

How the Brain Works

And Why it Probably Doesn't Work this way!

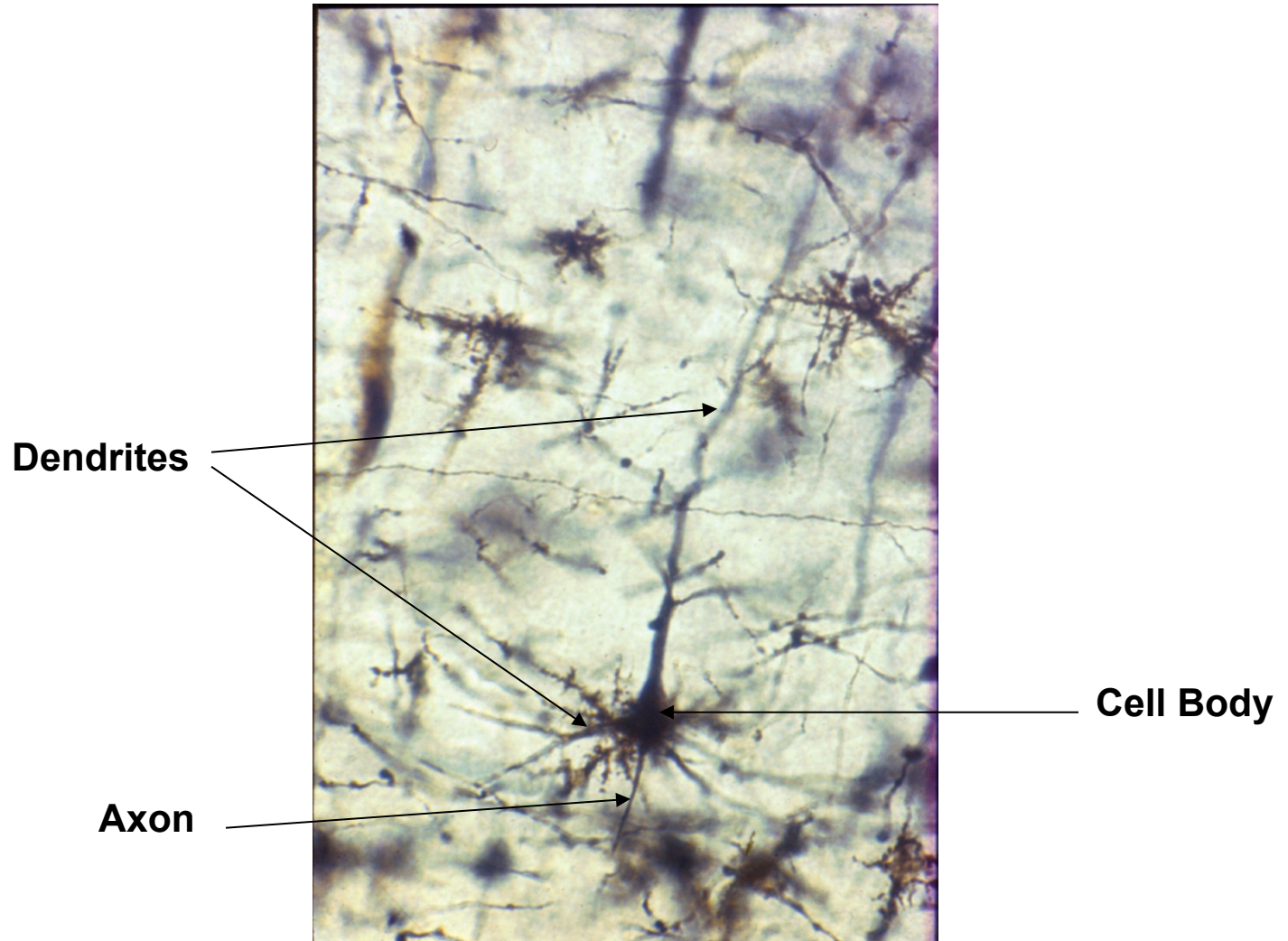
Jeanette J. Norden, Ph.D.

Professor and Director of Medical Education
Department of Cell & Developmental Biology
Vanderbilt University School of Medicine

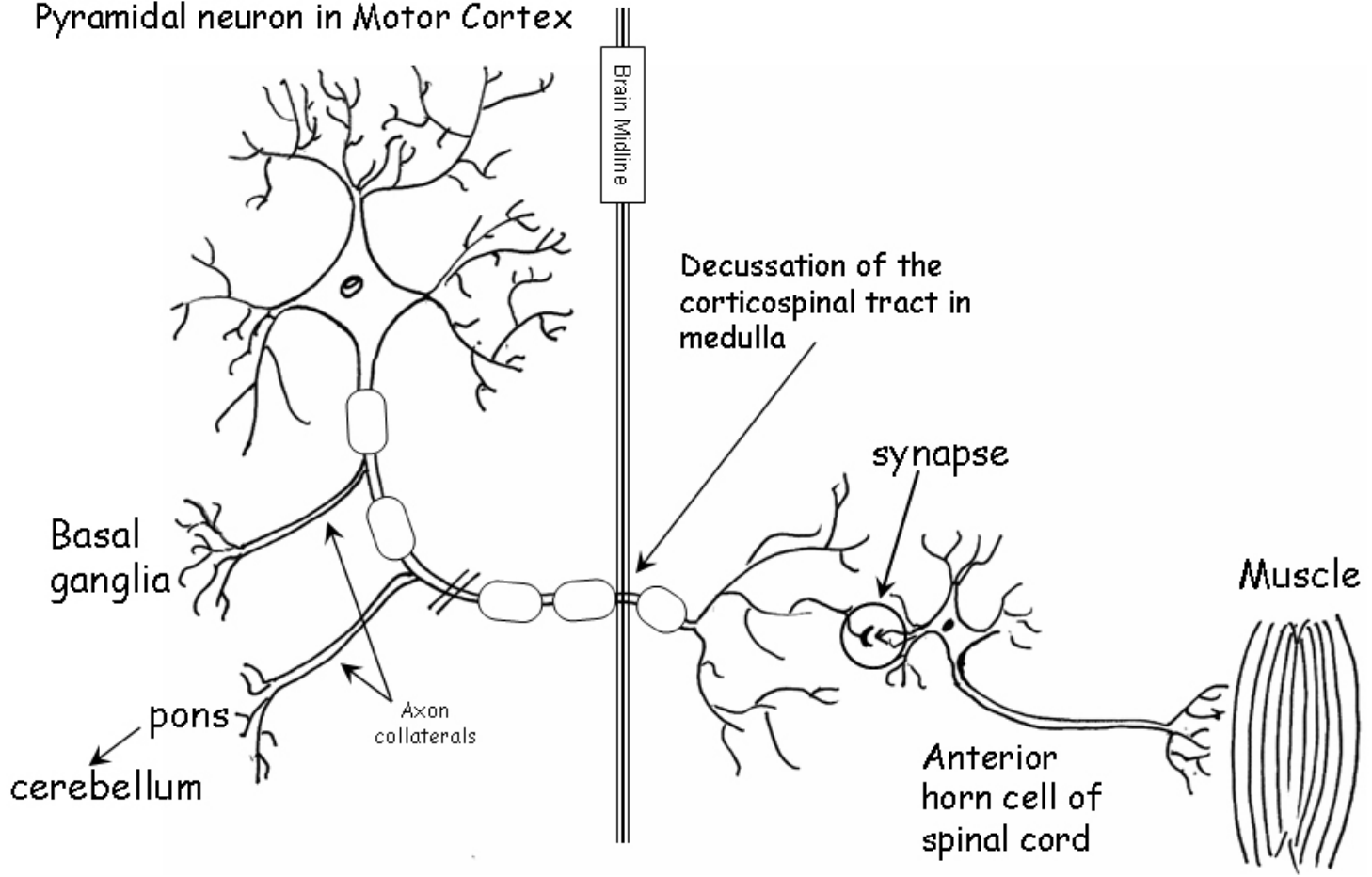


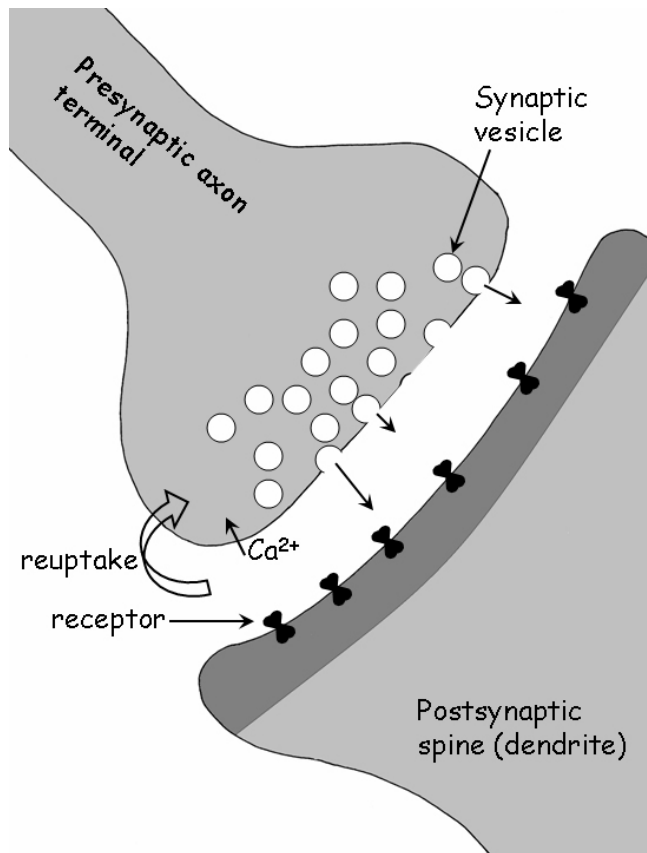
From Allman, 2000

Neurons are polarized cells of the CNS and PNS which are specialized for sending and receiving information; this “polarization” is reflected in their morphology



Pyramidal neuron in Motor Cortex





Neurotransmitters

- **Glutamate and Gaba**

Neuromodulators

- ***Biogenic amines:***

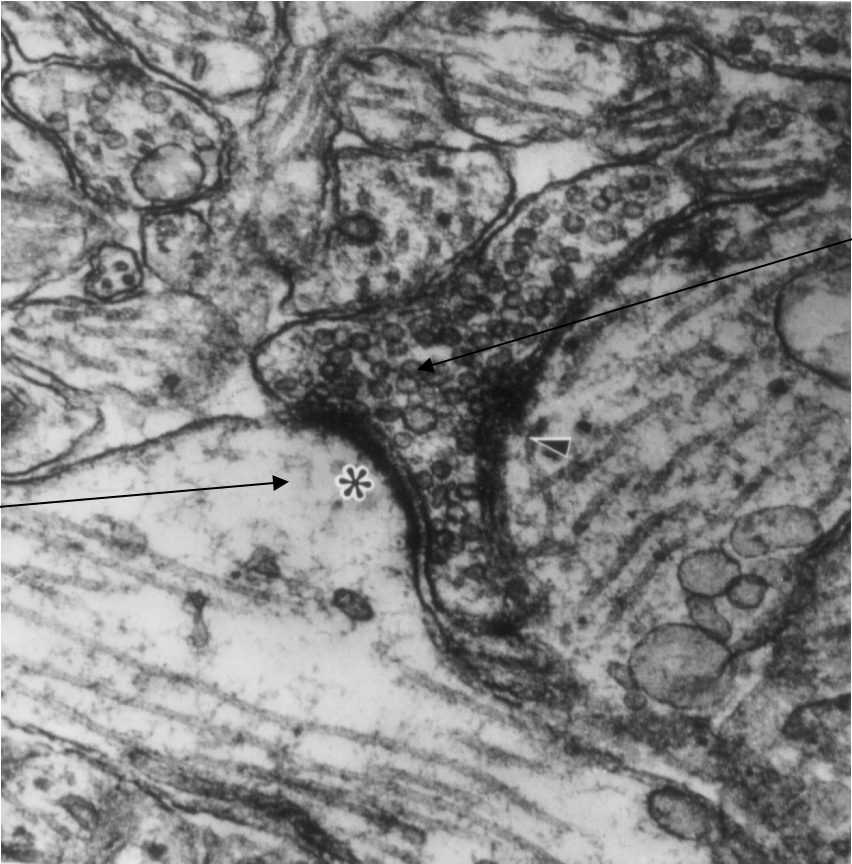
- **Norepinephrine**

- **Dopamine**

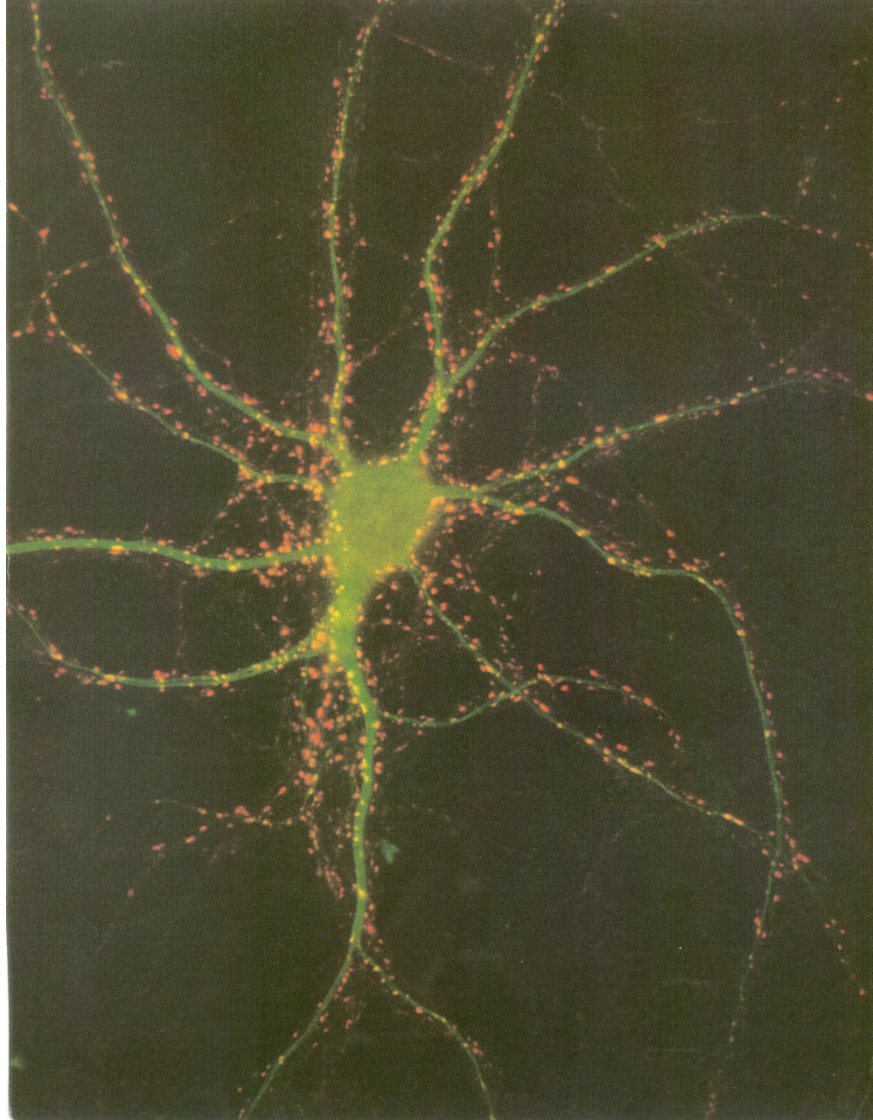
- **5HT
(Serotonin)****

>100 NTs, NMs in CNS!

**Postsynaptic
Dendritic Spine**

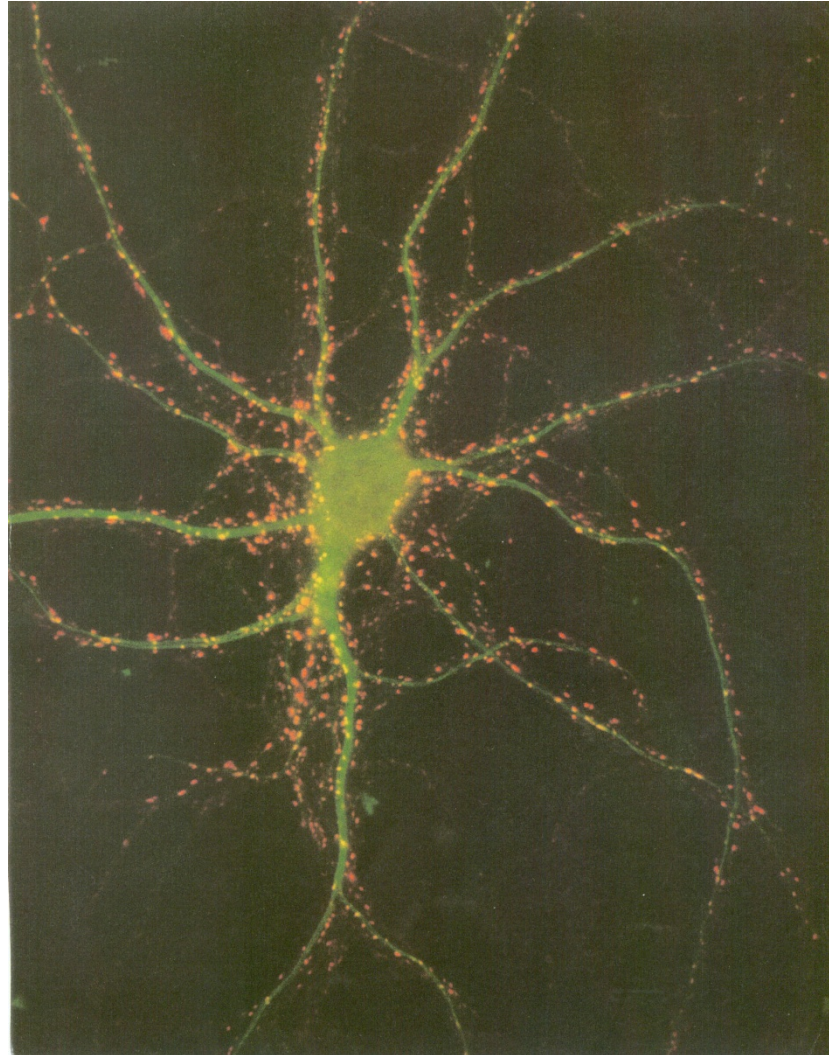


**Presynaptic Axon
Terminal**



Cover Image, Neuron, 1993

***Estimated 100 billion neurons
in the human brain, connected
by 100 trillion synapses!***



Cover Image, Neuron, 1993

Peripheral nervous system (PNS):

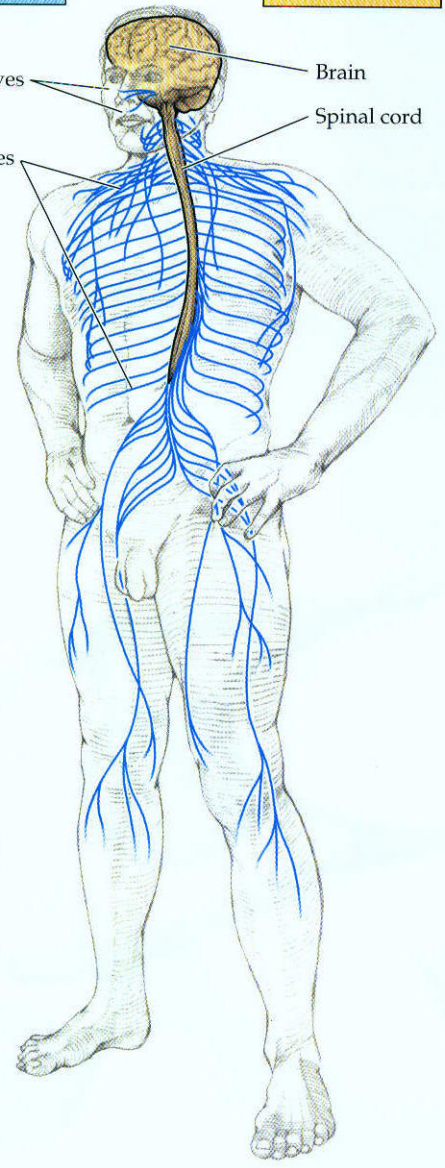
Central nervous system (CNS):

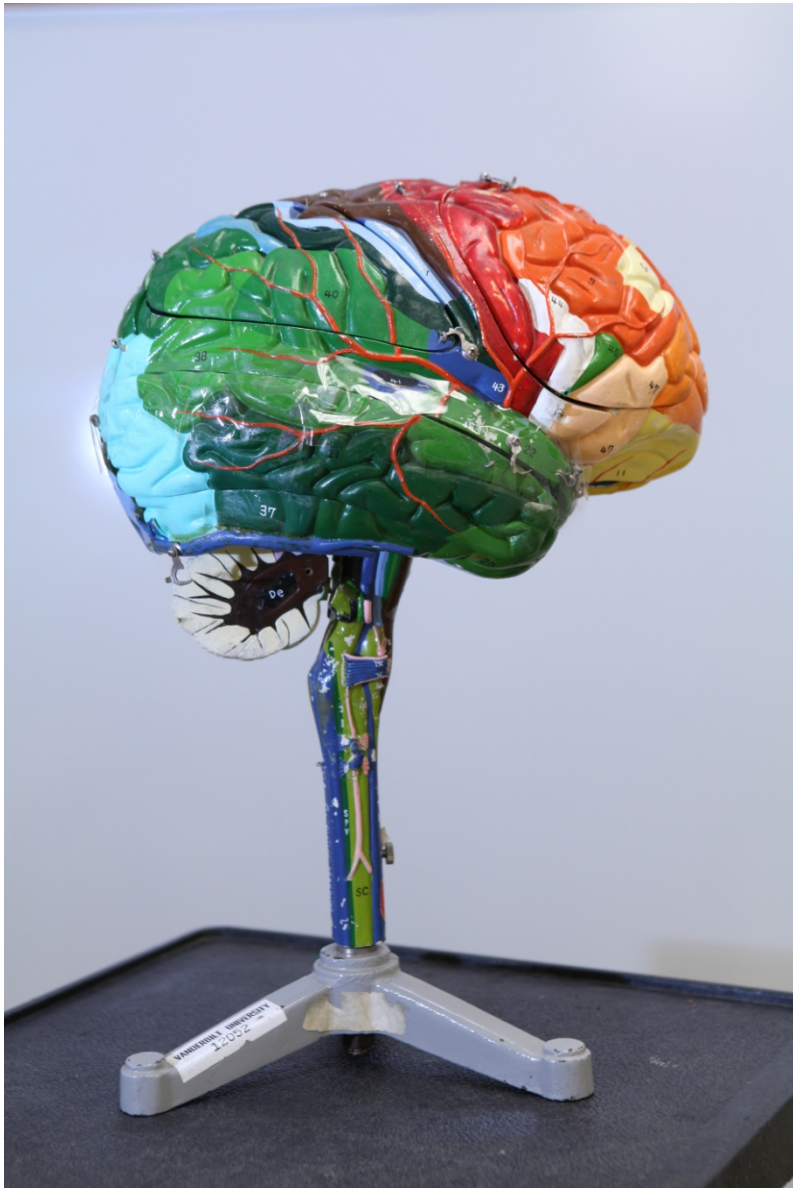
Cranial nerves

Brain

Spinal cord

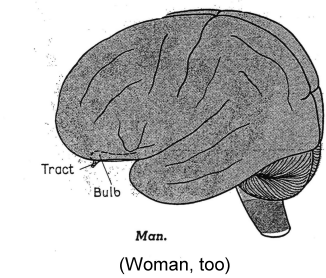
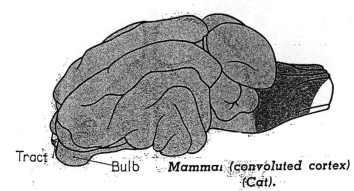
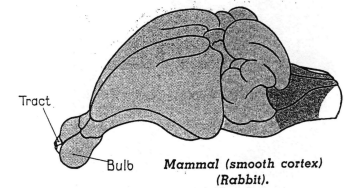
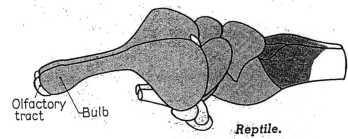
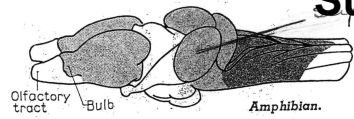
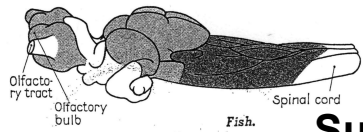
Spinal nerves



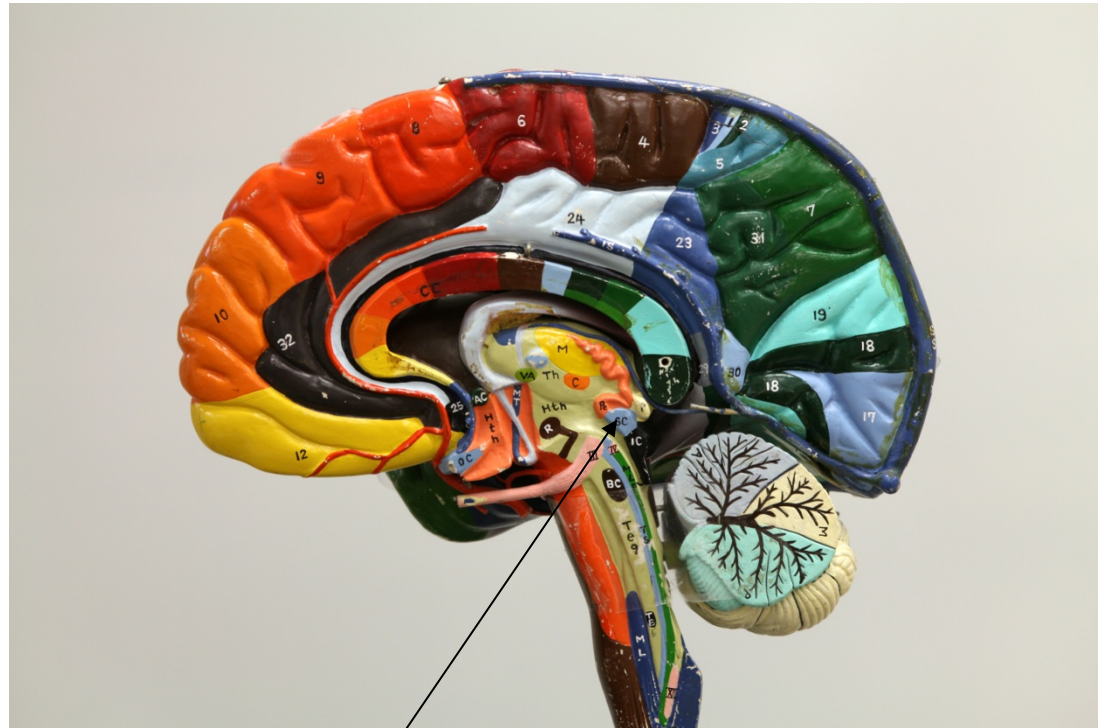




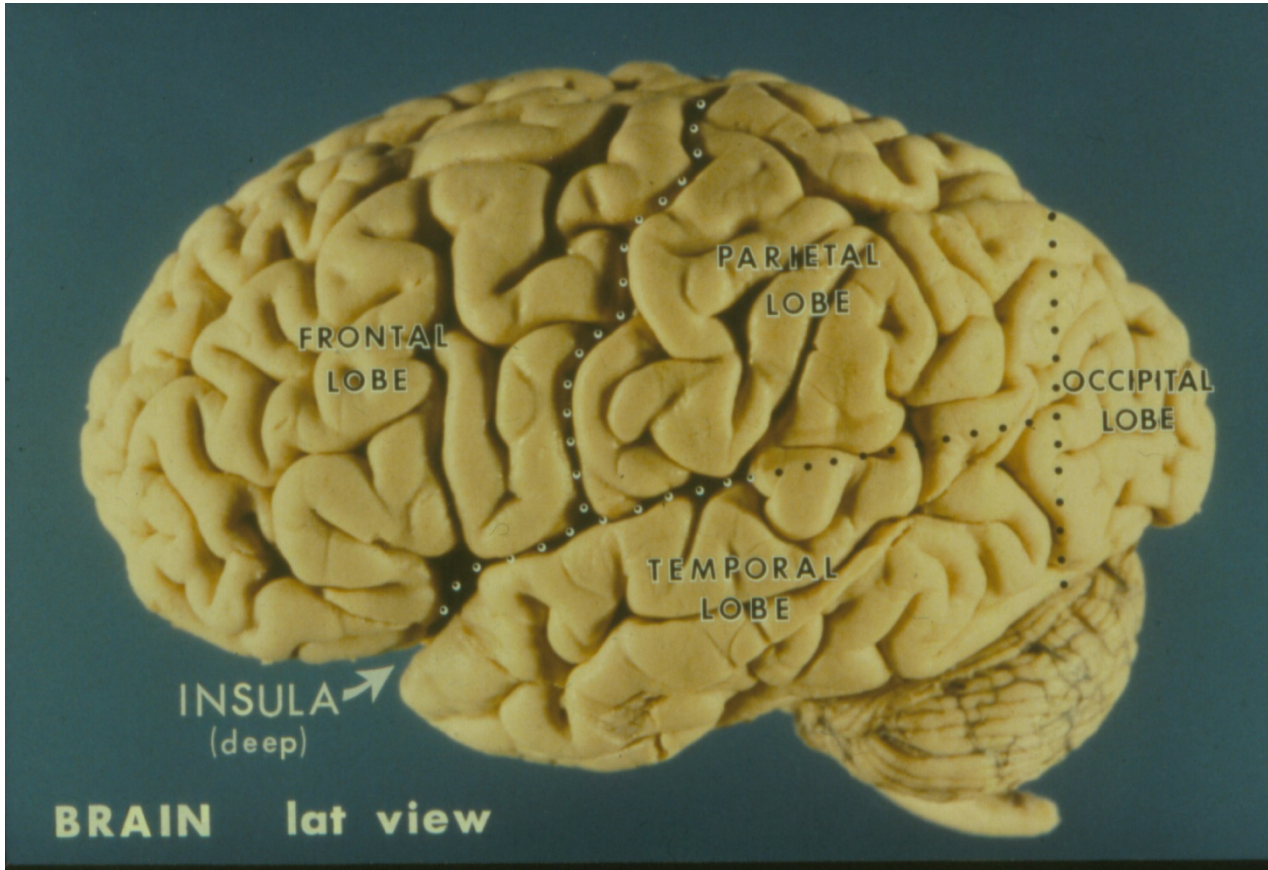
Phylogenetic Development of the Telencephalon

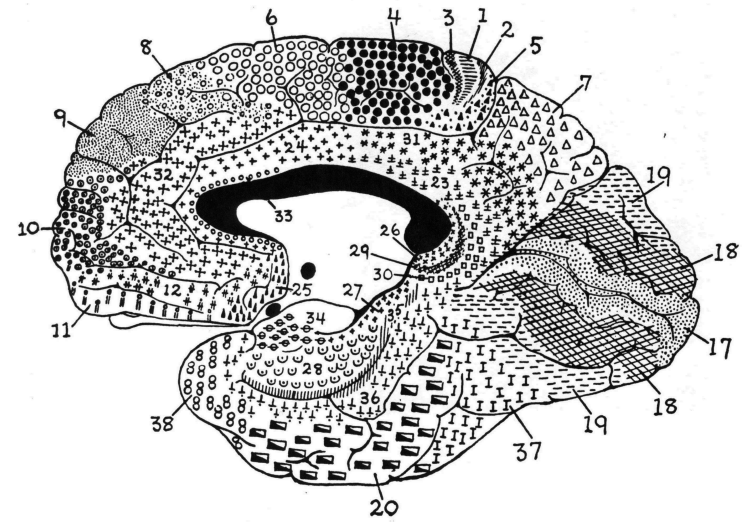
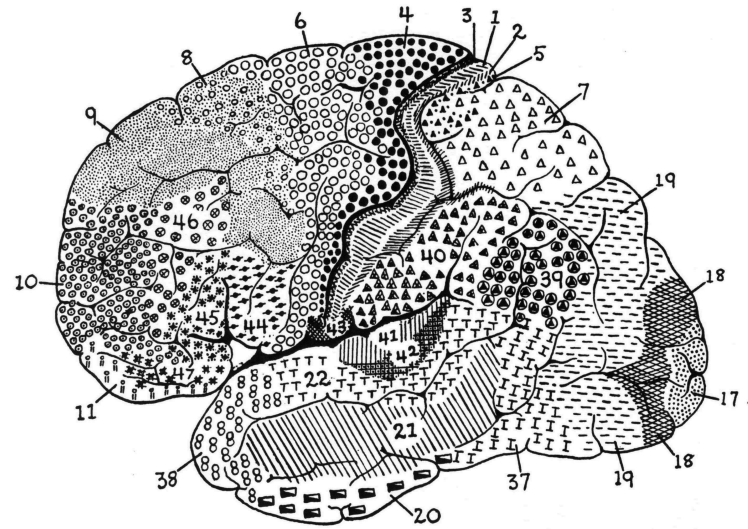


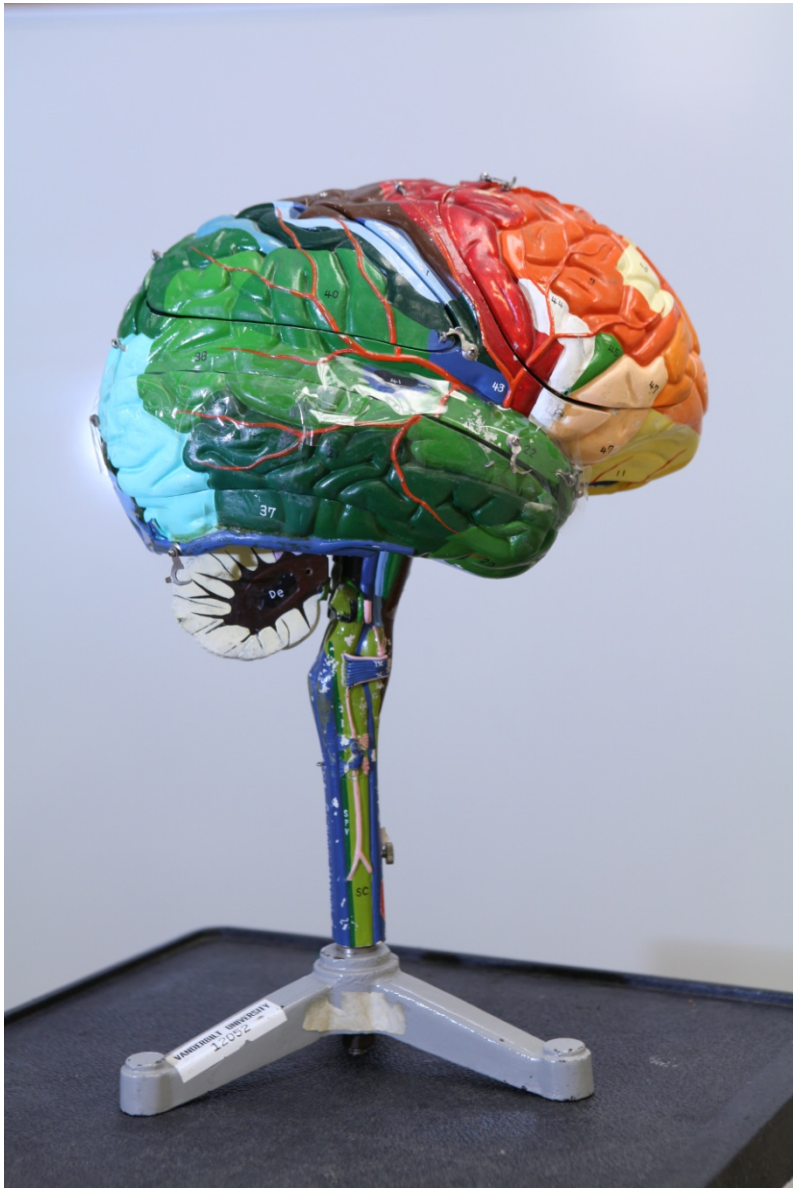
Superior colliculus



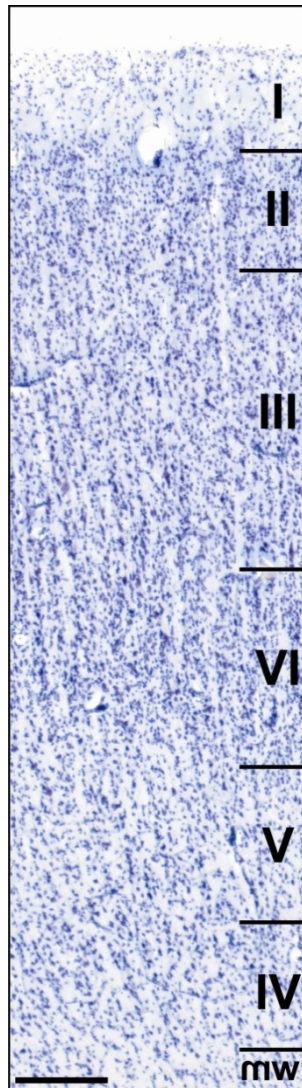
Superior colliculus



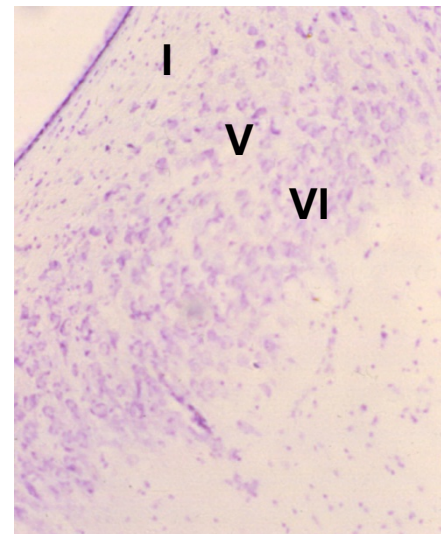




Neocortex

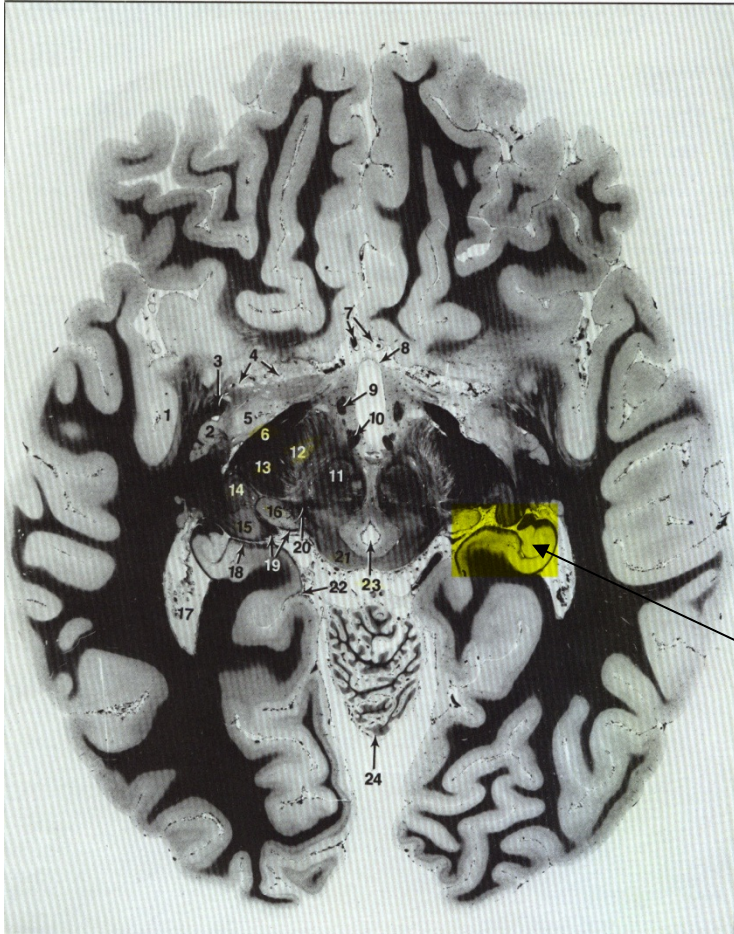


Archi/Paleocortex



Ex: Hippocampus

Human



Fix Atlas, 2008

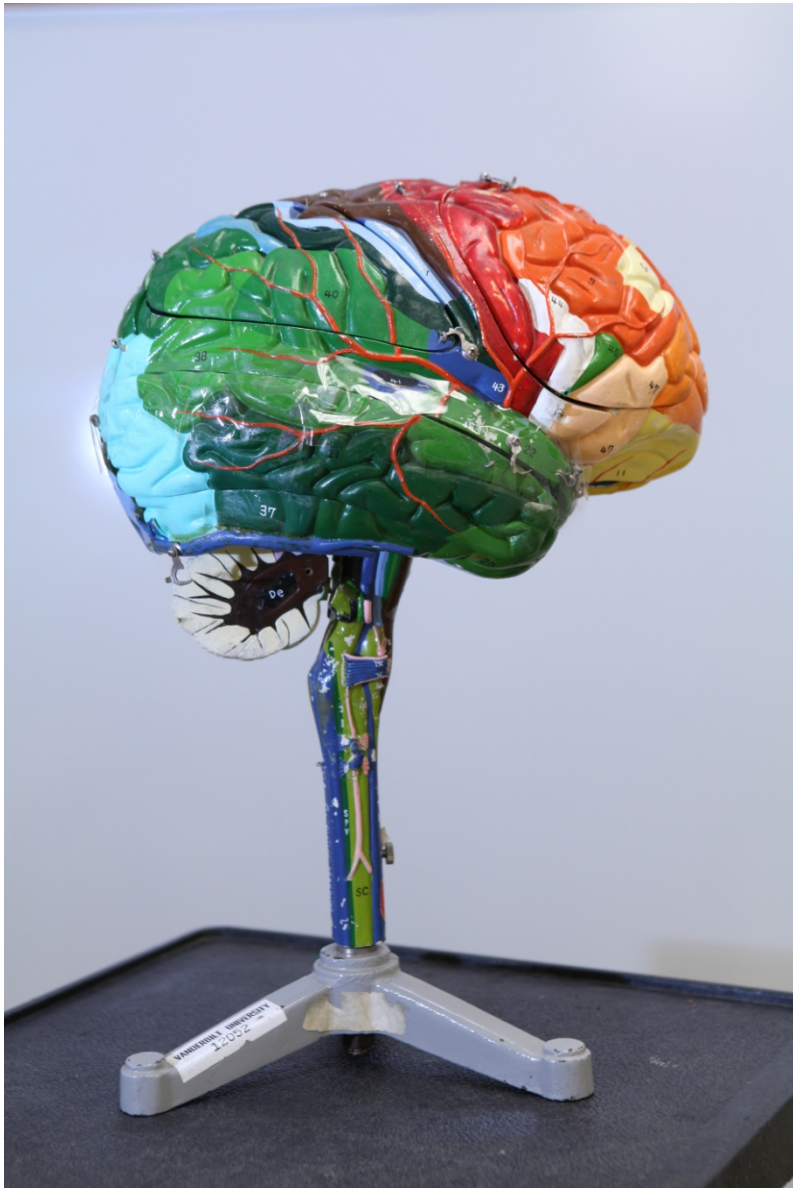
Hippocampus



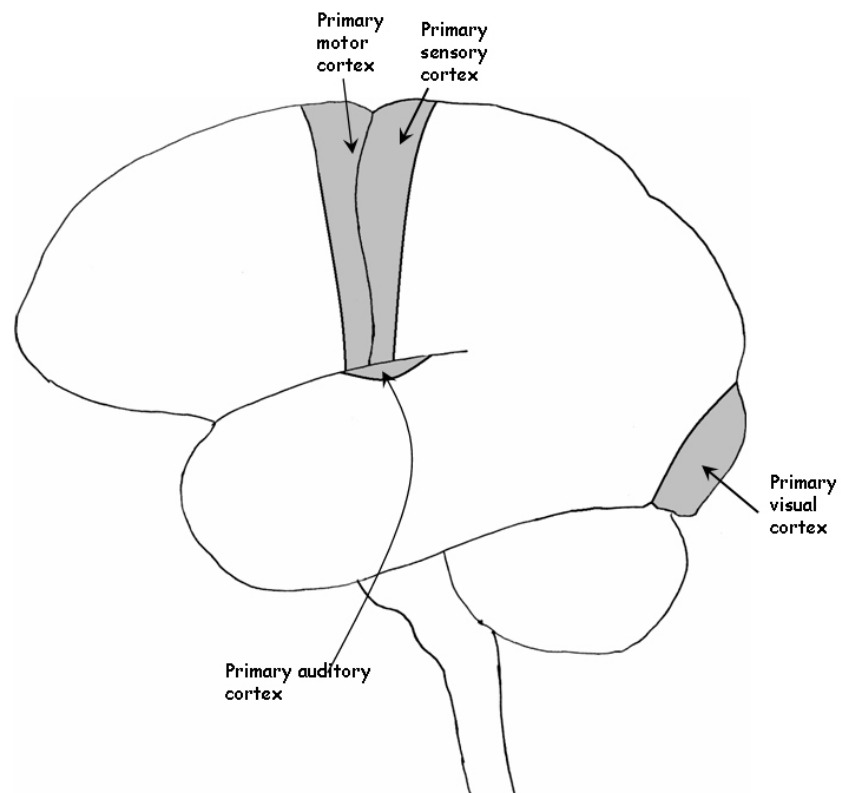
Rat



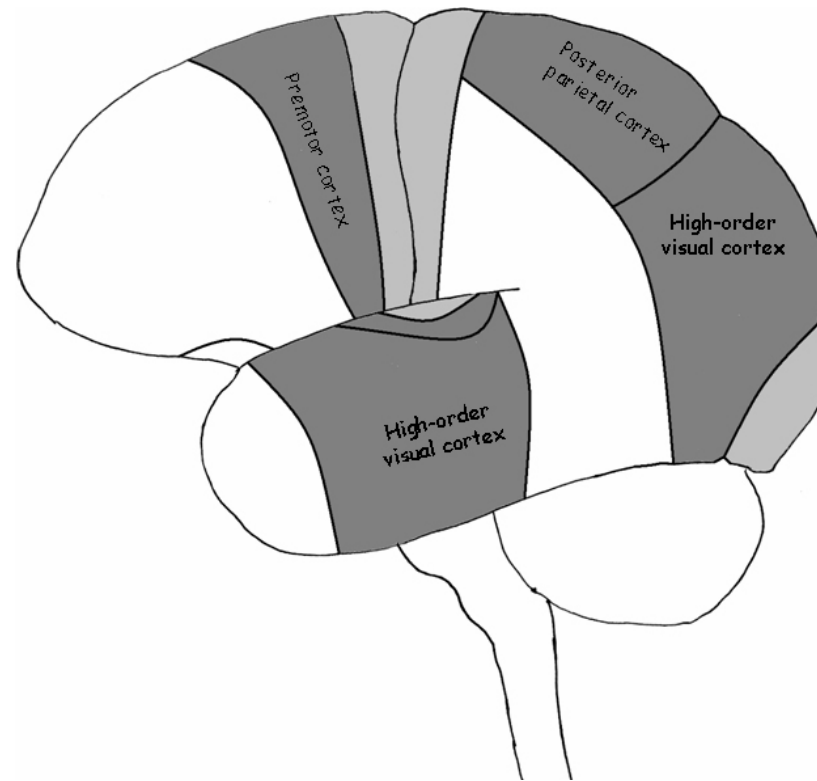
From Sherwood and Timiras, 1970



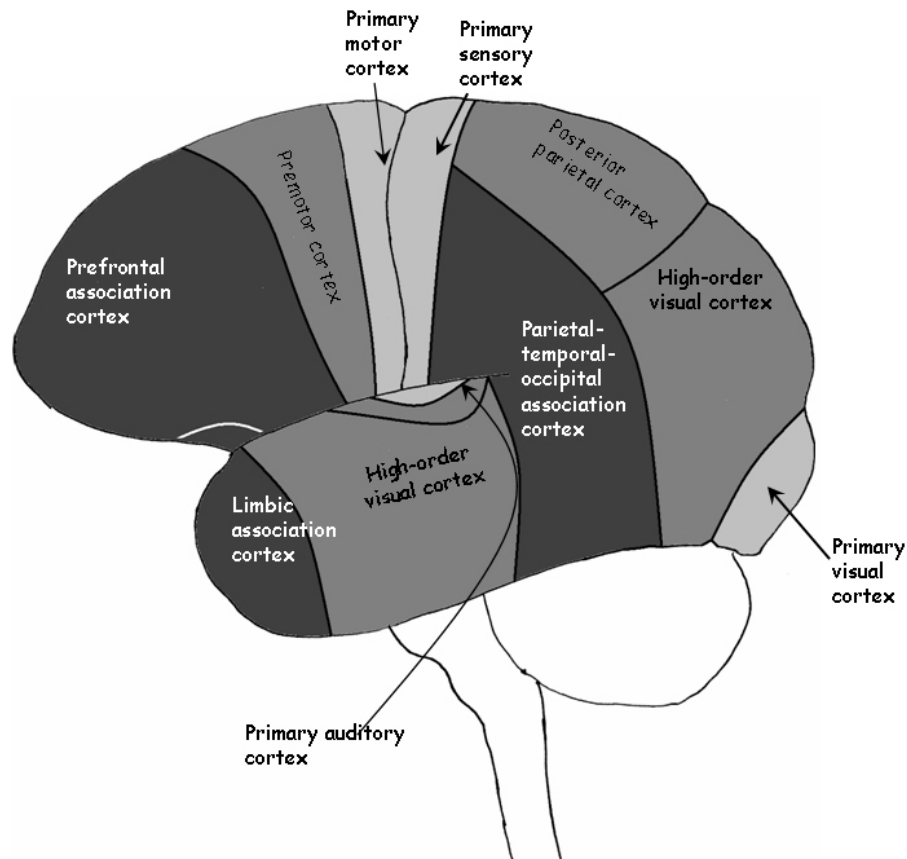
Primary Motor & Sensory Cortex



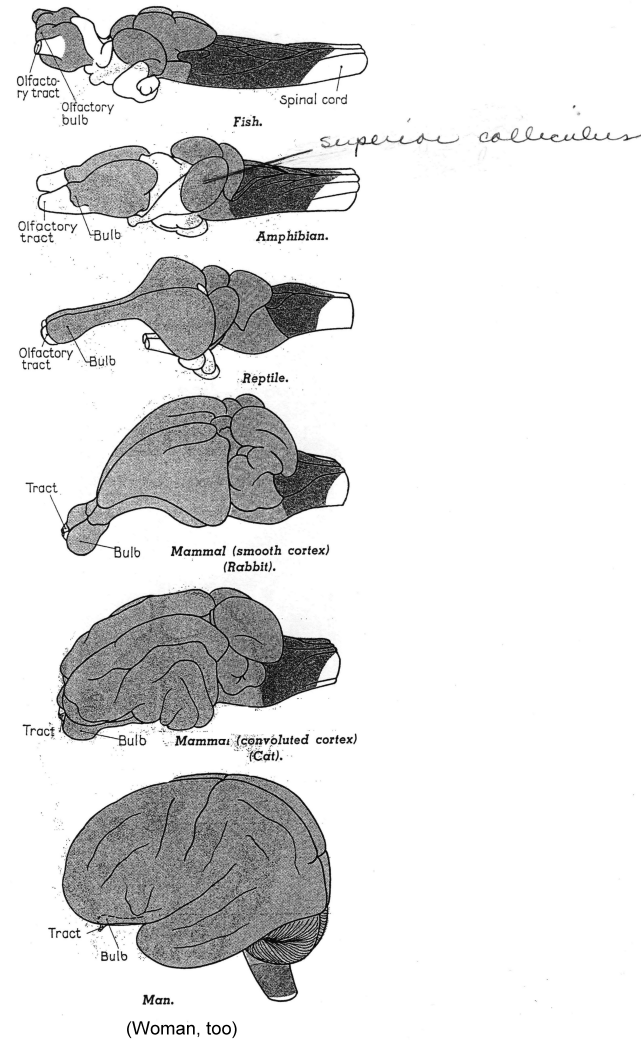
Secondary (Higher-order) Sensory & Motor Cortex



Association Cortex



Phylogenetic Development of the Telencephalon



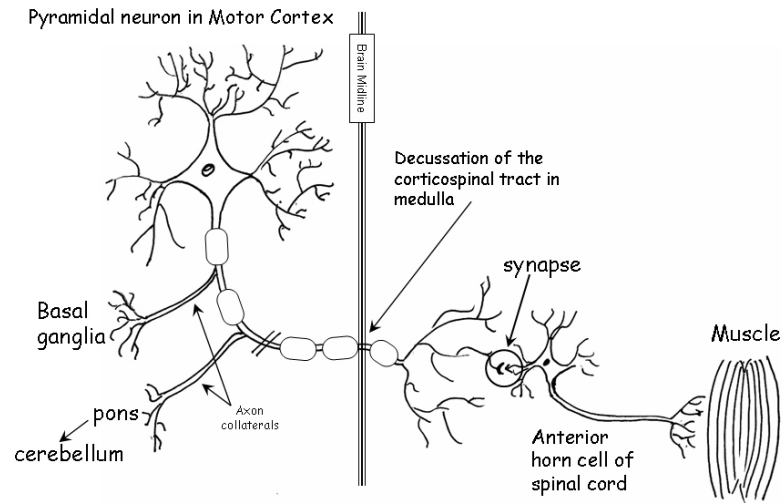
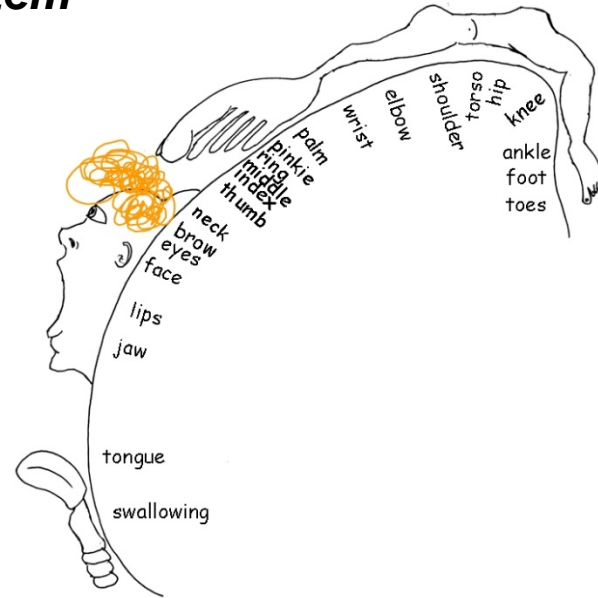
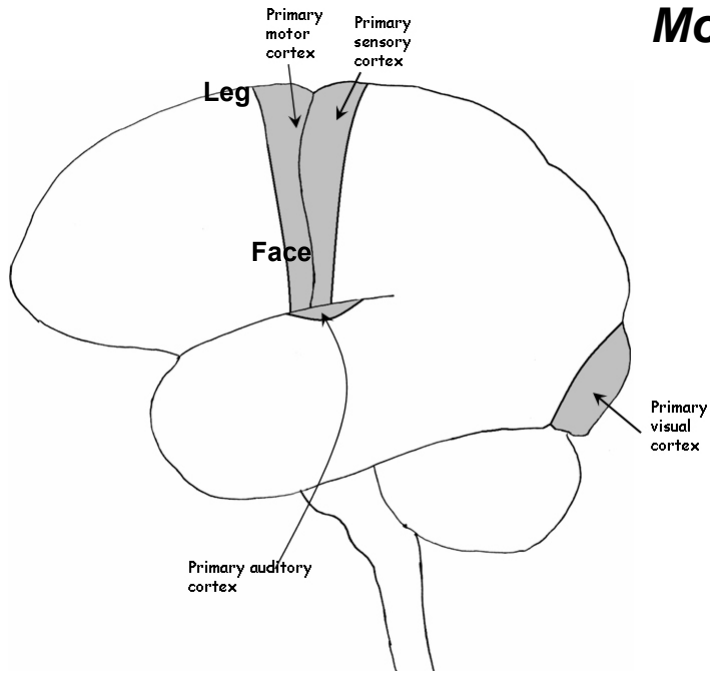
Myelin is a vertebrate innovation

Neocortex first appears in mammals

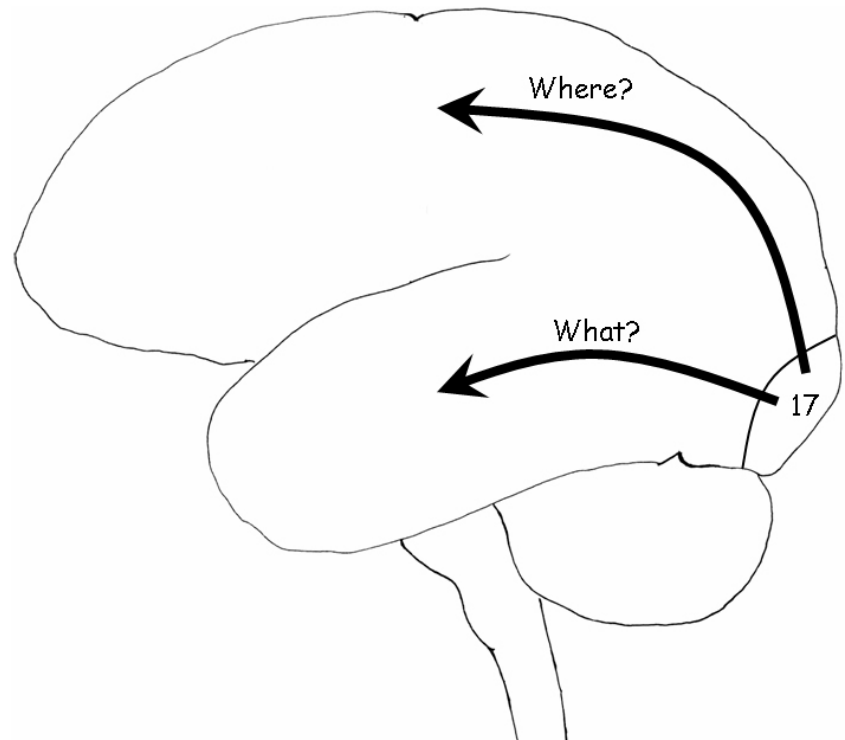
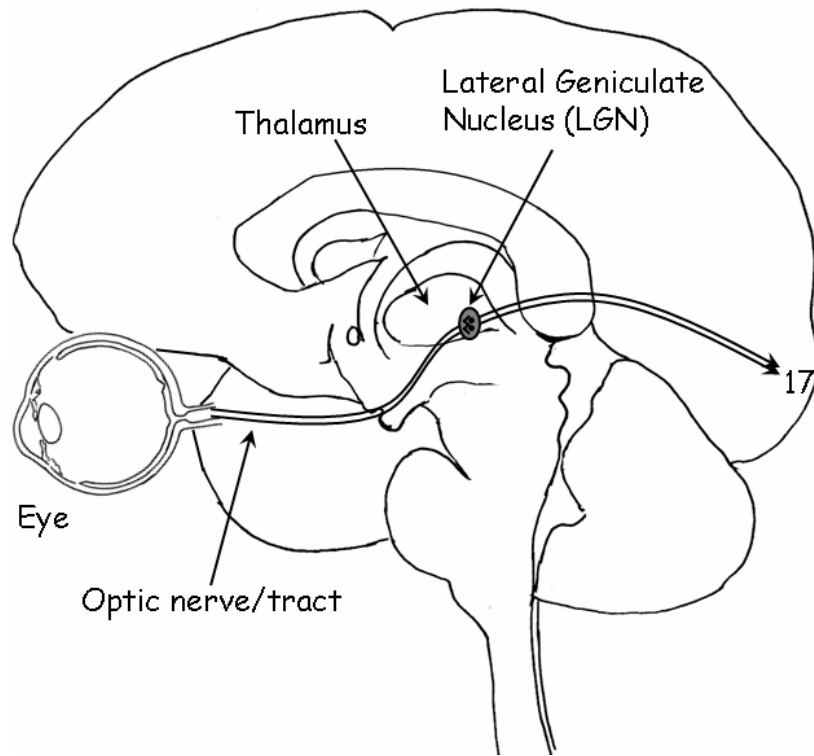
An area for visually-guided manipulation of objects is found only in primates

One class of neurons in specific neocortical areas (like anterior cingulate gyrus) is found only in humans and great apes

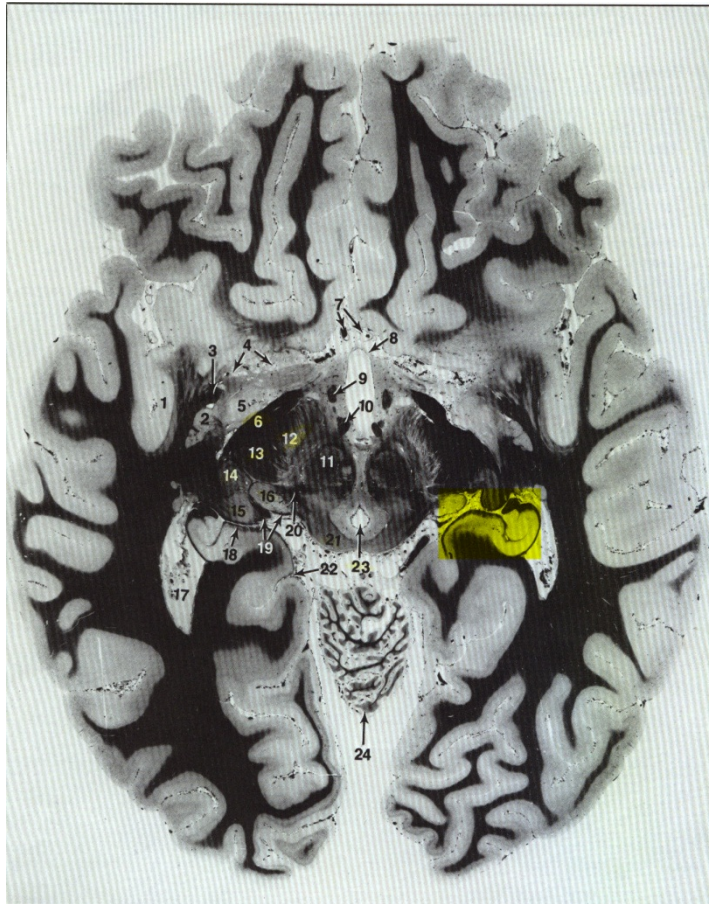
Motor System



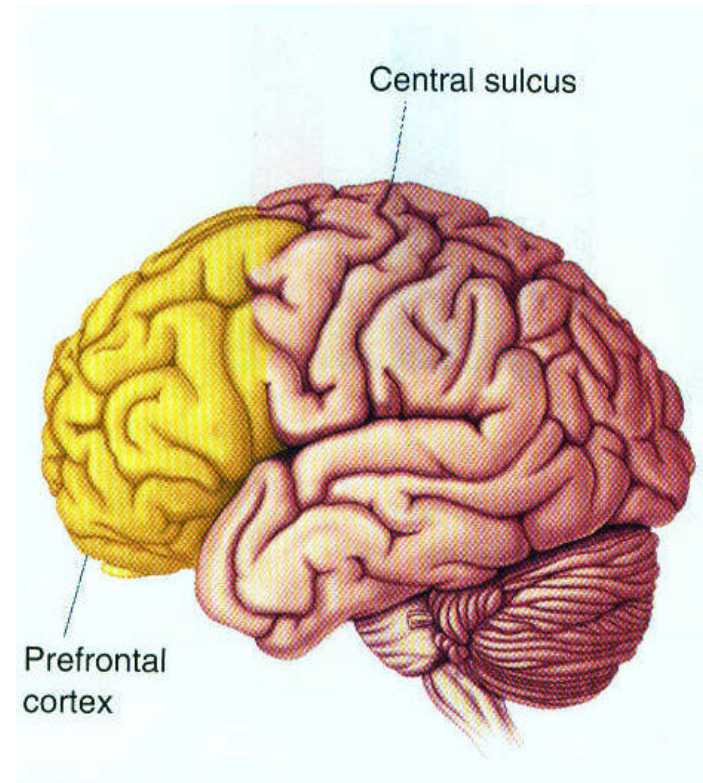
Visual System



Memory “Systems”



Hippocampus

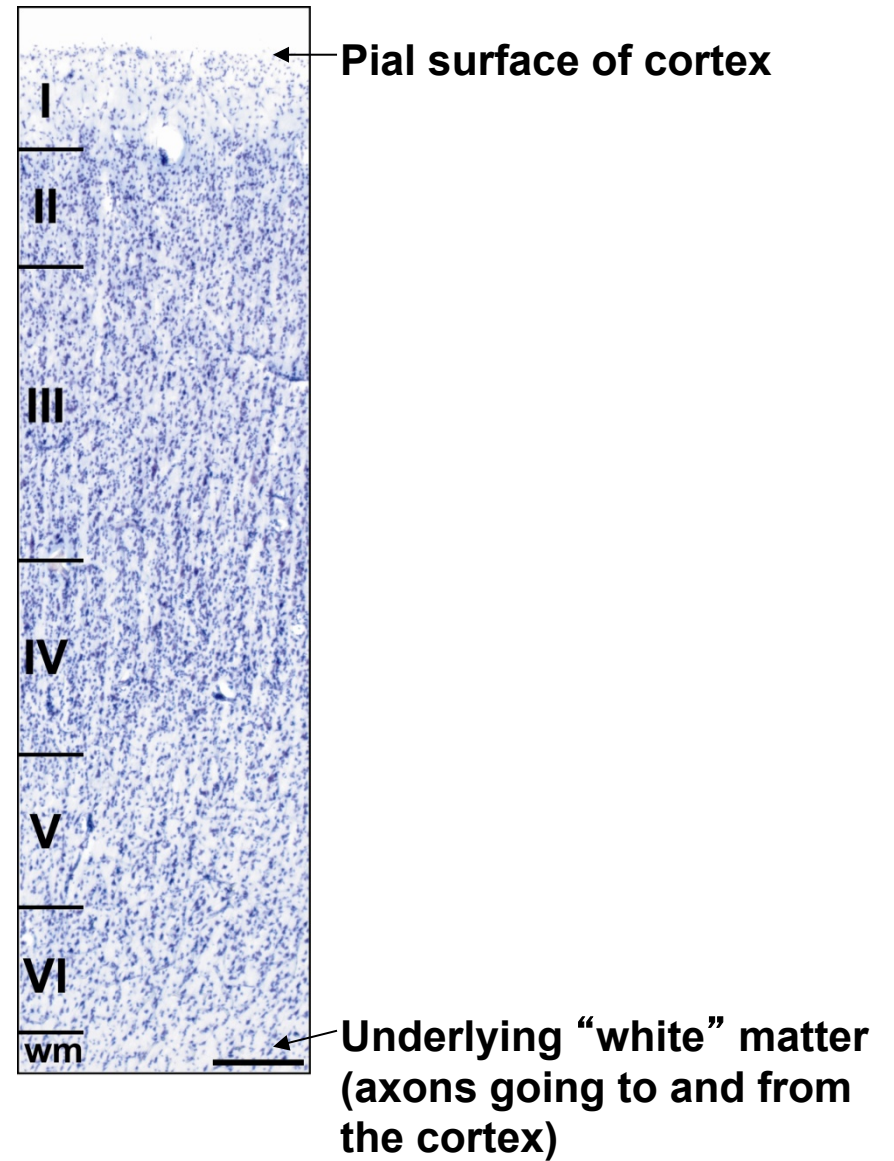
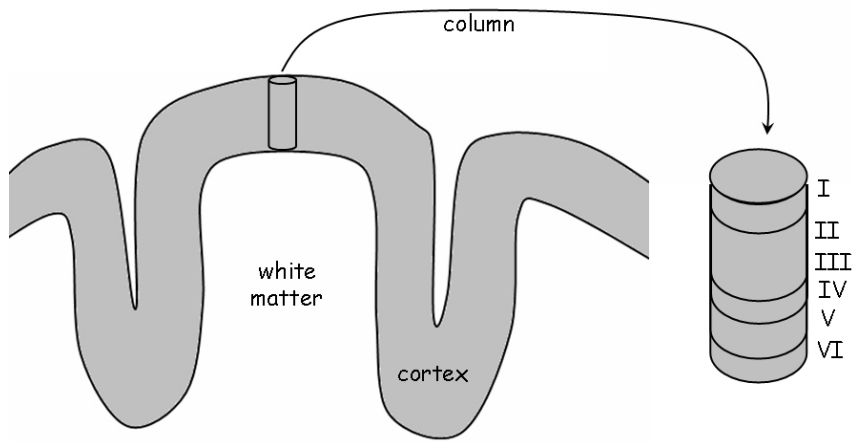


Prefrontal cortex

- **Traditional view of “How the Brain Works” – Hierarchical**

- **Works pretty well in the clinic!**

Each cortical “mini-column” (~30-50 μm) is a functional unit!



- **Human brain:**
 - 100 billion neurons
 - Interconnected by 100 trillion synapses
- **Cortex:**
 - >3 million mini-columns, each interconnected to an estimated 10^3 other mini-columns

- ***Traditional view: Hierarchical***
- ***Probably isn't how the brain actually works!***
 - ***Massive parallel & distributed processing involving many different areas of the brain***
 - ***Brain “constructs” reality***