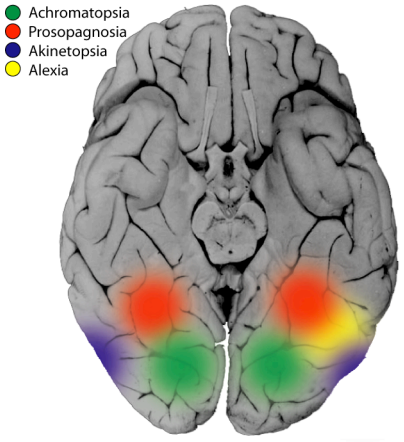
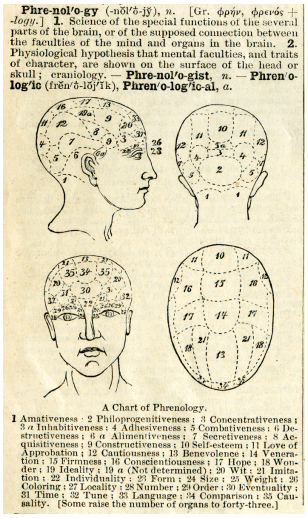
Functional specialization



Phrenology

Franz Joseph Gall
(1757-1828)



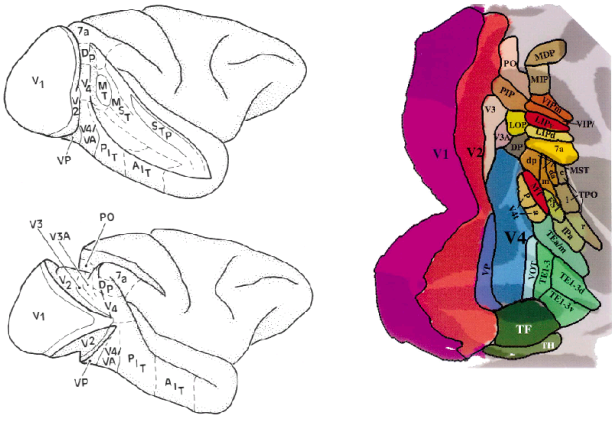
Phre-nol'o-gy (-nŏl'ŏ-jy), *n.* [Gr. φρήν, φρενός + *-logy.*] **1.** Science of the special functions of the several parts of the brain, or of the supposed connection between the faculties of the mind and organs in the brain. **2.** Physiological hypothesis that mental faculties, and traits of character, are shown on the surface of the head or skull; craniology. — **Phre-nol'o-gist**, *n.* — **Phren'o-log'ic** (frĕn'ŏ-lŏj'ĭk), **Phren'o-log'ic-al**, *a.*

A Chart of Phrenology.

1 Amativeness · 2 Philoprogenitiveness ; 3 Concentrativeness ; 3 *a* Inhabitiveness ; 4 Adhesiveness ; 5 Combativeness ; 6 Destructiveness ; 6 *a* Alimentiveness ; 7 Secretiveness ; 8 Acquisitiveness ; 9 Constructiveness ; 10 Self-esteem ; 11 Love of Approbation ; 12 Cautiousness ; 13 Benevolence ; 14 Veneration ; 15 Firmness ; 16 Conscientiousness ; 17 Hope ; 18 Wonder ; 19 Ideality ; 19 *a* (Not determined) ; 20 Wit ; 21 Imitation ; 22 Individuality ; 23 Form ; 24 Size ; 25 Weight ; 26 Coloring ; 27 Locality ; 28 Number ; 29 Order ; 30 Eventuality ; 31 Time ; 32 Tune ; 33 Language ; 34 Comparison ; 35 Causality. [Some raise the number of organs to forty-three.]

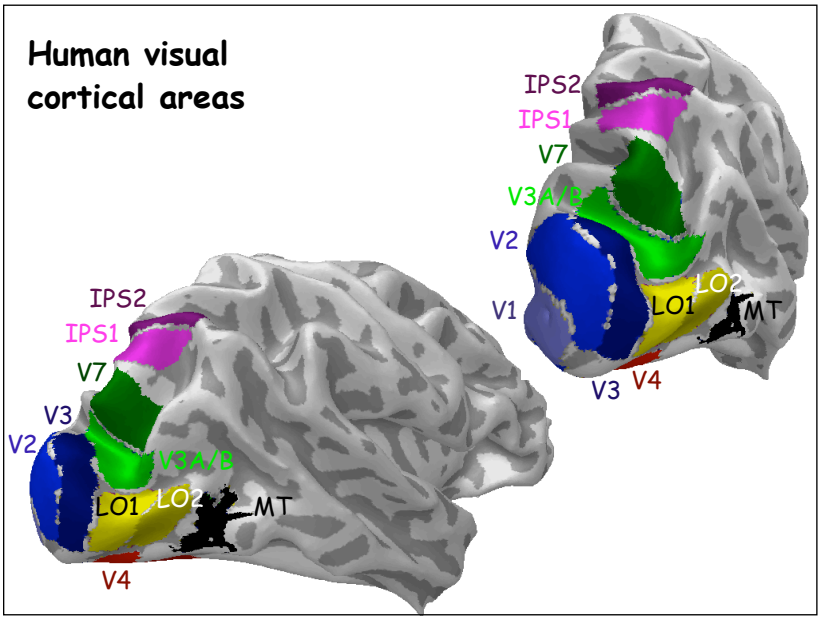
from Webster's Academic Dictionary, 1895

Macaque visual areas



Flattening the brain

Human visual cortical areas



Functional specialization

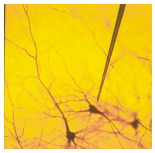
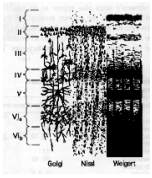
Match each cortical area to its corresponding function:

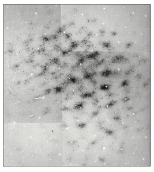
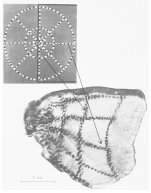
V1	Motion
V2	Stereo
V3	Color
V3A	Texture
V3B	Segmentation, grouping
V4	Recognition
V5	Attention
V7	Working memory
LO1	Mental imagery
IPS1	Decision-making
IPS2	Sensorimotor integration
Etc.	Etc.

Defining visual cortical areas

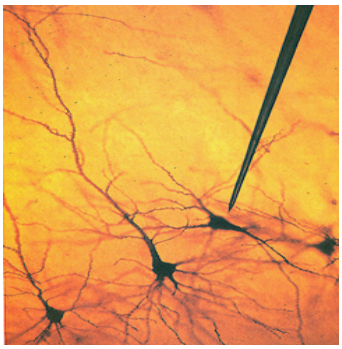
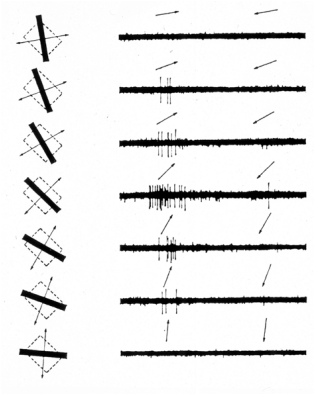
PhACT

Physiology **A**rchitecture **C**onnections **T**opography

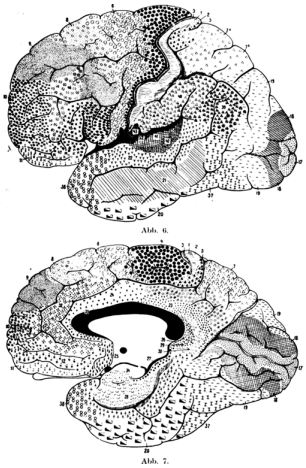
Physiology

Example: direction selectivity in V1

Cytoarchitecture: Brodmann's areas

Korbinian Brodmann
(1868-1918)



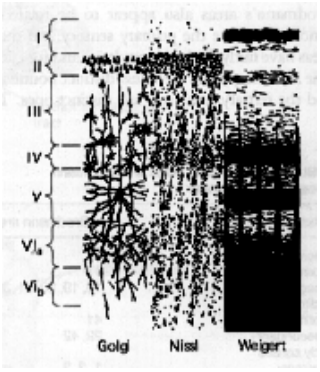
~50 cytoarchitectural areas defined by cell size, cell density, number of layers, density of myelinated axons.

Different stains for different features

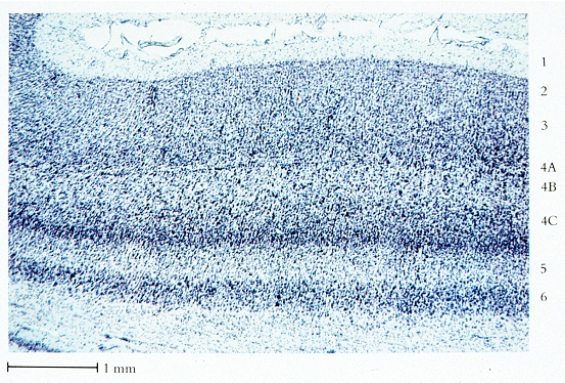
Golgi stain: small fraction of cell bodies and dendrites

Nissel stain: only cell bodies

Weigert myelin stain for axons

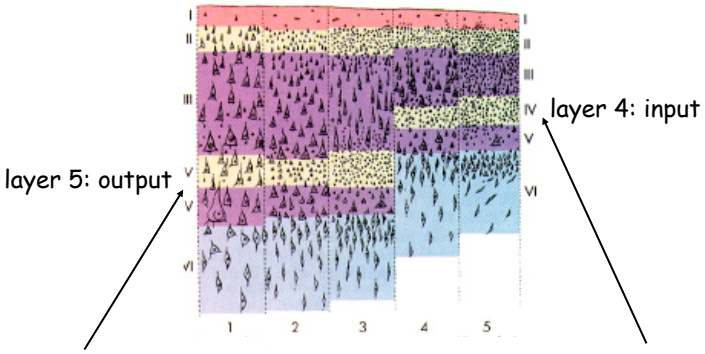


Cortical layers



Primary visual cortex slice (Nissl stain)

Cytoarchitecture and function



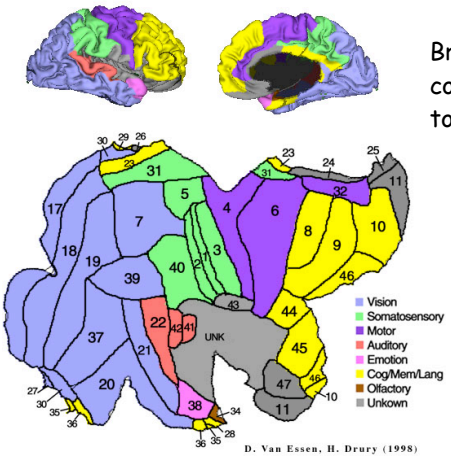
layer 5: output

layer 4: input

Motor cortex: expanded layer 5, reduced layer 4

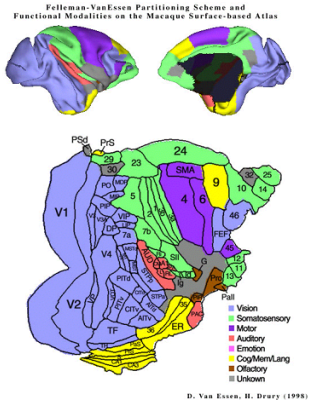
Primary visual cortex: expanded layer 4 with three sublayers

Brodmann areas and functional modalities

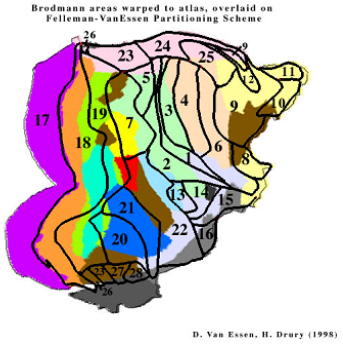


Brodmann areas correspond coarsely to functional modalities

Brodmann areas do not correspond exactly to functional areas

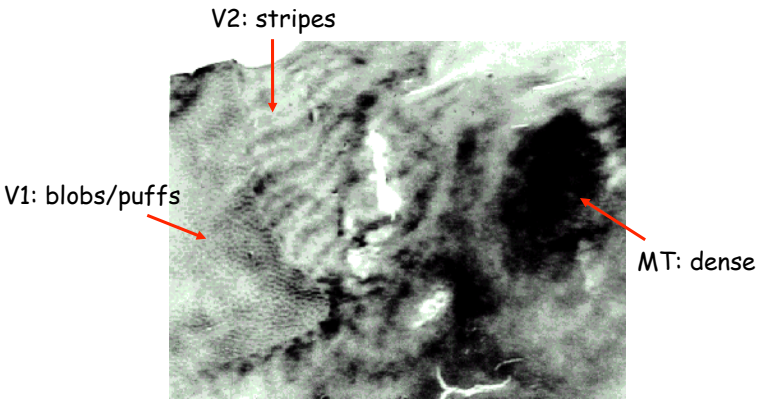


Functional areas in monkey brain



Brodmann areas superimposed

Architecture



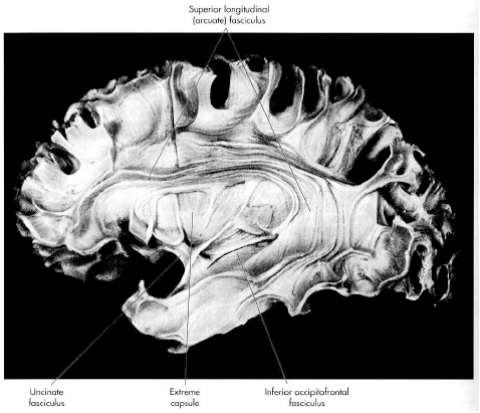
Example: cytochrome oxidase staining in human visual cortex

Connections: white matter bundles

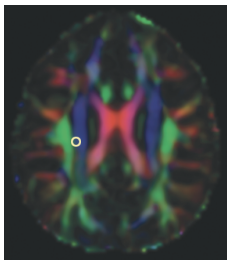
Superior longitudinal (arcuate): connects language centers (Broca's, Wernicke's).

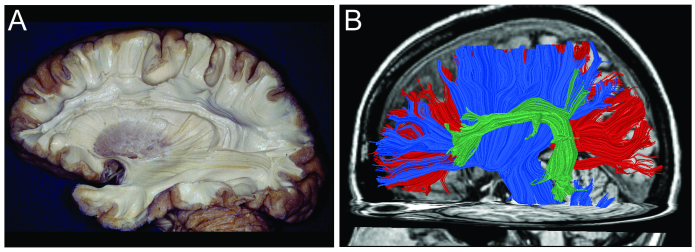
Superior occipitofrontal: dorsal (where) visual pathway.

Inferior occipitofrontal: ventral (what) visual pathway.

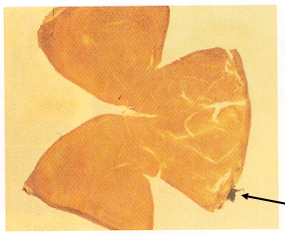


Tracing connections with diffusion tensor imaging

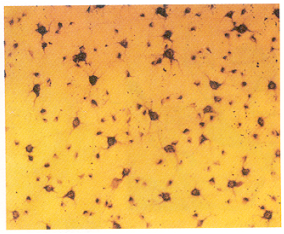




Tracing connections



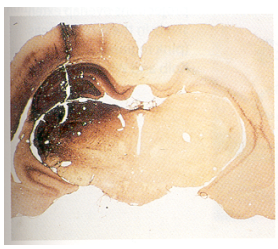
Low magnification



High magnification

Retina

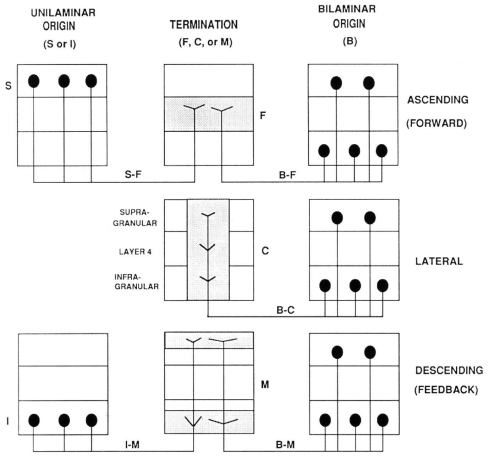
Injection site in LGN (rat)



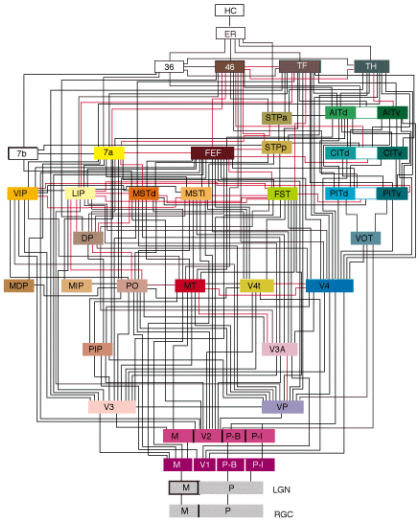
Retrograde tracer
(horseradish peroxidase)

Connections: laminar organization

S: supragranular origin
I: infragranular origin
B: bilaminar origin
(no more than 70%-30% split)
F: layer 4 termination
C: columnar termination
(equal density in all layers)
M: multilaminar termination
(avoids layer 4)

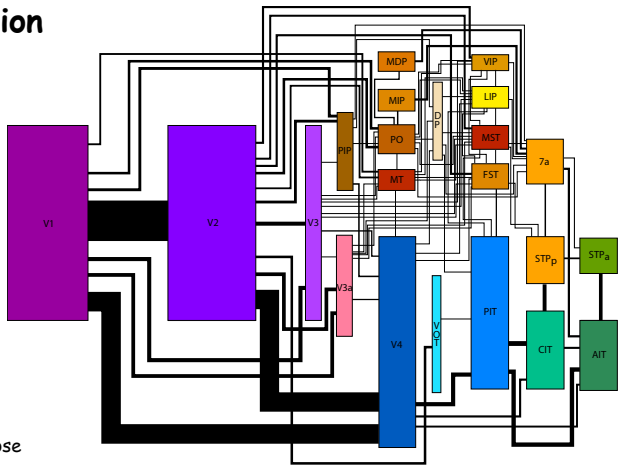


Connections: hierarchical organization of visual areas



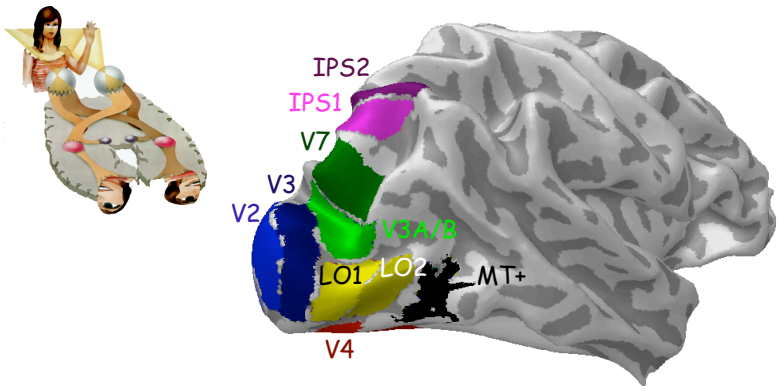
monkey visual cortex

Hierarchical organization



Line thickness represents a loose estimate of connection strength

Topography



Each visual brain area contains a map of the visual world and performs a different function.

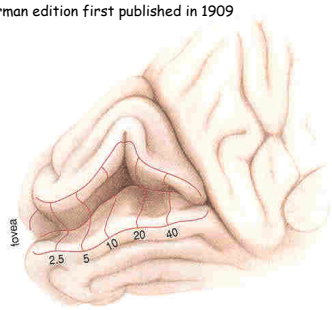
Retinotopy (human V1)

Tatsuji Inouye
(1880-1976)

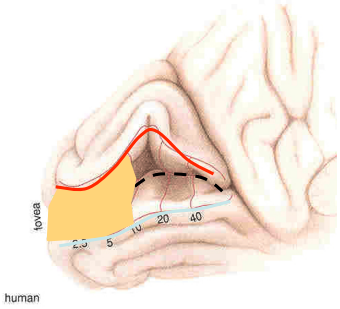
Visual Disturbances Following Gunshot Wounds of the Cortical Visual Area

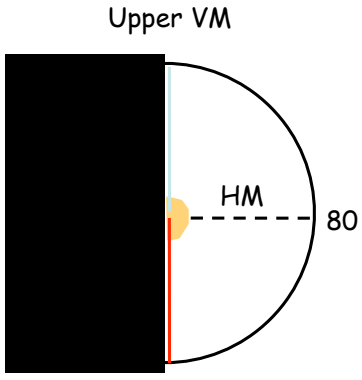
Based on observations of the wounded in the recent Japanese wars

German edition first published in 1909

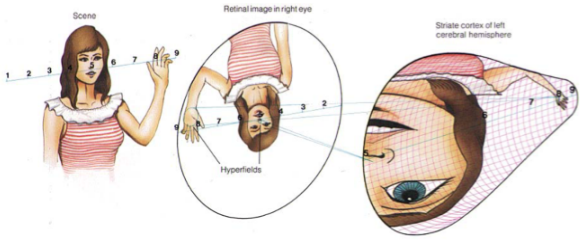


V1 retinotopy





V1 topography & magnification



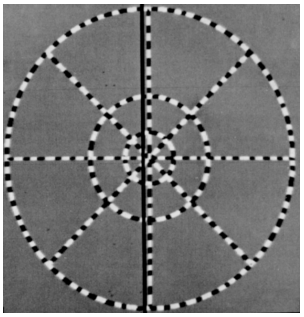
Cortical magnification

Retinal image

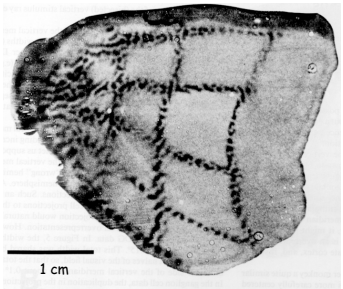
Cortical map

Retinotopy (monkey V1)

stimulus



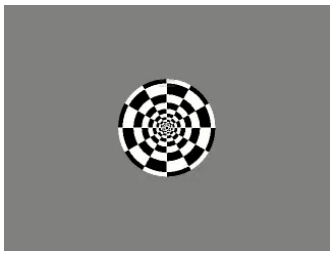
flattened left hemisphere



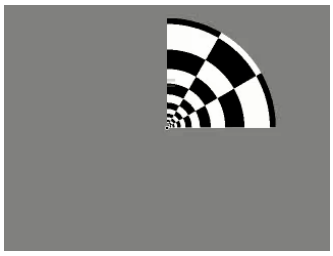
2-deoxyglucose

Measuring human retinotopic maps non-invasively

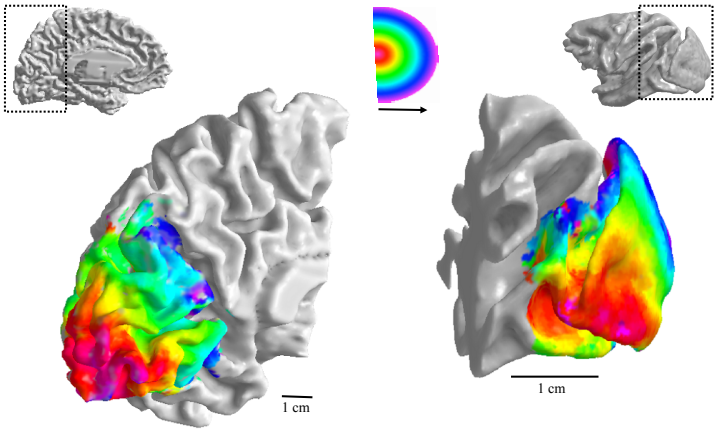
Radial component



Angular component

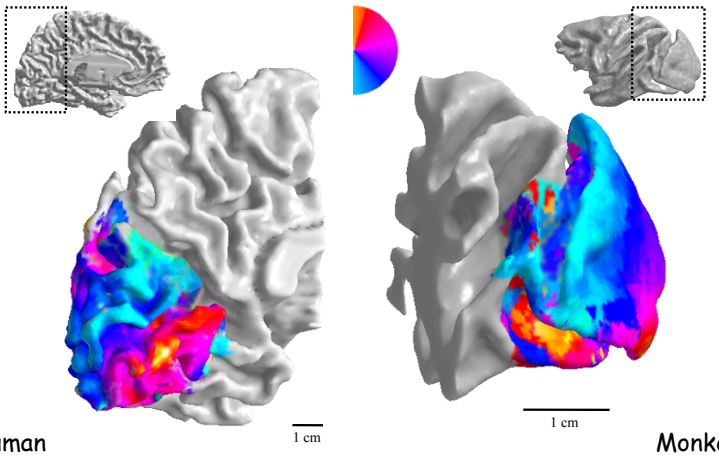


Retinotopy: radial component



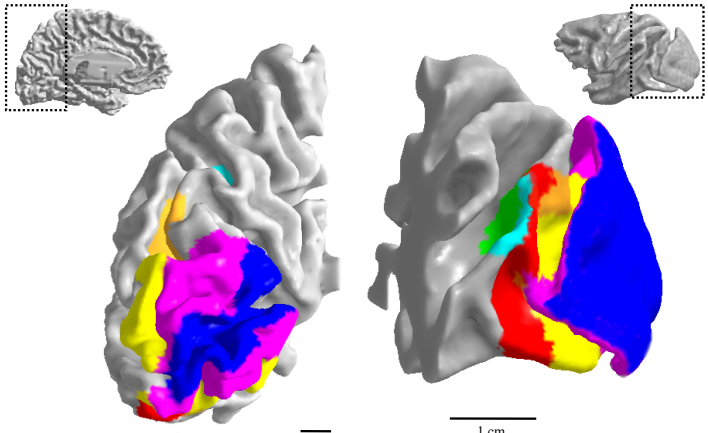
Human Monkey

Retinotopy: angular component



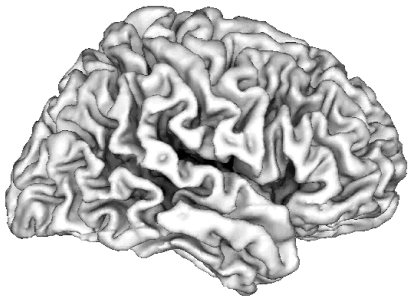
Human Monkey

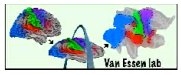
Visual areas



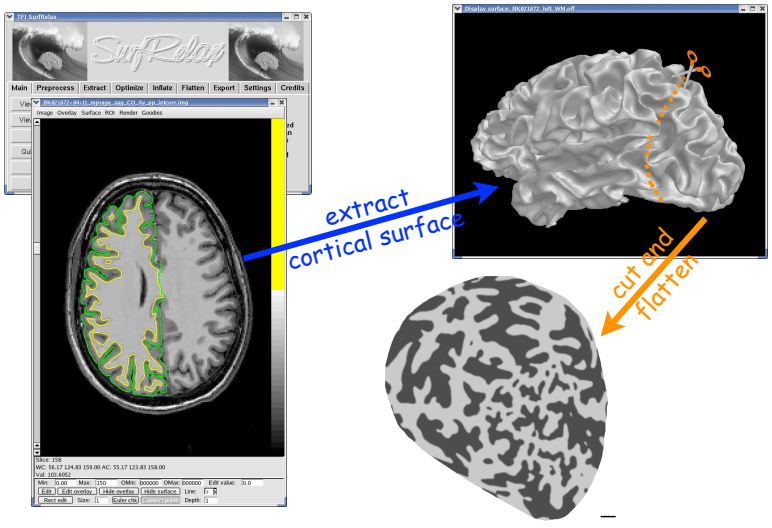
Human Monkey

Flattening the human brain

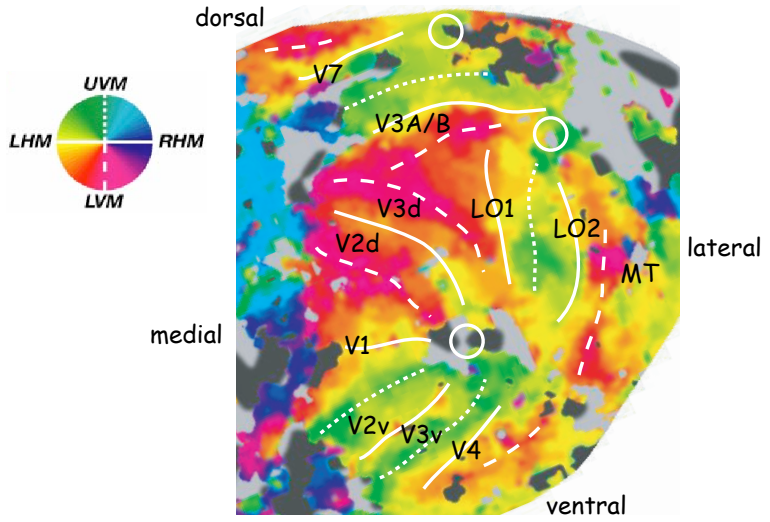




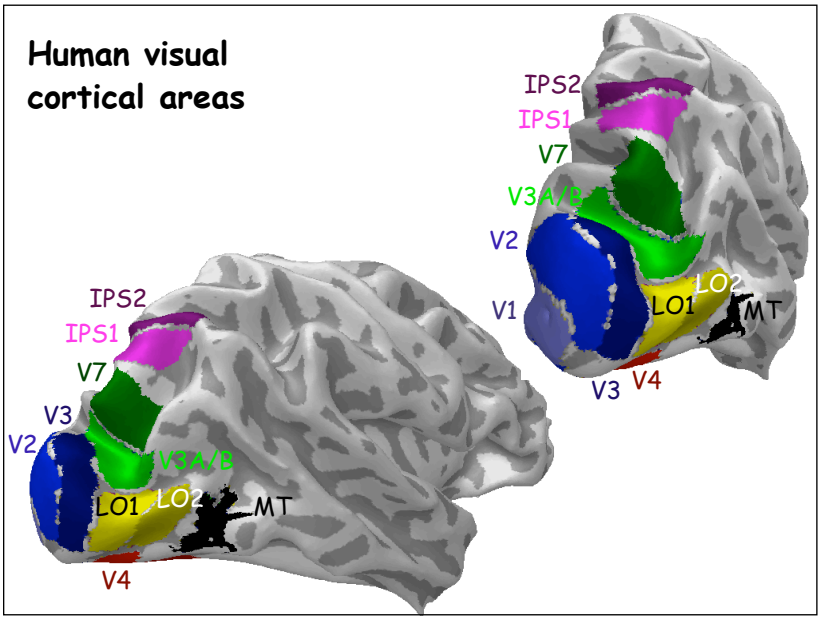
Cortical segmentation & flattening



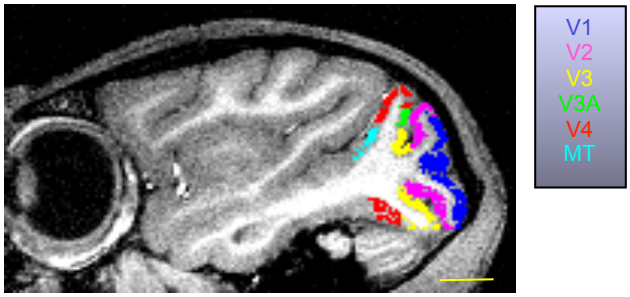
Retinotopy: angular component



Human visual cortical areas

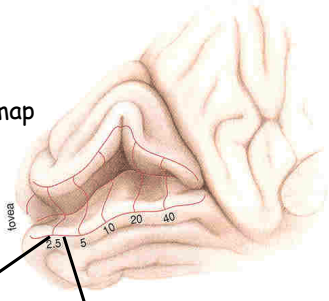


Monkey visual areas from fMRI

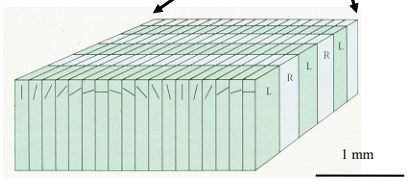


Topography: columnar architecture in V1

Retinotopic map



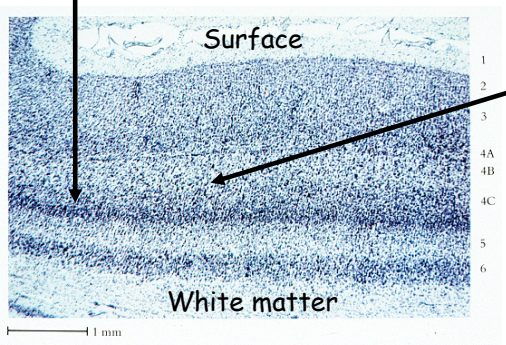
Columnar architecture



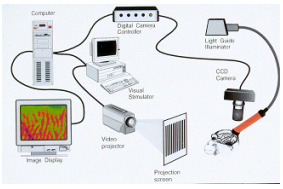
Columnar architecture

Perpendicular electrode penetration: same orientation preferences and ocular dominance.

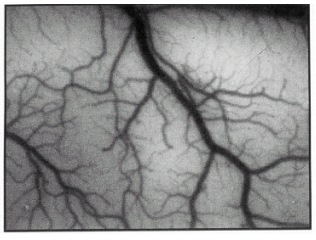
Tangential electrode penetration: orientation preference and/or ocular dominance varies.



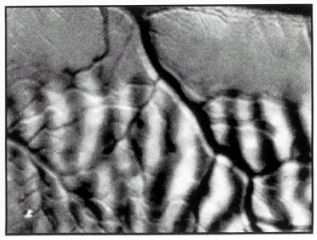
Ocular dominance columns



Optical imaging apparatus



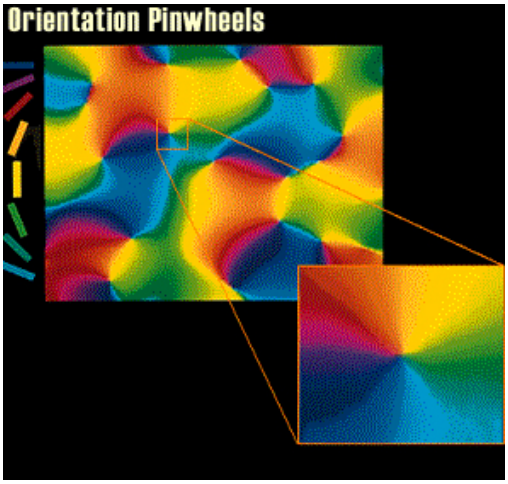
Reference image



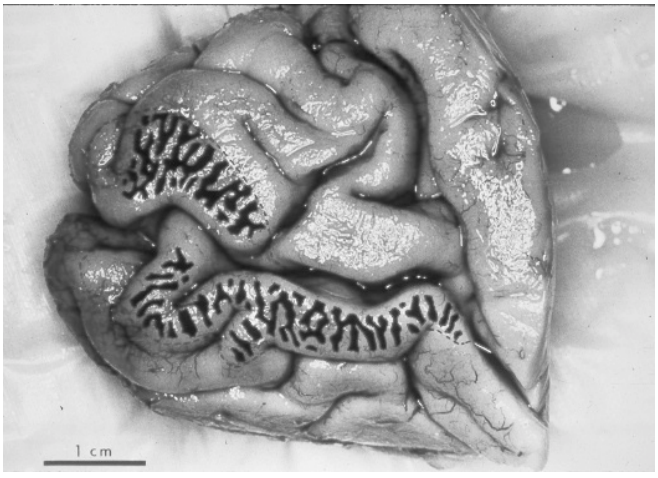
Functional difference image

Ocular dominance movie

Orientation columns and pinwheels

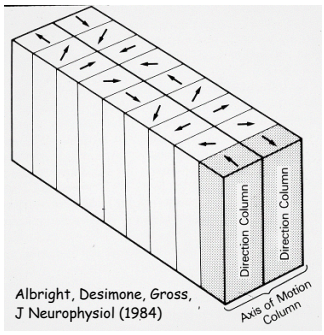


Human ocular dominance columns

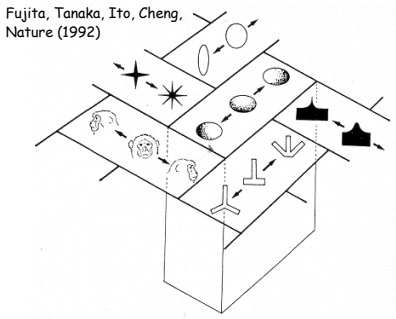


Amblyopia

Columnar architecture in other visual cortical areas

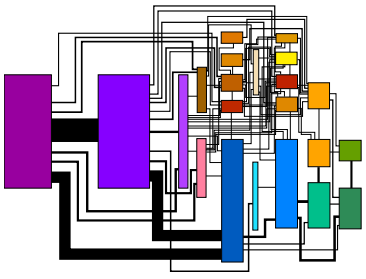


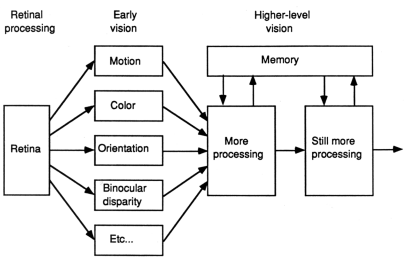
Direction columns in MT

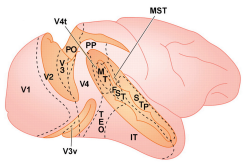


"Feature" columns in IT

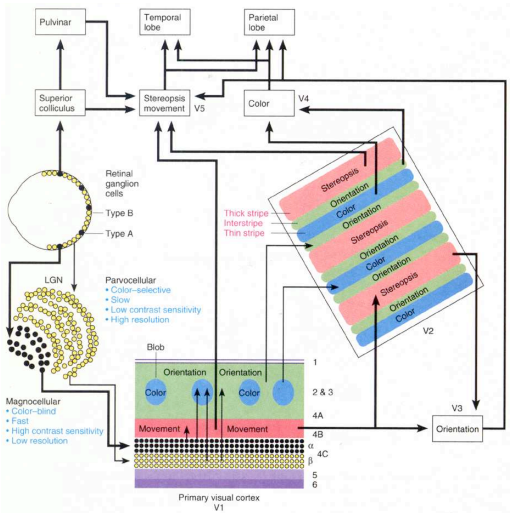
Functional specialization



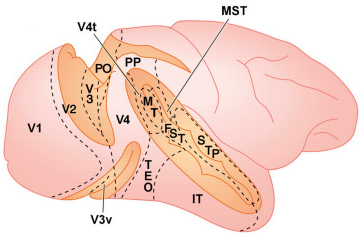


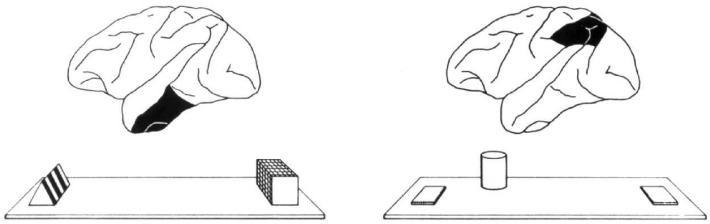


Parallel visual pathways



Dorsal & ventral streams: what vs. where

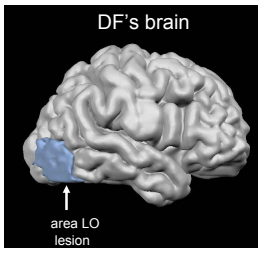


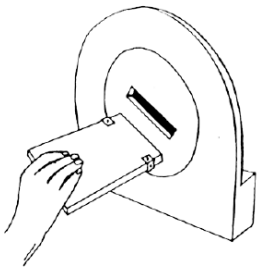


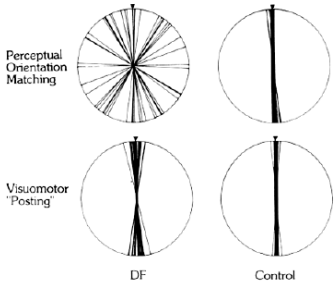
Object Discrimination

Landmark Discrimination

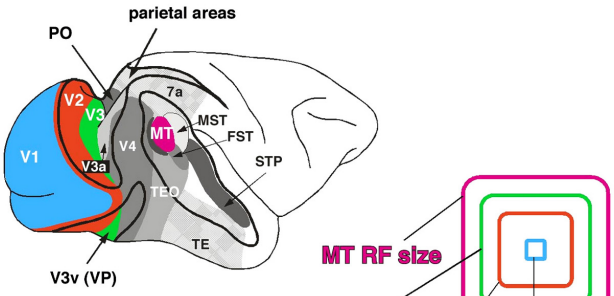
Dorsal & ventral streams: action vs. perception

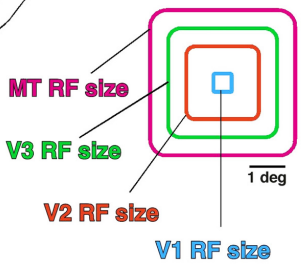




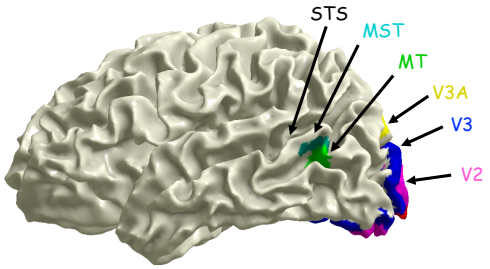


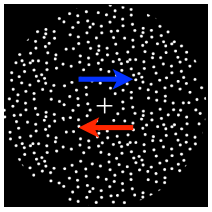
Increasing receptive field size



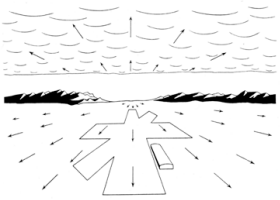


Increasingly complex selectivity





MT



MST

STS

Increasing invariance