# Cerebral Cortex

Lecture 4

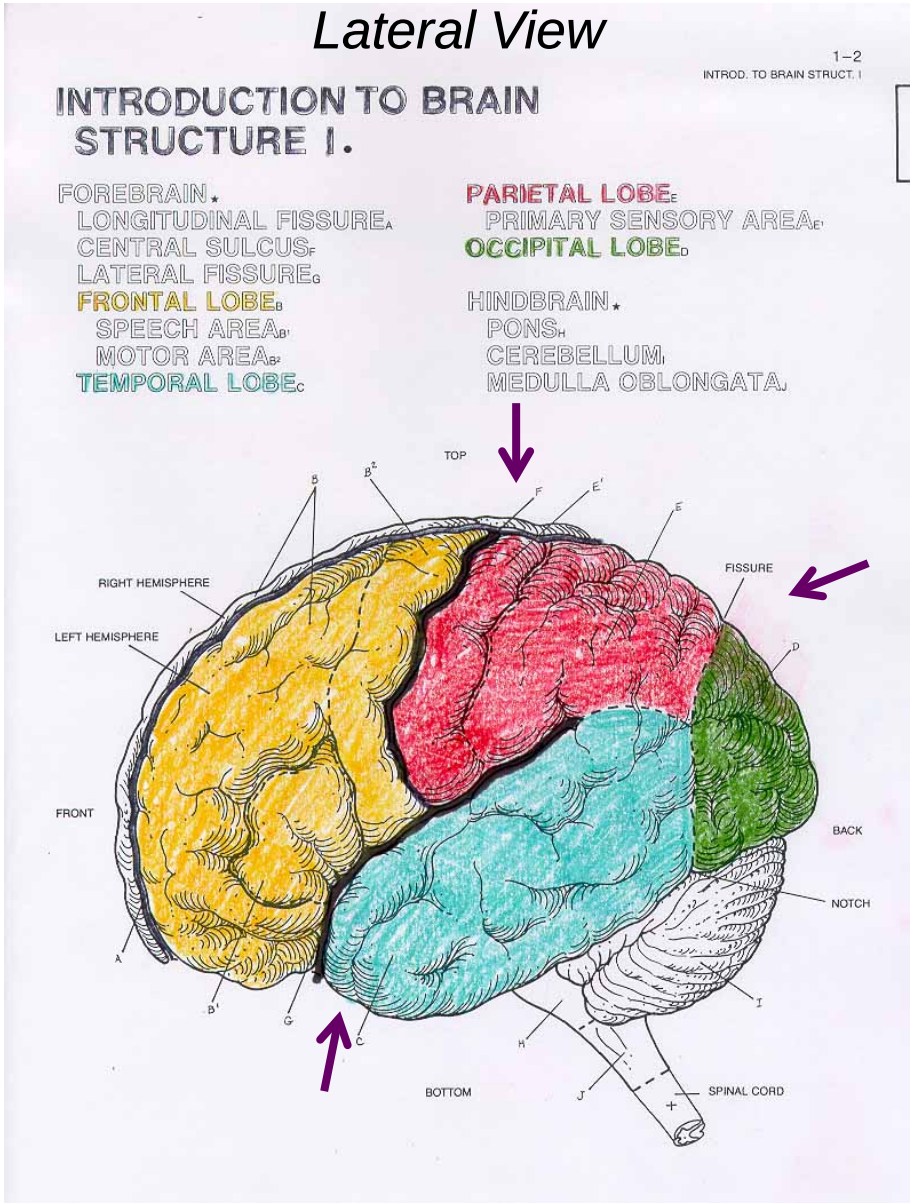
# Functional Specialization So Far

- Neurons and Nerves
  - Afferent, Efferent, Interneurons
- Peripheral Nervous System
  - Autonomic
    - Sympathetic, Parasympathetic
  - Somatic
    - Afferent, Efferent Pathways
- Brain
  - Hindbrain
    - Pons, Medulla, Cerebellum
  - Midbrain
    - Reticular Formation
  - Forebrain Subcortical Structures
    - Hypothalamus
    - Hippocampus
    - Amygdala

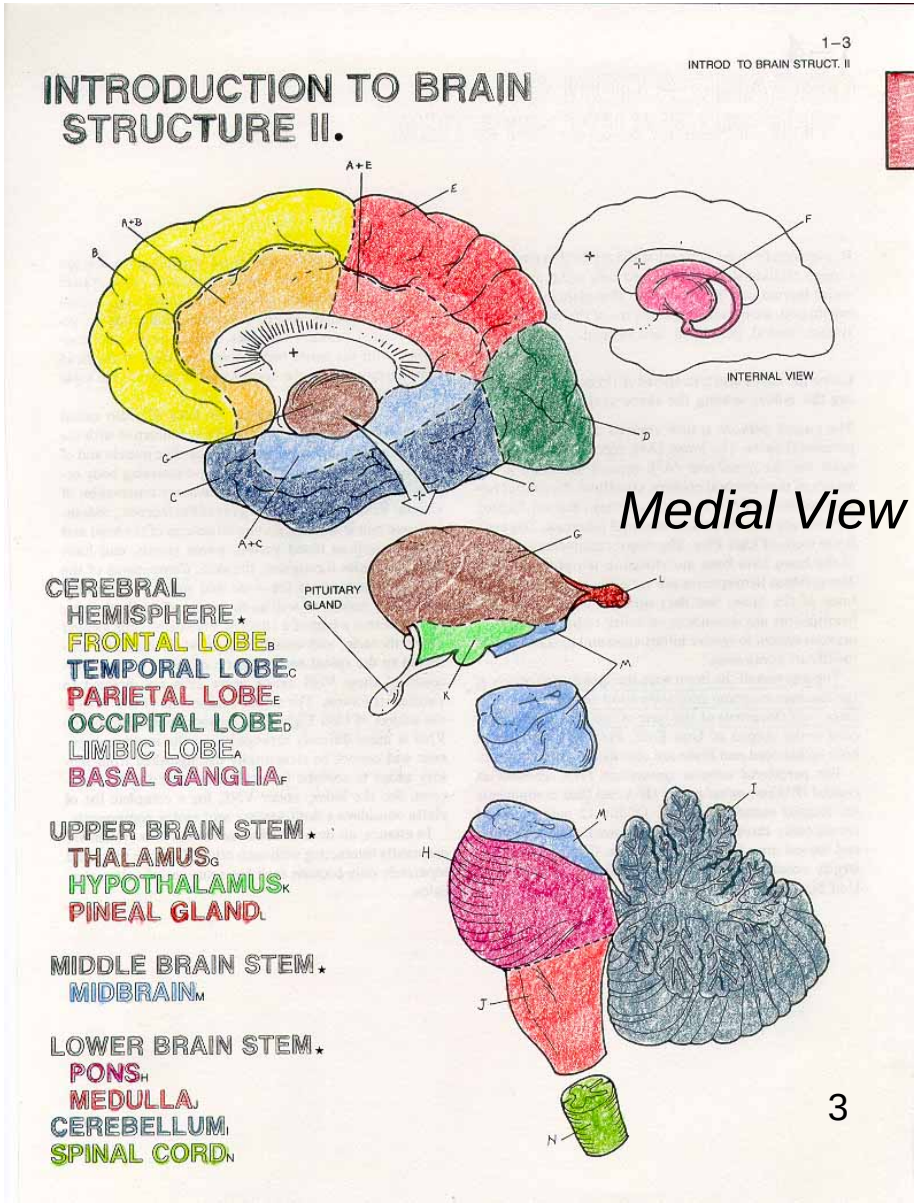
# Topography of Cerebral Cortex

Telencephalon

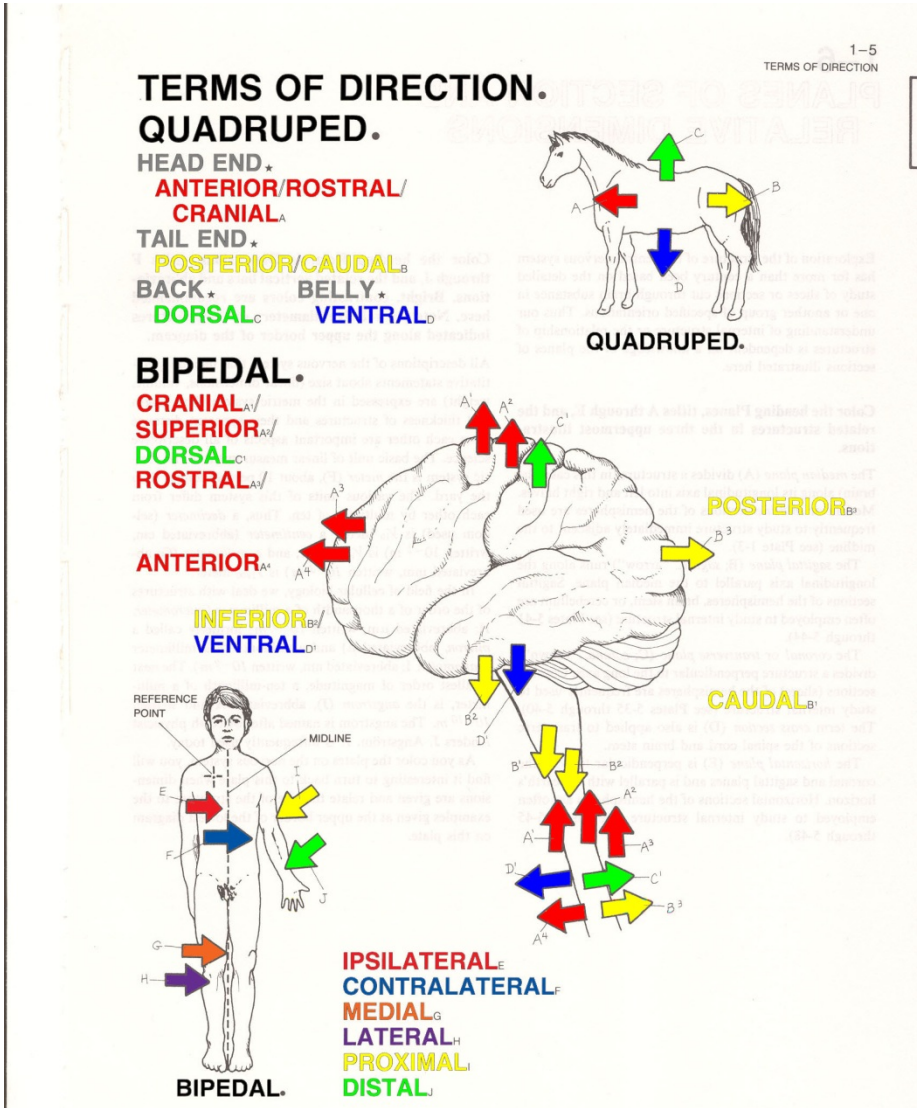
*Lateral View*

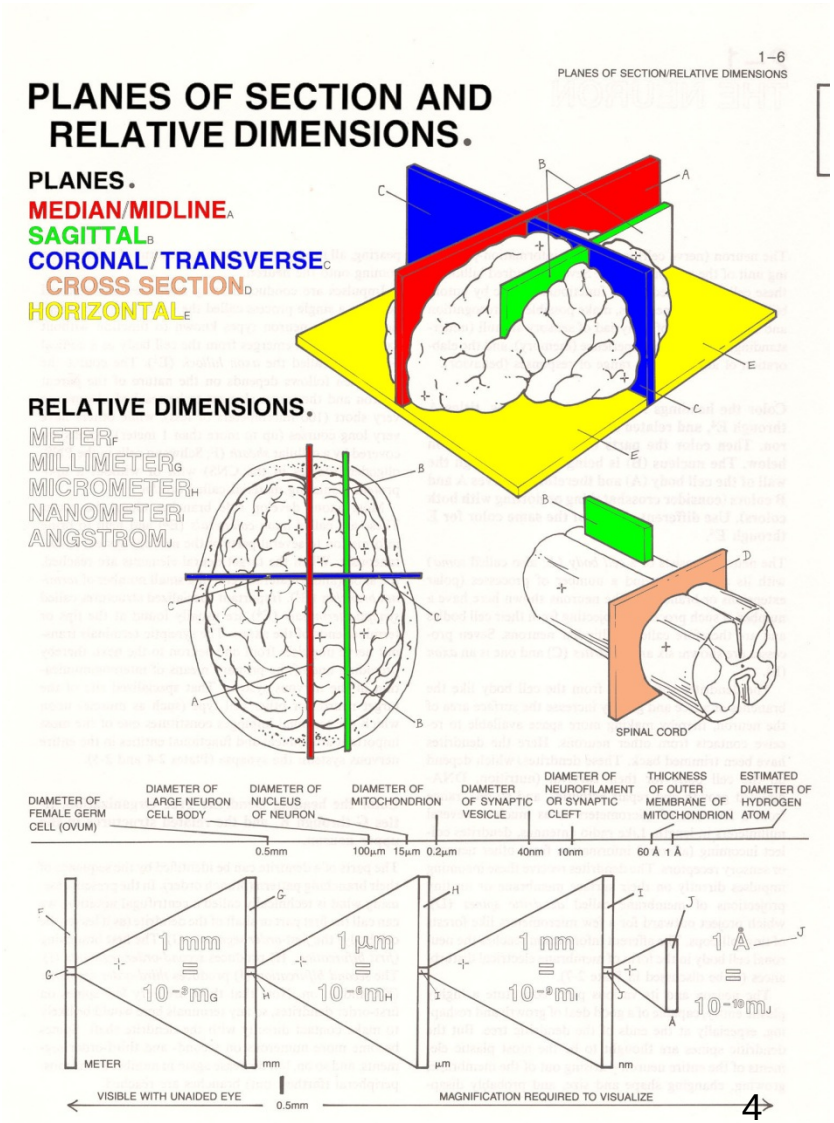



*Medial View*

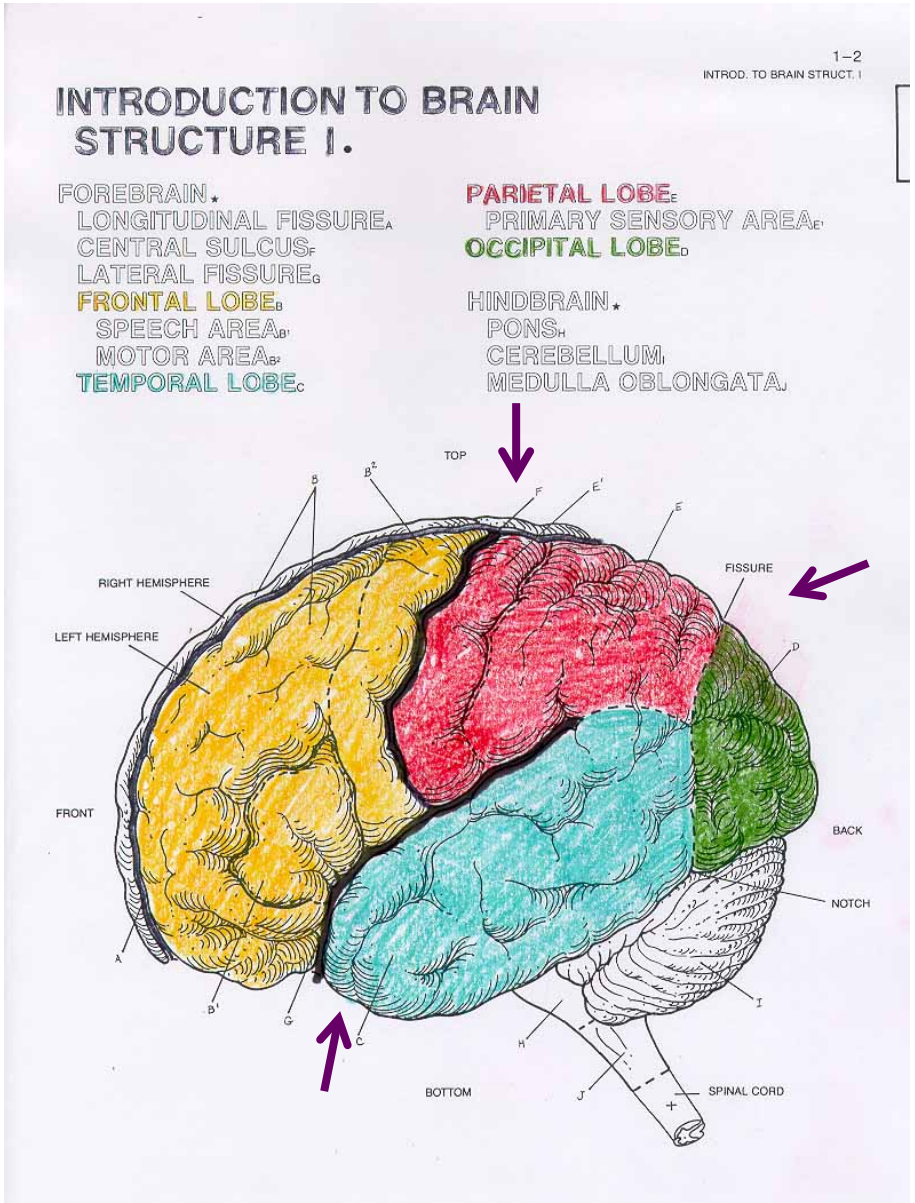


# Locating Yourself in the Brain



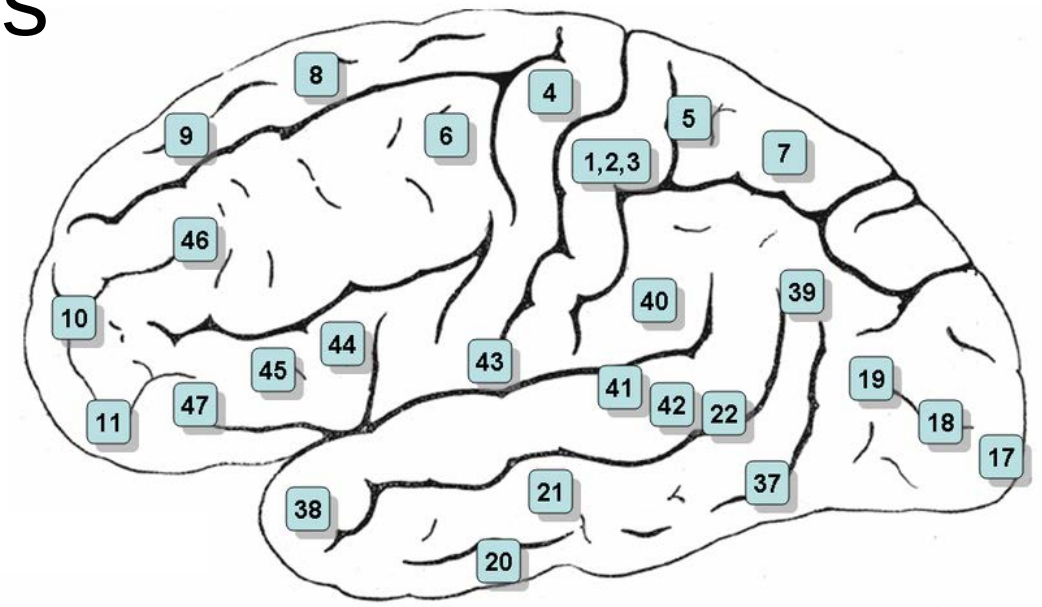
# Folds in Cerebral Cortex

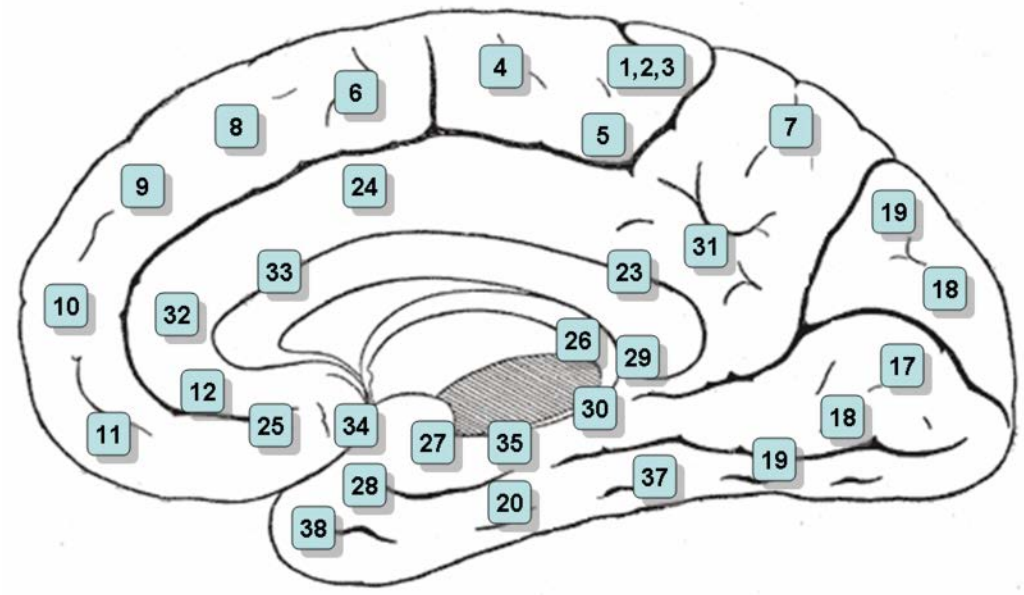


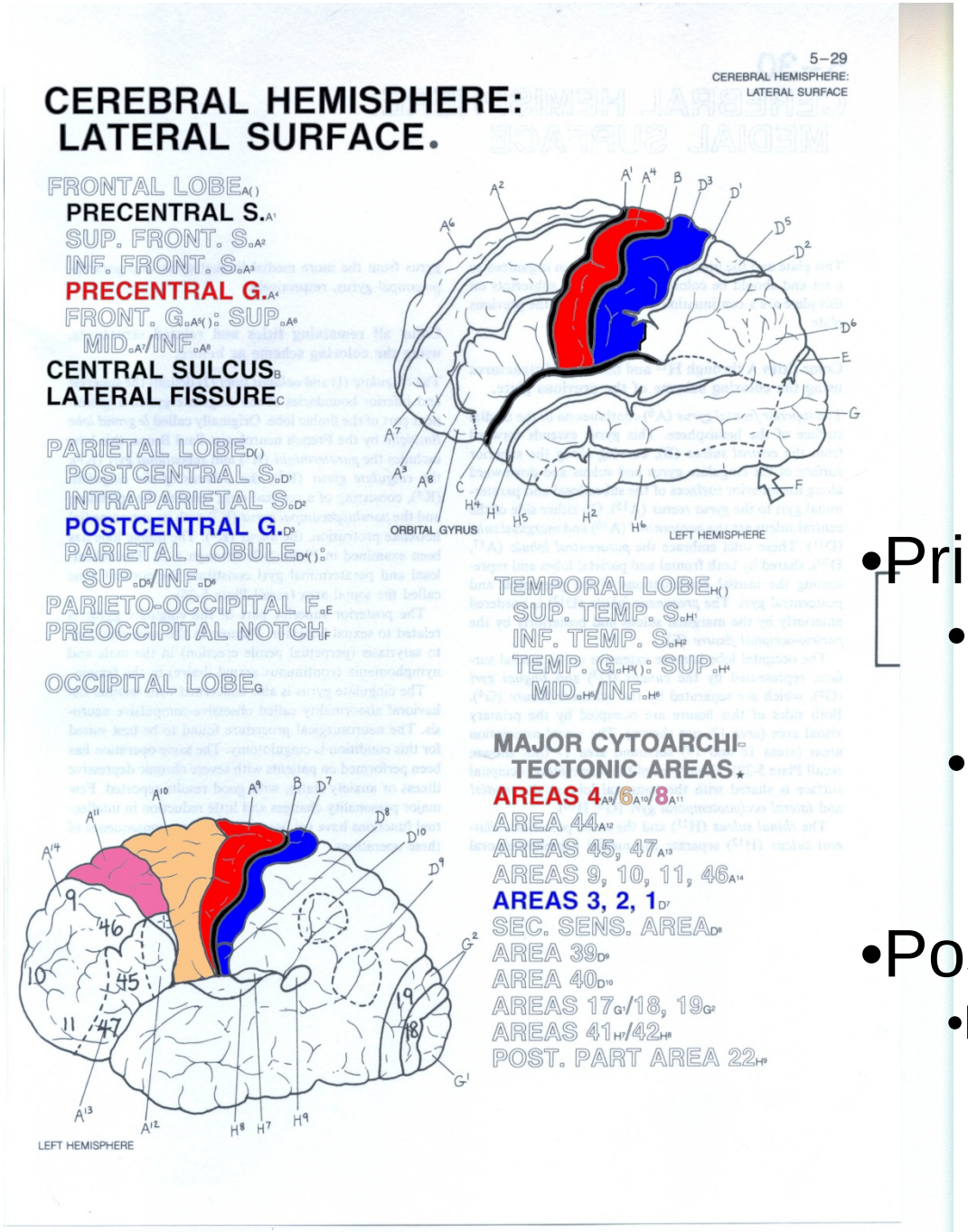

- Gyrus (Gyri)
  - Inferior Frontal
  - Superior Temporal
- Sulcus (Sulci)
  - Central Sulcus
  - Parieto-Occipital
  - Pre-Occipital Notch

# Cytoarchitectonics of the Cerebral Cortex

Brodmann (1909)





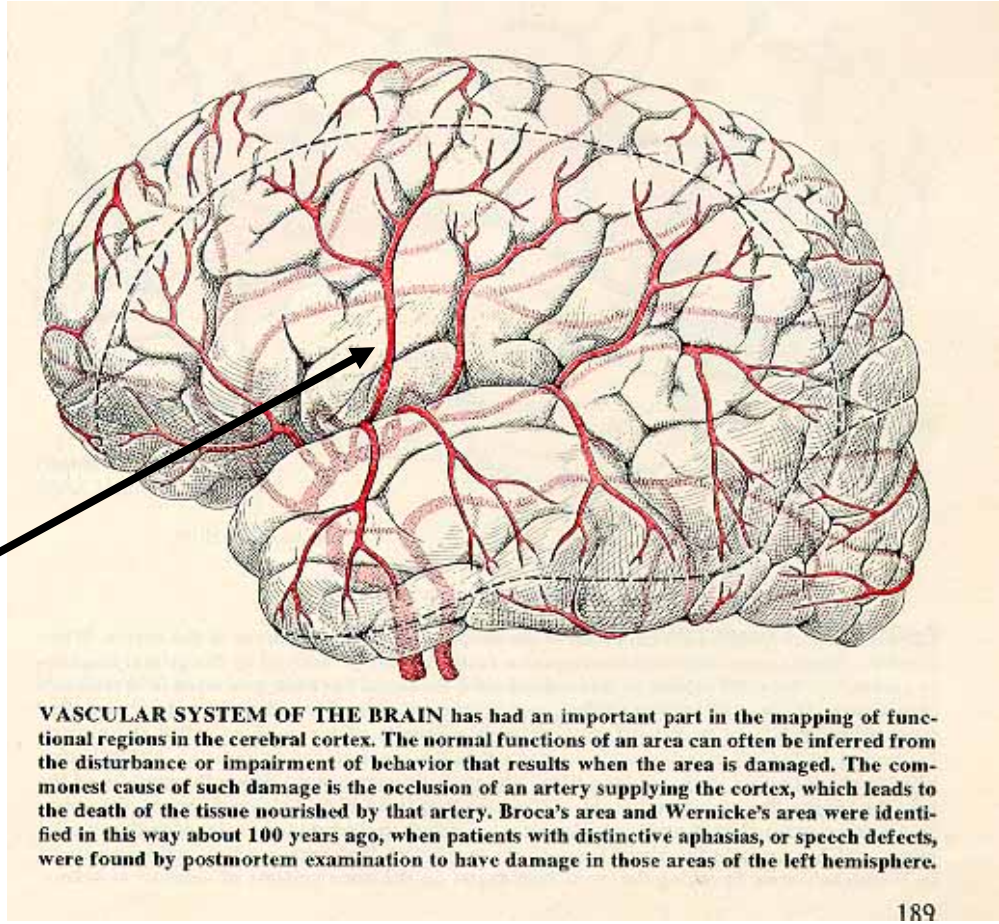

# Primary Motor and Somatosensory Areas

- Primary Motor Cortex
  - Precentral Gyrus
    - Brodmann Area 4
  - Premotor Cortex
    - Brodmann Area 6
    - Brodmann Area 8
- Postcentral Gyrus
  - Brodmann Areas 1-3

# Consequences of Stroke

## Insufficient Blood Supply to Brain

- Paralysis
  - voluntary motor function
- Anesthesia
  - tactile sensation
- Aphasia
  - speech, language



**VASCULAR SYSTEM OF THE BRAIN** has had an important part in the mapping of functional regions in the cerebral cortex. The normal functions of an area can often be inferred from the disturbance or impairment of behavior that results when the area is damaged. The commonest cause of such damage is the occlusion of an artery supplying the cortex, which leads to the death of the tissue nourished by that artery. Broca's area and Wernicke's area were identified in this way about 100 years ago, when patients with distinctive aphasias, or speech defects, were found by postmortem examination to have damage in those areas of the left hemisphere.

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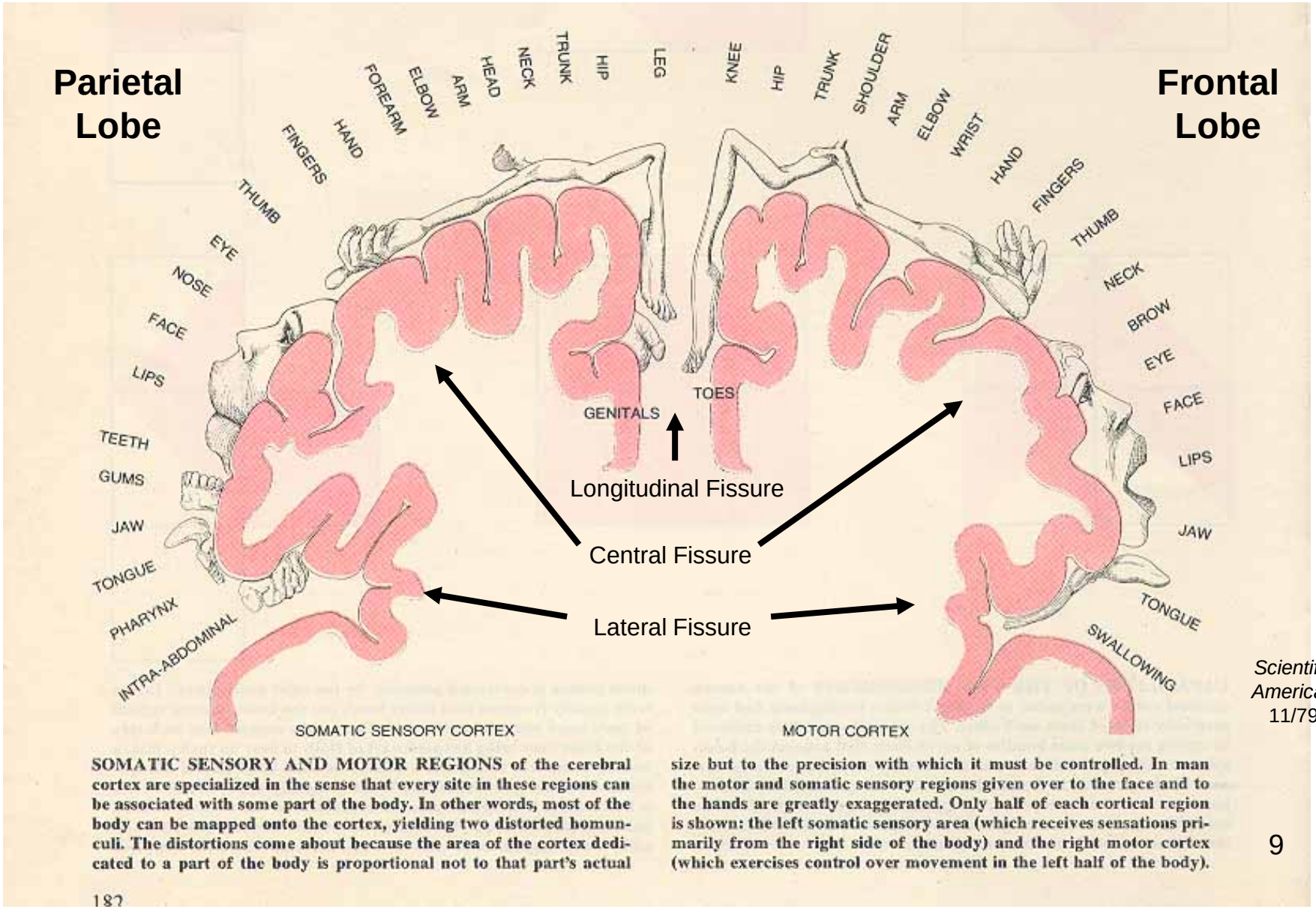
# Sensory and Motor Homunculus

Penfield & Jasper (1954)




**SOMATIC SENSORY AND MOTOR REGIONS** of the cerebral cortex are specialized in the sense that every site in these regions can be associated with some part of the body. In other words, most of the body can be mapped onto the cortex, yielding two distorted homunculi. The distortions come about because the area of the cortex dedicated to a part of the body is proportional not to that part's actual size but to the precision with which it must be controlled. In man the motor and somatic sensory regions given over to the face and to the hands are greatly exaggerated. Only half of each cortical region is shown: the left somatic sensory area (which receives sensations primarily from the right side of the body) and the right motor cortex (which exercises control over movement in the left half of the body).

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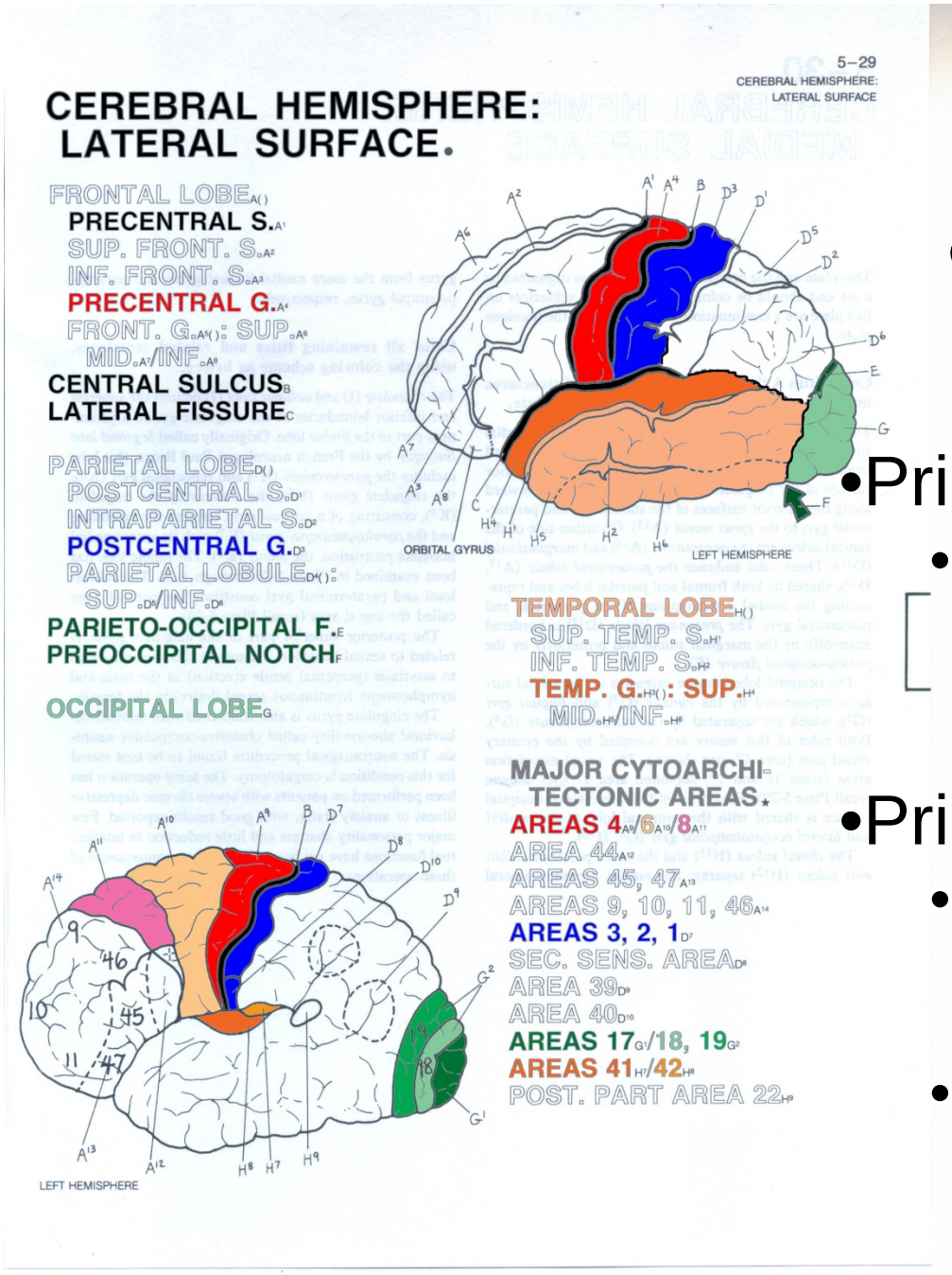
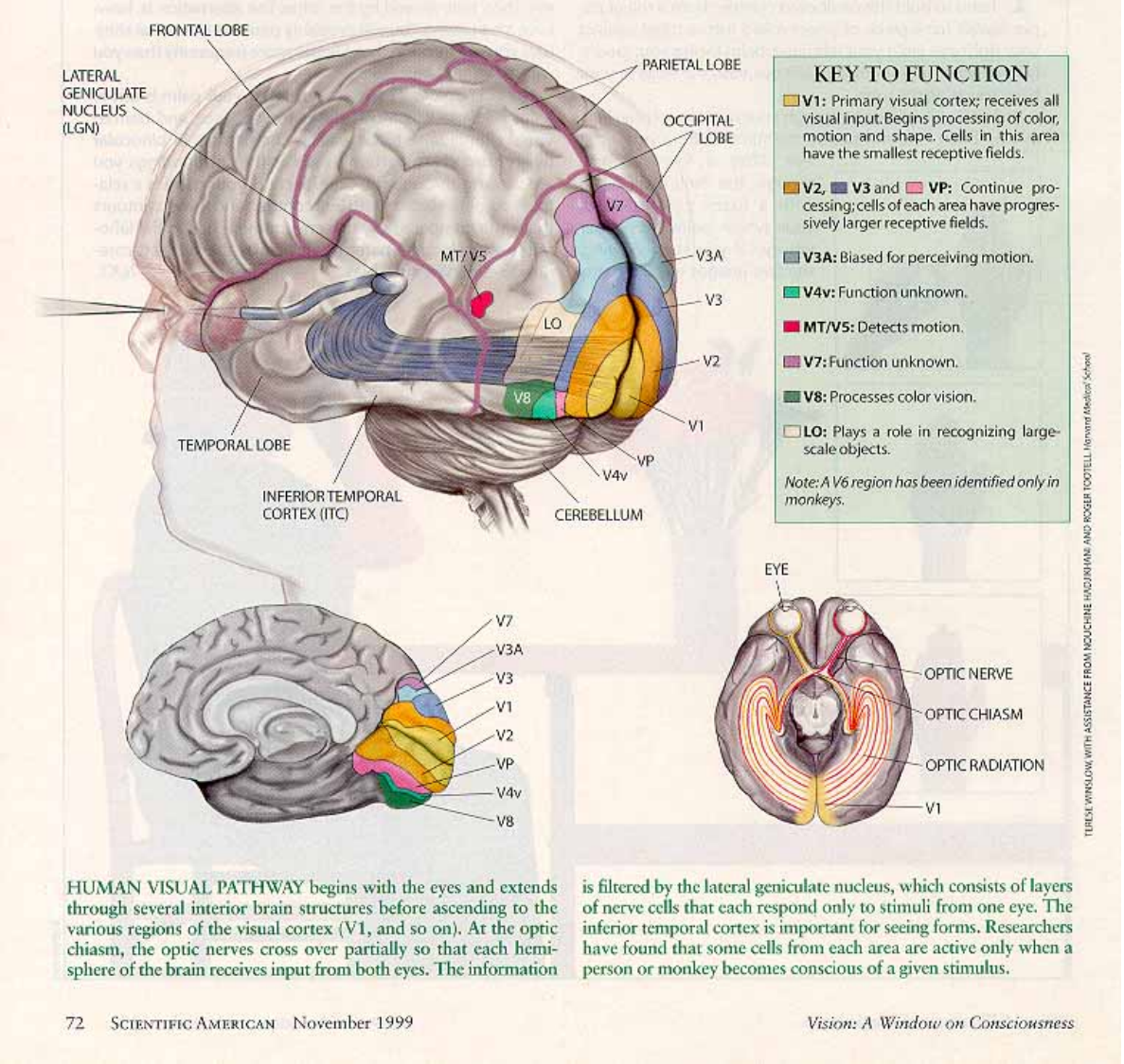
*Scientific American* 11/79




# Primary Auditory and Visual Areas

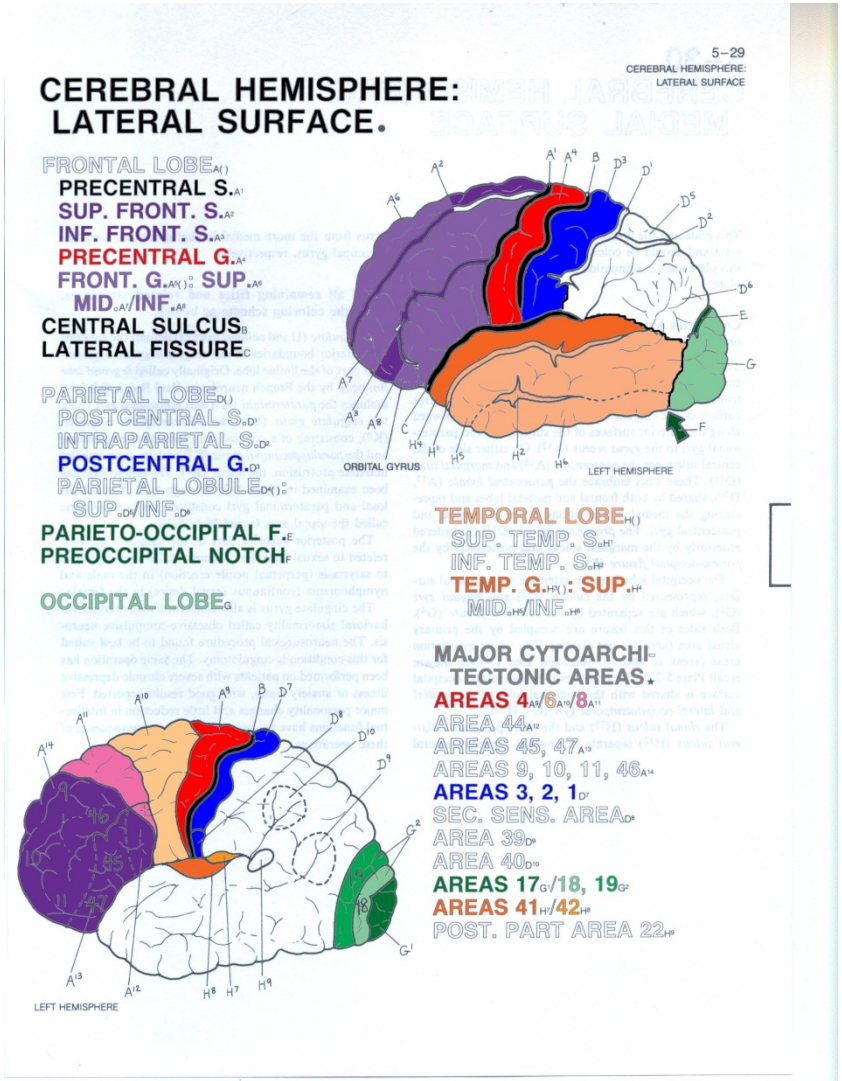
- Primary Auditory Cortex
  - Superior Temporal Gyrus
    - Heschl's Gyrus (AI)
    - Brodmann Areas 41, 42
    - "Tonotopic" Organization
- Primary Visual Cortex
  - Striate Cortex (VI)
    - Brodmann Area 17
    - "Retinotopic" Organization
  - Extrastriate Cortex
    - Brodmann's Areas 18, 19

# Specialization in Extra-Striate Cortex




HUMAN VISUAL PATHWAY begins with the eyes and extends through several interior brain structures before ascending to the various regions of the visual cortex (V1, and so on). At the optic chiasm, the optic nerves cross over partially so that each hemisphere of the brain receives input from both eyes. The information is filtered by the lateral geniculate nucleus, which consists of layers of nerve cells that each respond only to stimuli from one eye. The inferior temporal cortex is important for seeing forms. Researchers have found that some cells from each area are active only when a person or monkey becomes conscious of a given stimulus.

# “Association Areas”




- Posterior
  - Perceptual Integration
- Frontal
  - Executive Functions
  - Problem-solving
- “Prefrontal” Cortex
  - Frontal Gyri
    - Superior, Middle, Inferior
  - Frontal Sulci
    - Superior, Inferior

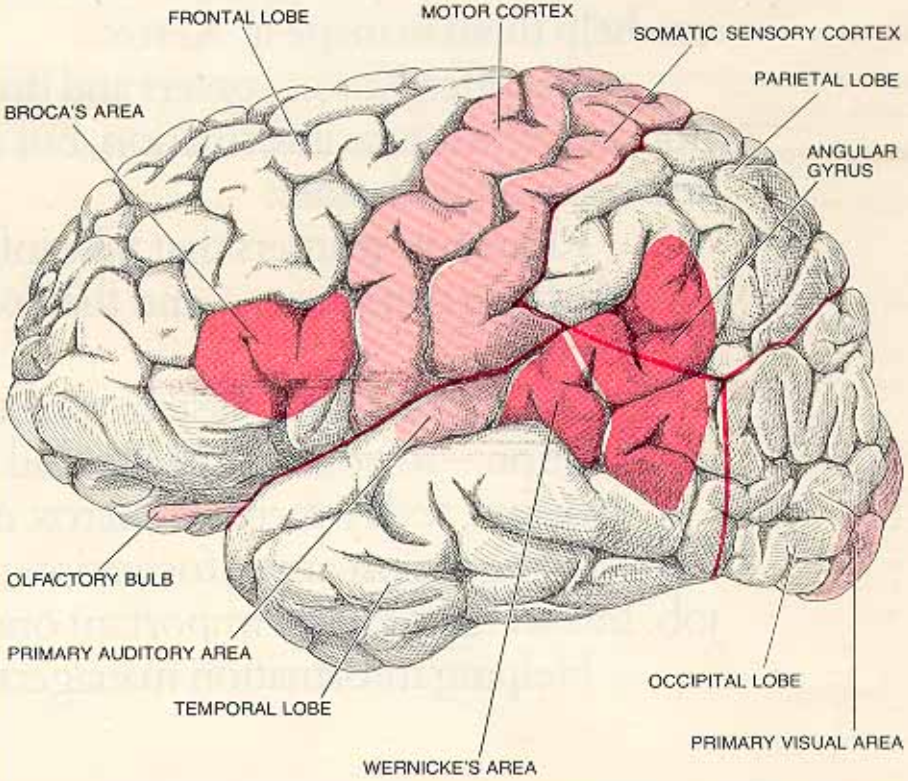
# Some Common Neurological Symptoms

| | |
|---|---|
| Amnesia | (Memory) |
| Aphasia | (Speech) |
| Alexia | (Reading) |
| Agraphia | (Writing) |
| Acalculia | (Math) |
| Apraxia | (Action) |
| Agnosia | (Knowledge) |

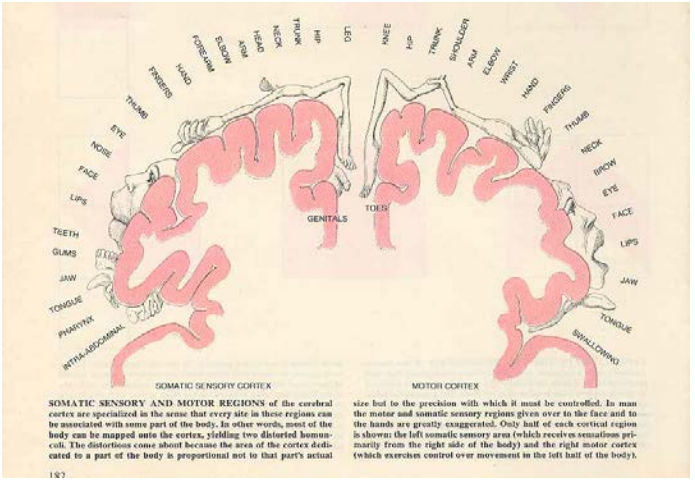
# Major Syndromes of Aphasia

- Broca's Aphasia: "Expressive"
  - Slow, Labored, Inarticulate Speech
    - Possible Problems with Writing, Reading Aloud
  - Speech Comprehensible
  - No Problems Understanding Speech, Reading
- Wernicke's Aphasia: "Receptive"
  - Fluent (Phonetics, Grammar)
  - Paraphasias
  - Semantic Deviance
  - Problems Understanding Speech, Writing

# Language Centers in the Brain



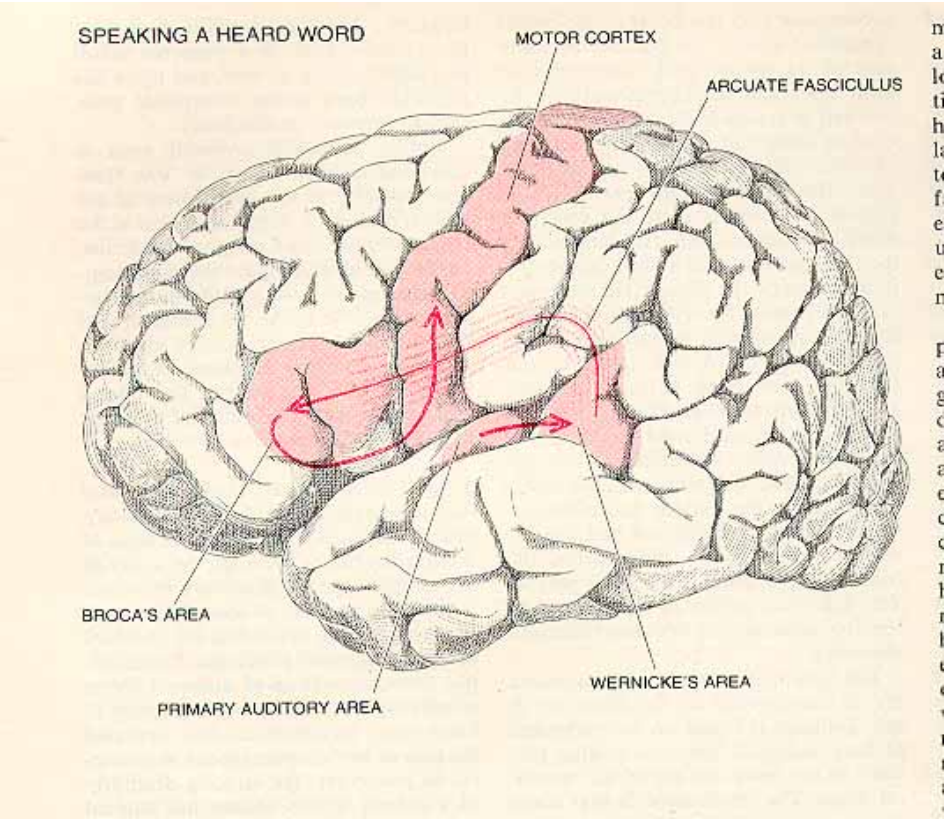

**MAP OF THE HUMAN CORTEX** shows regions whose functional specializations have been identified. Much of the cortex is given over to comparatively elementary functions: the generation of movement and the primary analysis of sensations. These areas, which include the motor and somatic sensory regions and the primary visual, auditory and olfactory areas, are present in all species that have a well-developed cortex and are called on in the course of many activities. Several other regions (*dark color*) are more narrowly specialized. Broca's area and Wernicke's area are involved in the production and comprehension of language. The angular gyrus is thought to mediate between visual and auditory forms of information. These functional specializations have been detected only on the left side of the brain; the corresponding areas of the right hemisphere do not have the same linguistic competence. The right hemisphere, which is not shown, has its own specialized abilities, including the analysis of some aspects of music and of complex visual patterns. The anatomical regions associated with these faculties, however, are not as well defined as the language areas. Even in the left hemisphere the assignment of functions to sites in the cortex is only approximate; some areas may have functions in addition to those indicated, and some functions may be carried out in more than one place.

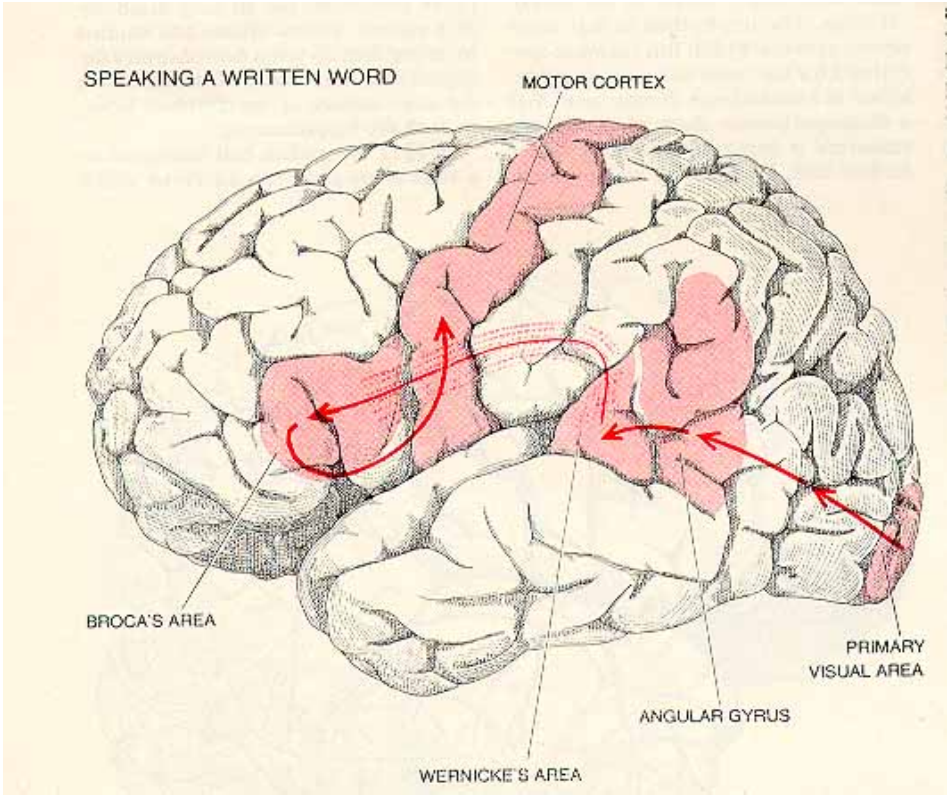



*Scientific American*

# Coordination of Language Functions

Petersen et al. (1988, 1989)

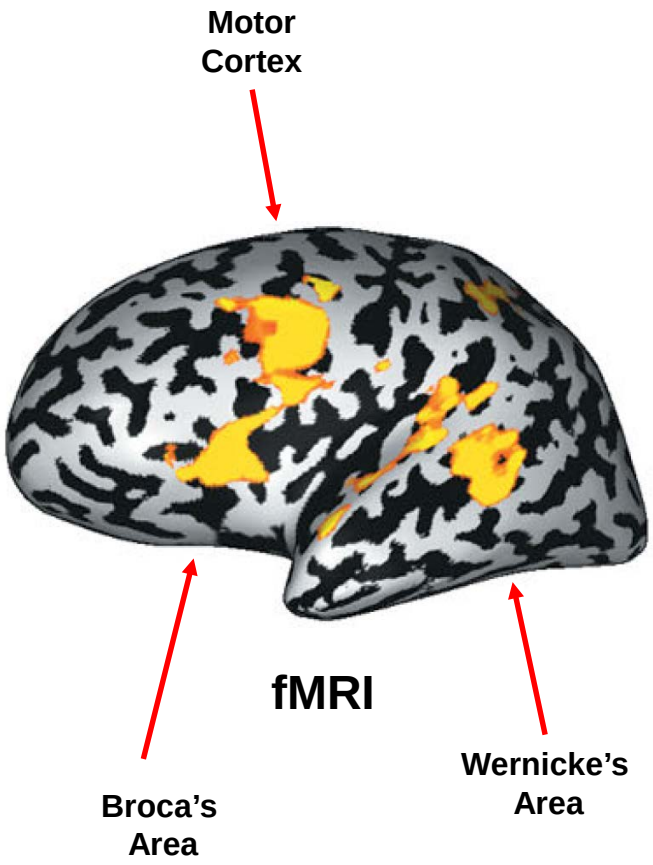



*Scientific American*

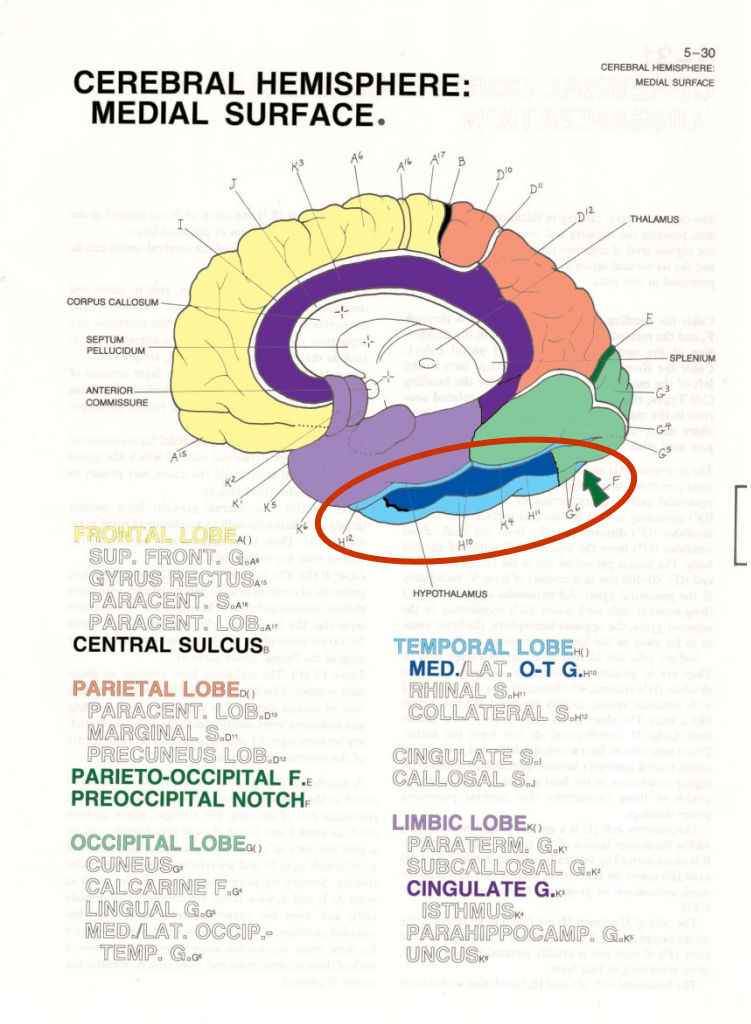
# Electrocorticogram of Verb Generation

Edwards et al. (2007, 2010)



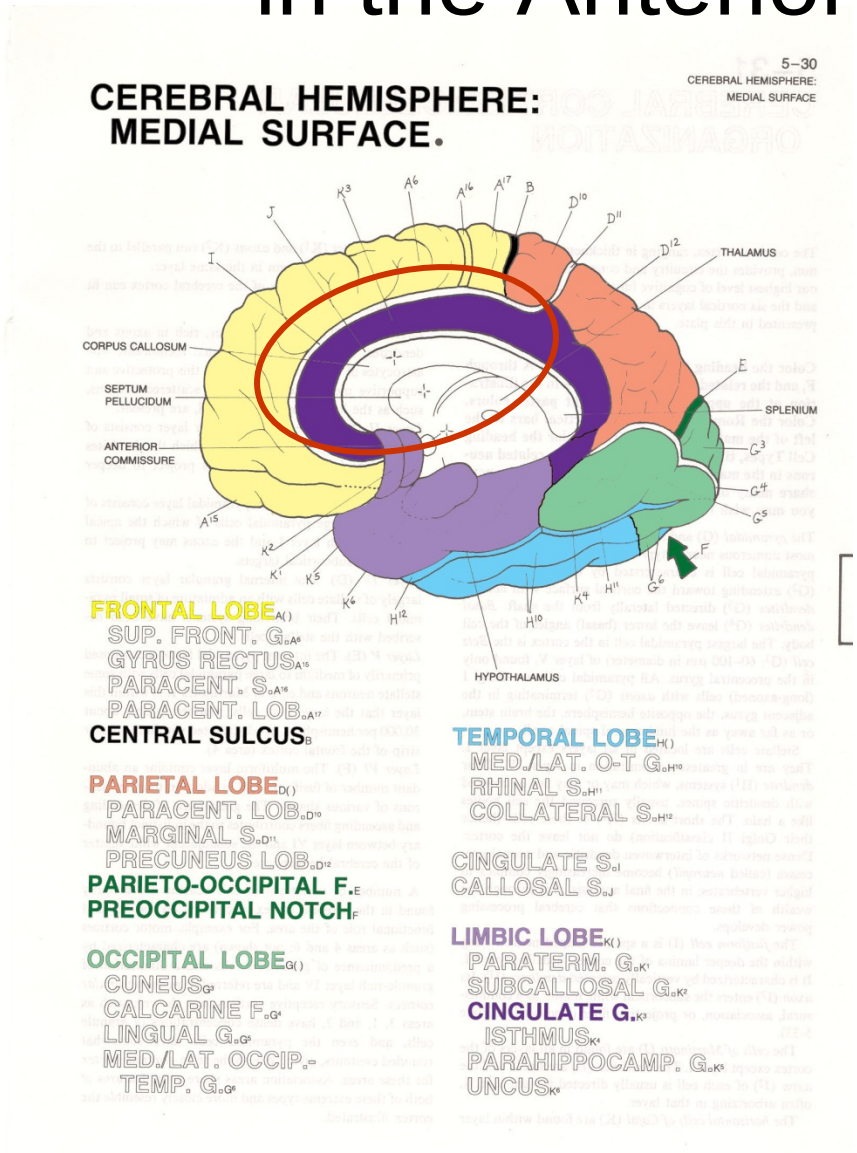

Courtesy of R.T. Knight

# Face Recognition in the Fusiform Gyrus




- Prosopagnosia
  - Bodamer (1947)
  - Brodmann Area 37
    - Also Areas 18, 19
- fMRI in Face Recognition
- “Fusiform Face Area” (?)

# Self-Regulation in the Anterior Cingulate Gyrus




- Part of Limbic Lobe
  - Anterior Cingulate Cortex
    - “ACC”
- Executive Functions
  - Controlled Processing
- Self-Regulation
  - Error Detection
  - Conflict Monitoring

# The Parietal Cortex and Attention

Typical performance by a “neglect” patient on the line-bisection task

- Hemispatial Neglect
  - Contralateral
- Temporoparietal Junction

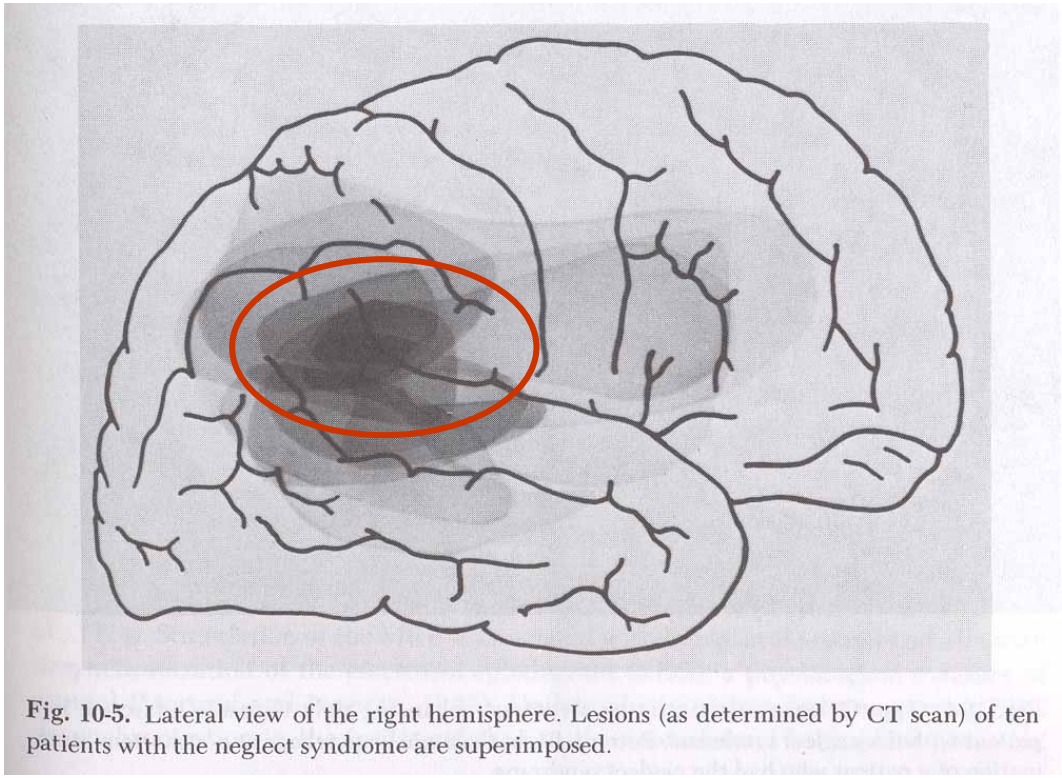
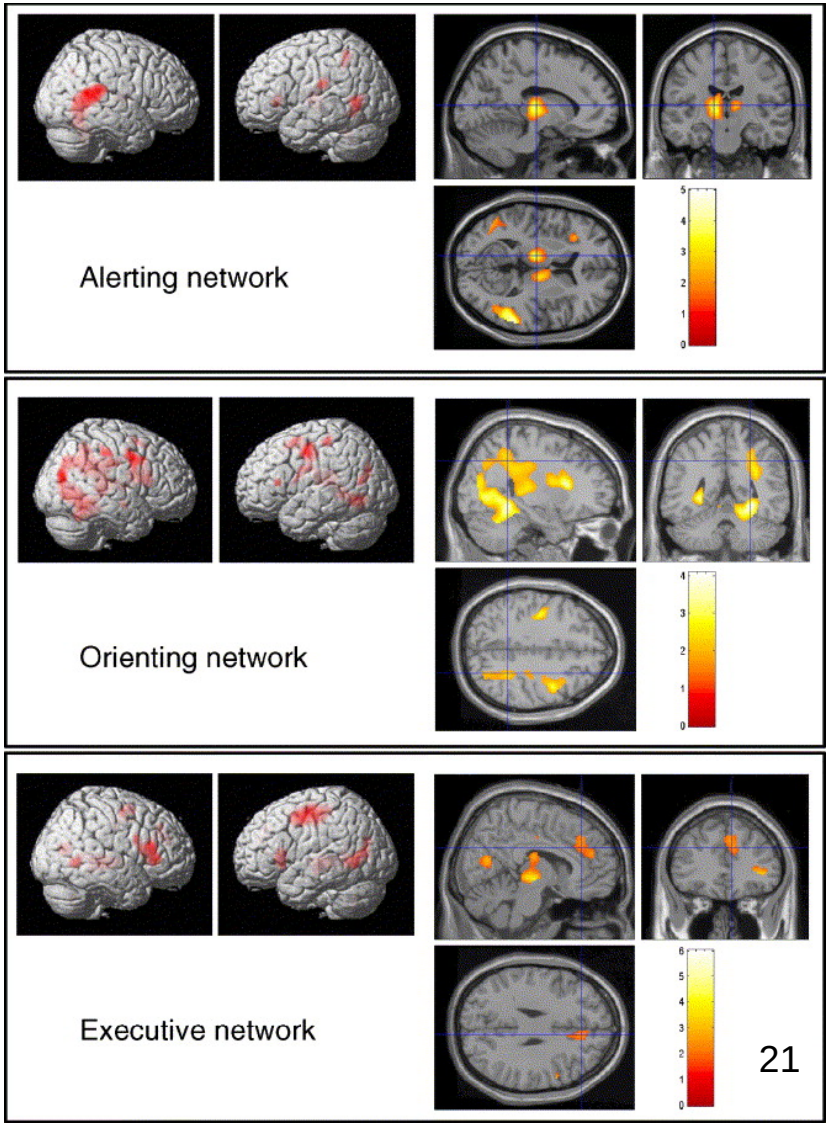


Fig. 10-5. Lateral view of the right hemisphere. Lesions (as determined by CT scan) of ten patients with the neglect syndrome are superimposed.

# Imaging the Stage Model of Attention

Fan et al. (2005), after Posner & Peterson (1990)

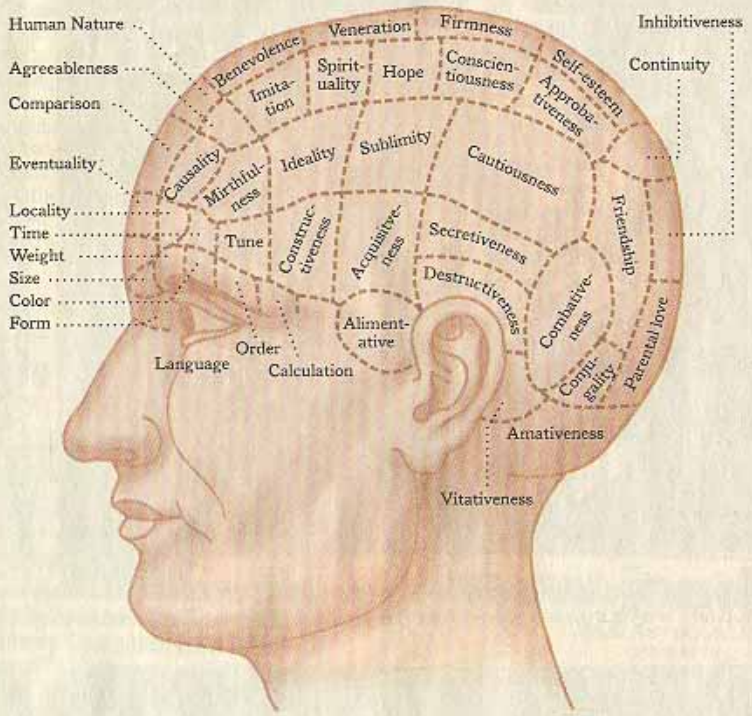
- Alerting and Interruption
  - Fronto-Parietal
  - Thalamus
- Orienting and Localizing
  - Superior Parietal
- Executive Control
  - Anterior Cingulate Gyrus
  - Frontal
    - Disengage
    - Move (Shift)
    - (Re-) Engage
    - Inhibit



# Old and New Views of Specialization

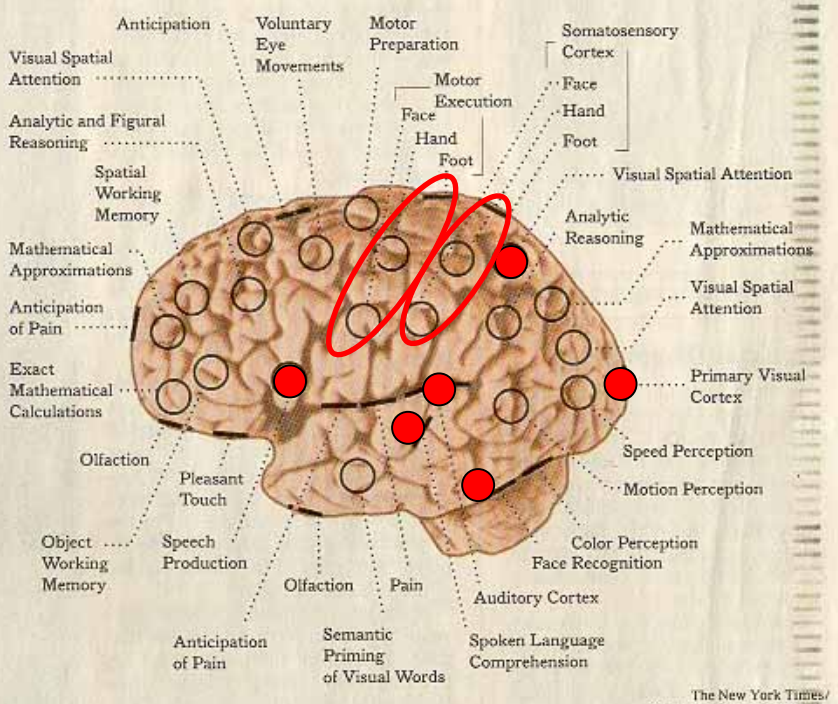
**19TH-CENTURY HEAD EXAMINATION**

According to phrenologists of the period, analysis of the shape and lumps of the skull would reveal a person's personality and intellect. Below, a contemporary map of localized characteristics.




**CURRENT MAPPING THROUGH FUNCTIONAL MAGNETIC RESONANCE IMAGING (FMRI)**

Now scientists can capture the brain in action by measuring changes in cerebral blood flow. Critics say the technique isn't being used to answer more complicated questions about the brain's processes.




The New York Times/
Diagram courtesy of Nature

## Just What's Going On Inside That Head of Yours?