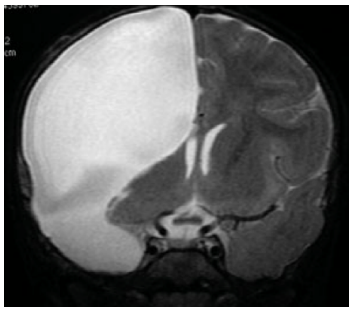
Chapter 10 : Neocortical Function

Case Report : Hemispherectomy

- AR, an 11 year old boy began developing seizures
  - right-sided weakness, difficulty talking (dysphasia)
- Over next six years, hospitalized many times
  - Right handed -> left handed
  - by age 15, IQ dropped 30 points (from 100 to 70)
  - by age 17, he was not testable due to emotional & language problems
- Dx : Rasmussen's Encephalitis
- Tx : removal of most of left hemisphere

Case Report : Hemispherectomy

- Note: image is from another patient with a Right-hemispherectomy



Case Report : Hemispherectomy

- Recover post hemispherectomy
- 10 years later
  - oral language skills : vastly improved (to average)
  - unable to read or write
  - motor skills : improved
    - could walk (with limp)
    - could raise right arm to shoulder level and grasp objects with right hand

How did AR recover?

- Levels of Function
  - Subcortical areas manage, direct, and control cortical areas
- Brain Plasticity
  - brain can respond to injury / damage / dysfunction
  - in AR's case: dysfunctional LH blocking language functions in RH. With LH removed, RH could work better and grow back some functions.

Levels of Function

Level	Function
Cortex	**Control and Intention:** Sequences of voluntary movements. Cognitive maps, relationships between objects, emotional values, motivation, long term planning
Basal Ganglia	**Self Maintenance:** Coordinates voluntary and automatic movements for self-preservation (simple eating, drinking, sex)
Diencephalon hypothalamus thalamus	**Affect and Motivation:** Voluntary movements, but without purpose. Integrated emotional behavior, but mis-directed. Thermoregulation.
Midbrain	**Spontaneous Movement:** Simple motor responses to visual/ auditory stimuli. Automatic behavior (grooming). Stand, walk, turn, jump in response to stimuli.
Hindbrain	**Postural Support:** hiss, bite, growl, chew, lick in response to stimuli. Standing, postural reflexes, sleepwalking.
Spinal cord	**Reflexes:** stretch, withdraw, scratch in response to stimuli

Decorticate Rats

- Decorticate rats behave in many ways normally
  - eat, drink
  - can run simple mazes
- Untrained observers have difficulty telling them apart from a rat with a cortex

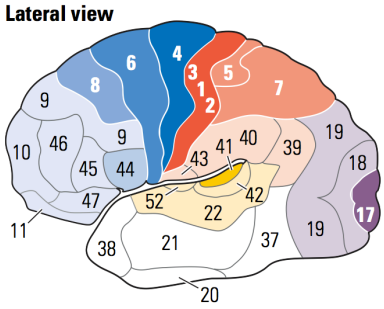
- Decorticate rats
  - don't build nests
  - do not hoard food
  - can't do skilled movements with tongue & mouth
  - can do simple learning

Cortex - what is it good for?

- Conclusions : Neocortex not necessary for basic survival
- Neocortex is a "new layer" evolutionarily developed
- Manages complex and new combinations of behavior

Cortical Mapping Ideas

- Broadmann's Map
- Primary/Secondary/ Tertiary
- Developmental
- Primordial zone
  - myelinates early : part of motor & somatosensory cortex
- Secondary zone (borders primordial zone)
  - myelinates next
- Tertiary zone (association)



Cortical Neuron Types

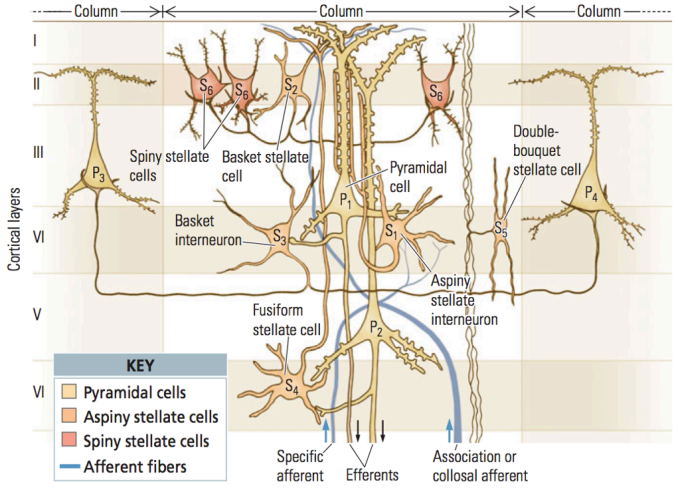
- Spiny
  - has dendritic spines
  - Examples:
    - Pyramidal cells
      - pyramid-shaped
      - 75% of all neurons
      - efferent (project out of brain, e.g. motor neurons)
    - Stellate cells
      - star-shaped

Cortical Neuron Types

- Aspiny
  - no dendritic spines
  - Inhibitory, use GABA and also use other NTs
  - diverse shape & chemistry
  - Examples:
    - basket cell

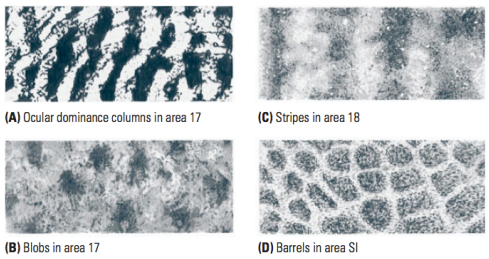
- Columns:
  - cells in vertical arrangement mostly talk to each other

Cortical Columns



Cortical Columns, Spots & Stripes

- Cortical neurons function in narrow columns
- Up to 300 neurons in 1mm wide strip
- "Column" or "Module"
- How determined?
  - radioactive staining - inject tagged AA into eyeball
- Not widespread agreement on definition or function



(A) Ocular dominance columns in area 17 (C) Stripes in area 18

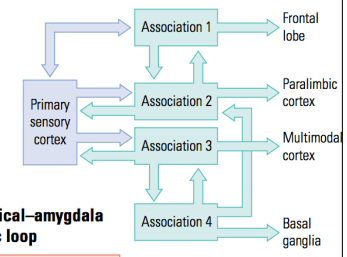
(B) Blobs in area 17 (D) Barrels in area SI

Representation & Mapping

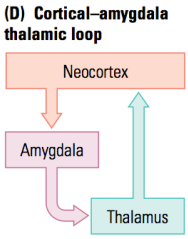
- Early views
  - brain areas have mapping to specific topics
  - e.g. motor cortex maps to body muscles
    - sensory cortex maps to skin receptors
- Later research
  - found multiple maps in many parts of the brain
    - e.g. monkeys: approx 30 areas mapping to vision
  - found multimodal / polymodal areas
    - combining sensory / motor information
  - found maps are widely distributed / general (not as localized as thought)
- Conclusion:
  - # of maps --> amount of "intelligence" ?

Cortical Systems & Subcortical Loops

- Cortex connections can be divided into 5 major areas



- Subcortical connections form loops between subcortical and cortex (6 major ones discovered)



The Binding Problem

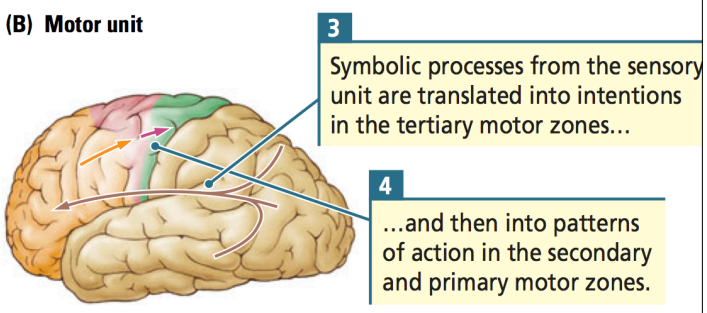
- How does the brain integrate sensory perception into a *gestalt* (a "whole")
- Possible solutions
- 1. A top-level cortical area binds them together
  - problem - this doesn't seem to exist
- 2. All areas are interconnected and share information
  - problem - not all areas are connected
- 3. Intracortical networks among subsets of regions
  - may actually be how the brain works?
  - called "integration"
- Still not really solved

A Hierarchical Model : Structure

- Alexander Luria's model
- Cortex : two parts
  - posterior : sensory
  - anterior : motor
- Each part has 3 zones:
  - primary
  - secondary
  - tertiary (association)

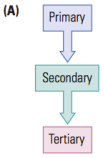
A Hierarchical Model : Function

- Processing is serial:
  - posterior (1,2,3) --> anterior (3,2,1)

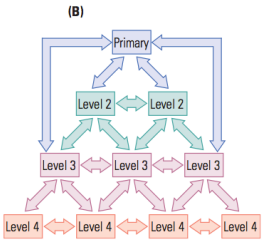


Luria's model : accurate?

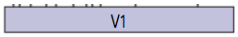
- Problems
  - serial connections may not exist
  - subcortical connections bypass cortex



- Newer models:
  - still hierarchy, but some levels bypass each other
  - includes parallel processing.
- "Distributed Hierarchy"



Modern Distributed Hierarchical Models



Are Humans Special?

- Do Human brains have any unique properties?
- Biological, Psychological and Theological Question

- Human brains have
  - High density of neurons with fast conduction velocity
    - --> increased processing capability
  - Von Economo Neurons
    - large bipolar neurons in cingulate cortex (also seen in great apes, but to a lesser extent)
    - develop around age 4
      - might hold "theory of mind"?
      - defective in Autism?