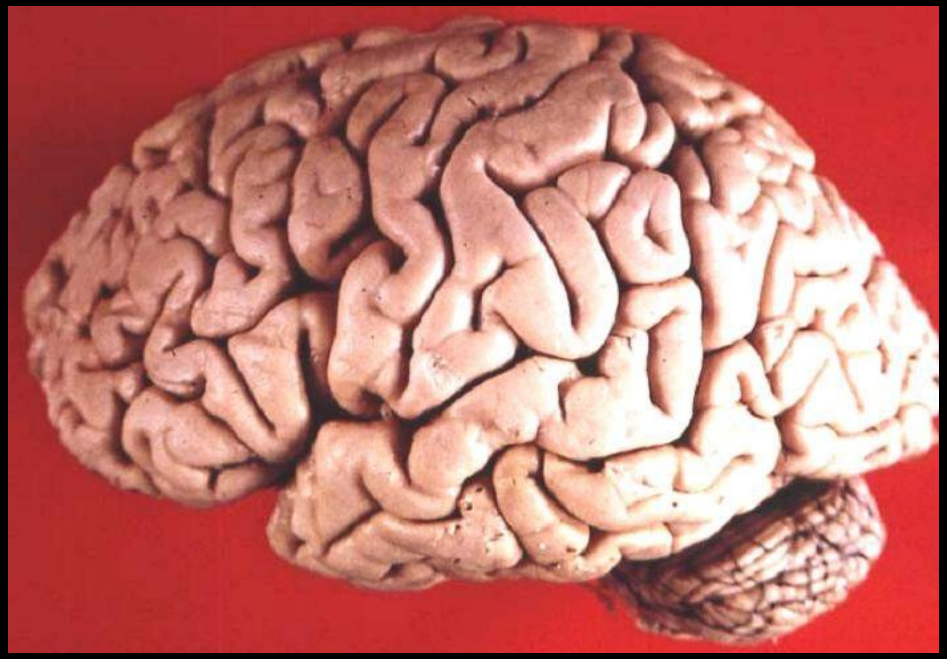
The Brain

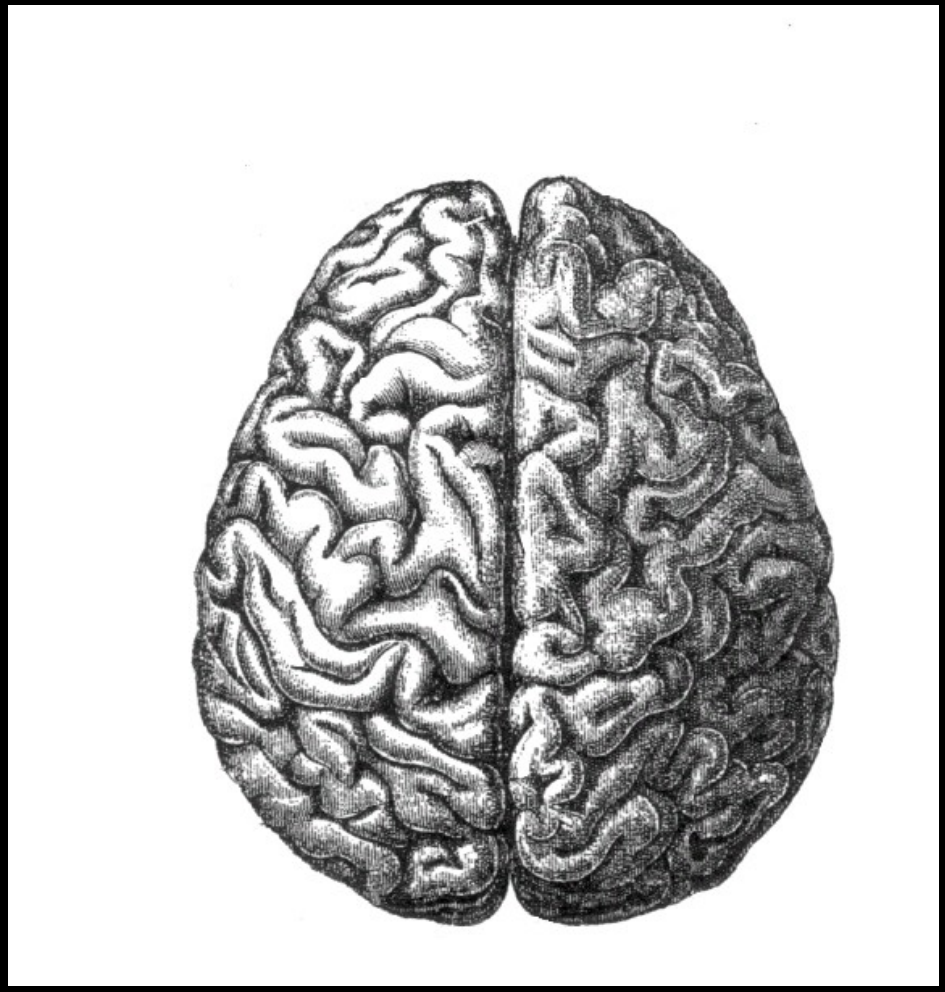
- What is it?
  - Neurons
  - Glial Cells
  - Connective Tissue
  - Connective Fiber
  - White Matter
  - Grey Matter
  - Cerebro-spinal Fluid

A More Realistic View



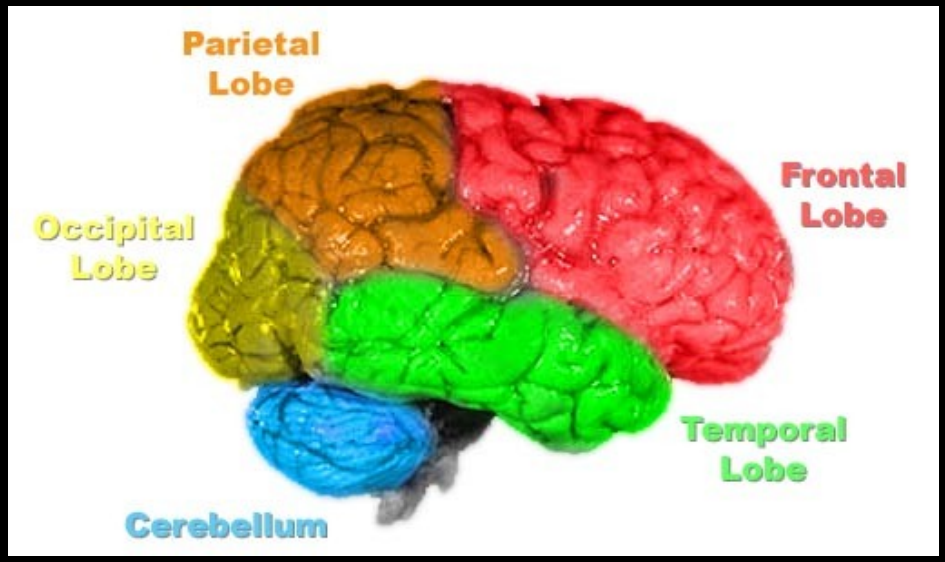
- When we look at the brain we see mostly the Cerebral Cortex
- A wrinkly Tissue that wraps around the rest of the brain hiding all but the cerebellum and brain stem
- The cerebrum is 1/3 of the brain by weight

Top View of Cortex



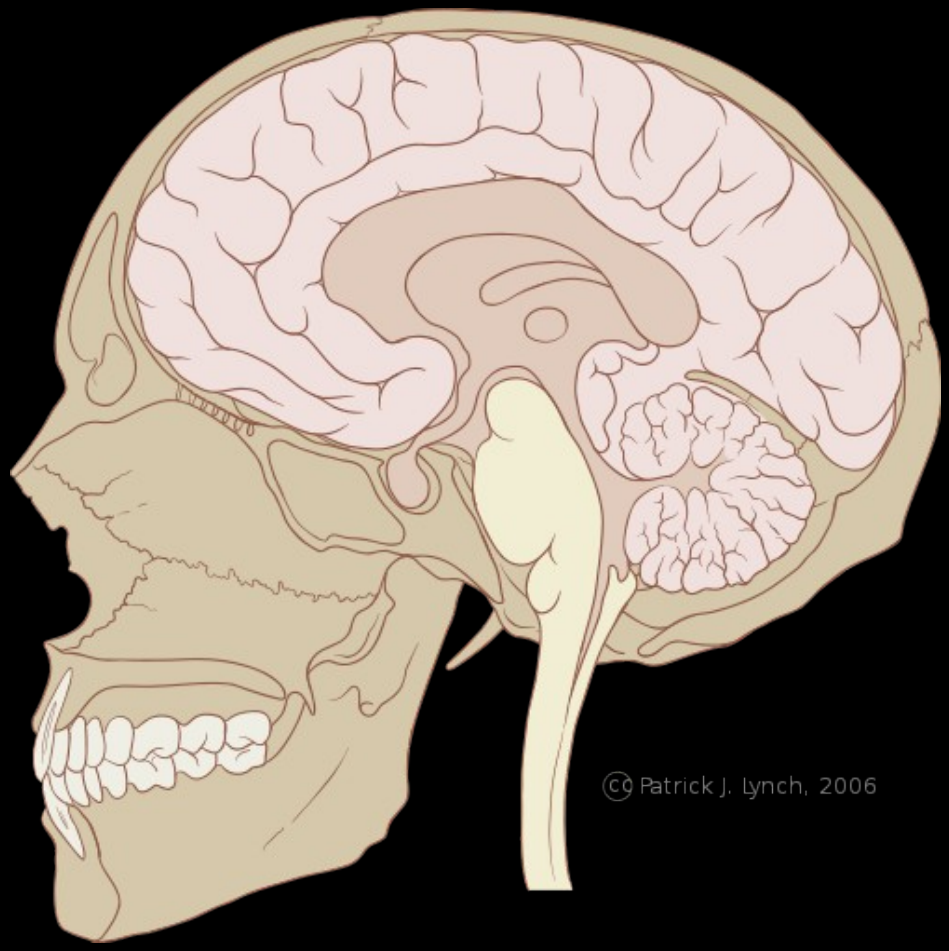
- As you can see the Cortex is divided down the mid-line of the brain into two hemispheres
- One side tends to dominate the other, Usually the Left side Dominating the Right

Anatomical Detail at Lobe Level



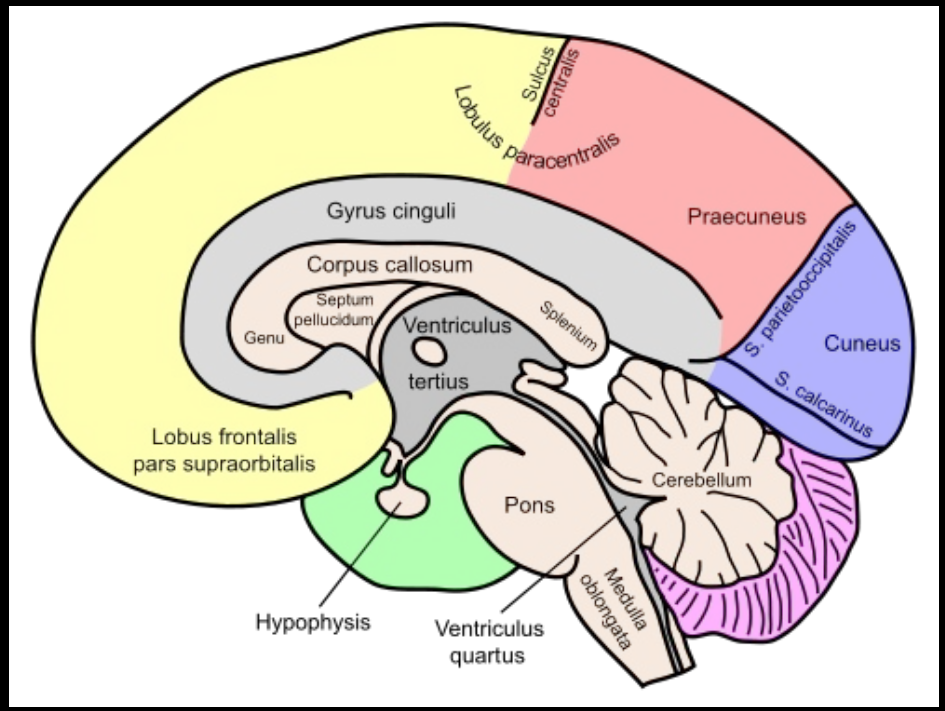
- Divides between the different areas within the Cortex isolate each sensory modality.
- Each such lobe has a Medical Name based on the plate of the skull that sits over it.

Cutting the Brain Down the Middle



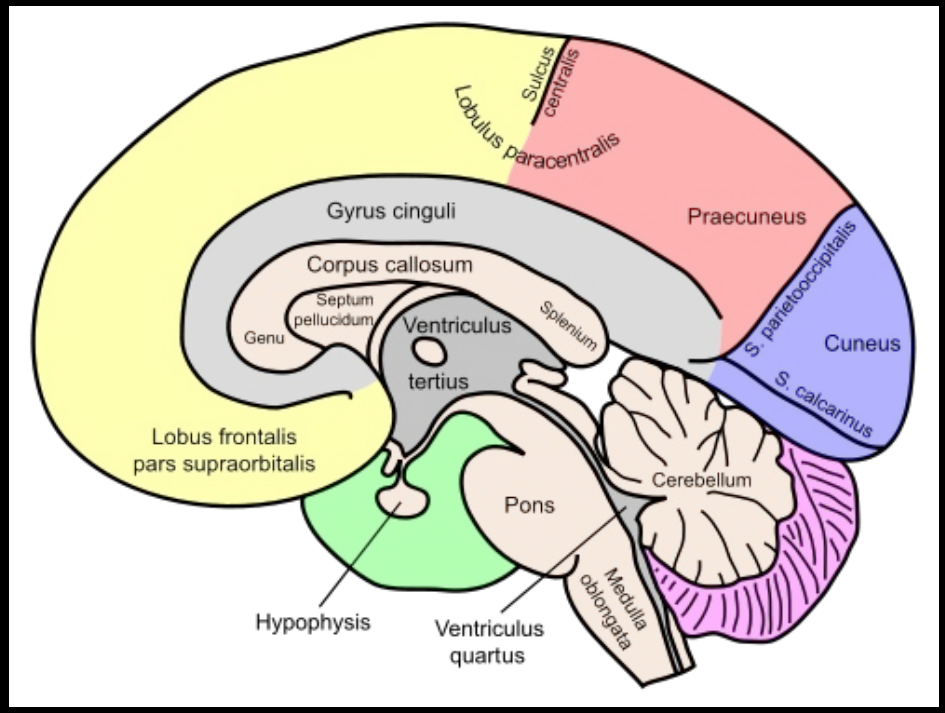
- A view like this, is called a saggital section. It is created by cutting the brain down the center line between the hemispheres. As you can see, the Cerebral Cortex is the outer layer and much more is hidden

Features Hidden under the Cortex



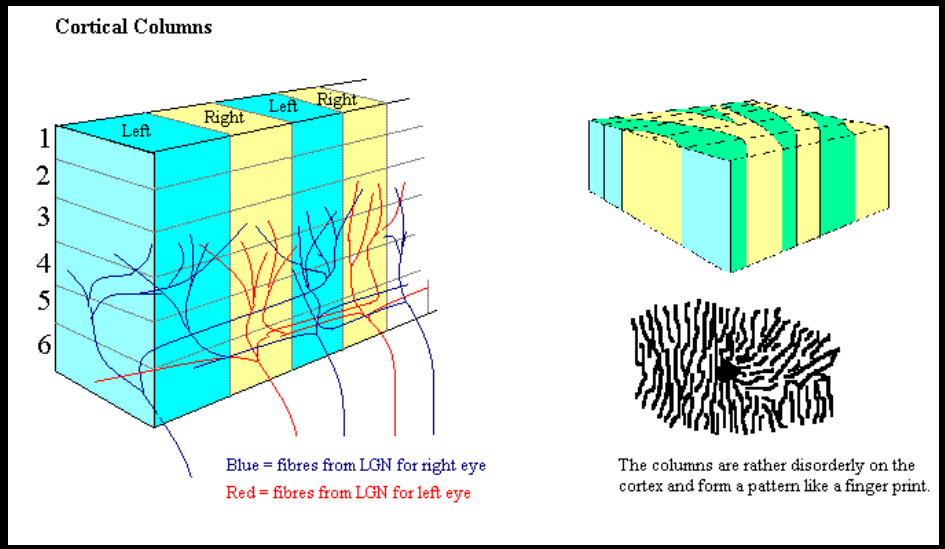
- In this picture you see some of the different features of the area under the cortex picked out with color.
- Of interest is the Cingular gyrus (grey) the Basal Ganglia (green) and the Corpus Collosum (tan) under the C.G.

The Telencephalic Cortex



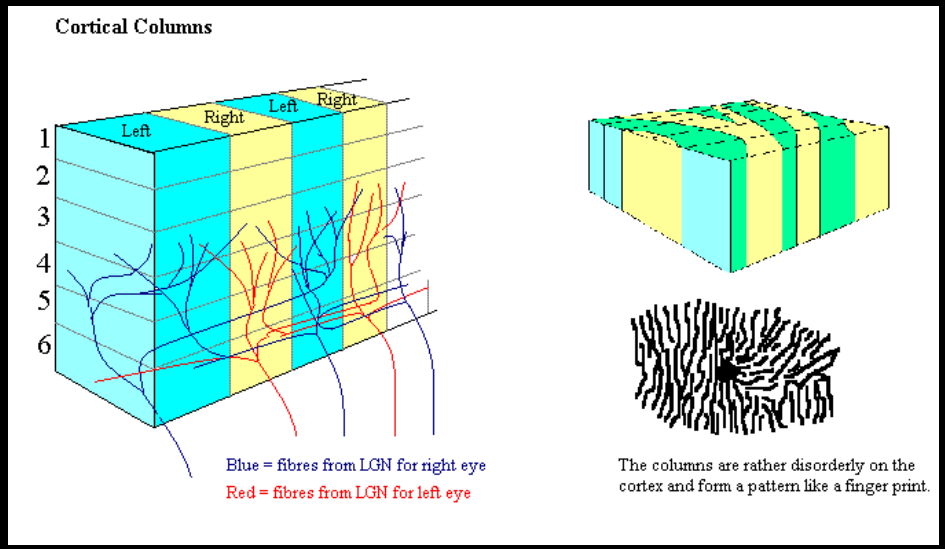
- The Telencephalic Cortex consists of the Cerebral Cortex, and the Cingulate Gyrus, which connects to the Hippocampus.
- Most of the cortex tissues in the brain are either in the Telencephalic or Cerebellular cortex.

Isocortical Tissue



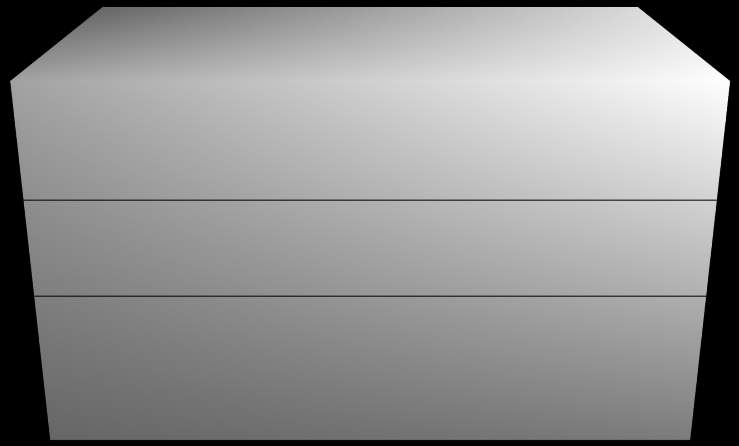
- Most of the Cortical Tissue in the brain is Isocortical or Six layer Tissue as illistrated.
- Some areas have more layers such as the occipital Lobe, and other areas have fewer

Agranular Tissues



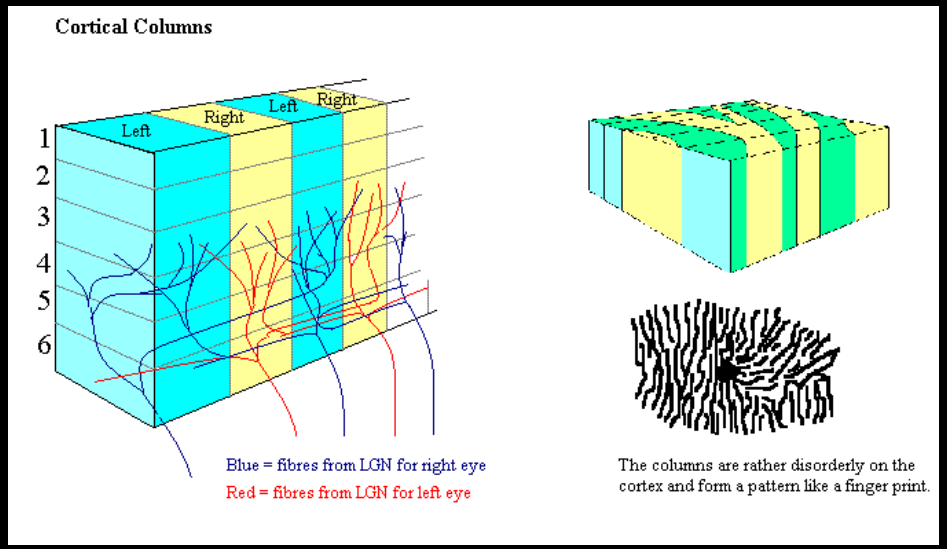
- When a basically Isocortical Tissue is missing the 4th layer or Granular Layer it is called Agranular.
- The granular layer is connected to the LGN in this drawing.

Allocortical Tissue



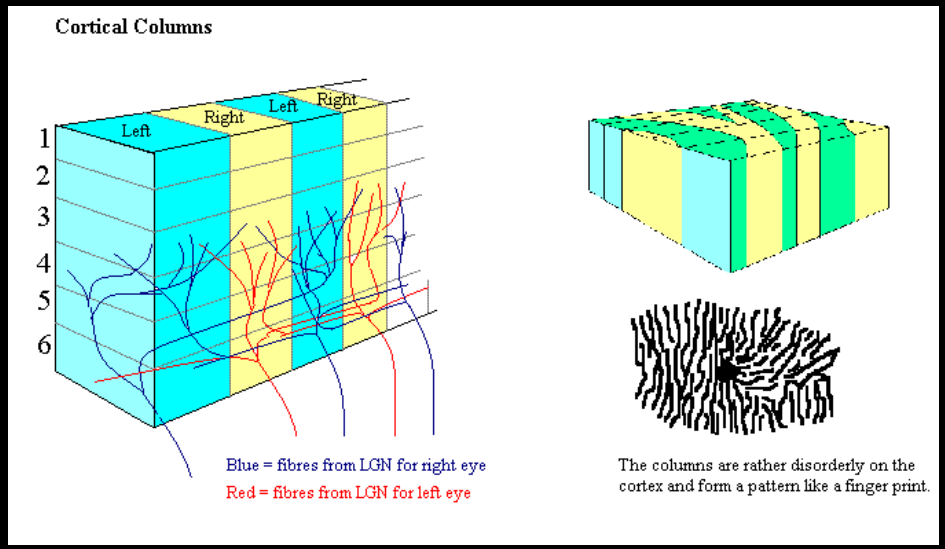
- Allocortical Tissue is Cortex Tissue that does not follow the 5 layer or more rule.
- Some Allocortical Tissues have only 3 layers some have as many as 5 but are differently organized than Isocortical Tissues.

Allocortical Layers



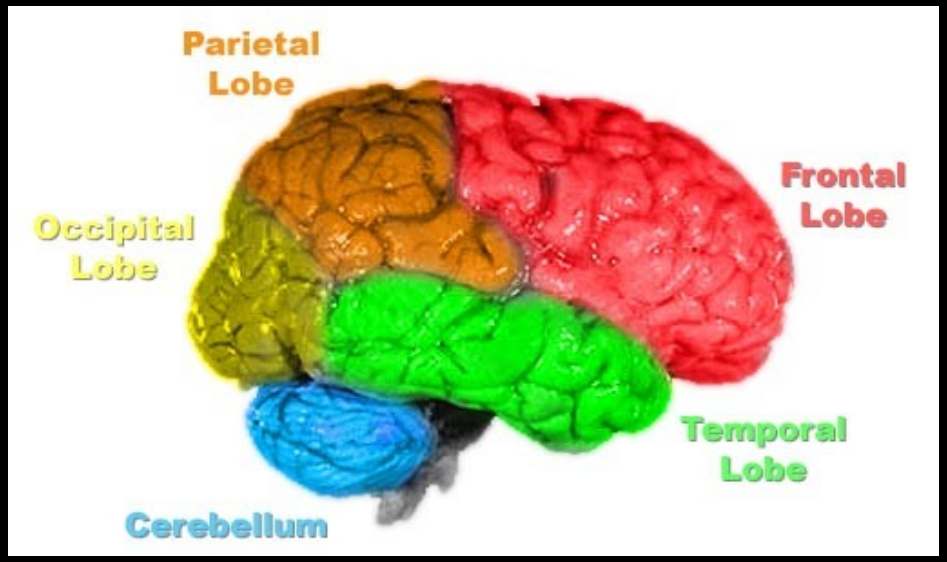
- One hypothesis is that the top three layers of the Isocortical tissues are actually Allocortical
- This means that Isocortical tissues have Allocortical functions plus something else.

Isocortical Columns



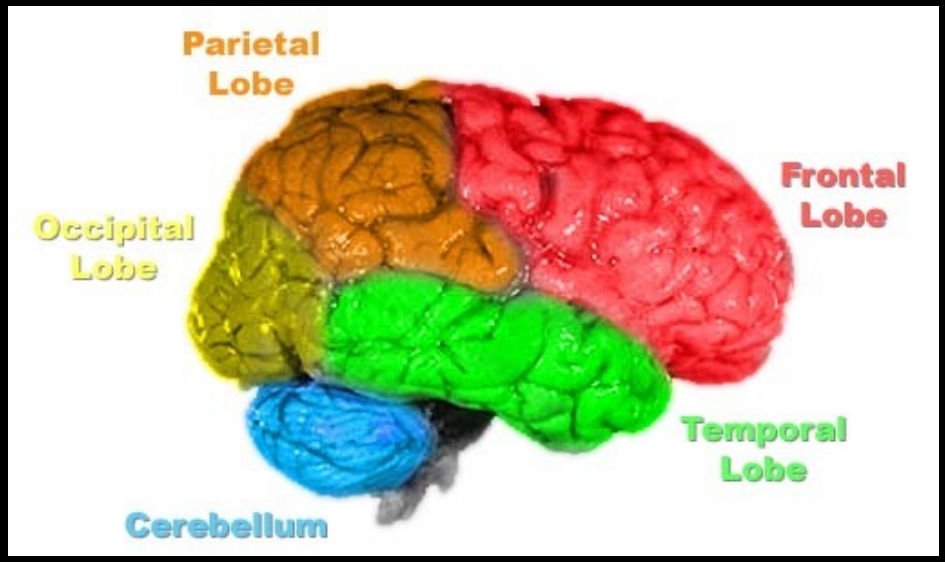
- In this hypothesis the Isocortical Columns are part of this new function that is added onto the base Allocortical function.
- Theoretically organizing the memory into columns makes it easier add-ressing specific areas

Sensory Modality



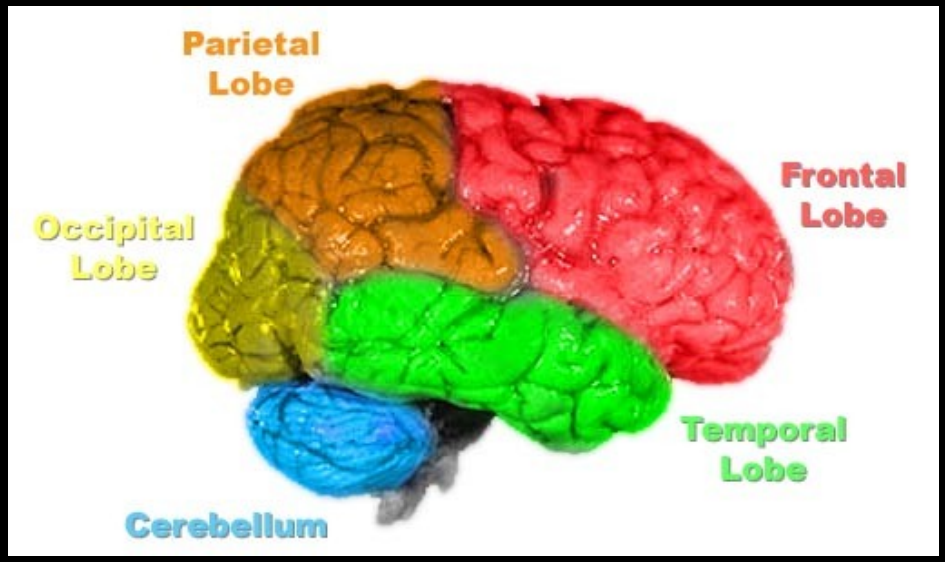
- Each lobe of the brain with the exception of the frontal lobe, is associated with a particular sensory input.
- The Occipital Lobe seen here at the far left, is the visual processing center

Other Modalities



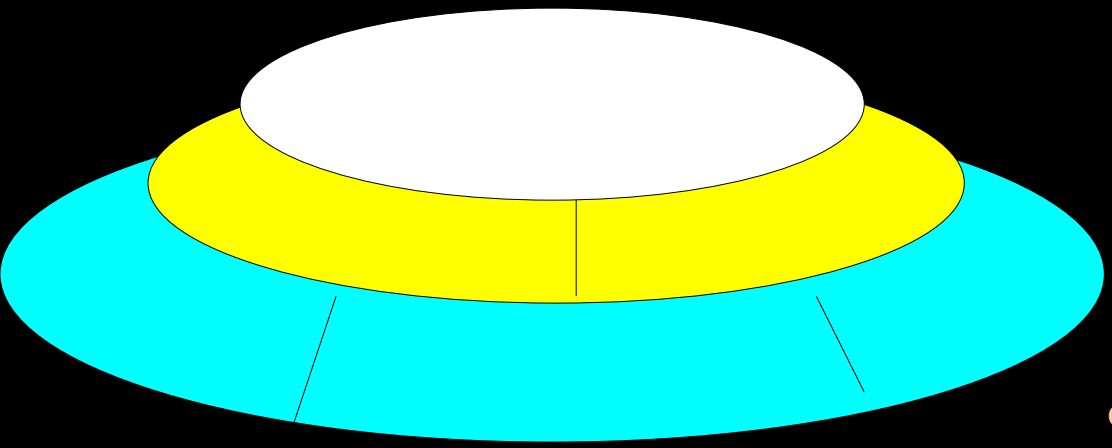
- The Parietal Lobe above it seems to take proprioceptive inputs
- The Temporal Lobe seen here in green seems to take auditory inputs

The Frontal Lobe



- While the frontal lobe Seen here in Red, has the sensory center for the olfactory sense, it is such a small portion of the lobe that it is not considered its main utility, which seems to be higher processing functions.

Sensory Processing Centers



- Each Sensory Modality has essentially three types of cortex tissues.
- Core (white)
- Belt (yellow)
- Associative (blue)

Core Processing Centers

- The Core Processing Center is the primary perception area for that sensory modality.
- Core areas stain darker with an AcetylCholine based stain.
- There is a hypothesis that the primary perception is based heavily on the output of the Implicit Memory, and doesn't easily isolate into specific memory elements

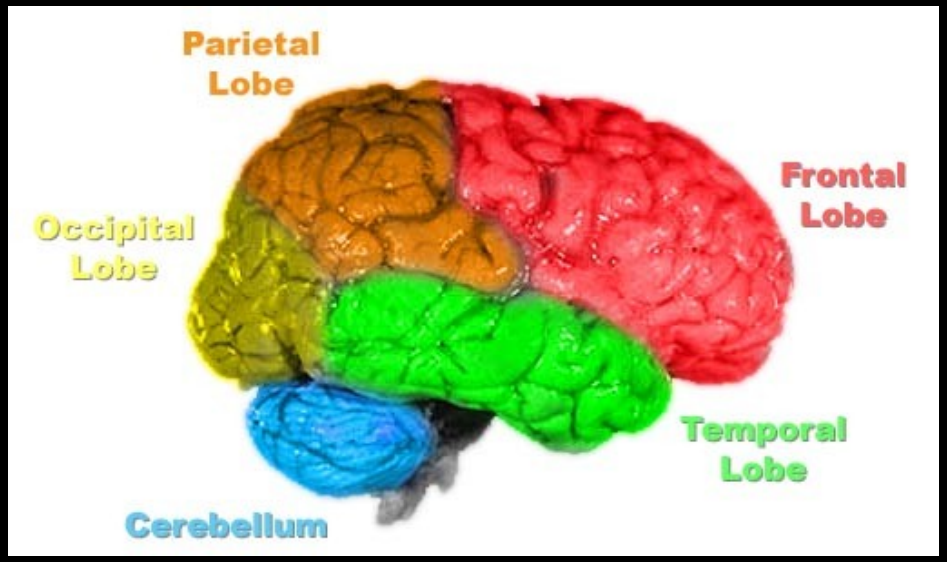
Belt Processing Centers

- The belt centers take their output directly from the core areas as well as from sensory sources, it is hypothesized that in this area of the processing centers, individual elements of memory are isolated, and compared with each other.
- This makes for a more explicit memory system where individual elements can be picked out of the background clutter

Association Areas

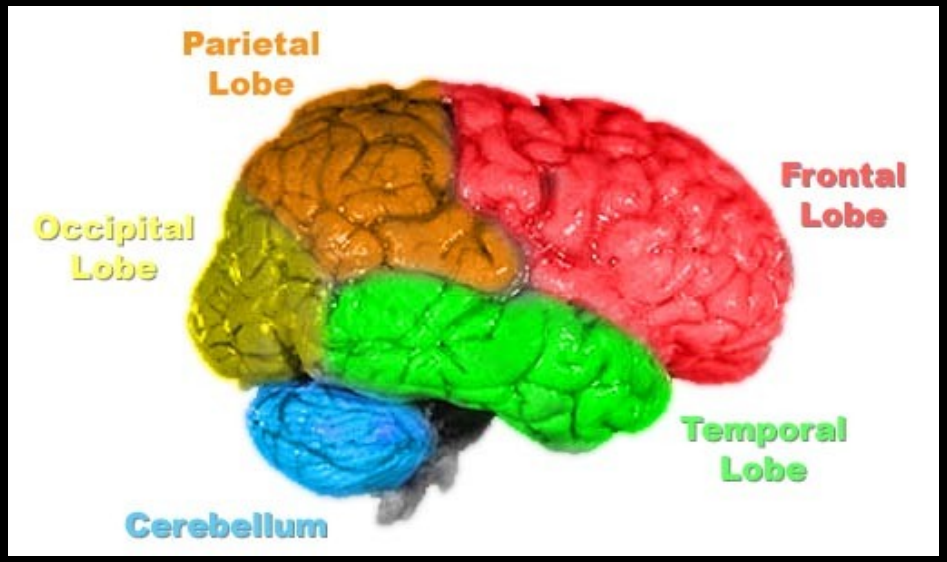
- The Association Areas take input mainly from the belt areas.
- The hypothesis is that these areas determine how memory elements associate or relate to each other.
- David Hofsteader attempted to capture this function in a program called “Copycat” which implemented something he called a “Slipnet”

Advanced Processing



- Processing routes through the cortex for even more advanced processing include a where route that moves up the brain from the Occipital Lobe to the parietal Lobe. Parietal outputs include where in relation to the organism a stimulus is.

Auditory Where route

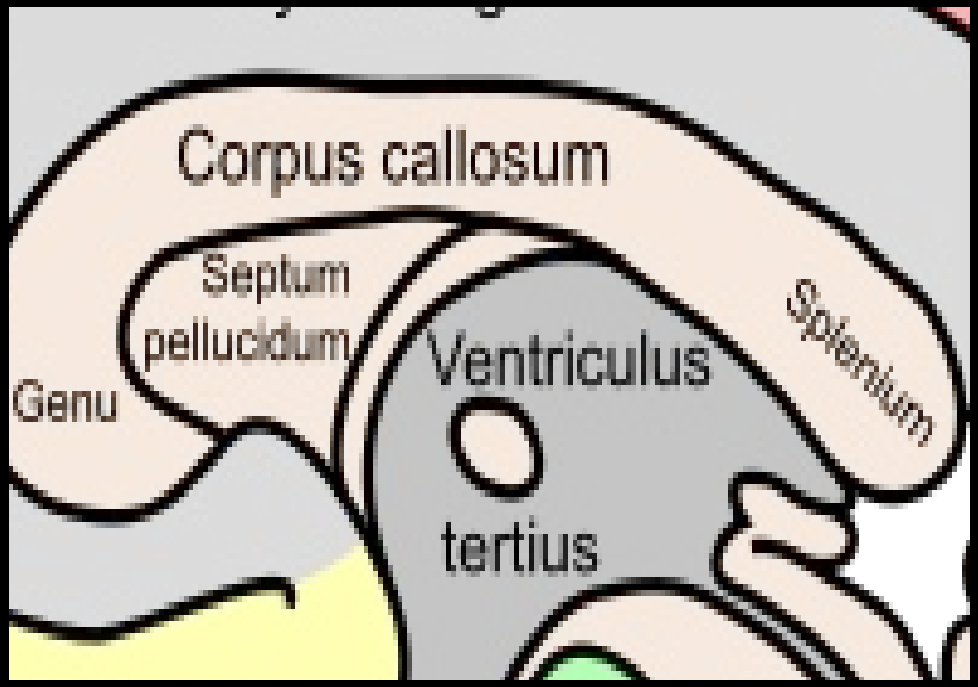


- A similar link from the auditory center at the top of the temporal lobe, probably sends signals on a where link for sounds.
- A link also projects from the occipital lobe to the temporal lobe called the What link.

Connectonics

- Recently work has been done using a post processing scheme called DSI that works from MRI data. This processing shows the patterns of connections throughout the brain.
- One discovery that is claimed for this processing method, is the discovery of an internal network that projects from modules all over the cerebral cortex forward to an area of the frontal lobe called the Anterior Cingulate Cortex.

Commissures

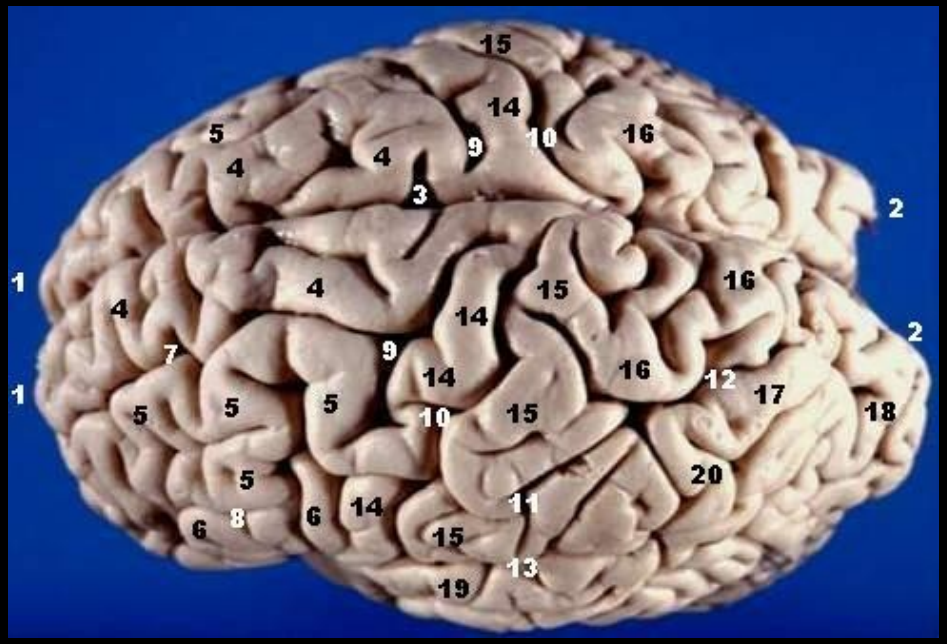


- The Internal Network is not the only set of connections within the brain, as well there are connections between the two hemispheres of the brain at locations called commissures.
- The Corpus Collosum is one of four of these.

Commissures

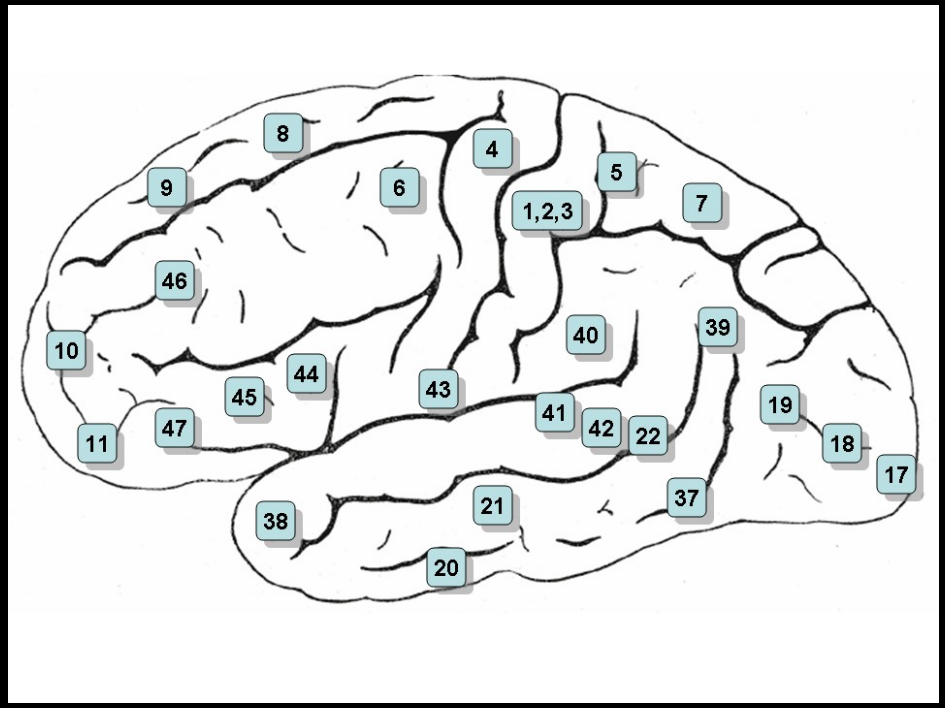
- These connections between the two sides of the brain are instrumental in coordinating the processing between the two sides.
- One connects the two hippocampi and the medial Temporal Lobes
- One connects the superior Temporal Lobes, and
- One connects the Occipital lobes it is this later one that may cause the pupils of the eyes to lose synchronization after a concussion.

Cortex Organization



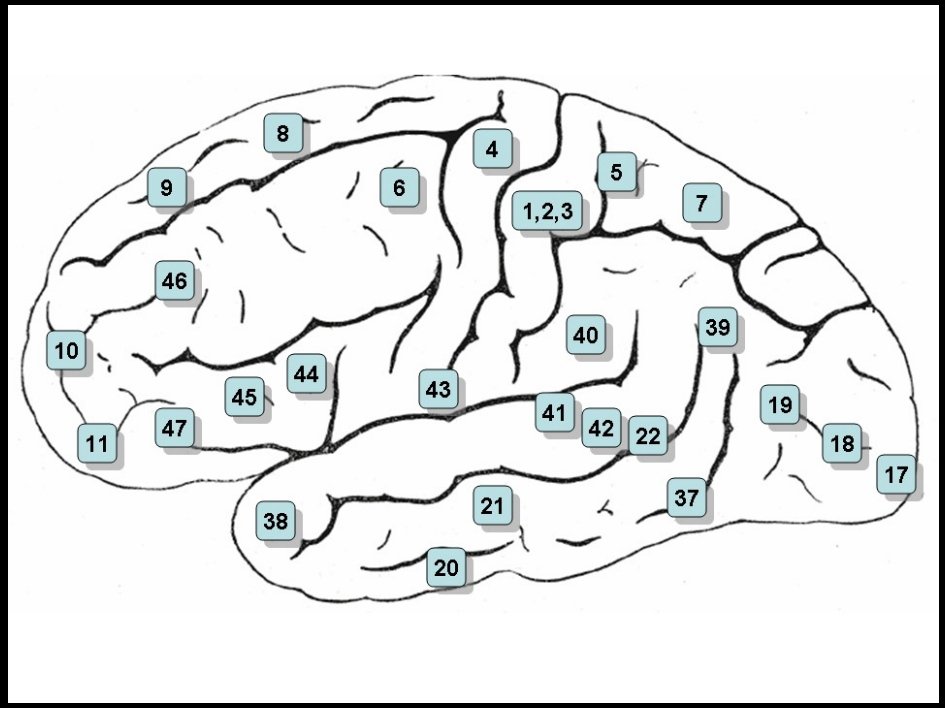
- The Cortex can be seen to be organized in areas approximately the size and shape of the folds in its surface
- Each bulge called a Gyrus and each fissure called a Sulcus seem to suggest natural separations in the brain.

Brodmann Areas



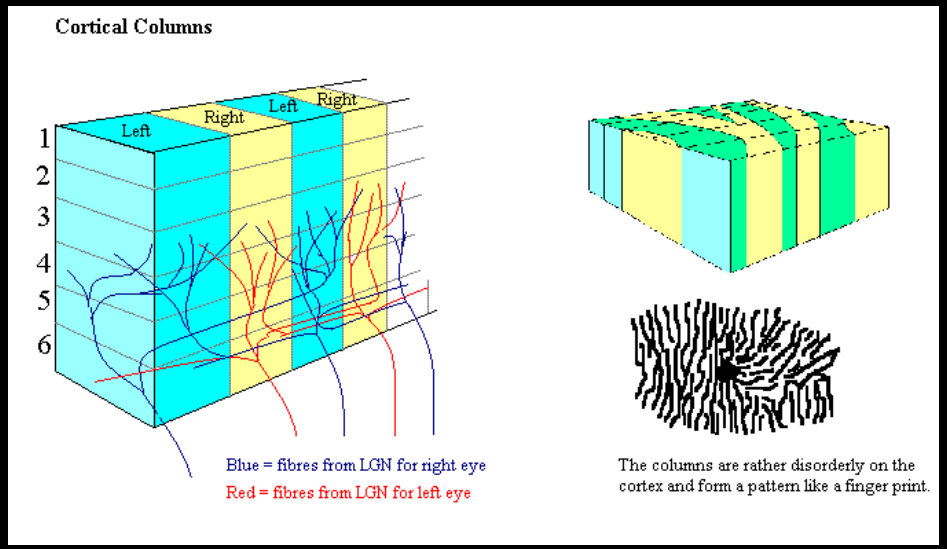
- Another way of organizing the brain lies in cataloging the changes in the micro-architecture of the Cortex.
- One popular method is Brodmann maps such as this one

Brodmann Areas



- The Structure of the Cortex, is mapped using staining studies.
- Changes in the way that the layers stain indicates changes in the micro-structure of the area

Architectonics

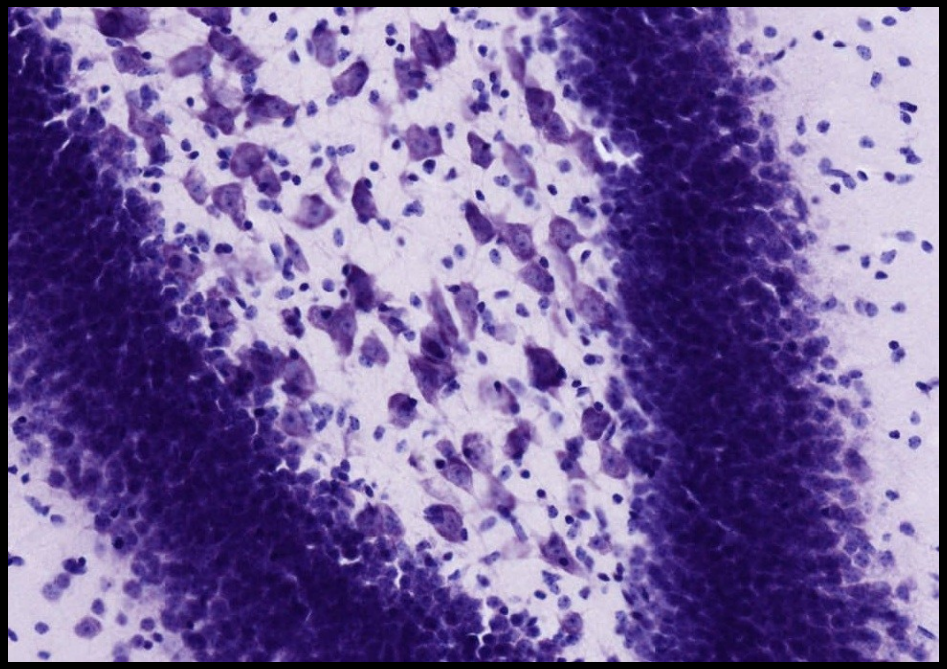


- It is the staining studies that have been used to develop the discipline of Architectonics which is what told us that the cortex had six layers.
- Core/Belt/Associative areas can also be determined by the way that they stain.

Why Stain?

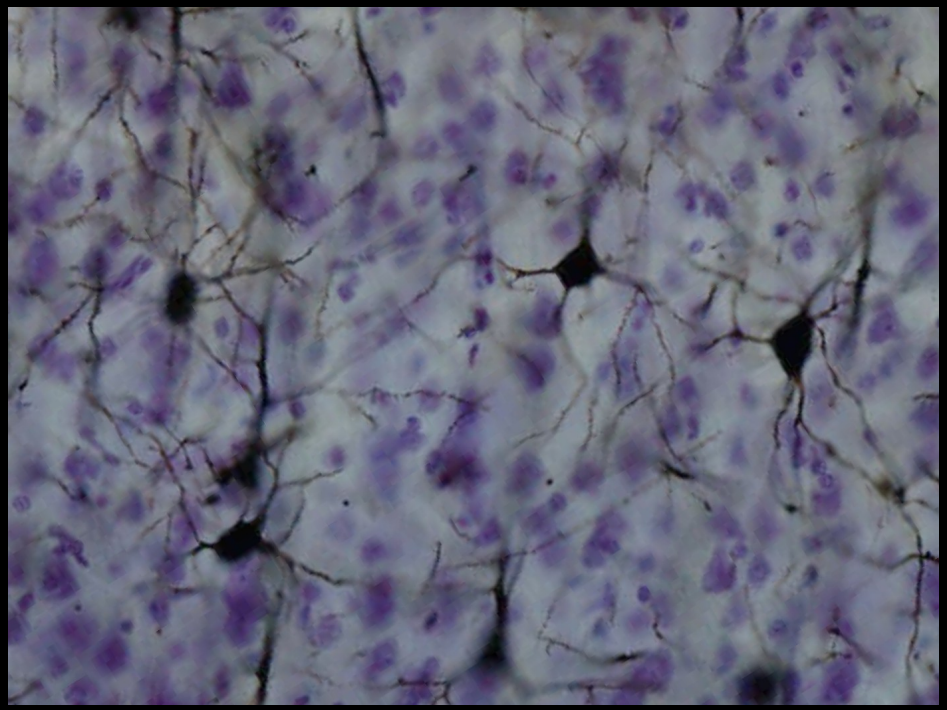
- The brain is unique in the body, because most of its cells are translucent and so it is very difficult to pick out detail even under a microscope.
- A possible exception is the separation of the Grey Area which is mostly active neurons and their supporter glial cells, and the White area which is mostly neural fibers, and the glial cells that produce Myelin.
- Myelin coats nerve fibers increasing the speed with which they transmit.

Nissl Stain



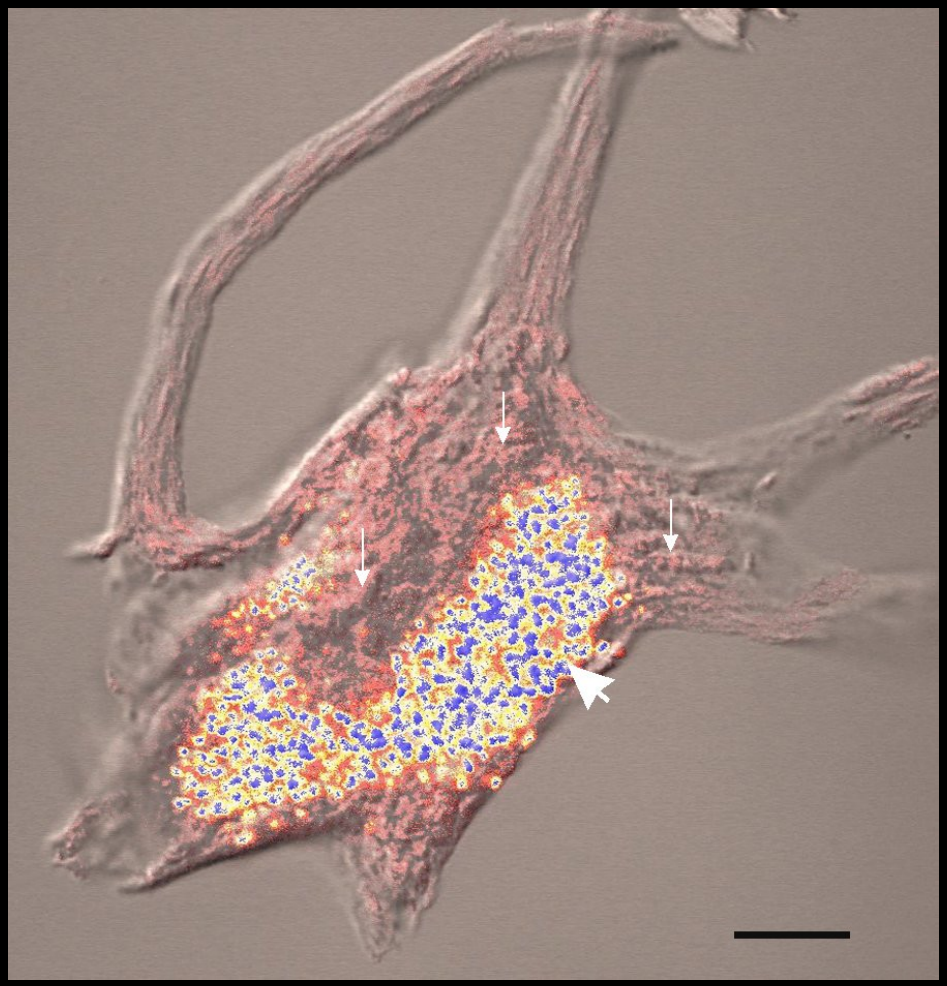
- The Nissl Staining Technique is inexpensive and Popular Producing a Purple stain as seen here.
- It is not however very accurate at depicting the smaller cells.

Golgi Staining



- Golgi staining results in black neurons
- However as you can see, here, if the section being stained is too thick, it does not offer much contrast.

Pigment Staining



- An example of a pigment stain is the stain for lipfuscin which gathers in some neural cells more than others.
- Pigment stains are more variable since only some cells present the pigment

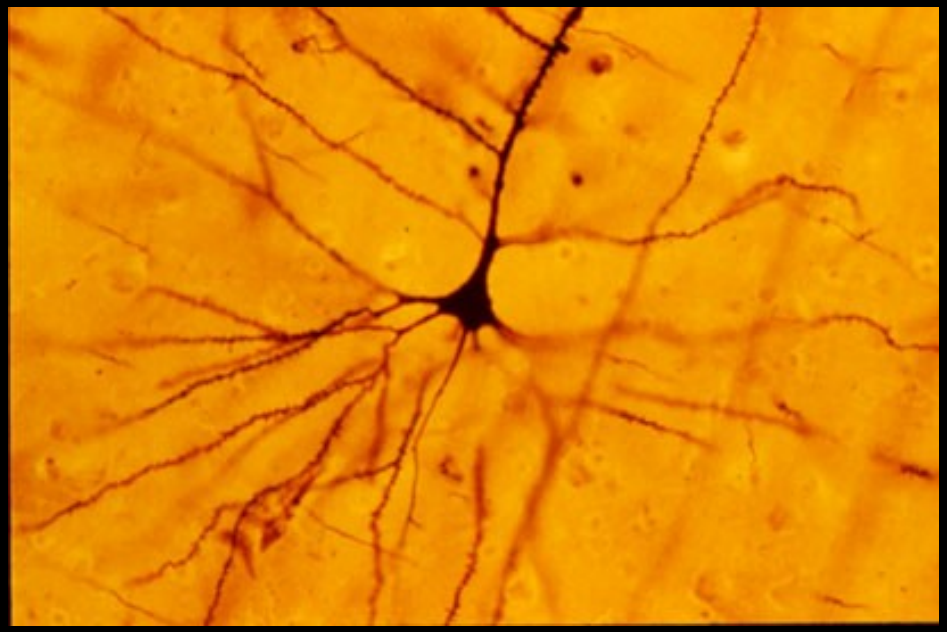
Cajal et al.

- Cajal was one of the first to publish a comprehensive book based on staining studies he used a silver stain that is too expensive for current studies.
- Currently Nissl staining is the main staining approach used in most online brain atlases.
- Nissle, Pigment, and Myelin staining have been used together to produce a more complete picture of the organization of the brain at the micro-level.

Pyramid Cells

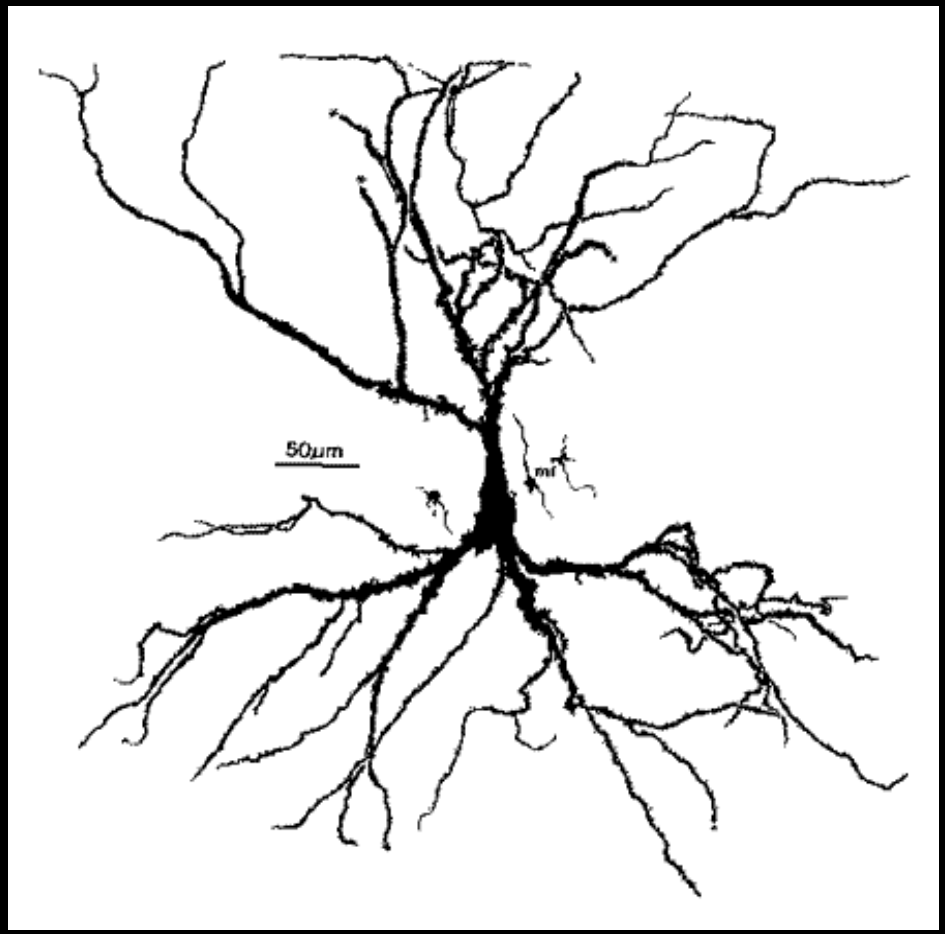
- From staining studies it has been shown that the Cortex tissues are dominated by Pyramidal cells, and cells that might be precursors to pyramidal cells called by some Modified Pyramidal cells.
- As well a certain number of stellate type cells have been found including but not limited to Martinotti Cells, Spiny Stellate cells, and pentagonal cells.
- The pyramidal cell is labelled because of the distinctive shape of its soma.

Golgi Stained Pyramidal Cell



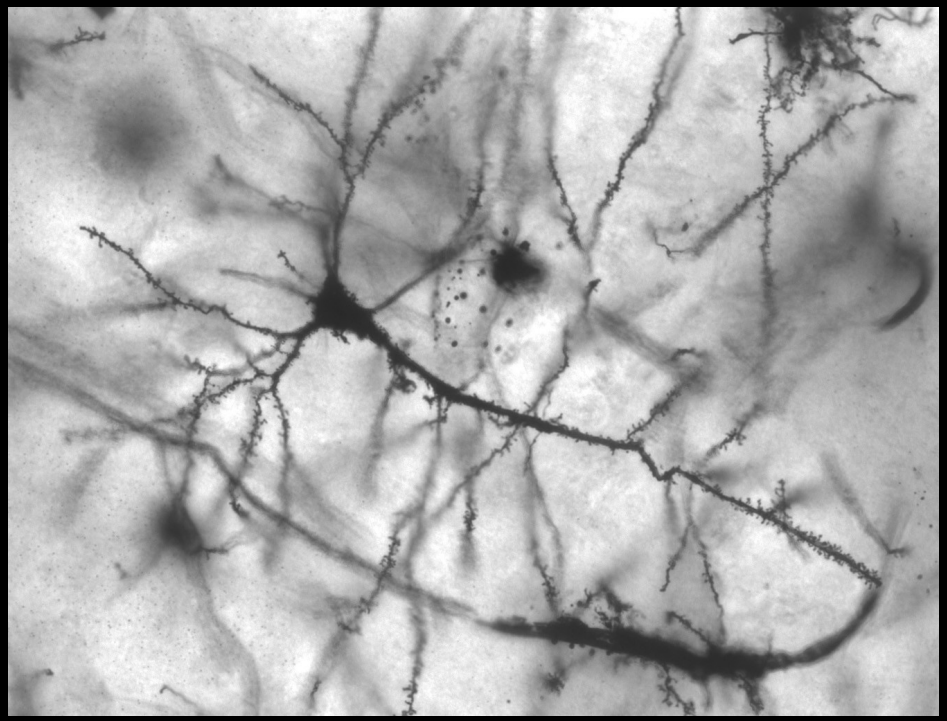
- Here we see a fairly typical Pyramidal cell, Note the Apical Dendrite, and the Basal Dendrites
- Modified Pyramidal Cells may have more dedrites coming out of the soma or Pyramidal cell body

Hippocampal Pyramid Cell



- Unlike Pyramidal Cells in the Cerebral Cortex, Hippocampal Pyramids have a radial rather than vertical orientation.
- The Apical Dendrite is much more complex as a result.

More realistic View

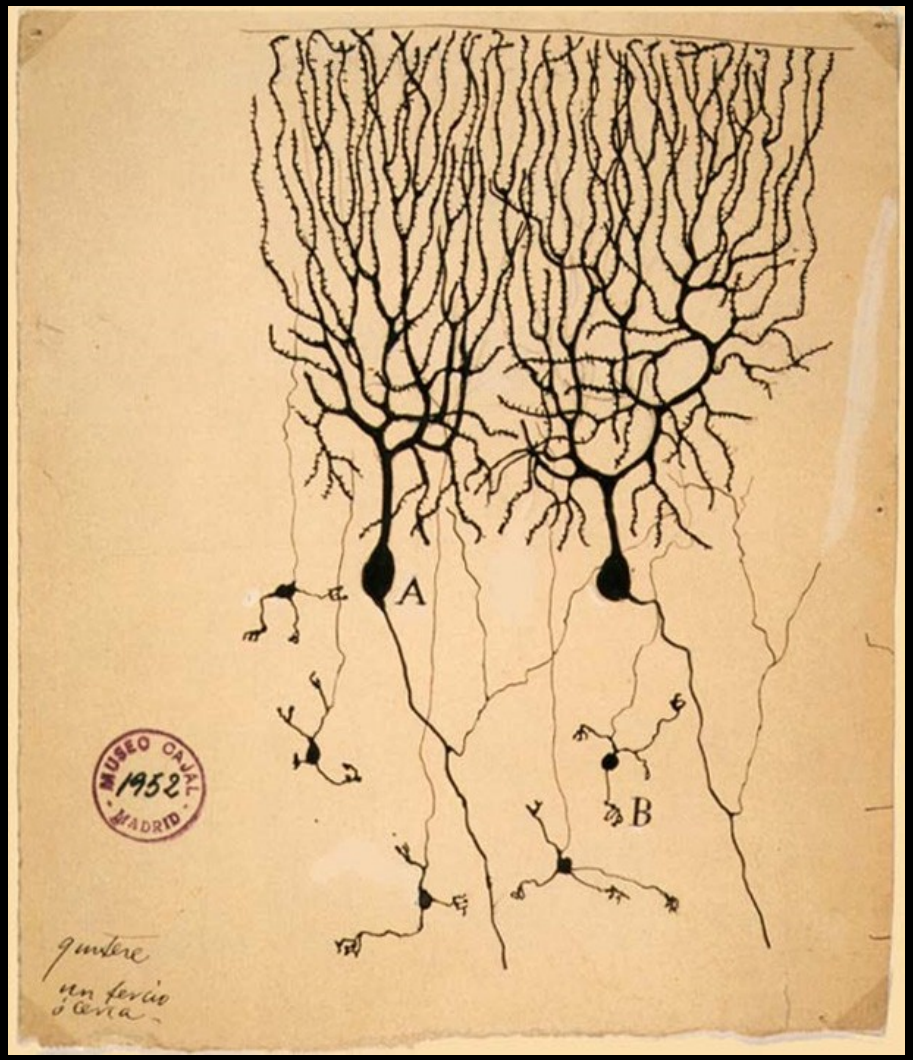


- Unlike the previous two preparations which segregated the neurons, most sections, have multiple neurons that are intertwined, and at different focal lengths confusing the picture

Memory Cells

- It is my contention that pyramidal cells have their unique shape because they are optimized for planar organization, and they are also optimized for a storage role.
- There are uncounted numbers of pyramidal cells in the Telencephalic Cortex, most of them too small to be seen except by pigment staining techniques.

Purkinje Cells

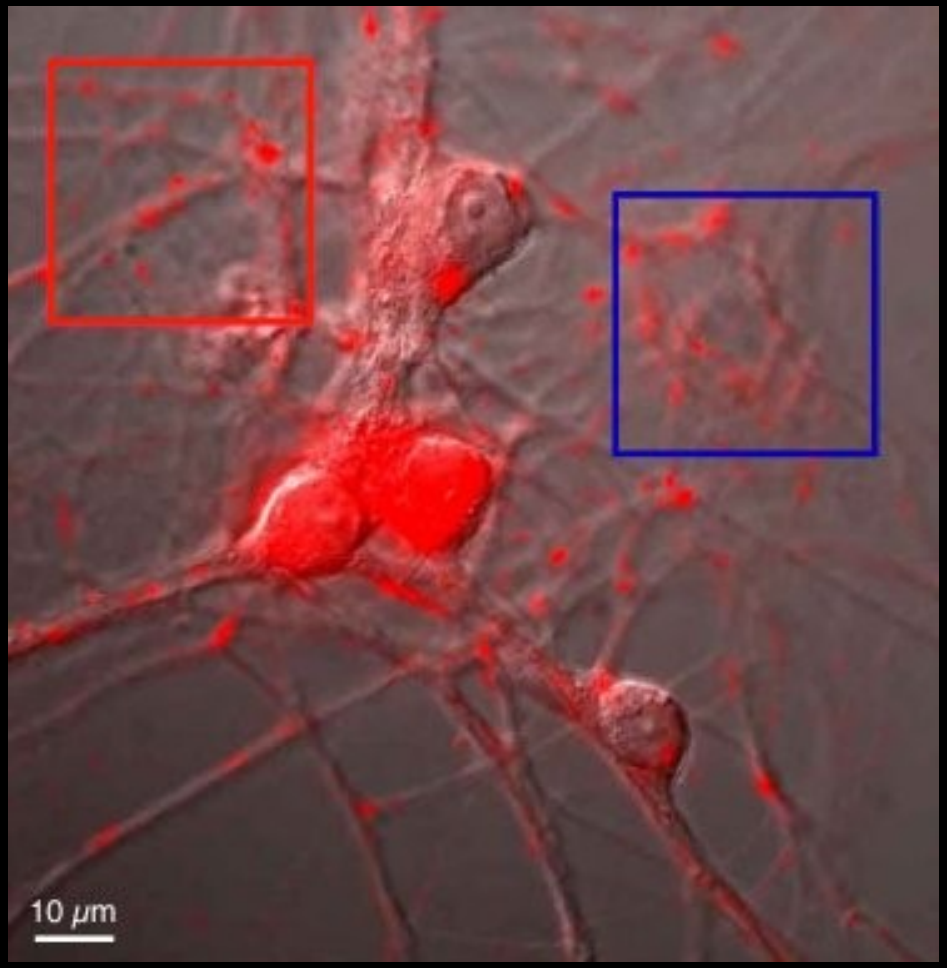


- The Purkinje Cell, has a significantly more complex Dendritic Structure
- It has been suggested that this structure allows multiple memories to activate in sequence

Processing Cells

- The stellate cells are probably processing cells, processing cells have bushy dendritic processes to calculate their outputs, and often have bushy Axions to spread the results over a wide area.
- An example is the Martinotti Cell which is thought to promote columns by inhibiting responses from outside the column.

Spiny Type Neurons



- An example of a processing neuron might be the spiny type stellate neurons seen here in a fluorescent red stain.
- These neurons are thought to influence the Martinotti cells allowing thalamic inputs to activate Columns.

Transport Cells

- Another type of cell that is optimized for its role is the bipolar cell. It seems to be optimized for transport of information within the brain, and to the body. It is interesting that studies of infant brains seem to suggest that bipolar cells dominate the cortex, and later turn into pyramidal cells.
- This might indicate that pyramidal cells are differentiated from bipolar cells, and that the brain uses this effect to first connect neurons and then allow them to learn to store data.

Memory Loops

- There are three main loops of neural fiber in the brain. One of these loops called the Main Memory loop connects the brain to the thalamus. It is thought to be the loop in which the brain stores most of its memory.
- Another connects the cortex and the hippocampus. It is thought to be the route by which long-term memory or perhaps episodal memory are formed.

Skill Memory

- The last neural fiber loop passes through the cerebral cortex, and the cerebellar cortex, and is thought to have something to do with skill memory.

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