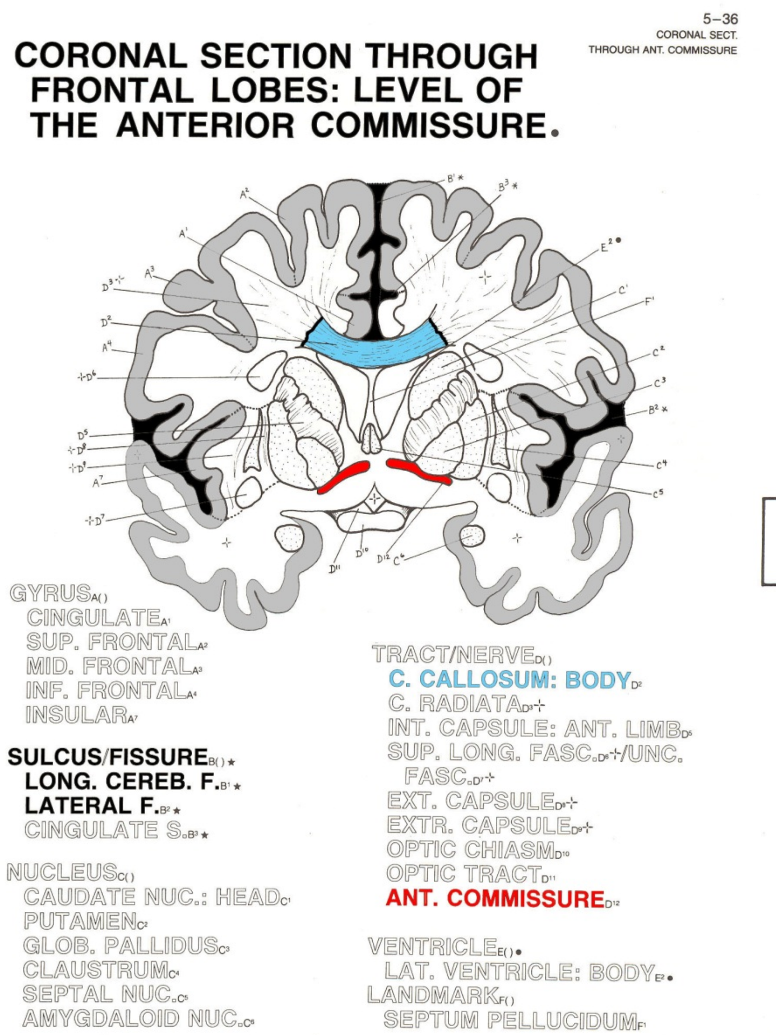


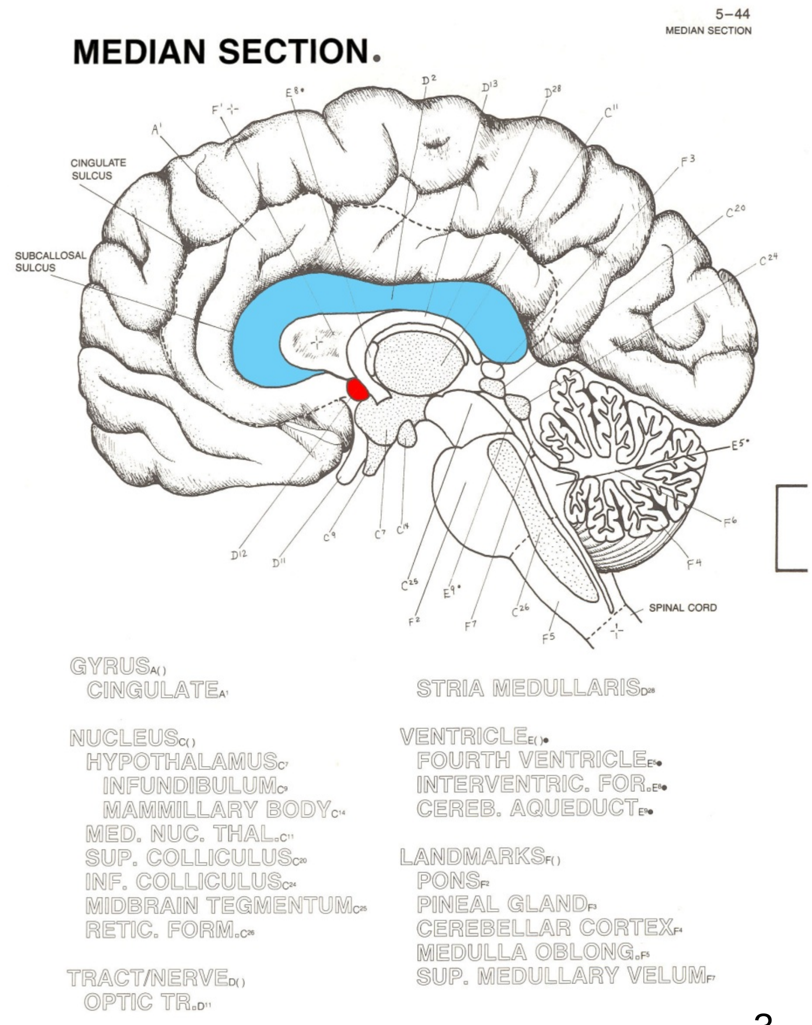




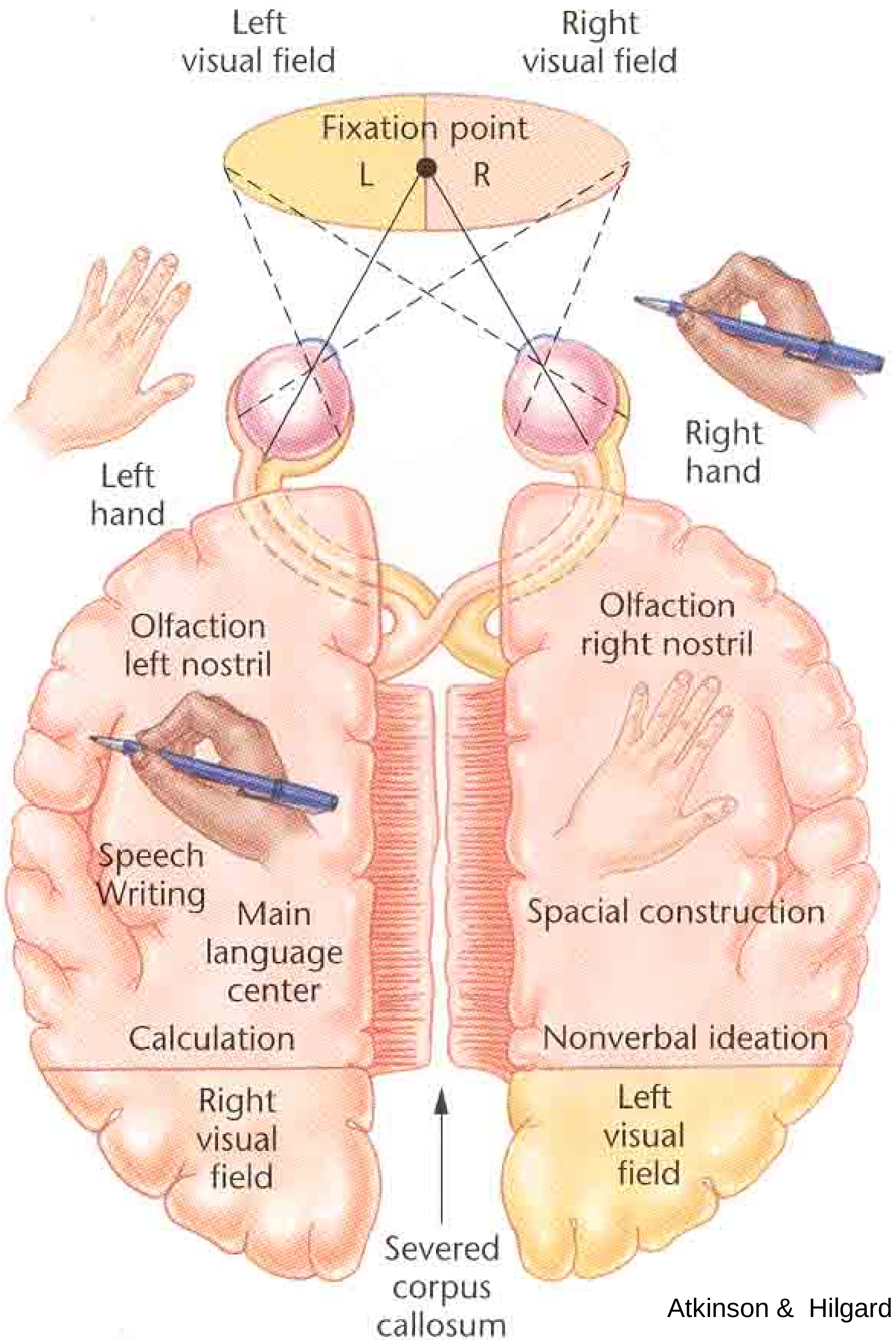
The Cerebral Commissures

Corpus Callosum; Anterior Commissure





Contralateral Projection



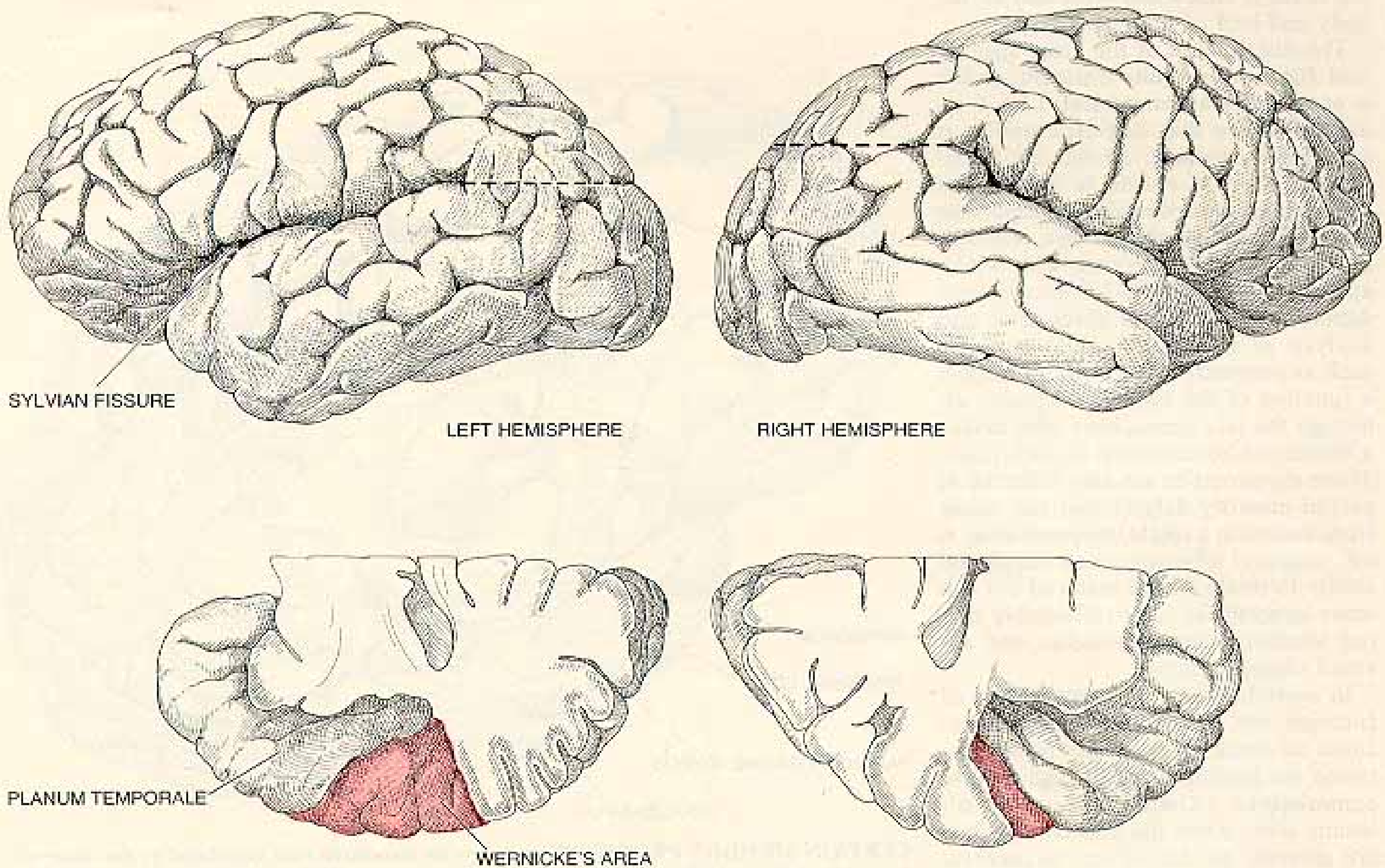
Atkinson & Hilgard

Yuja Wang

Wynton Marsalis

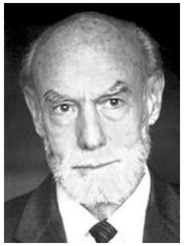
Dennis Brain

Hemispheric Asymmetry



ANATOMICAL ASYMMETRY of the cortex has been detected in the human brain and may be related to the distinctive functional specializations of the two hemispheres. One asymmetry is readily observed in the intact brain: the sylvian fissure, which defines the upper margin of the temporal lobe, rises more steeply on the right side of the brain. A more striking asymmetry is found on the planum temporale, which forms the upper surface of the temporal lobe, and which can be seen only when the sylvian fissure is opened. The posterior part of the planum temporale is usually much larger on the left side. The enlarged region is part of Wernicke's area, suggesting that the asymmetry may be related to the linguistic dominance of the left hemisphere. The distribution of the asymmetries varies with handedness.

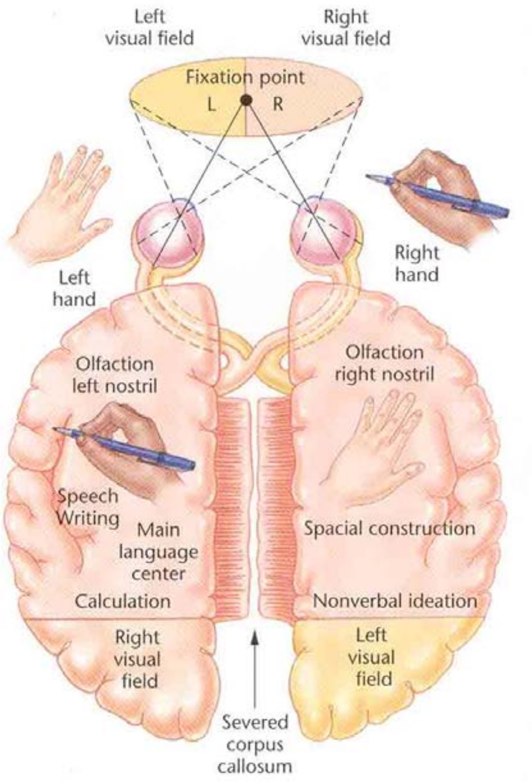
Scientific American

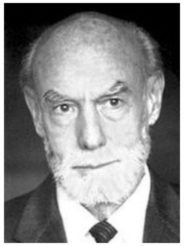


Cerebral Commissurotomy: "Split-Brain" Patients

Sperry, Gazzaniga, & Bogen (1969)

- Intractable Epilepsy
- Sever Transcortical Connections
  - Corpus Callosum



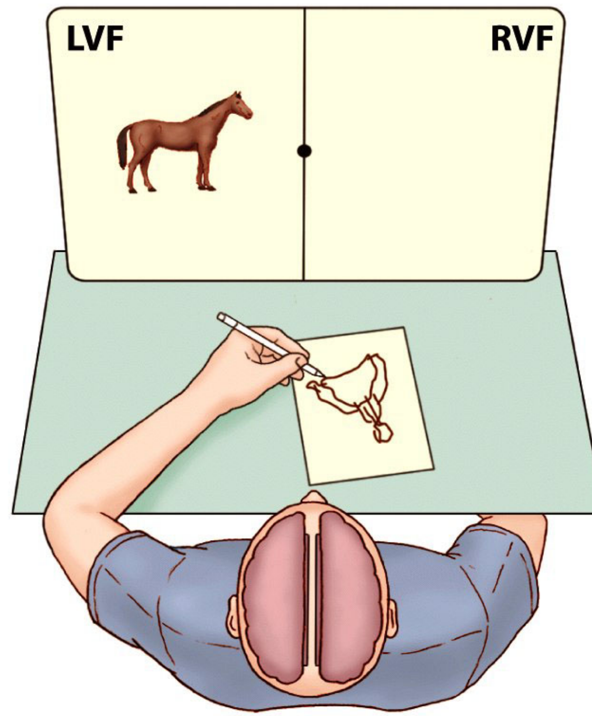


Cerebral Commissurotomy: "Split-Brain" Patients

Sperry, Gazzaniga, & Bogen (1969)

- Intractable Epilepsy
- Sever Transcortical Connections
  - Corpus Callosum

KEY	**RING**



Gleitman 7e

Hemispheric Specialization

(Especially in Right-Handed Males)

- Left Hemisphere
  - Language
    - Broca's, Wernicke's Areas
  - Sequential Analyses
  - Mathematical Computation
  - Fine Motor Control
- Right Hemisphere
  - Simple "Left-Hemisphere" Functions
  - Spatial Analysis
  - Pattern Recognition

Amazon.com (July 2012)

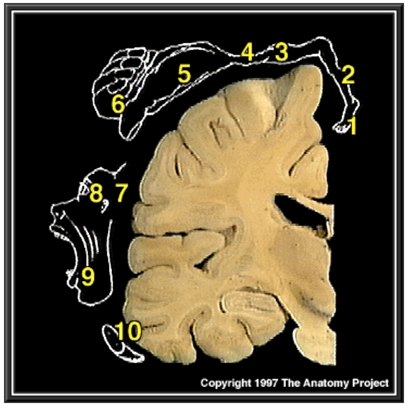
Origins of Lateralization

- Phylogeny (Across Species)
  - Nonprimates
  - Monkeys and Other Lesser Apes
  - Chimpanzees and Other Great Apes
- Ontogeny (Across Life Span)
  - Premature Infants

National Geographic

The Advantage of Lateralization

- Contralateral vs. Ipsilateral Projection
- Motor Control
  - Speech
  - Fine Motor Control
  - Gesture
- Why on the *Left*?



Beware the Adaptationist Fallacy!

Gould & Lewontin (1979)

Cave of the Hands, ,Rio Pinturas, Santa Cruz, Argentina

Summary on Specialization

- Neurons and Nerves
  - Synapses and Neurotransmitters
- Somatic and Autonomic Nervous System
  - Sympathetic and Parasympathetic
  - Central and Peripheral
- Hindbrain, Midbrain, Forebrain
- Cerebral Cortex
  - Hemispheric Specialization
  - Doctrine of Modularity

Limitations on Modularity

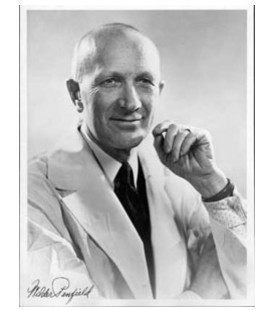
- Holism
  - Integration, Coordination of Modules
- Equipotentiality
  - Plasticity Early in Development
- Recovery of Function
  - Redundancy (if not Optimality)
- Regeneration (?)
- Function vs. Content
  - Functions may be localized
  - Contents distributed widely across cortex

Localization of Content?

- Localist View of Knowledge Representation
  - Activity of Single Neurons
    - Or Small Clusters of Neurons
  - Centered on Specific Cortical Location

- Distributed View (Lashley; Hebb)
  - Reverberating Pattern of Neural Activity
  - Distributed Widely over Cerebral Cortex

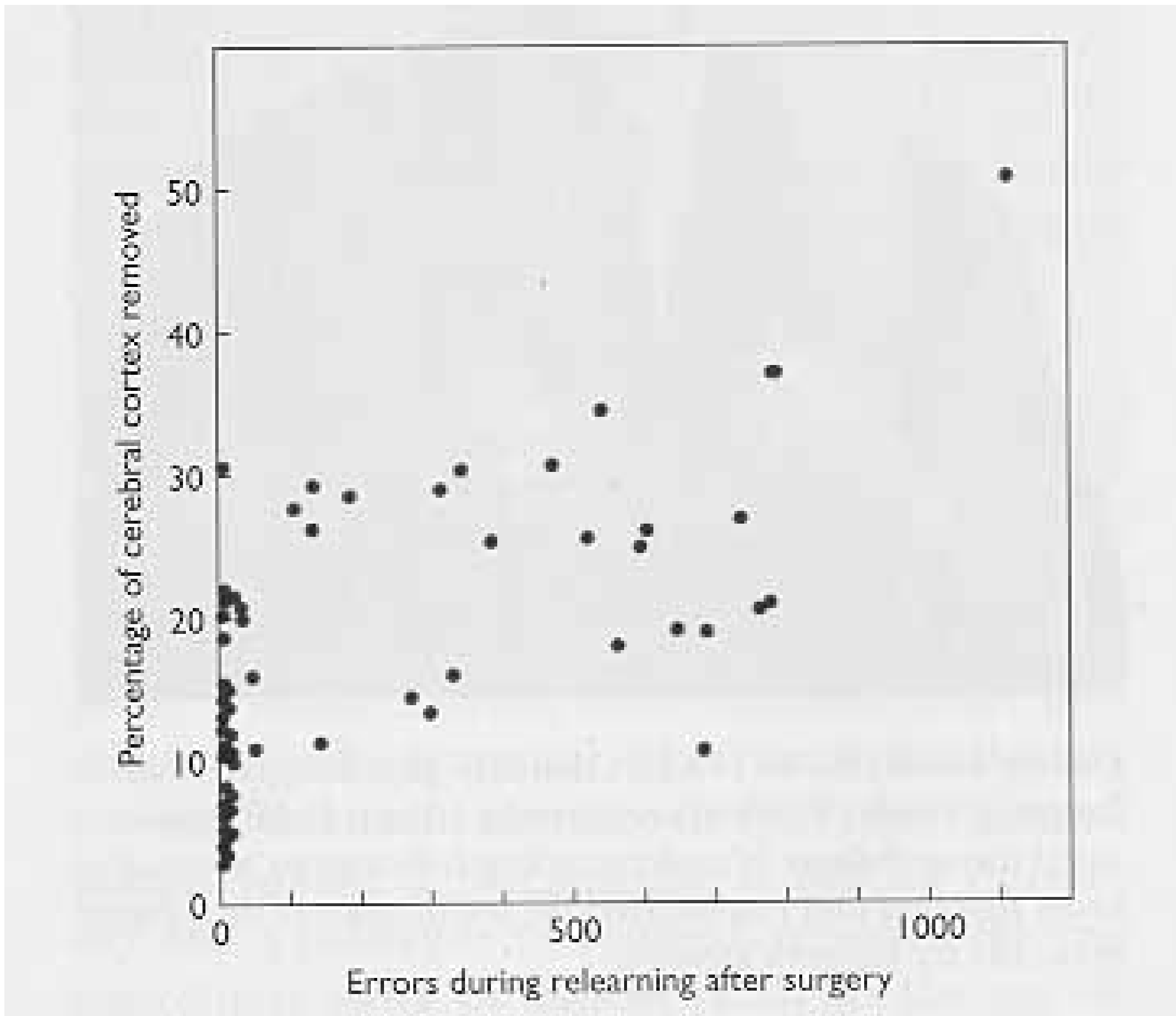
Localization of Content



- Penfield (1954)
  - Electrical Stimulation
  - “Sensory” Memories?
  - “Grandmother Neurons”?
- Lashley (1950), “Search for the Engram”
  - Rats Learn Maze
  - Ablate Portions of Cerebral Cortex

Extent of Cortical Damage and Errors in Maze Learning

Lashley & Wiley (1933)



The Law of Mass Action

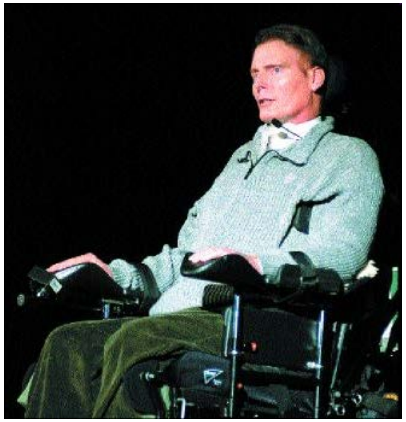
Lashley (1950)

- Degree of Memory Impairment is Correlated with the Extent of Cortical Damage
  - Exact Site of Damage Does Not Matter
- Specific Items of Knowledge are Distributed Widely within Cerebral Cortex
  - Involve Large Ensembles of Neurons
- Knowledge Preserved So Long as Critical Mass of Neural Tissue is Preserved

Recovery of Function

- In Aphagia
  - Lesions in Lateral Hypothalamus

- In Aphasia
  - Lesions in Broca's and Wernicke's Areas
- In Paraplegia
  - Severing of Spinal Cord



Mechanisms of Recovery of Function

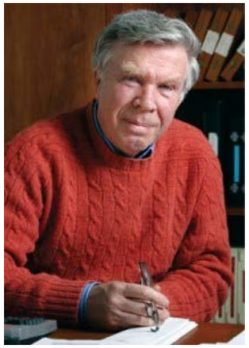
- Incomplete Damage
- Redundancy in Neural Organization
- Neurogenesis
- Plasticity

Neurogenesis

Rakic (1985); Nottebohm (1989); E. Gould (1999); Rakic (2001)

- Pasko Rakic's Dictum: No Neurogenesis
  - Organism Born with All Its Neurons
  - Neural Loss is Permanent
  - Peripheral vs. Central

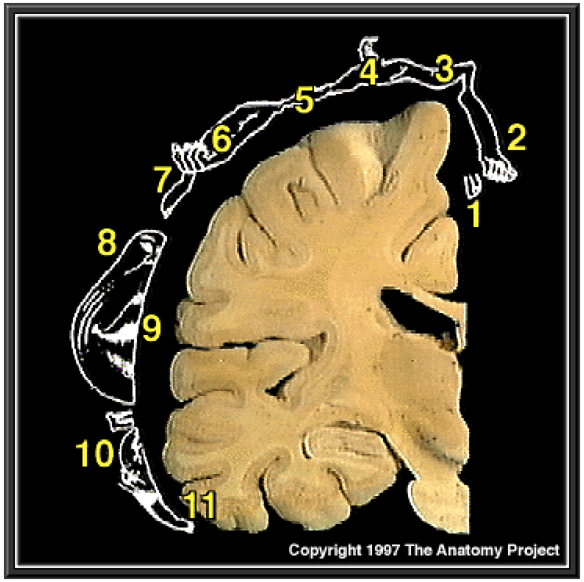
- Songbirds (Nottebohm)



- Mammalian Hippocampus (Gould)
- Mammalian Neocortex
  - Enriched Environment
  - Learning

Evidence of Plasticity

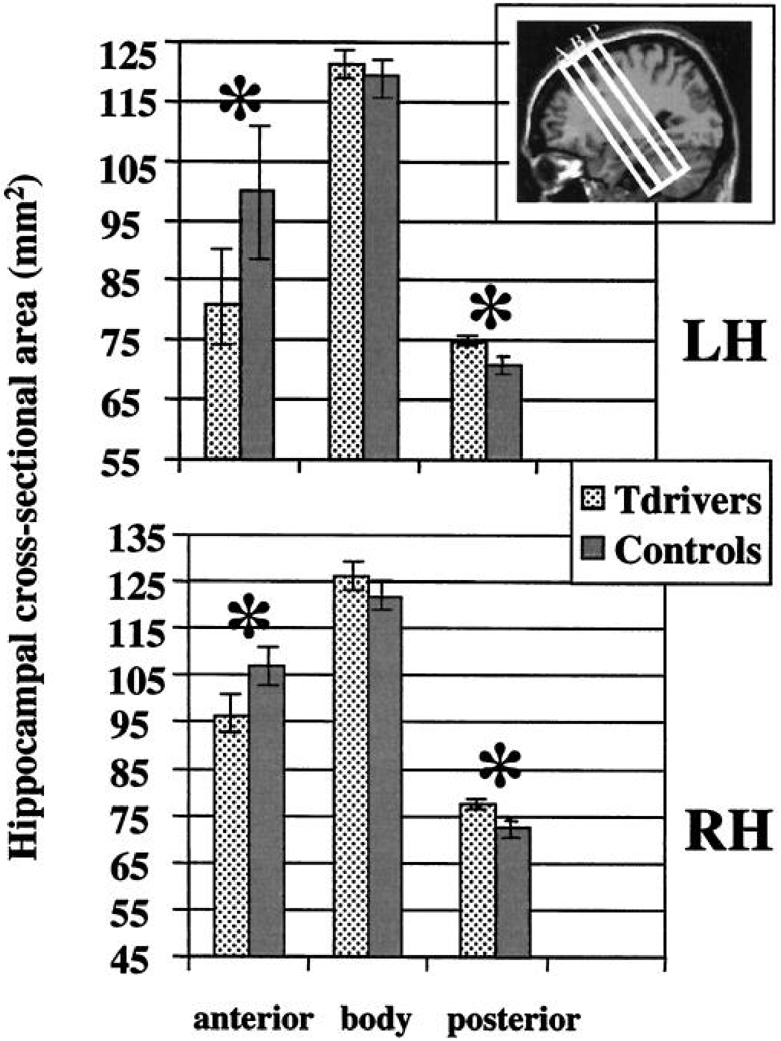
Merzenich et al. (1988); Kass (1995)

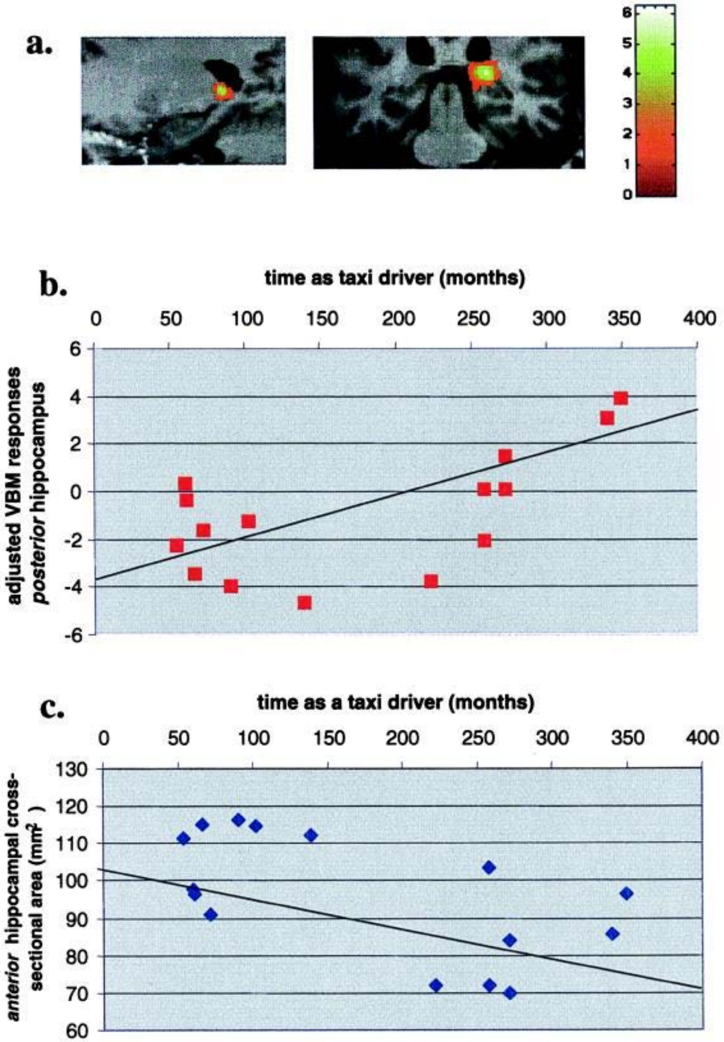


- Somatotopic Cortical Mapping
- Mapping Changes with Experience
  - Sever the Nerves to a Digit
  - Amputate Digit
  - Sew Adjacent Digits Together
  - Exercise

“The Knowledge” and Plasticity in the Hippocampus

Maguire et al. (2000)





The Biological Bases of Mind and Behavior

- Nervous System
  - Brain
  - Autonomic Nervous System
- Endocrine and Immune Systems
  - Psychoneuroendocrinology
  - Psychoneuroimmunology
- Ethology and Evolutionary Psychology
- (Behavior) Genetics