

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

INTRODUCTION TO BRAIN STRUCTURE I.

1-2
INTROD. TO BRAIN STRUCT. I

FOREBRAIN.

LONGITUDINAL FISSURE,
CENTRAL SULCUS,
LATERAL FISSURE.

FRONTAL LOBE.

SPEECH AREA,
MOTOR AREA.

TEMPORAL LOBE.

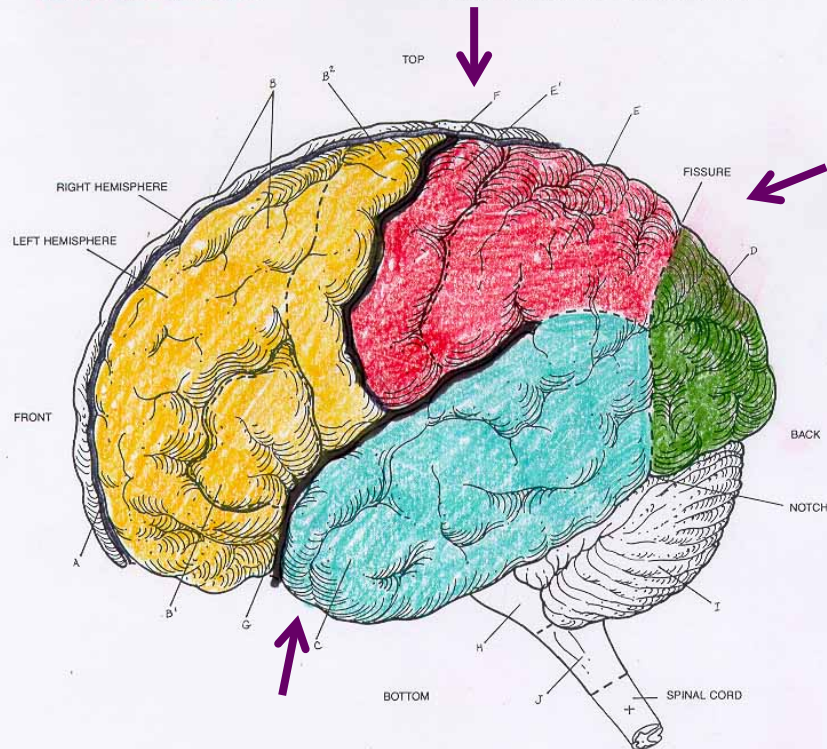
PARIETAL LOBE.

PRIMARY SENSORY AREA.

OCCIPITAL LOBE.

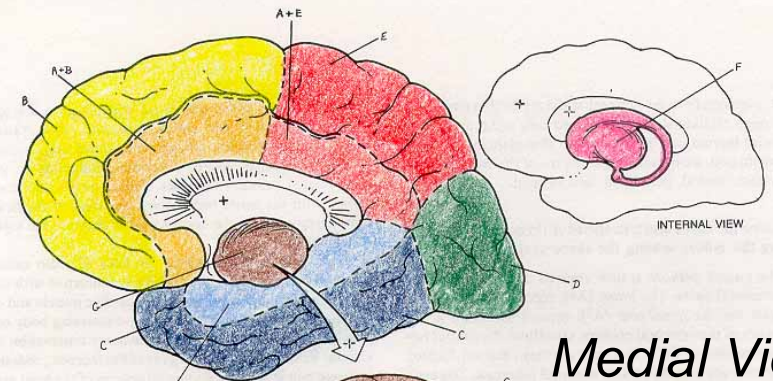
HINDBRAIN.

PONS,
CEREBELLUM,
MEDULLA OBLONGATA.



INTRODUCTION TO BRAIN STRUCTURE II.

1-3
INTROD. TO BRAIN STRUCT. II



CEREBRAL HEMISPHERE,
FRONTAL LOBE,
TEMPORAL LOBE,
PARIETAL LOBE,
OCCIPITAL LOBE,
LIMBIC LOBE,
BASAL GANGLIA.

UPPER BRAIN STEM,
THALAMUS,
HYPOTHALAMUS,
PINEAL GLAND.

MIDDLE BRAIN STEM,
MIDBRAIN.

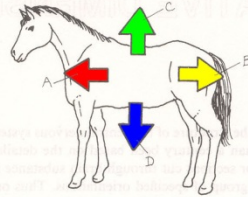
LOWER BRAIN STEM,
PONS,
MEDULLA,
CEREBELLUM,
SPINAL CORD.

Locating Yourself in the Brain

1-5
TERMS OF DIRECTION

TERMS OF DIRECTION. QUADRUPED.

HEAD END*
ANTERIOR/ROSTRAL/CRANIAL_A
 TAIL END*
POSTERIOR/CAUDAL_B
 BACK. **BELLY.**
DORSAL_C **VENTRAL**_D



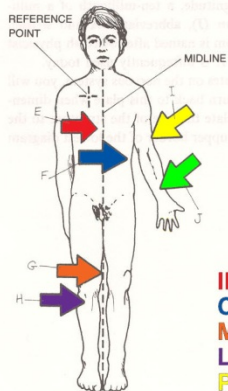
QUADRUPED.

BIPEDAL.

CRANIAL_A/
SUPERIOR_{A2}/
DORSAL_C/
ROSTRAL_{A1}

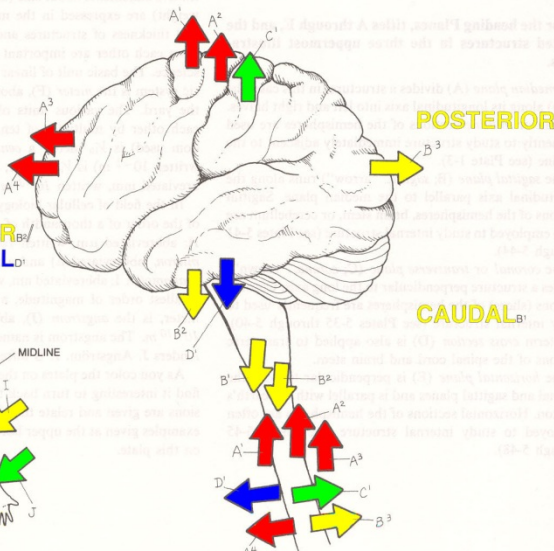
ANTERIOR_{A4}

INFERIOR_{B1}/
VENTRAL_{D1}



BIPEDAL.

IPSILATERAL_E
CONTRALATERAL_F
MEDIAL_G
LATERAL_H
PROXIMAL_I
DISTAL_J

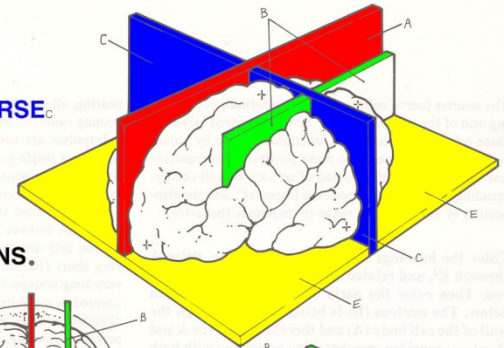


PLANES OF SECTION AND RELATIVE DIMENSIONS.

1-6
PLANES OF SECTION/RELATIVE DIMENSIONS

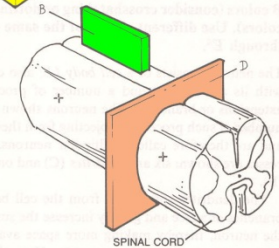
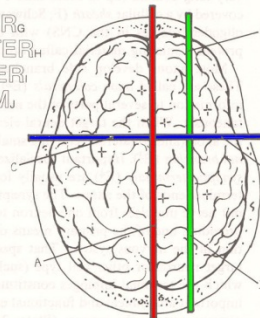
PLANES.

MEDIAN/MIDLINE_A
SAGITTAL_B
CORONAL/TRANSVERSE_C
CROSS SECTION_D
HORIZONTAL_E

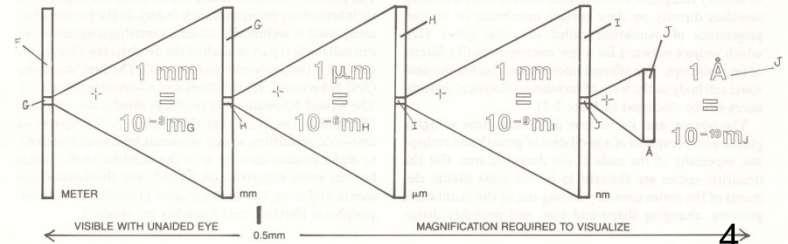


RELATIVE DIMENSIONS.

METER
 MILLIMETER
 MICROMETER
 NANOMETER
 ANGSTROM.



DIAMETER OF FEMALE GERM CELL (OVUM)	DIAMETER OF LARGE NEURON CELL BODY	DIAMETER OF NUCLEUS OF NEURON	DIAMETER OF MITOCHONDRION	DIAMETER OF SYNAPTIC VESICLE	DIAMETER OF NEUROFILAMENT OR SYNAPTIC CLEFT	THICKNESS OF OUTER MEMBRANE OF MITOCHONDRION	ESTIMATED DIAMETER OF HYDROGEN ATOM
100µm	0.5mm	100µm	15µm	0.2µm	40nm	10nm	60 Å



Folds in Cerebral Cortex

INTRODUCTION TO BRAIN STRUCTURE I.

1-2
INTROD. TO BRAIN STRUCT. I

FOREBRAIN.

LONGITUDINAL FISSURE.
CENTRAL SULCUS.
LATERAL FISSURE.

FRONTAL LOBE.

SPEECH AREA.
MOTOR AREA.

TEMPORAL LOBE.

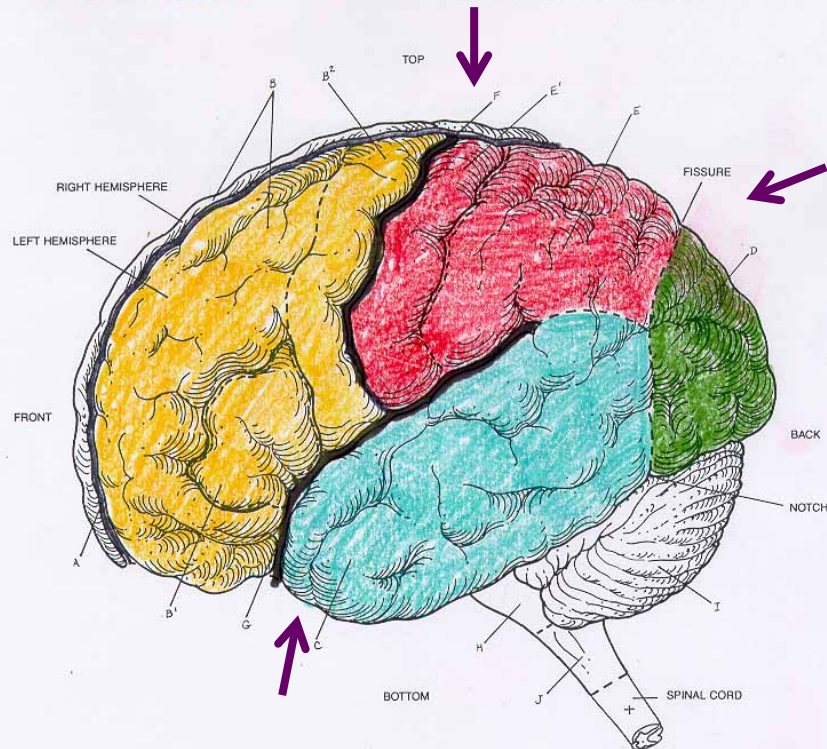
PARIETAL LOBE.

PRIMARY SENSORY AREA.

OCCIPITAL LOBE.

HINDBRAIN.

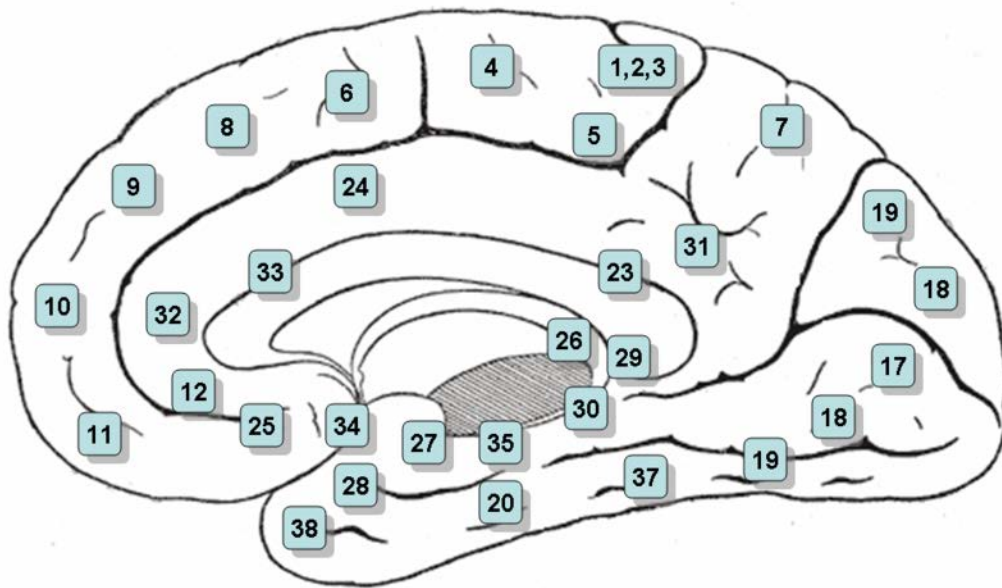
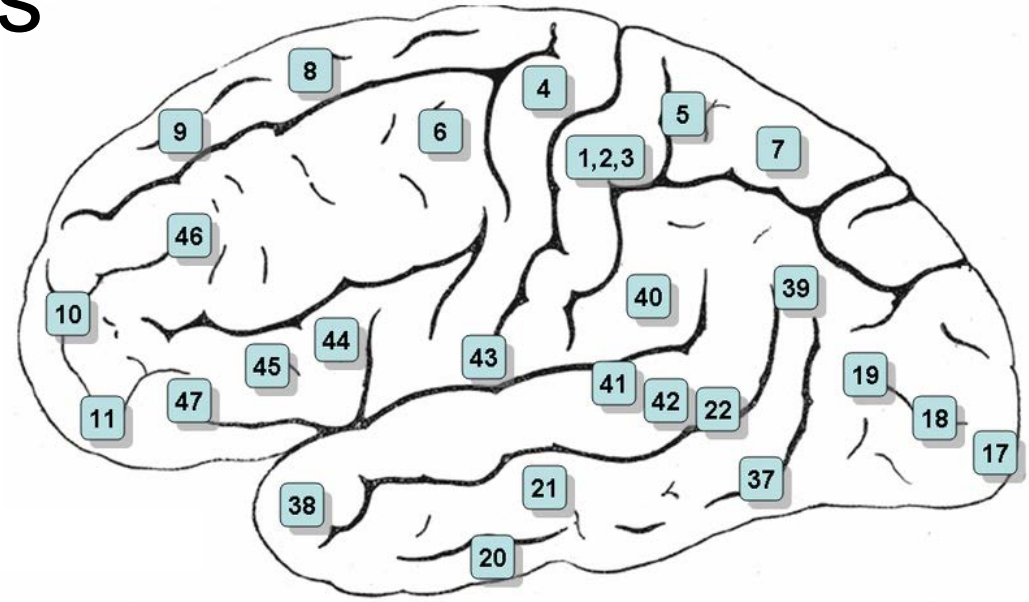
PONS.
CEREBELLUM.
MEDULLA OBLONGATA.



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

Cytoarchitectonics of the Cerebral Cortex

Brodmann (1909)



CEREBRAL HEMISPHERE: LATERAL SURFACE.

FRONTAL LOBE_{A(1)}

PRECENTRAL S._{A¹}

SUP. FRONT. S.

INF. FRONT. S.

PRECENTRAL G._{A⁴}

FRONT. G.

MID./INF.

CENTRAL SULCUS_B

LATERAL FISSURE_C

PARIETAL LOBE_{D(1)}

POSTCENTRAL S.

INTRAPARIETAL S.

POSTCENTRAL G._{D³}

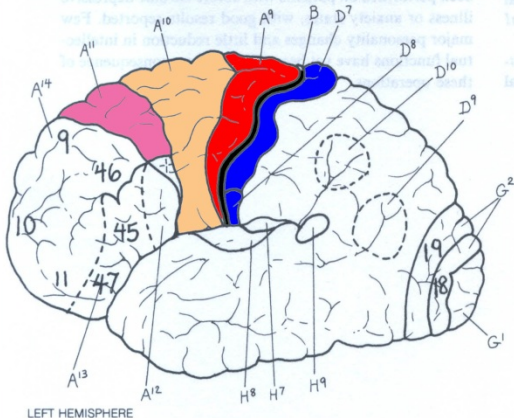
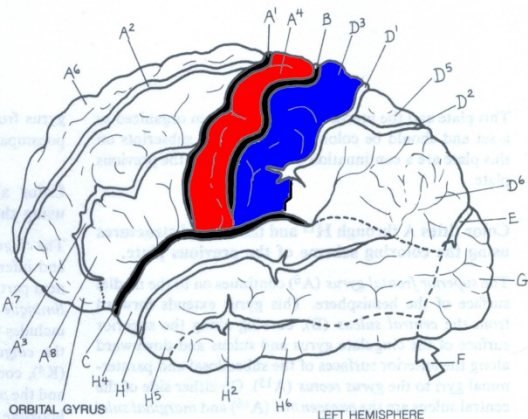
PARIETAL LOBULE

SUP./INF.

PARIETO-OCCIPITAL F.

PREOCCIPITAL NOTCH_F

OCCIPITAL LOBE_G



TEMPORAL LOBE_{H(1)}
SUP. TEMP. S.
INF. TEMP. S.
TEMP. G.
MID./INF.

MAJOR CYTOARCHI- TECTONIC AREAS*

- AREAS 4_{A⁴}, 6_{A¹⁰}, 8_{A¹¹}
- AREA 44_{A¹²}
- AREAS 45, 47_{A¹³}
- AREAS 9, 10, 11, 46_{A¹⁴}
- AREAS 3, 2, 1_{D⁷}
- SEC. SENS. AREA_{D⁸}
- AREA 39_{D⁹}
- AREA 40_{D¹⁰}
- AREAS 17_{G¹}, 18, 19_{G²}
- AREAS 41_{H⁷}, 42_{H⁸}
- POST. PART AREA 22_{H⁹}

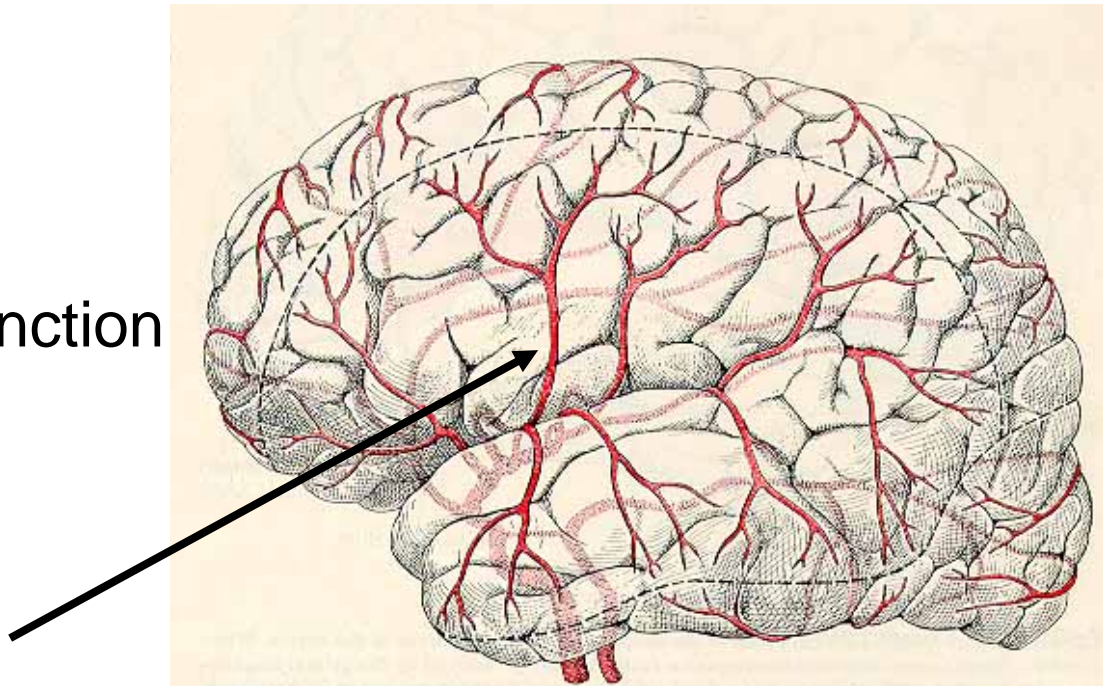
Primary Motor and Somatosensory Areas

- 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

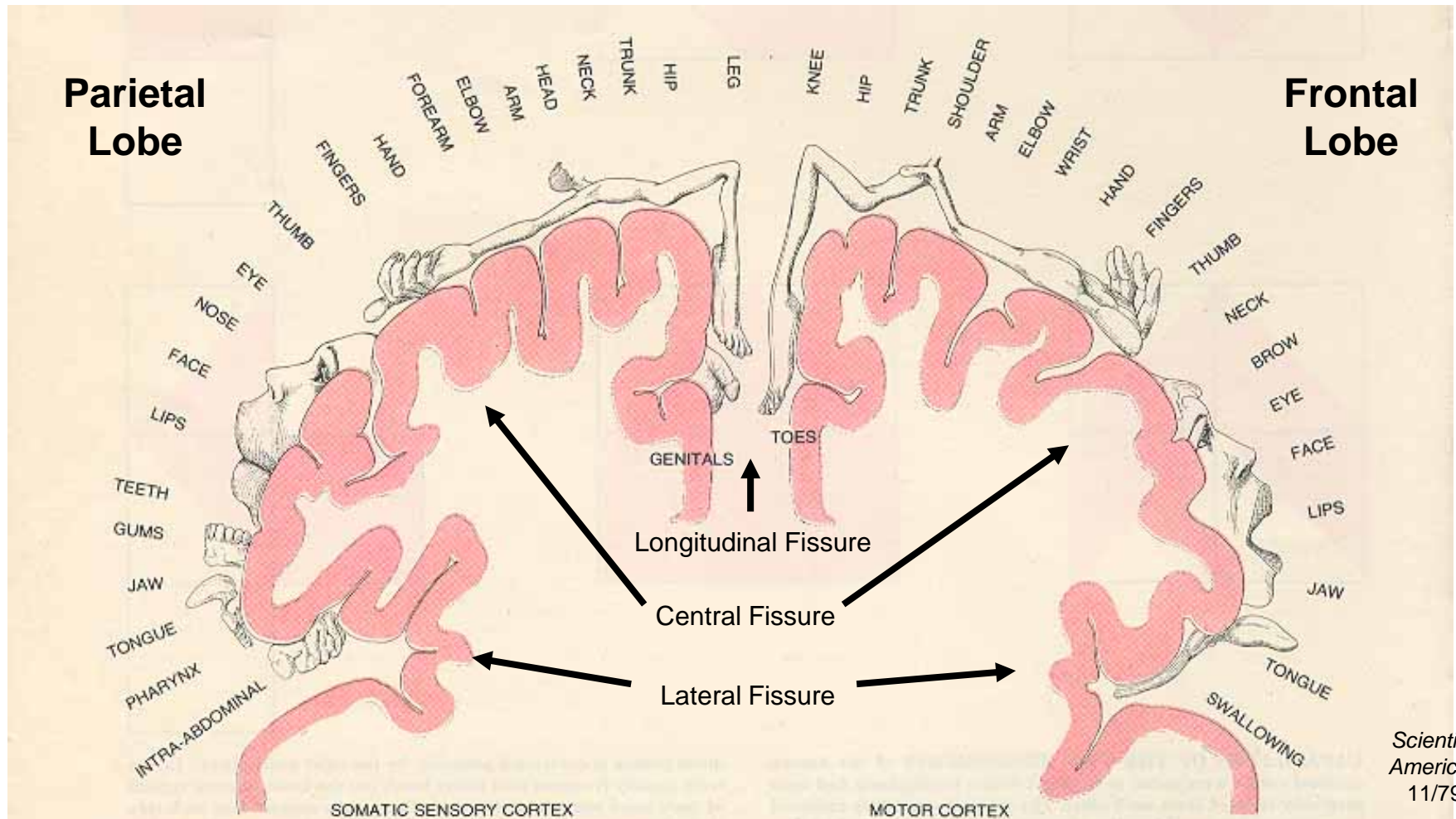
- Paralysis
 - voluntary motor function
- Anesthesia
 - tactile sensation
- Aphasia
 - speech, language



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.

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).

Scientific American
11/79

CEREBRAL HEMISPHERE: LATERAL SURFACE.

FRONTAL LOBE^(A)

PRECENTRAL S.^{A1}

SUP. FRONT. S.^{A2}

INF. FRONT. S.^{A3}

PRECENTRAL G.^{A4}

FRONT. G.^(A5): SUP.^{A6}

MID./INF.^{A8}

CENTRAL SULCUS^B

LATERAL FISSURE^C

PARIETAL LOBE^(D)

POSTCENTRAL S.^{D1}

INTRAPARIETAL S.^{D2}

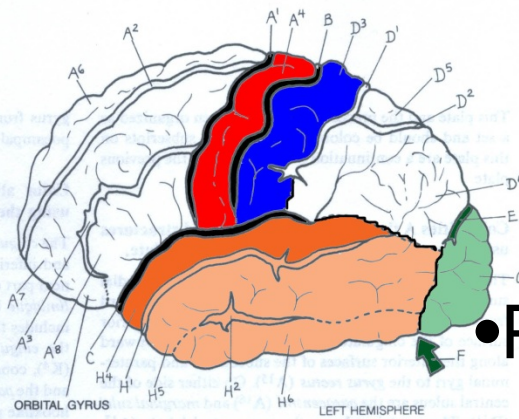
POSTCENTRAL G.^{D3}

PARIETAL LOBULE^(D4): SUP.^{D5}/INF.^{D6}

PARIETO-OCCIPITAL F.^E

PREOCCIPITAL NOTCH^F

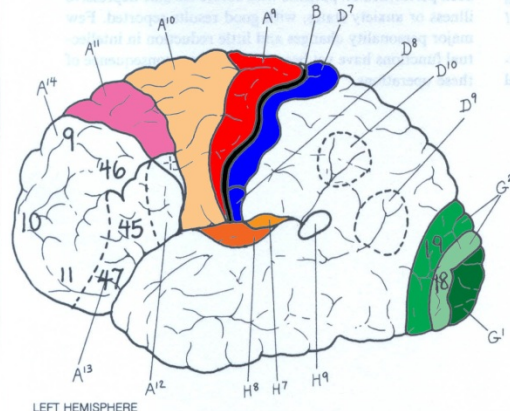
OCCIPITAL LOBE^G



TEMPORAL LOBE^(H)
SUP. TEMP. S.^{H1}
INF. TEMP. S.^{H2}
TEMP. G.^(H3): SUP.^{H4}
MID./INF.^{H5}

MAJOR CYTOARCHI-TECTONIC AREAS*

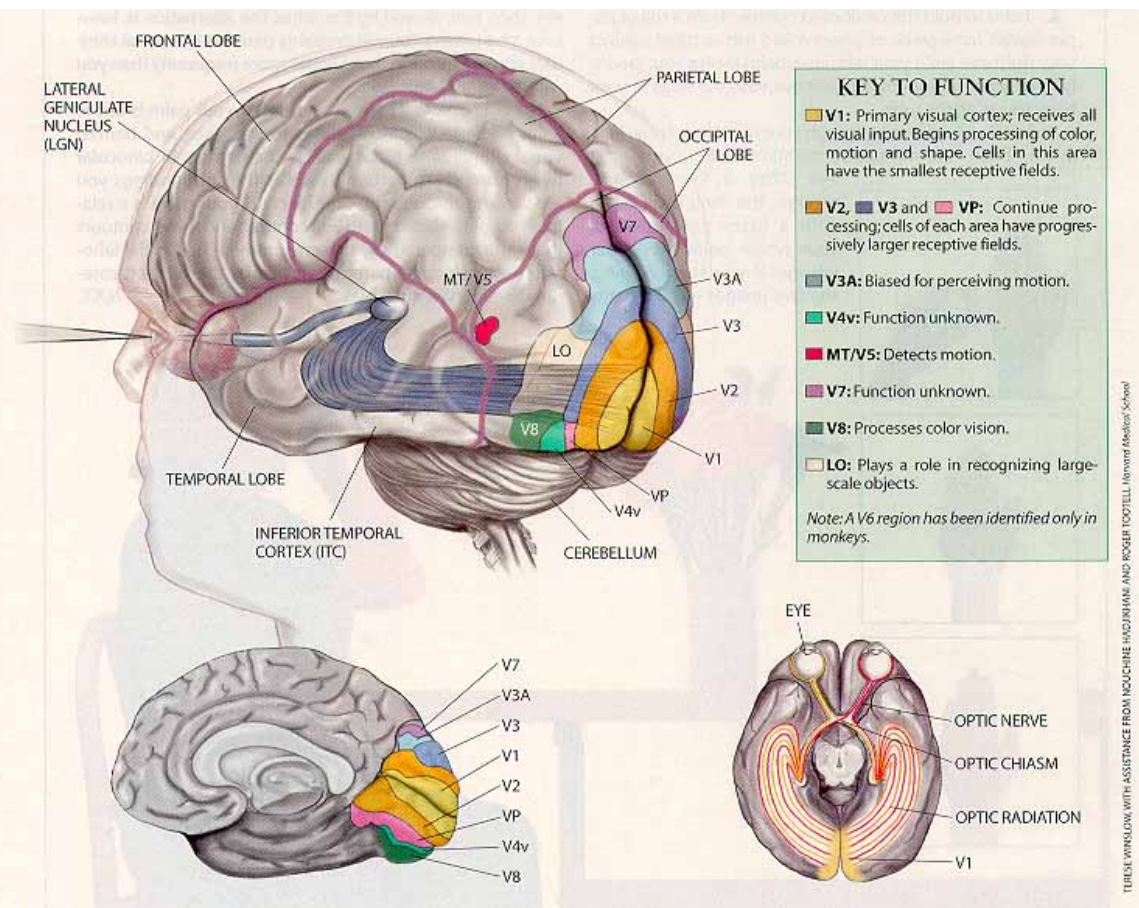
- AREAS 4^{A9}/6^{A10}/8^{A11}
- AREA 44^{A12}
- AREAS 45, 47^{A13}
- AREAS 9, 10, 11, 46^{A14}
- AREAS 3, 2, 1^{D7}
- SEC. SENS. AREA^D
- AREA 39^{D9}
- AREA 40^{D10}
- AREAS 17^{G1}/18, 19^{G2}
- AREAS 41^{H7}/42^{H8}
- POST. PART AREA 22^{H9}



Primary Auditory and Visual Areas

- Primary Auditory Cortex
 - Superior Temporal Gyrus
 - Heschl's Gyrus (A1)
 - Brodmann Areas 41, 42
 - "Tonotopic" Organization
- Primary Visual Cortex
 - Striate Cortex (VI)
 - Brodmann Area 17
 - "Retinotopic" Organization
 - Extrastriate Cortex
 - Brodmann's Areas 18, 19

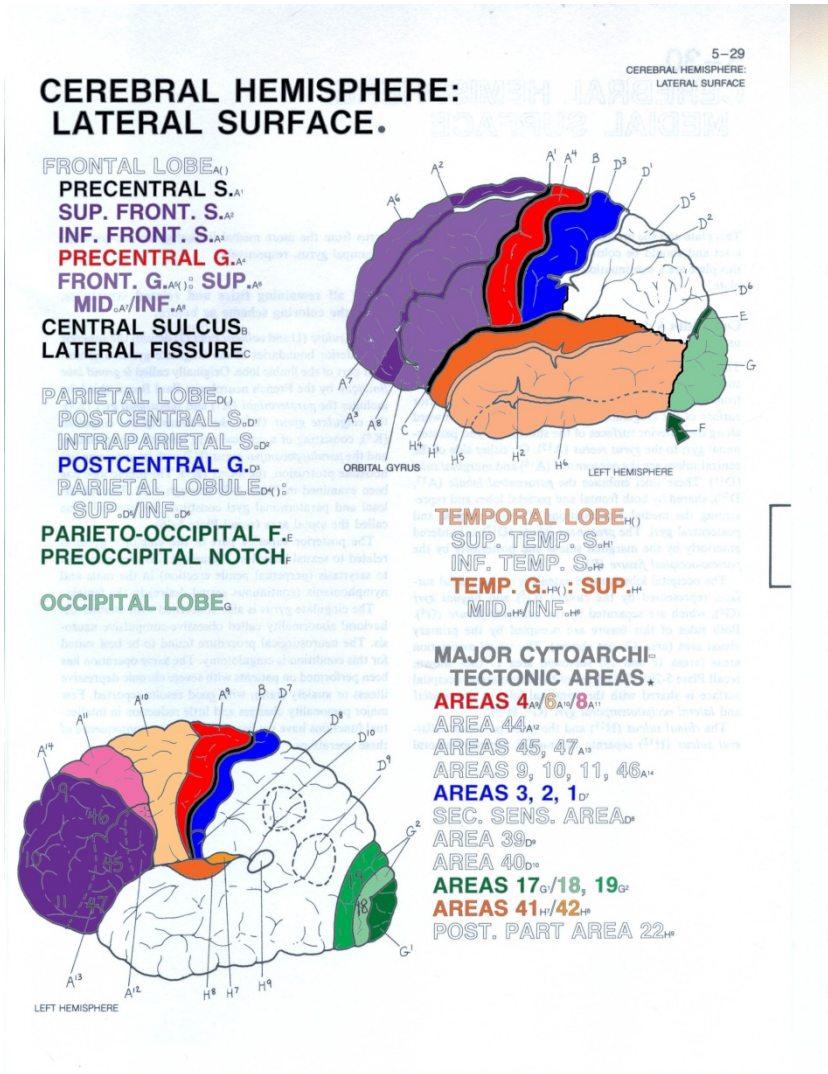
Specialization in Extra-Striate Cortex



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)

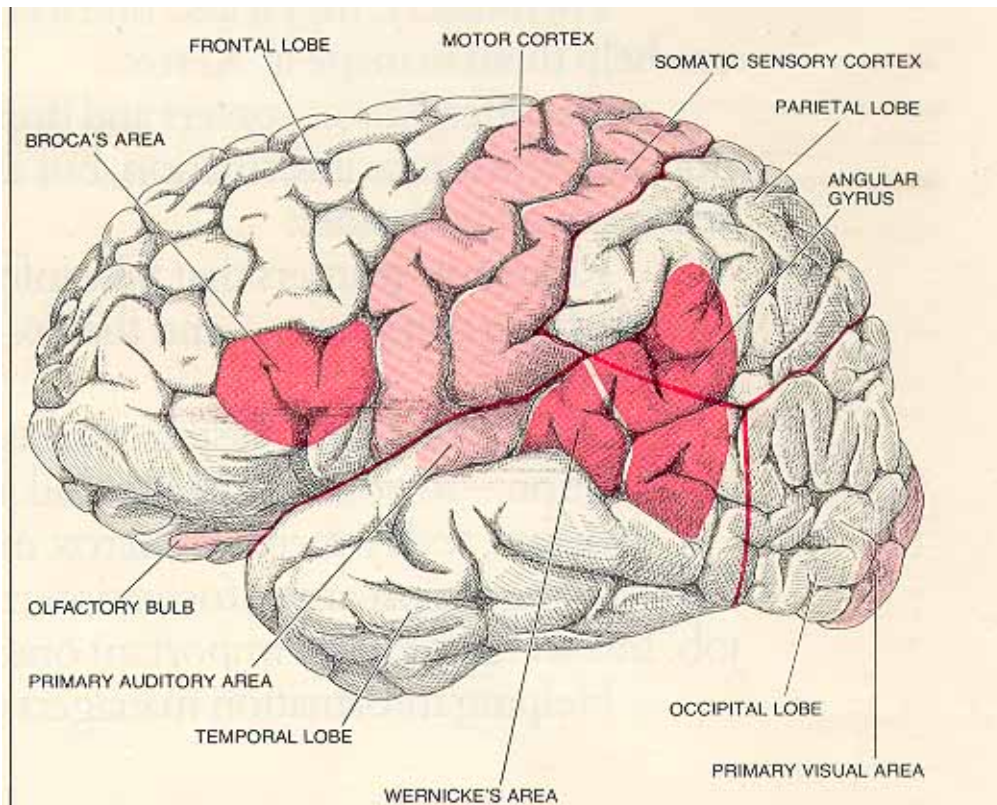
Agnosia

(Knowledge)

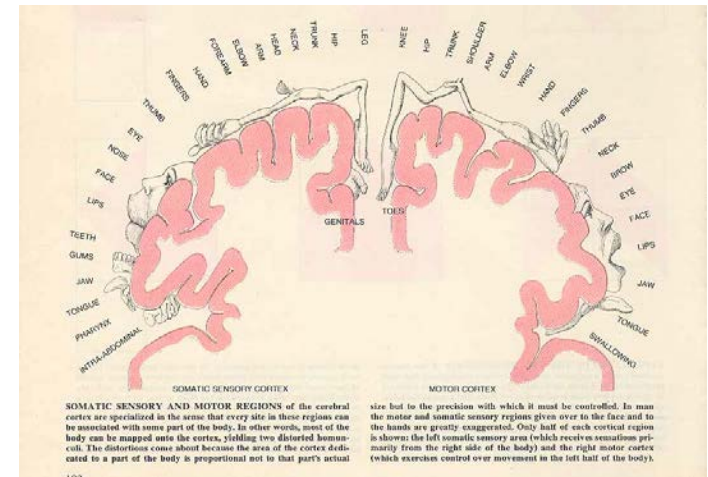
Major Syndromes of Aphasia

- 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



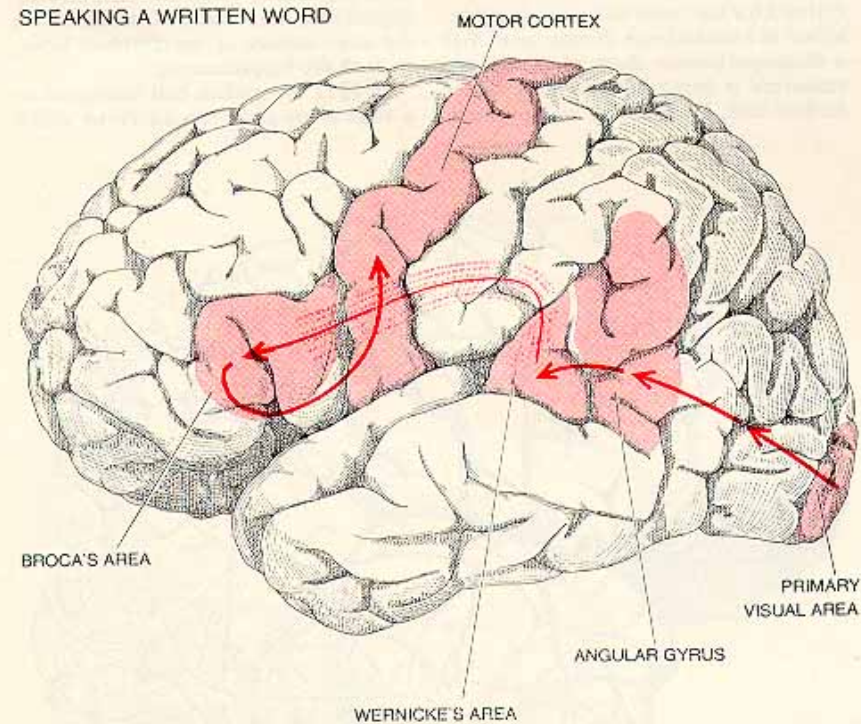
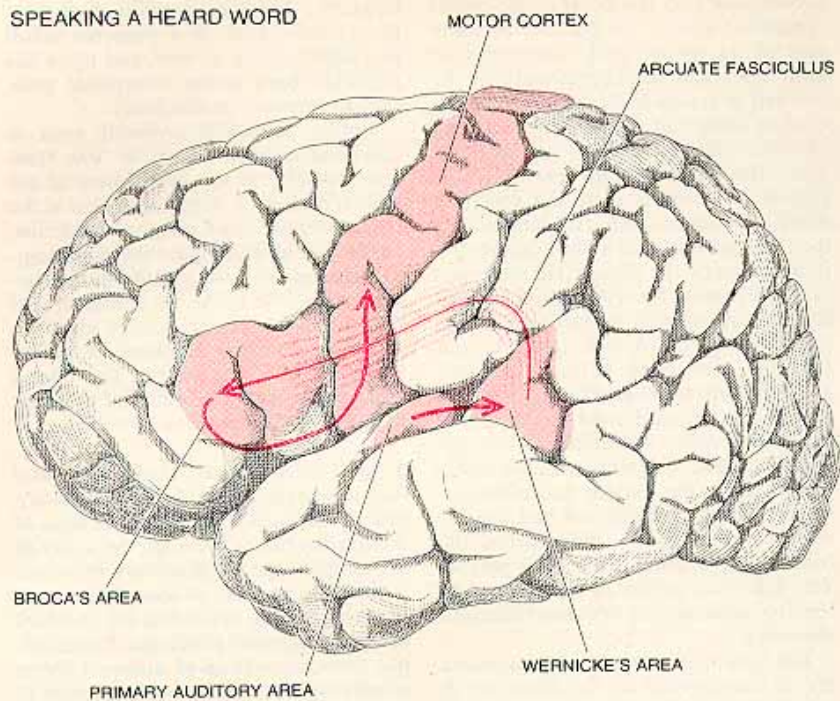
MAP OF THE HUMAN CORTEX shows regions whose functional specializations have been identified. Much of the cortex is given over to comparatively elementary functions: the generation of movement and the primary analysis of sensations. These areas, which include the motor and somatic sensory regions and 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.



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 homomorphs. 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 sensation 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).

Coordination of Language Functions

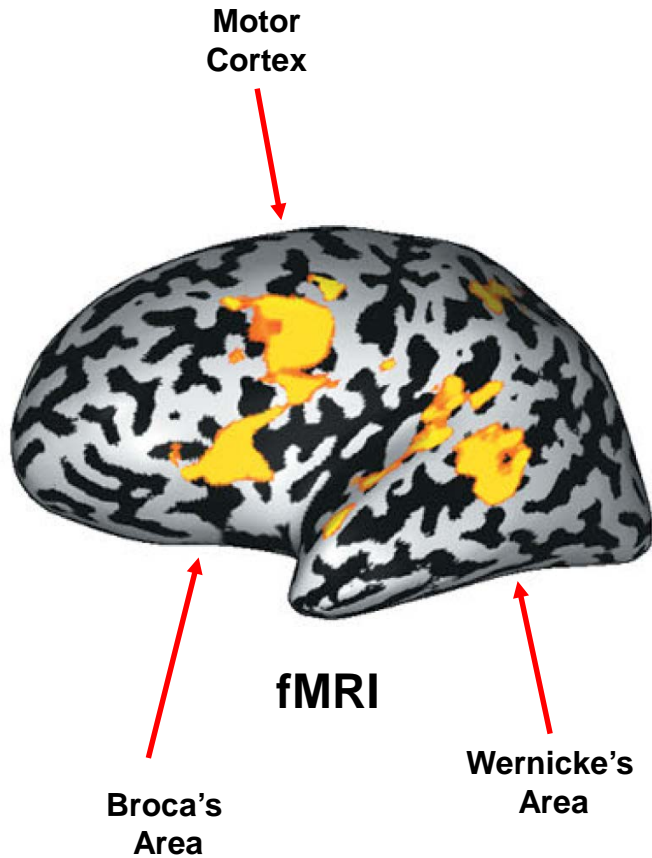
Petersen et al. (1988, 1989)



Scientific American

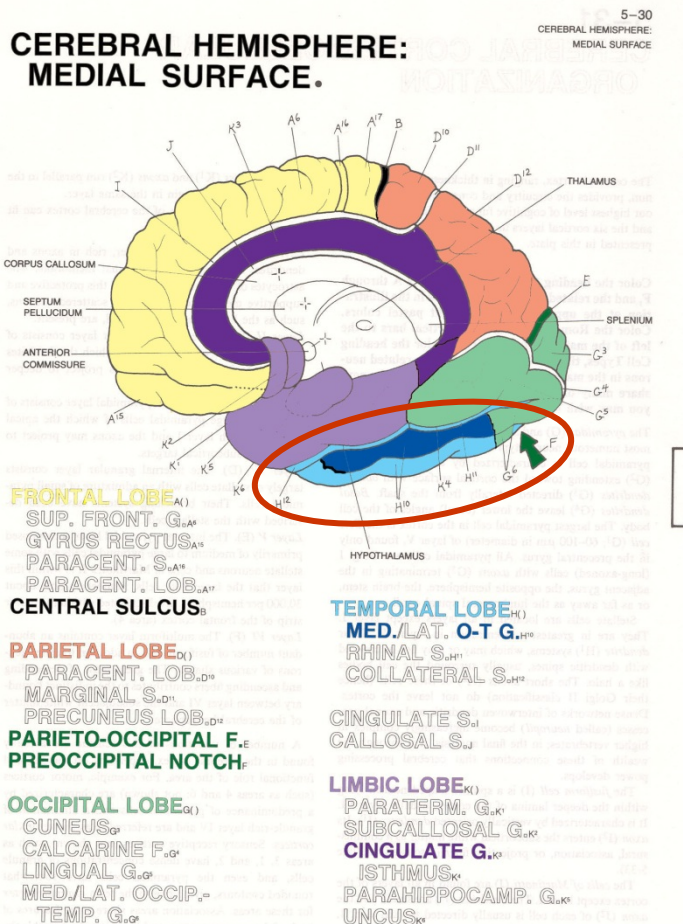
Electrocorticogram of Verb Generation

Edwards et al. (2007, 2010)



Courtesy of R.T. Knight

Face Recognition in the Fusiform Gyrus

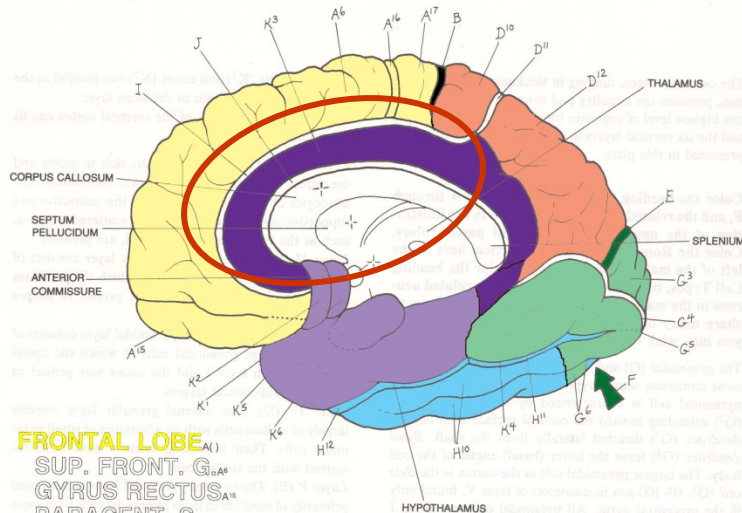


- Prosopagnosia
 - Bodamer (1947)
 - Brodmann Area 37
 - Also Areas 18, 19
- fMRI in Face Recognition
- “Fusiform Face Area” (?)

Self-Regulation in the Anterior Cingulate Gyrus

CEREBRAL HEMISPHERE:
MEDIAL SURFACE.

5-30
CEREBRAL HEMISPHERE:
MEDIAL SURFACE



FRONTAL LOBE^(A)

SUP. FRONT. G.^{A1-A6}
GYRUS RECTUS^{A15}
PARACENT. S.^{A16}
PARACENT. LOB.^{A17}

CENTRAL SULCUS^B

PARIENTAL LOBE^(C)

PARACENT. LOB.^{D10}
MARGINAL S.^{D11}
PRECUNEUS LOB.^{D12}

PARIETO-OCCIPITAL F.^E

PREOCCIPITAL NOTCH^F

OCCIPITAL LOBE^(G)

CUNEUS^{G1}
CALCARINE F.^{G4}
LINGUAL G.^{G2}
MED./LAT. OCCIP.-
TEMP. G.^{G3}

TEMPORAL LOBE^(H)

MED./LAT. O-T G.^{H10}
RHINAL S.^{H11}
COLLATERAL S.^{H12}

CINGULATE S.^I

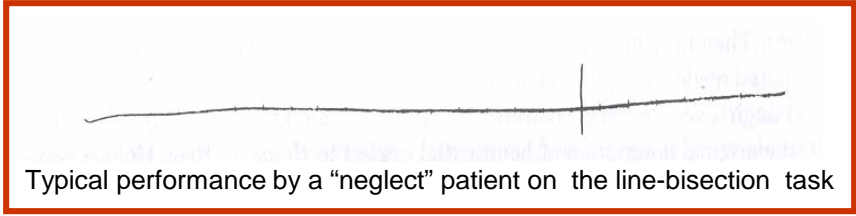
CALLOSAL S.^J

LIMBIC LOBE^(K)

PARATERM. G.^{K1}
SUBCALLOSAL G.^{K2}
GINGULATE G.^{K3}
ISTHMUS^{K4}
PARAHIPPOCAMP. G.^{K5}
UNCUS^{K6}

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

The Parietal Cortex and Attention



- Hemispatial Neglect
 - Contralateral
- Temporoparietal Junction

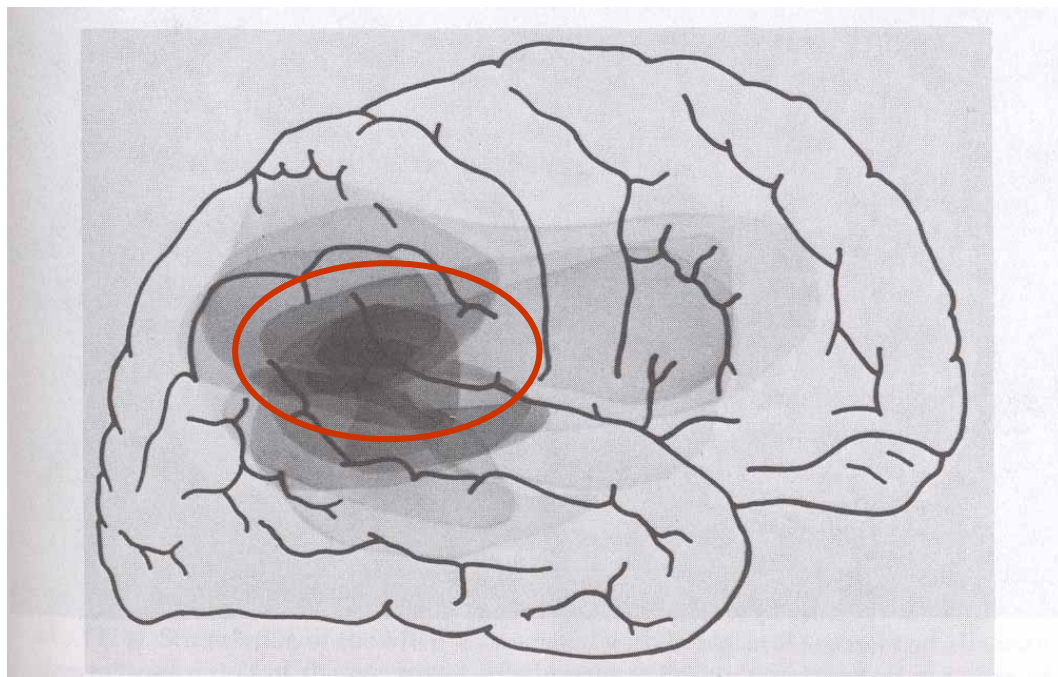
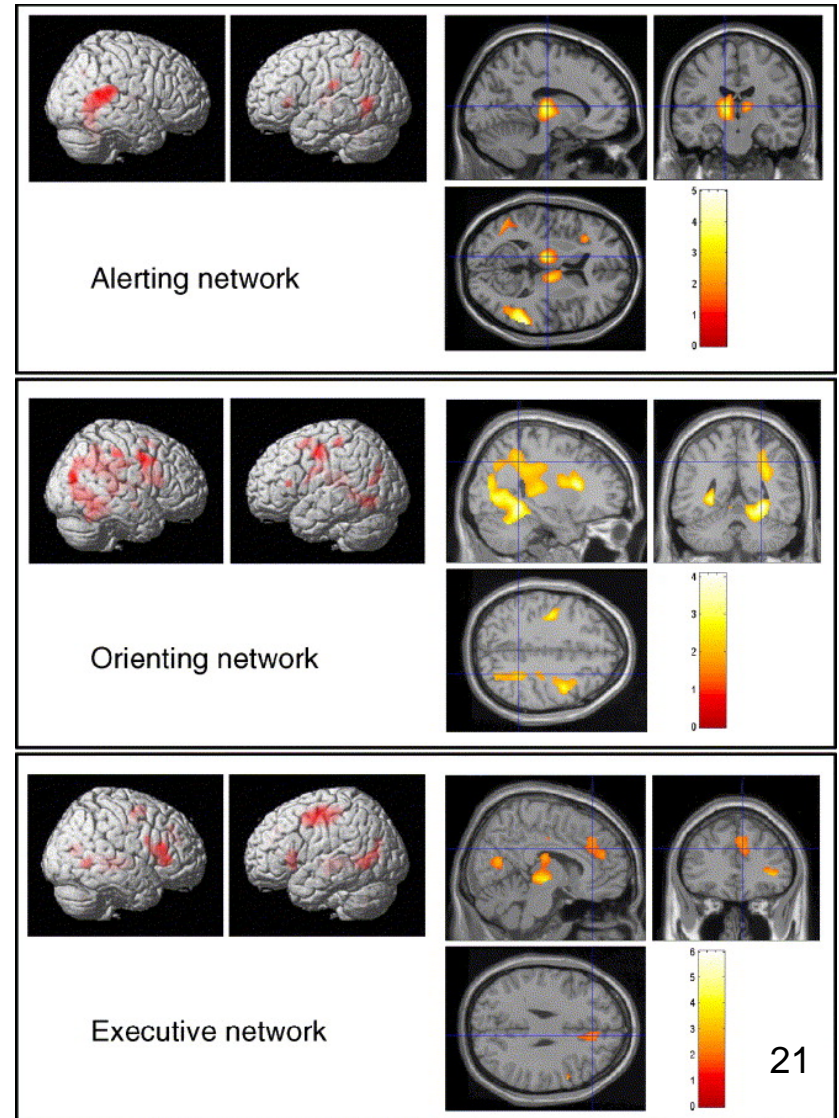


Fig. 10-5. Lateral view of the right hemisphere. Lesions (as determined by CT scan) of ten patients with the neglect syndrome are superimposed.

Imaging the Stage Model of Attention

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

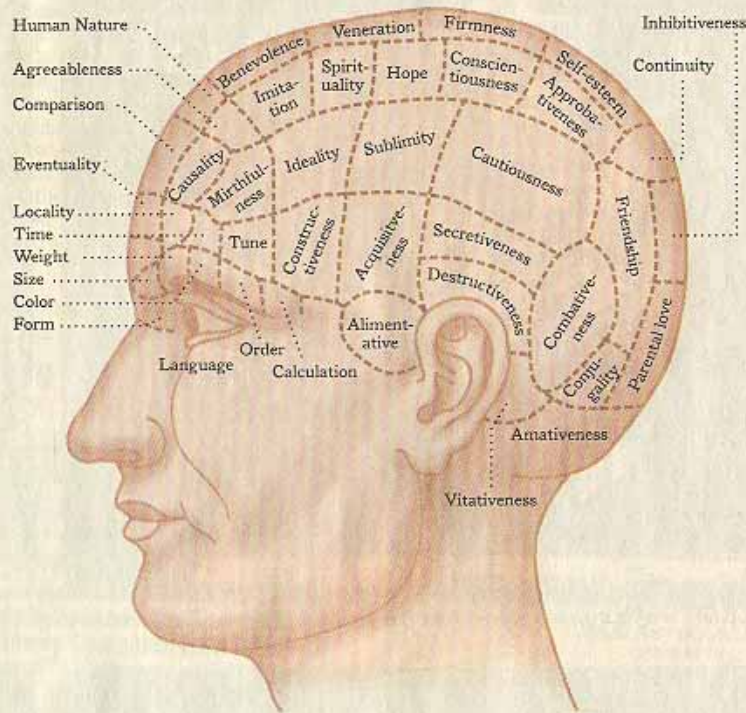
- Alerting and Interruption
 - Fronto-Parietal
 - Thalamus
- Orienting and Localizing
 - Superior Parietal
- Executive Control
 - Anterior Cingulate Gyrus
 - Frontal
 - Disengage
 - Move (Shift)
 - (Re-) Engage
 - Inhibit



Old and New Views of Specialization

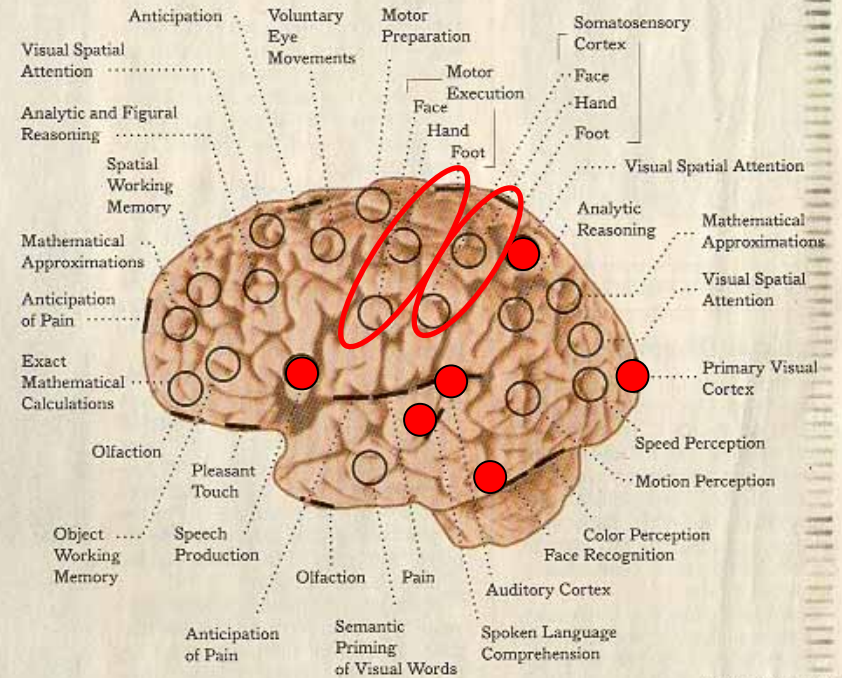
19TH-CENTURY HEAD EXAMINATION

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?