

**Learning Objectives:**

- A) Develop an understanding of neocortical organization that provides a broad framework for the lectures on specific systems (e.g., visual system, somatosensory system).
- B) Understand the major connections of neocortex, which will be relevant to upcoming lectures as well.
- C) Learn the broad concepts of laminar and regional organization of neocortex, and how they relate to afferents and efferents.
- D) Develop a basic understanding of the major cell types, key concepts of synaptic organization, and the neurotransmitters used by key cortical circuits.

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**The organization of Cerebral Cortex**

- **Macro-organization (sulci, afferents, efferents)**
- **Regional and laminar organization**
- **Cellular organization**
- **Neurotransmitter/circuit links**
- **Intro to cortical integration**

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**Classical terminology, based on phylogenetic concepts, divides cerebral cortex into two major categories:**

- 1) allocortex, which includes archicortex (e.g., hippocampus) and paleocortex (parahippocampal cortex).
- 2) Isocortex, which is commonly referred to as neocortex, and is the focus for today.

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Cerebral cortex (e.g., neocortex) is a sheet of nerve cells with complex interconnections that represent maps, memories, and decisions.




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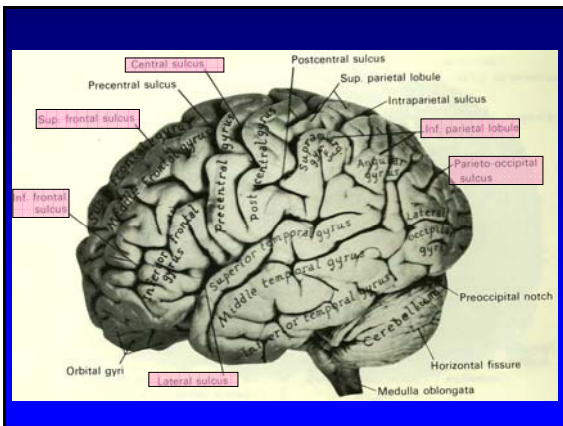
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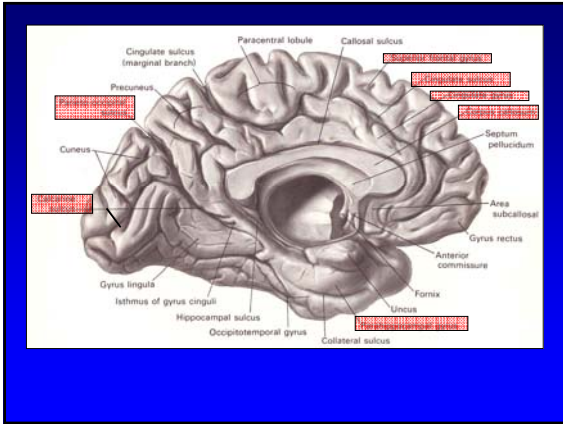
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- Major neocortical afferents**
- 1) Thalamus- nuclei linked to regions (e.g. LGN/V1)  
Initial representation of topographic maps
  - 2) Other Neocortical areas- corticocortical circuits  
Functional systems of linked cortical areas
  - 3) Extrathalamic subcortical (e.g., monoaminergic)  
Regulation of mood and attention
  - 4) Amygdala (primarily prefrontal and temporal)  
Confers emotional tone to neocortical functions
  - 5) Parahippocampal areas (primarily association cortex)  
Feed into hippocampus; role in memory

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- Major Neocortical Efferents**
- 1) Thalamus- reciprocal projections from Layer 6
  - 2) Other Neocortical areas- generally reciprocal
  - 3) Amygdala (primarily prefrontal and temporal)
  - 4) Parahippocampal areas (primarily association cortex)
  - 5) Basal Ganglia ( heavy from motor and prefrontal- *not reciprocal*)
  - 6) Projections to multiple “downstream” motor areas from motor cortex:
    - a) Pons
    - b) Brain stem motor nuclei
    - c) Tectum
    - d) Spinal cord

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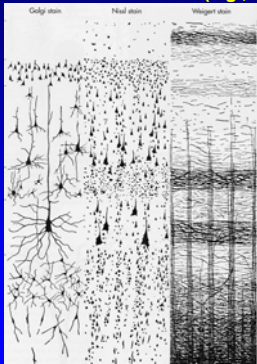
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Neocortex is a laminated brain structure with 6 layers that are often subdivided (e.g., layer IV of primary visual).



- Molecular (Plexiform) layer  
I
- External granule layer  
II
- External pyramidal layer  
III
- Internal granule layer  
IV
- Ganglionic layer  
V (Internal pyramidal layer)
- Multiform layer  
VI (Polymorphic layer)
- Subcortical white matter

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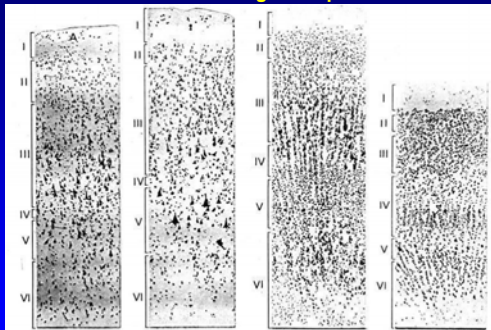
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Cortical lamination: regional specialization



Frontal-premotor Area 6    Primary motor Area 4    Occipital V2, Area 18    Occipital V1, Area 17

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Brodmann's cytoarchitectural map of neocortex

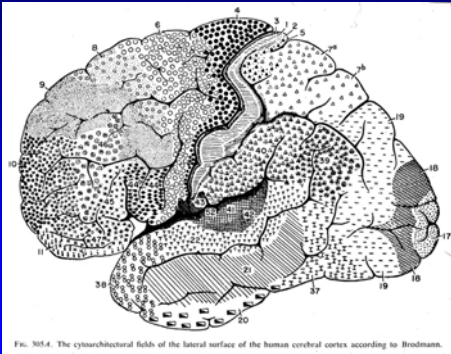


FIG. 305A. The cytoarchitectural fields of the lateral surface of the human cerebral cortex according to Brodmann.

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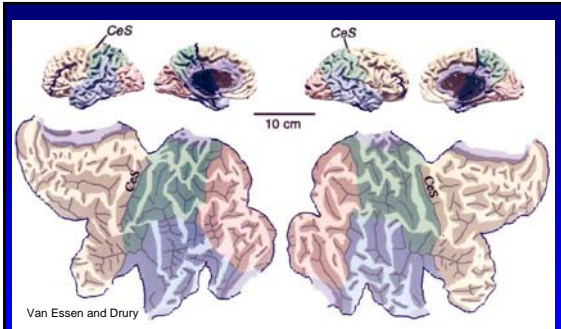
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A human brain atlas (The Visible man), showing normal views of left and right, and flattened maps. Lobes are designated by color; CeS is central sulcus. Structural and functional regional boundaries can be superimposed.

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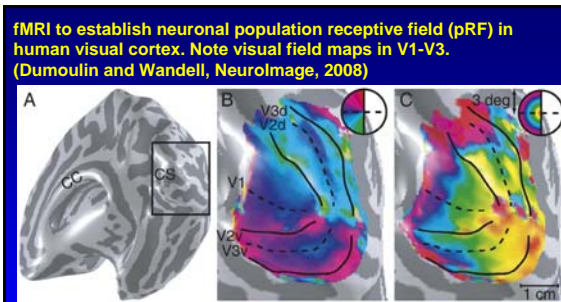
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fMRI to establish neuronal population receptive field (pRF) in human visual cortex. Note visual field maps in V1-V3. (Dumoulin and Wandell, NeuroImage, 2008)

Human hemisphere with surface smoothed through expansion of sulci. CC: corpus callosum CS: Calcarine sulcus (17 or V1)

Visual fields mapped with rotating wedge (B) and expanding ring stimuli in different portions of visual field. Note size of foveal representation.

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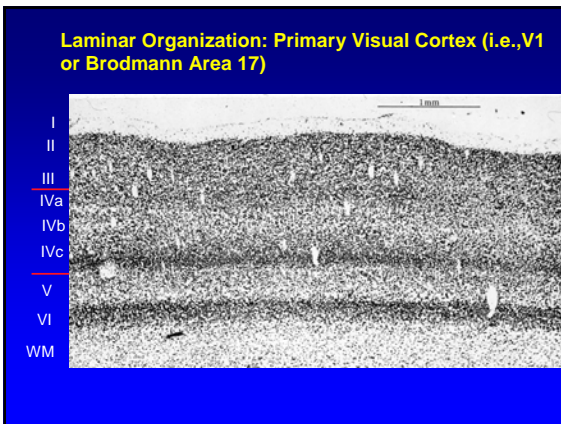
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Laminar Organization: Primary Visual Cortex (i.e., V1 or Brodmann Area 17)

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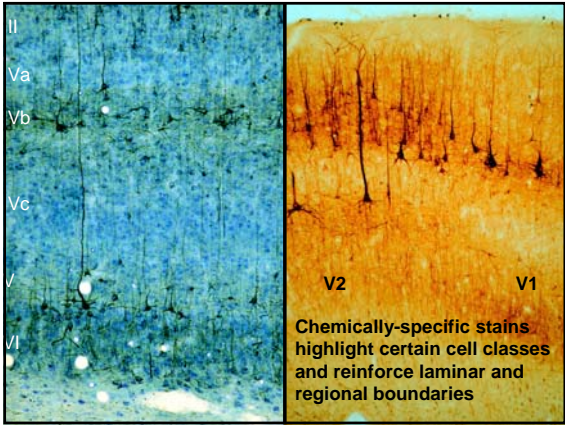
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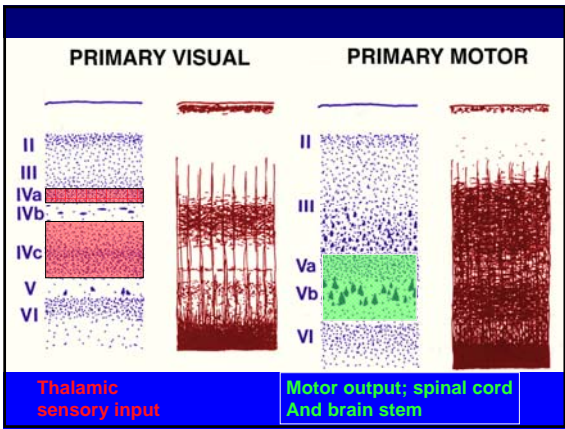
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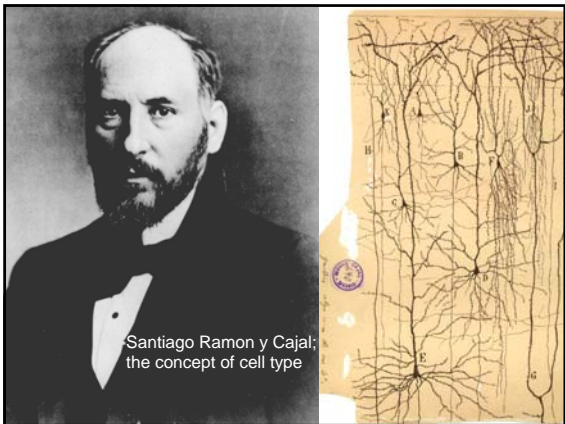
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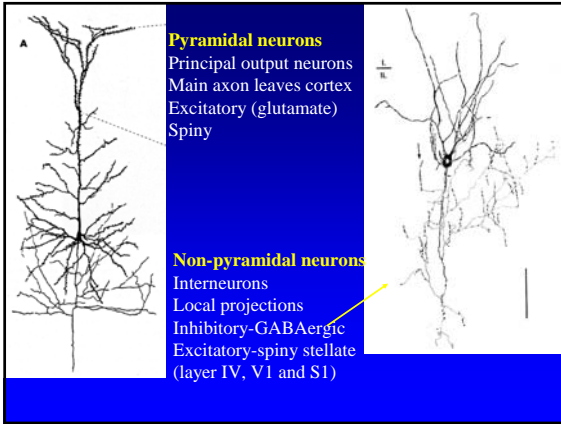
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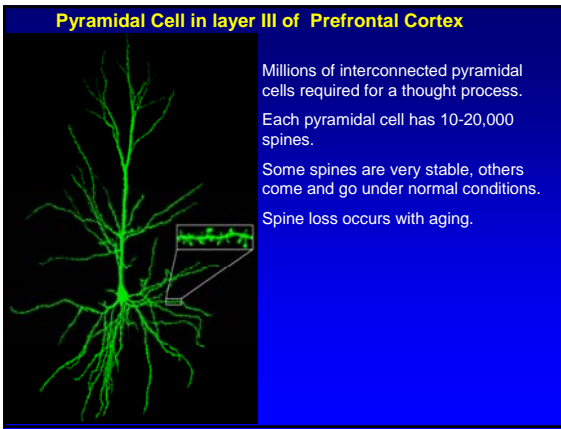
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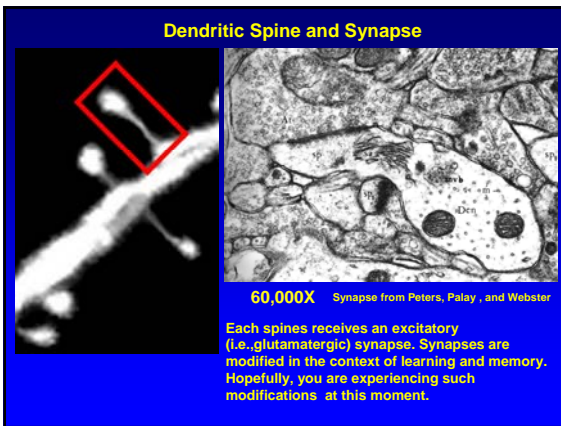
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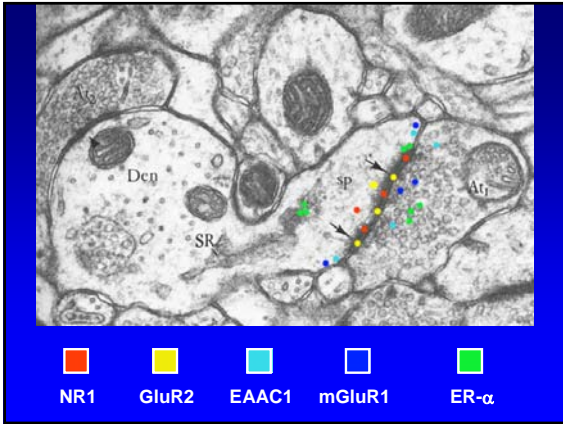
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### Neocortex: Cell types and Circuitry

Cortical cell types can be sub-divided further by their location, morphology, targets, and biochemical profile.

- Pyramidal neurons
- Non-pyramidal neurons

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### Relationship between layer of origin and target.

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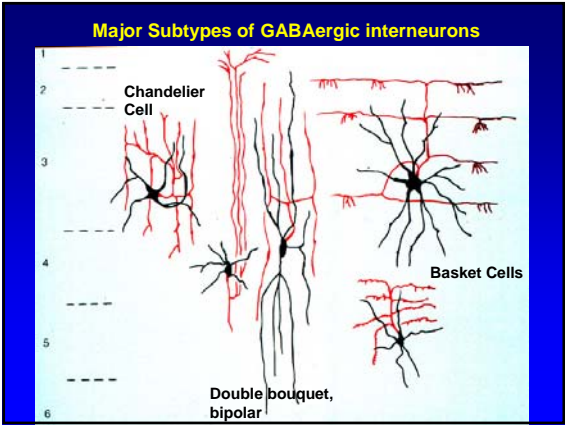
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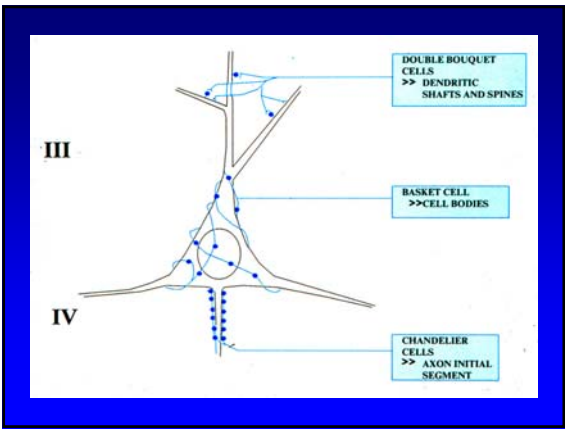
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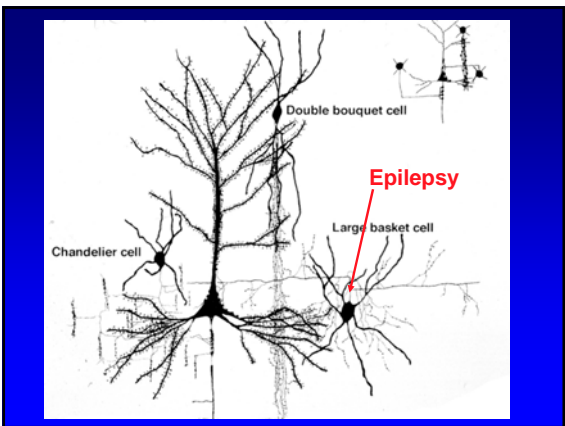
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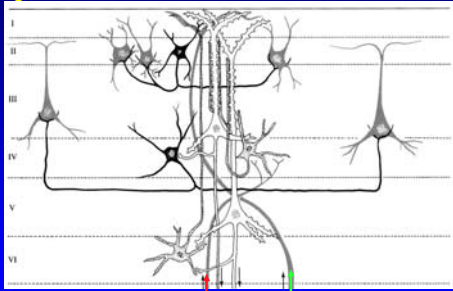
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The basic information processing unit in the neocortex is thought to be a radial column



Thalamic afferent      Corticocortical afferent

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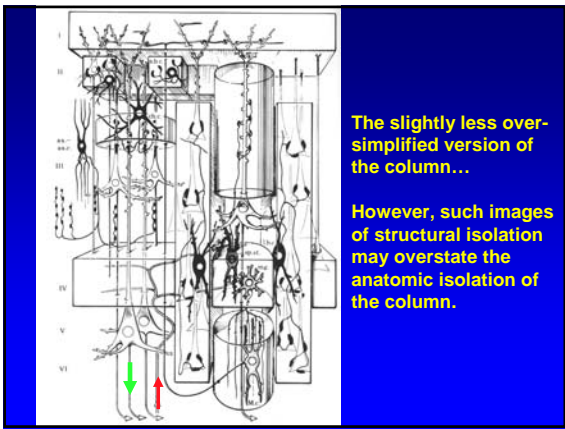
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The slightly less over-simplified version of the column...  
However, such images of structural isolation may overstate the anatomic isolation of the column.

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**Extrathalamic Subcortical Afferents**

- A) Monoaminergic projections:
  - 1) Noradrenergic (NA) from Locus Coeruleus in Pons
  - 2) Serotonergic (5-HT) from Dorsal Raphe in midbrain
  - 3) Dopaminergic (DA) from Ventral Tegmental Area in rostral midbrain
  - 4) involved in regulation of attention, mood, affective state, sleep/wakefulness, vigilance, etc.
  - 5) Site of action of antidepressants, anti-psychotics, and many drugs of abuse.
- B) Cholinergic projection from Nucleus Basalis- involved in learning and memory, and its degeneration is implicated in AD
- C) All four are widespread, highly divergent projections from small nuclei to the entire cerebral cortex. They do not carry modality-specific information and are not topographic.

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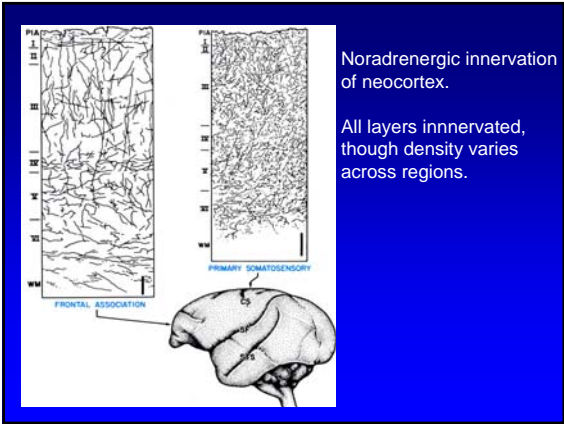
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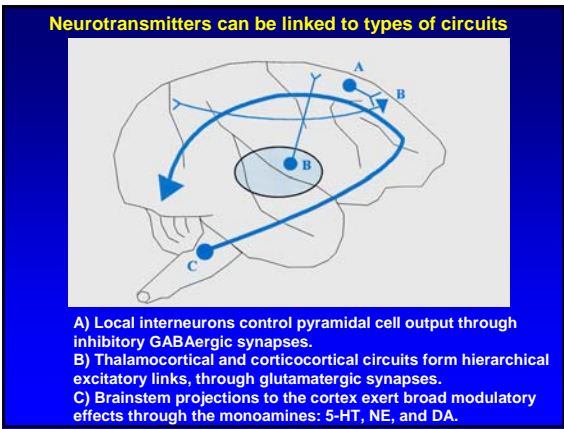
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**Take Home messages:**

The major cortical afferents and efferents are those that reciprocally link a cortical region to a thalamic nucleus and those that link cortical regions to each other.

Even though there is a high degree of regional specialization in neocortex, basic principles of laminar and cellular organization are apparent throughout neocortex.

Pyramidal cells are excitatory and are the key output neurons. Their activity and responsiveness to afferents are regulated by intrinsic inhibitory interneurons.

Neurotransmitters can be linked to types of circuits, with glutamate the neurotransmitter of major afferents and efferents, GABA utilized by local interneurons, and monoamines providing a global modulatory influence.

**Onward to Cortical integration....**

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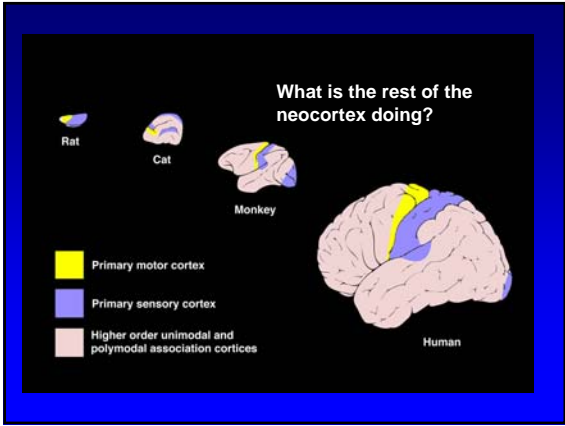
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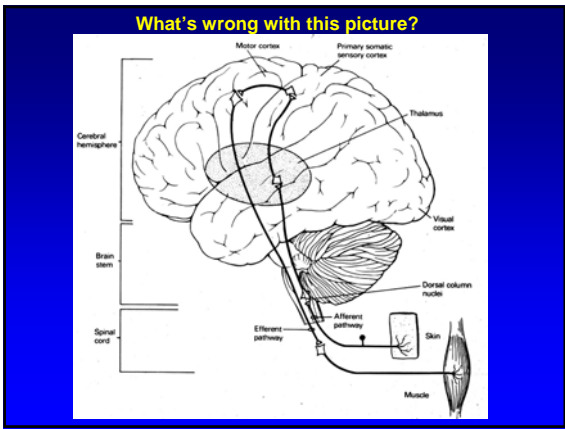
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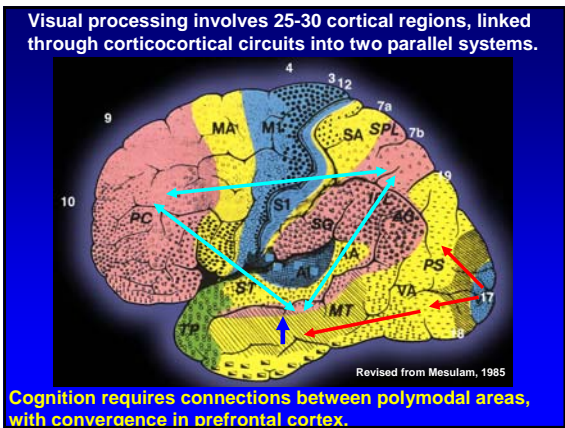
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Cognition requires connections between polymodal areas, with convergence in prefrontal cortex.

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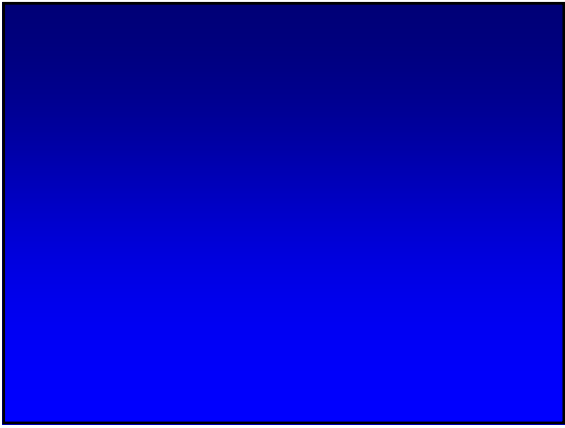
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