Exams:
8 pts/section
Short answer

Cognitive Neuroscience
8/31/21

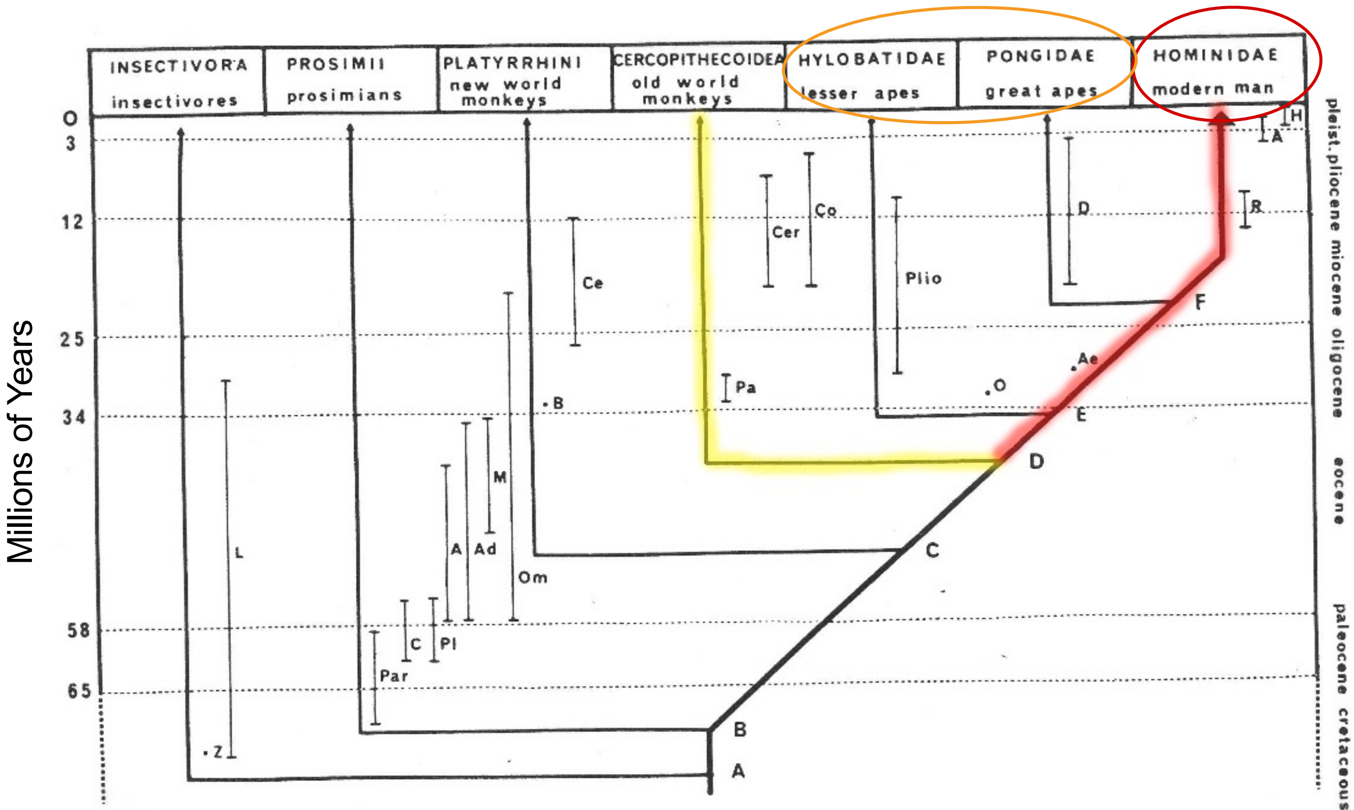
What can neuroanatomy tell us about brain mechanisms of cognition?

1. Gross morphology: Human and monkey cerebral hemispheres are a lot alike.

2. Cytoarchitecture: There are a lot of cortical areas.

3. Ascending connections: Peripheral systems map onto cortical districts.

4. Cortico-cortical connections: Hierarchy.



Old world monkeys, including macaques, are comparatively close to humans in the evolutionary tree.

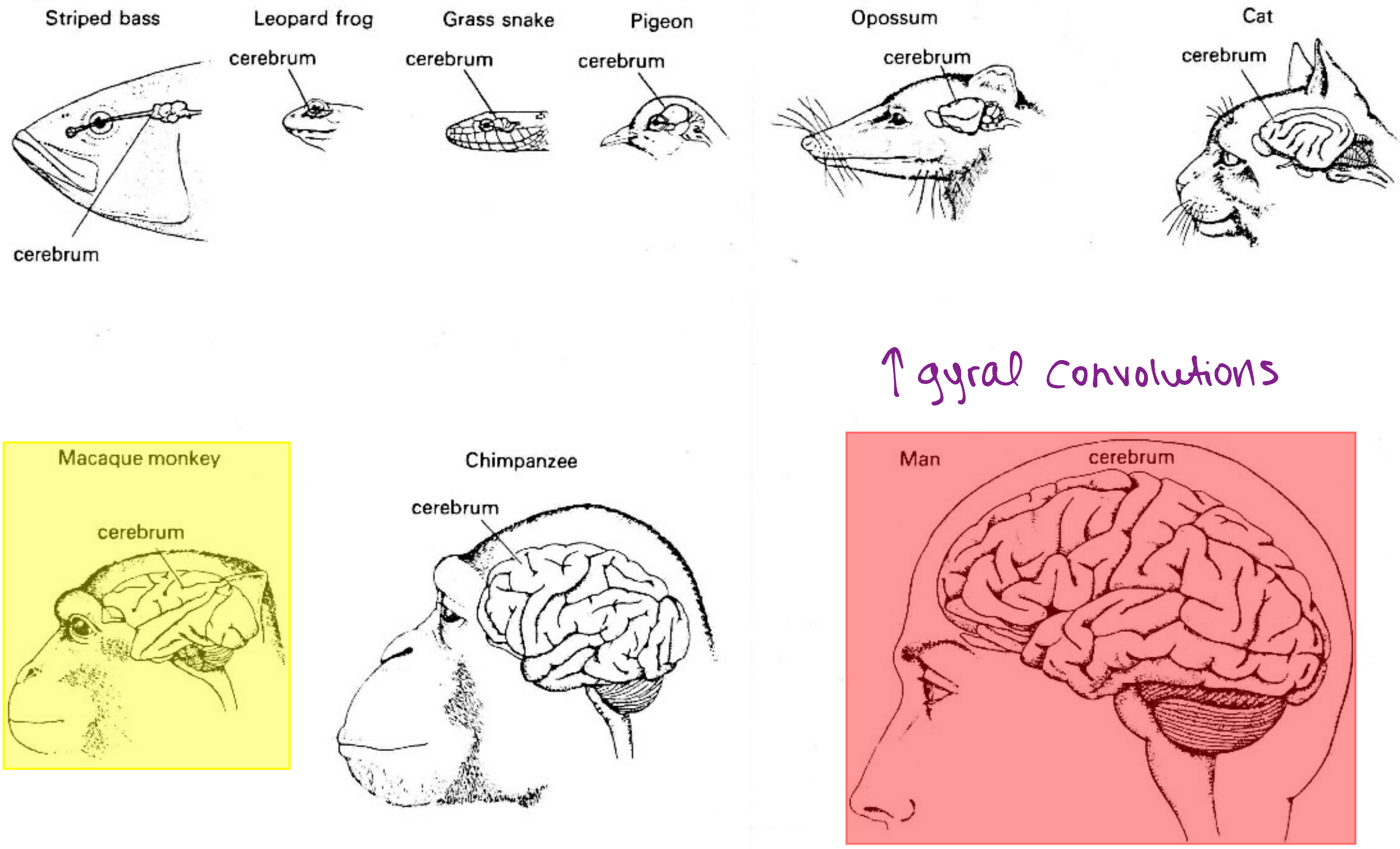
new world:
→ marmosets reproduce quickly

old world:
→ closer to us ancestrally
→ smarter, harder working

R.E. Passingham & G. Ettlinger
A Comparison of Cortical Functions in Man and Other Primates

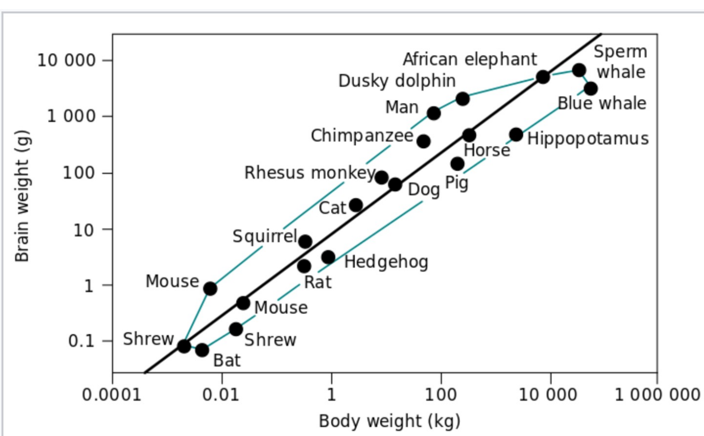
thumbs
walk on all 4 limbs

Advantage:
→ prolific, not threatened



↑ gyral convolutions

Figure 3 The external appearance of vertebrate brains. A selection of vertebrate brains drawn to the same scale. The cerebrum, or forebrain, is labelled, and can be seen to increase in size through the series, although due allowance should be made for the overall body size of the animals involved. The opossum, for instance, would weigh at least four times as much as the pigeon, while its brain is only a little larger than the pigeon's. On the other hand a cat and a macaque monkey may weigh about the same amount (say 4 kg) overall, but the cat's brain would be under 30 gm, and the monkey's brain over 60 gm. The spinal cord is visible in all cases and the cerebellum, just above the spinal cord and finely convoluted, can be seen clearly in the pigeon brain, and in the larger examples. The optic lobe, or tectum, of the pigeon midbrain can be seen as an oval below the cerebrum. (From 'The Brain' by D. H. Hubel. Copyright 1979 by *Scientific American*, Inc. All rights reserved)



Wikipedia

Sperm Whale

Macaque and human brains look similar - although mass of brain relative to body is greater in humans.

The Functional Organisation of the Human Brain, pp. 150-151

Body size ↑ = brain size ↑

Size ↑ = ↑ wrinkled

no gyral folds

1 cm

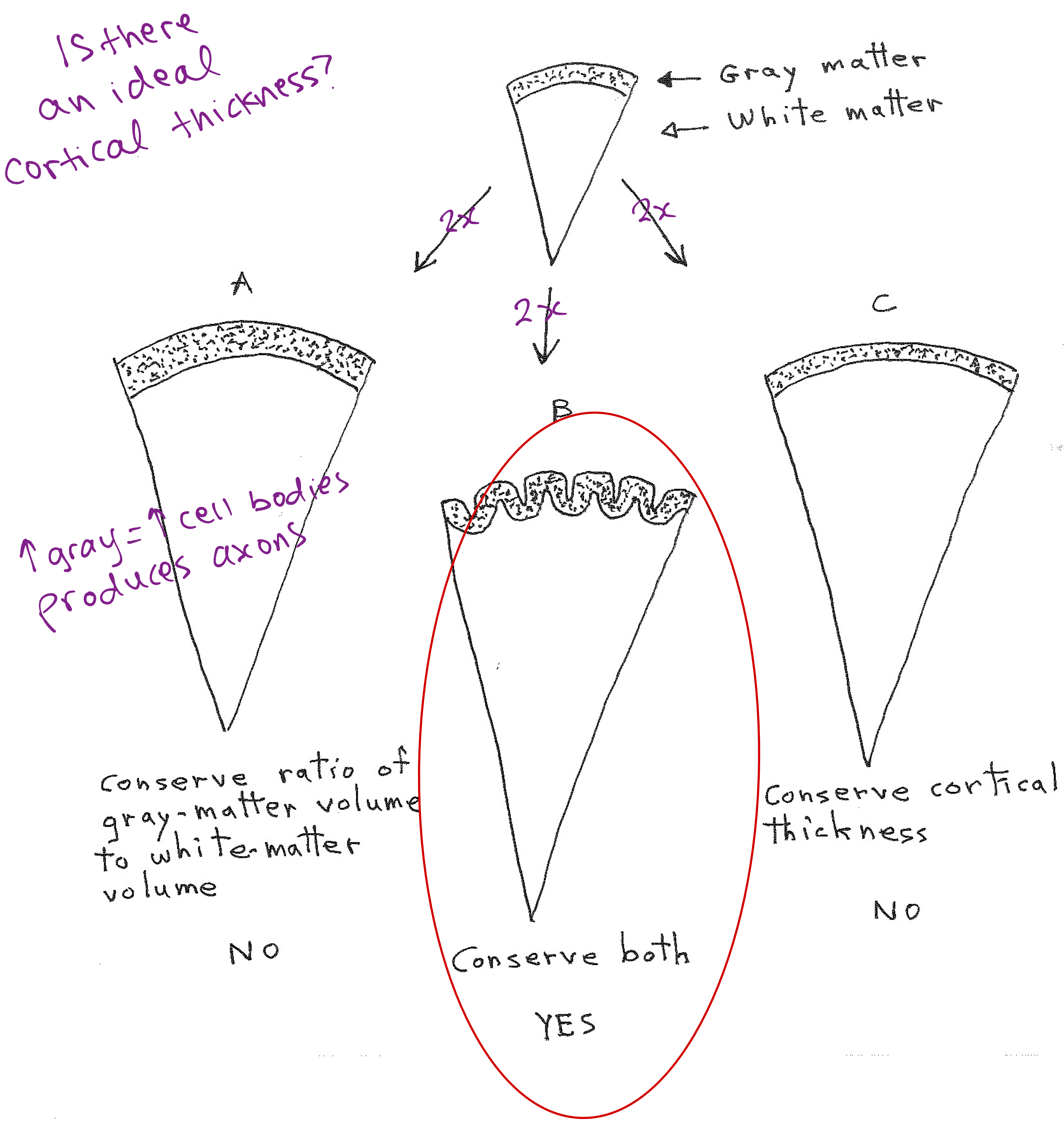
Rat

1 cm

Capybara (largest rodents)

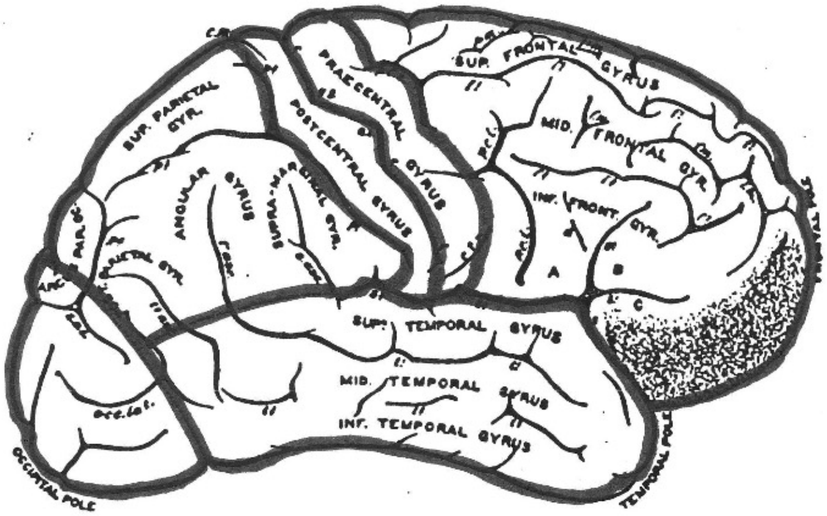
Conserve the surface-to-volume ratio.

Why do that?



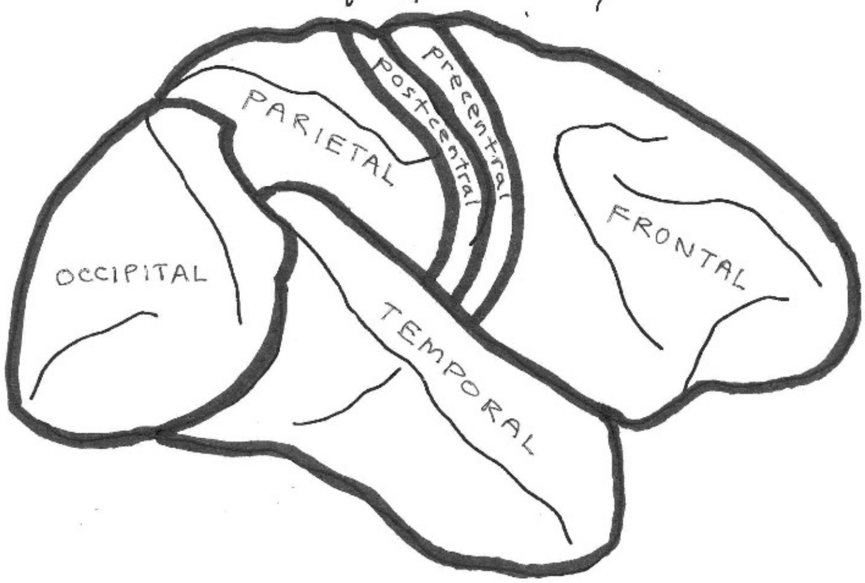
Three ways of enlarging a cerebral hemisphere. Only B conserves both gray-white volume ratio and cortical thickness.

Human



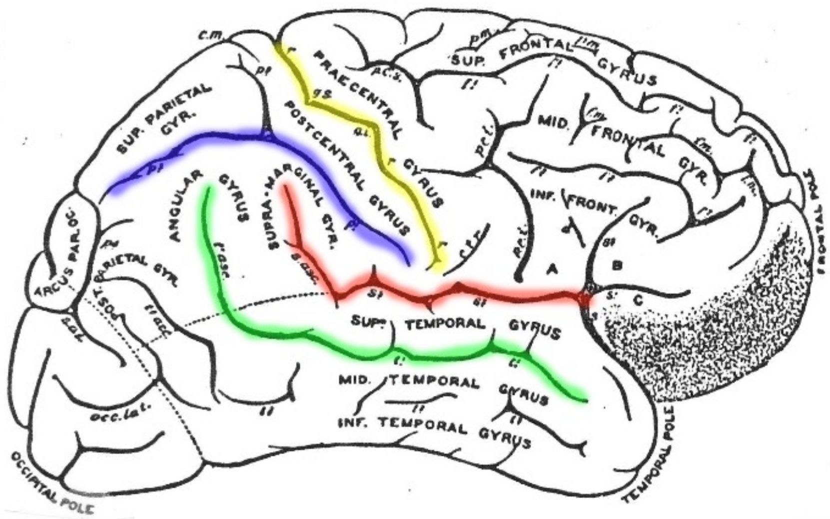
Lobes are kinda meaningless

Macaque Monkey



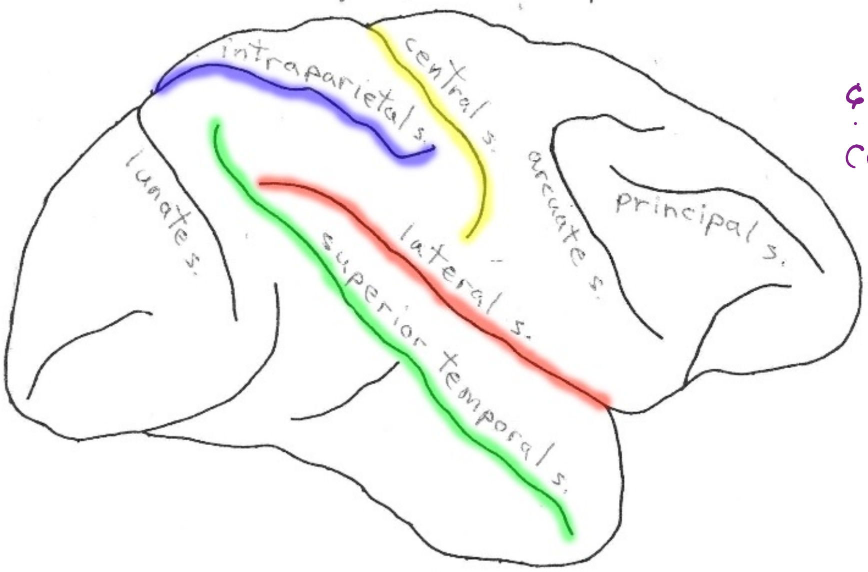
Equivalent rather arbitrary systems have been adopted for dividing macaque & human cerebral hemispheres into lobes.

Human



pattern of
Sulci are different

Macaque Monkey



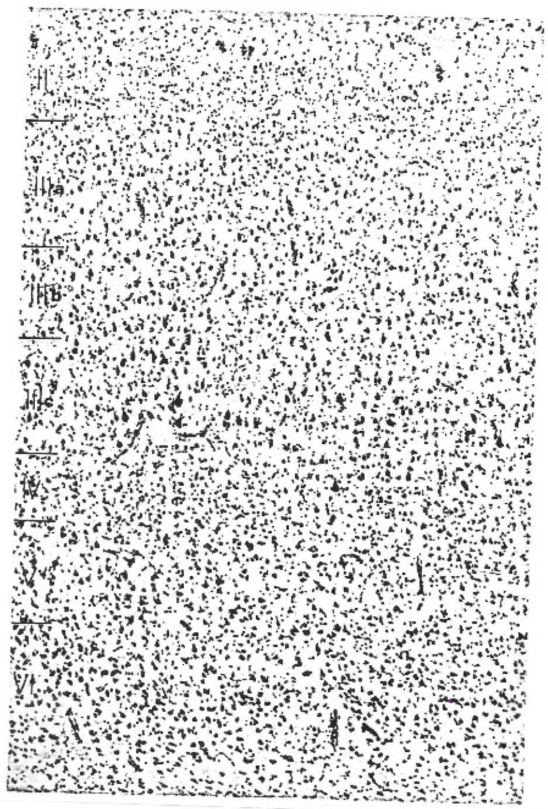
Sylvian fissure
& deep clefts are
consistent in primates

Connections
b/t cortices ?

The human brain – being larger than that of the macaque – has a much more complex and variable pattern of sulcal morphology. However, some sulci – central, lateral, superior temporal and intraparietal among them – can be identified in both species.

Areas within the cerebral cortex can be distinguished on the basis of subtle differences in cytoarchitecture. For example, granule cells are densely packed in layer IV of primary visual cortex and layer V of primary motor cortex contains huge pyramidal cells.

lots of small cells

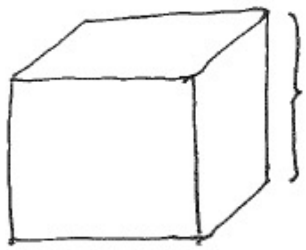


Orbitofrontal cortex

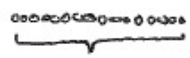
Photograph of Nissl-stained sections of human brain.

F. Sanides, Functional Architecture of Motor and Sensory Cortices in Primates in the Light of a New Concept of Neocortex Evolution, in The Primate Brain, C. R. Noback & W. Montagna, eds., 1970 (p. 146).

~ 20 μm

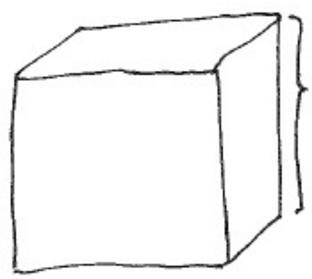


1 mm



50 neurons

~ 10^5 neurons / mm^3



100 mm

~ 10^6 mm^3 / human brain

~ 10^{11} neurons / human brain

(100 billion)

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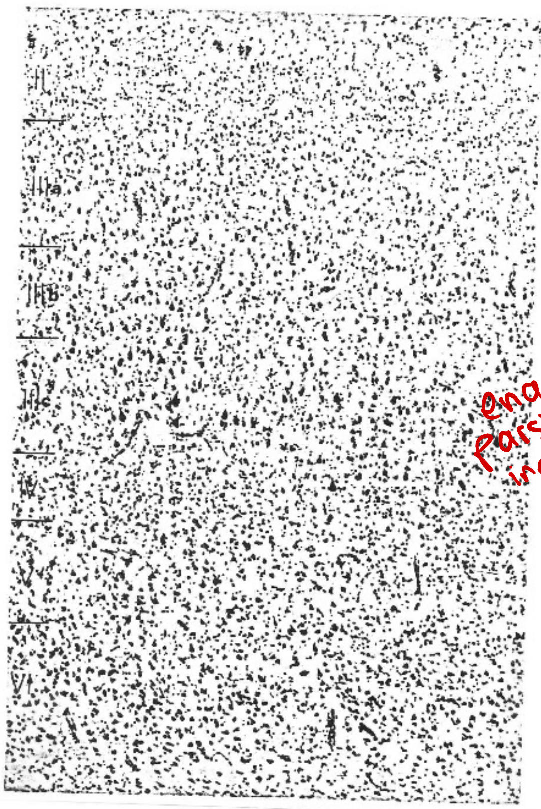

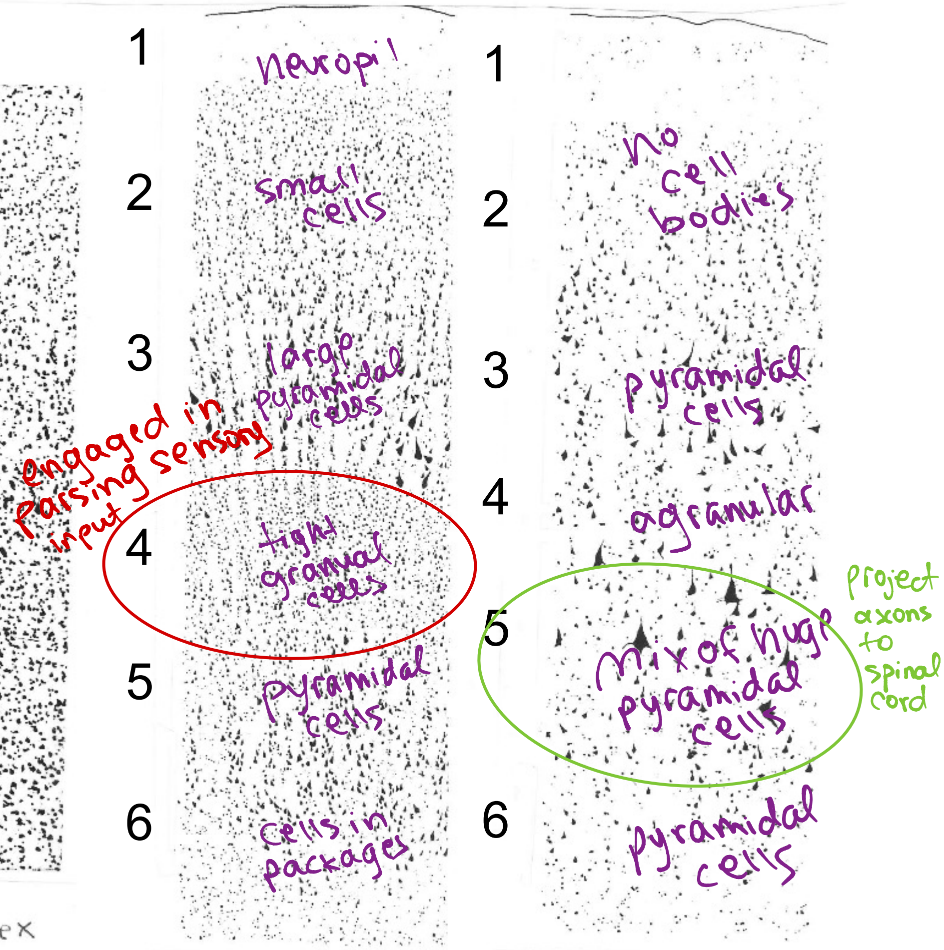

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Photograph of Nissl-stained sections of human brain.

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Primary Visual Cortex

how different?

Primary Motor Cortex

Drawings from Nissl-stained sections of human brain.

A. W. Campbell, Histological Studies on the Localisation of Cerebral Function, Cambridge University Press, 1905 (pp. 296 and 312).

Definitions of some Brodmann areas

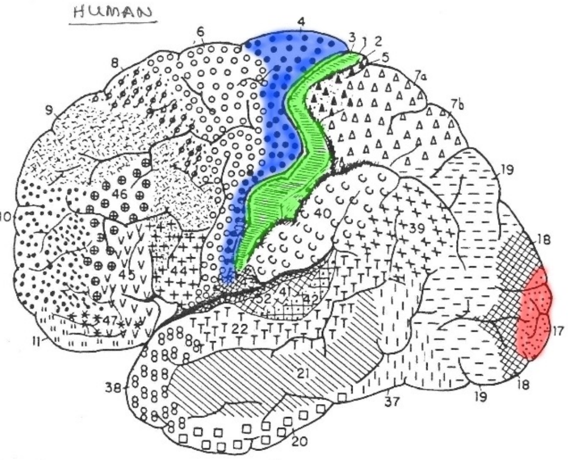
area[s], Brodmann's numbered areas of the cerebral cortex subdivided by Brodmann on the basis of their cytoarchitectural characteristics. They include the following areas:

3, 1, and *2.* the somesthetic area in the postcentral gyrus;
4. motor area in the precentral gyrus;
5. sensory association area in the superior parietal lobule posterior to the postcentral gyrus;
6. premotor area in the frontal lobe anterior to area 4;
7. sensory association area in the superior parietal lobule between areas 5 and 19;
8. frontal eye field in the frontal lobe anterior to area 6;
9. in the frontal lobe anterior to area 8;
10. in the anterior part of the frontal lobe including the frontal pole;

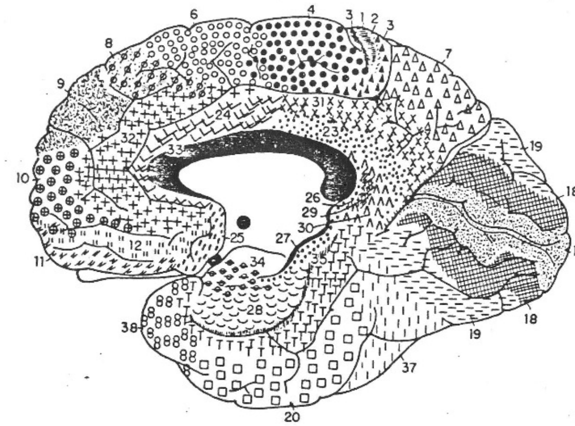
11. in the frontal lobe, ventral to areas 10 and 47 laterally and area 12 medially;
12. in the frontal lobe in the ventral part of the medial hemispheric wall;
17. striate area, visual projection cortex adjoining the calcarine fissure in the occipital lobe, including the occipital pole;
18. parastriate area, visual association cortex, adjacent to area 17 in the occipital lobe;
19. peristriate area [preoccipital cortex], visual association cortex, adjacent to area 18 in the occipital lobe;
20. in the inferior temporal gyrus;
21. in the middle temporal gyrus, making up most of the gyrus;
22. auditory association cortex, mainly on the lateral surface of the superior temporal gyrus and adjoining areas 41 and 42;
23. in the posterior part of the cingulate gyrus;
24. in the anterior part of the cingulate gyrus;
25. parolfactory area on the medial surface of the frontal lobe;
26. in the isthmus of the fornicate gyrus adjoining the corpus callosum;
27. in the parahippocampal gyrus, adjacent to the hippocampal fissure;
28. entorhinal area, making up most of the parahippocampal gyrus;
29. in the isthmus of the fornicate gyrus between areas 26 and 30;
30. in the isthmus of the fornicate gyrus just posterior to area 29;
31. in the cingulate gyrus just above area 23 and posterior to area 24;
33. in the cingulate gyrus adjacent to the anterior portion of the sulcus of the corpus callosum;
34. uncus of the temporal lobe;
35. adjacent to the rhinal fissure in the temporal lobe;
36. most of the fusiform gyrus in the temporal lobe;
37. in the posterior portion of the temporal lobe on its medial and lateral surfaces;
38. temporal pole;
39. angular gyrus;
40. supramarginal gyrus;
41 and *42.* auditory projection area making up the transverse temporal gyri on the opercular surface of the temporal lobe;
44. opercular portion of the inferior frontal gyrus;
45. triangular portion of the inferior frontal gyrus;
46. part of the frontal eye field, in the middle frontal gyrus;
47. orbital portion of the inferior frontal gyrus;
48. retrosubicular area posterior to area 35 on the medial aspect of the temporal lobe;
52. on the opercular surface of the superior temporal gyrus between area 41 and the insula, probably an association area for auditory and perhaps visceral functions.

Lockard, Desk Reference for Neuroanatomy

Brodmann Areas



Cytoarchitectonic areas of the brain (Brodmann, 1903–1908). Copyright 1960 by Masson & Co., Paris. Reproduced by permission.



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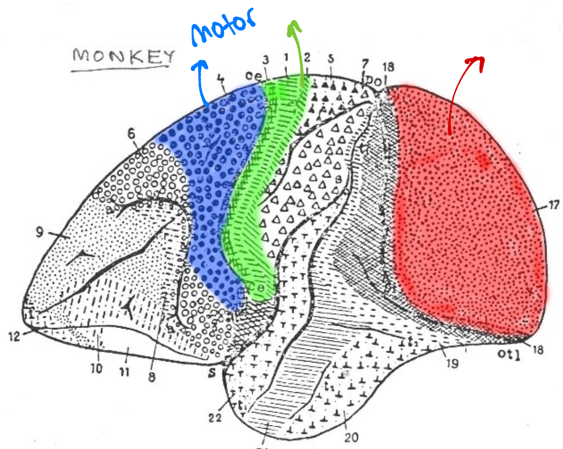


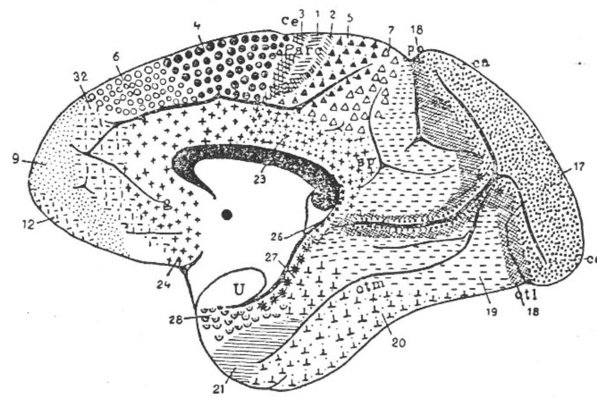
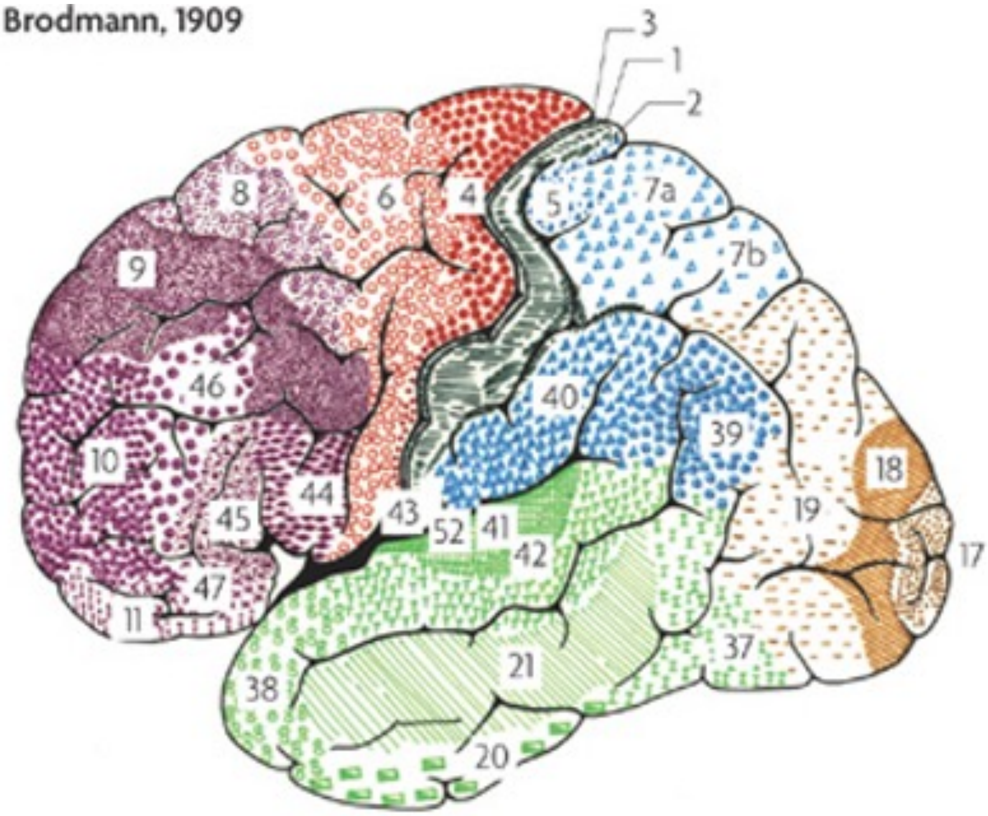
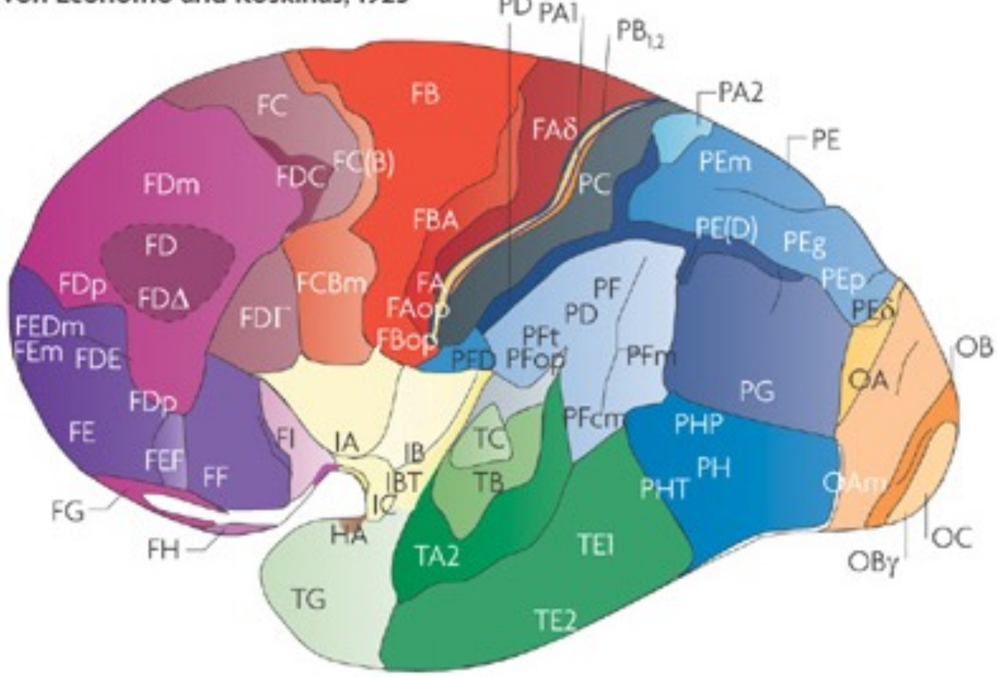


FIG. 35. — Brodmann's map of the cerebral cortex of Cercopithecus (Campbelli?).

Brodmann, 1909

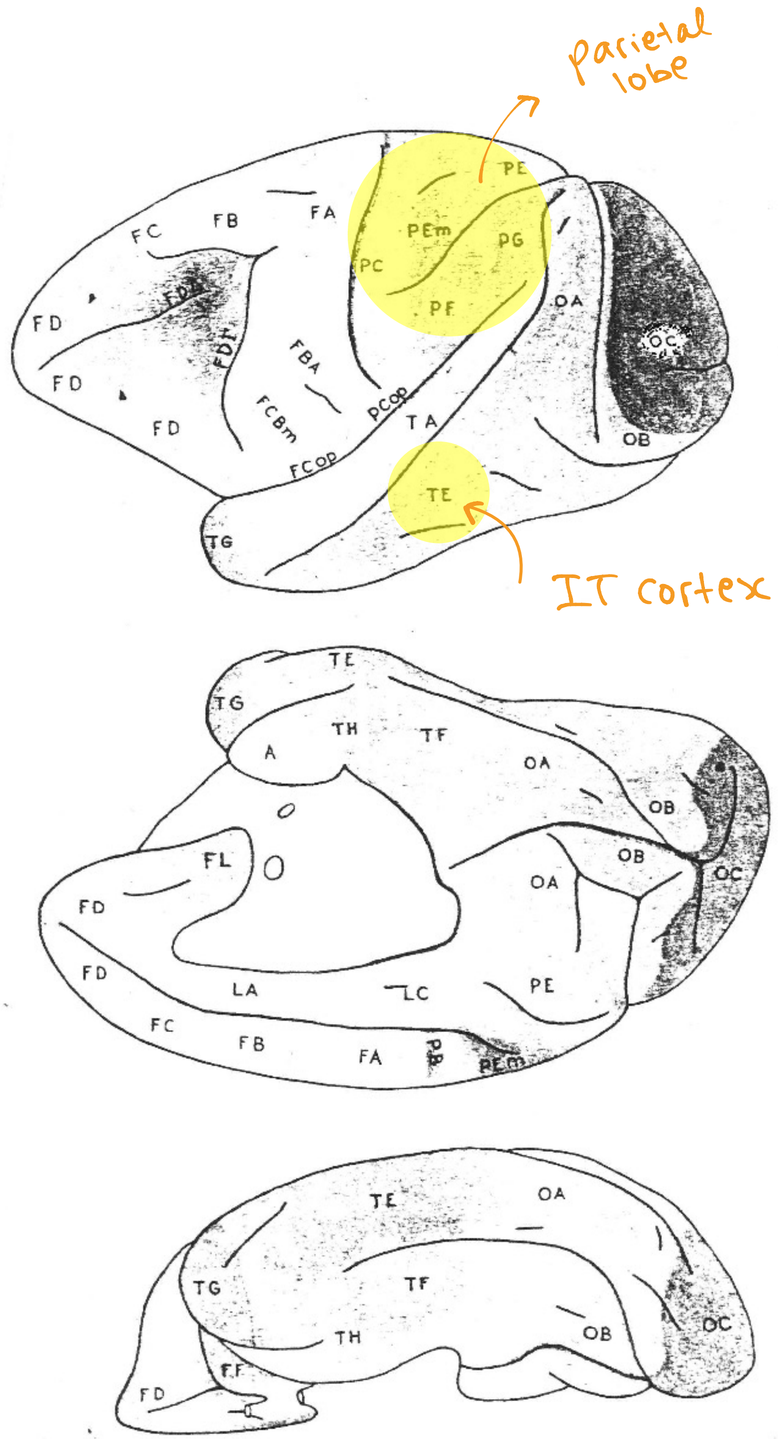


von Economo and Koskinas, 1925



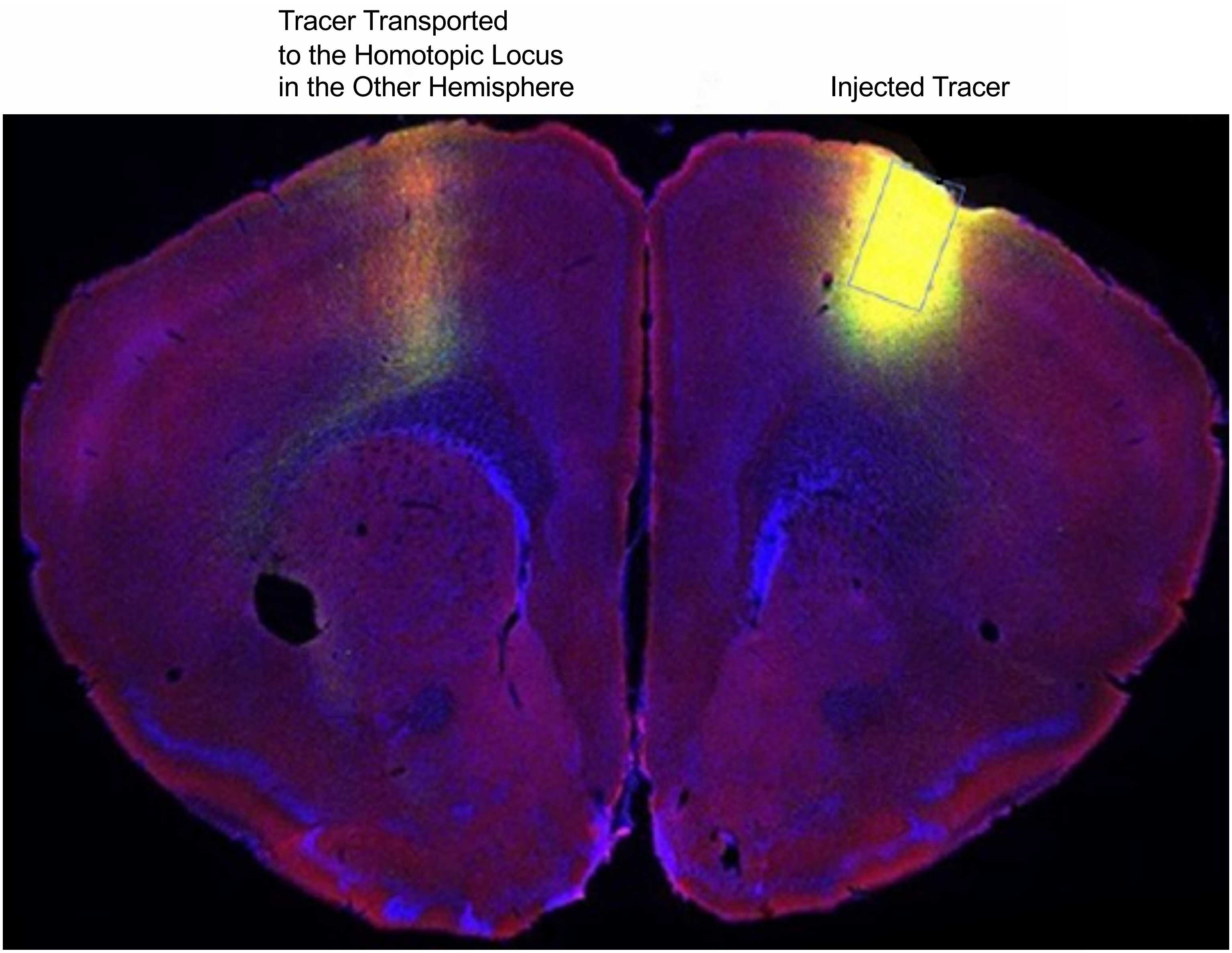
Zilles and Amunts, Nature Reviews Neuroscience 11: 139-145 (2010)

Areas in Brodmann and von Economo systems coincide sometimes but not always.



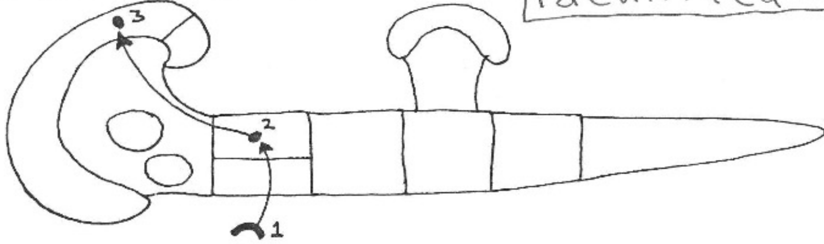
Cortical Areas of Macaca
(See page 57)

Von Bonin & Bailey's (1947) cytoarchitectural divisions are sometimes used in preference to Brodmann divisions in reference to monkey cortex. Examples are area "TE" (inferotemporal cortex) and areas PE, PF and PG in the parietal lobe.



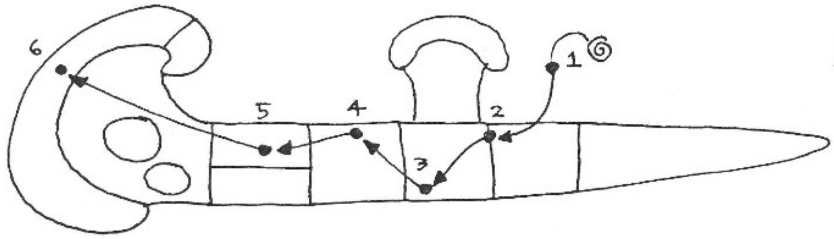
Tracers are used to analyze patterns of inter-areal connectivity in the cerebral hemisphere.

Several major districts of the cerebral cortex can be looked on as direct extensions of functionally identified subcortical systems.



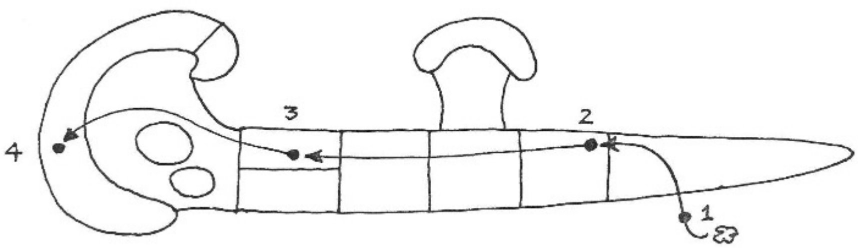
VISION

1. retina
2. lateral geniculate nucleus (LGN)
3. primary visual cortex



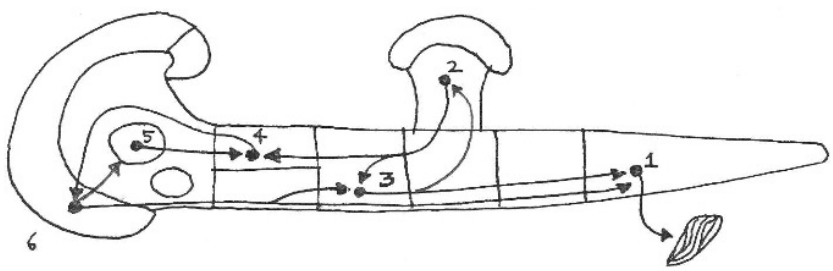
HEARING

1. cochlea
2. cochlear nucleus
3. superior olive
4. inferior colliculus
5. medial geniculate nucleus
6. primary auditory cx.



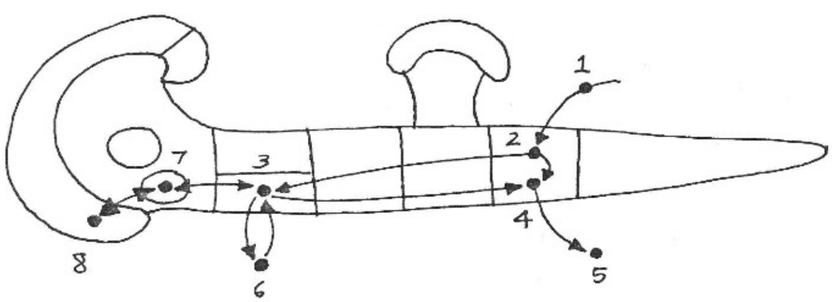
TOUCH

1. spinal ganglion
2. dorsal column nuclei
3. ventrobasal nucleus
4. primary somesthetic cx



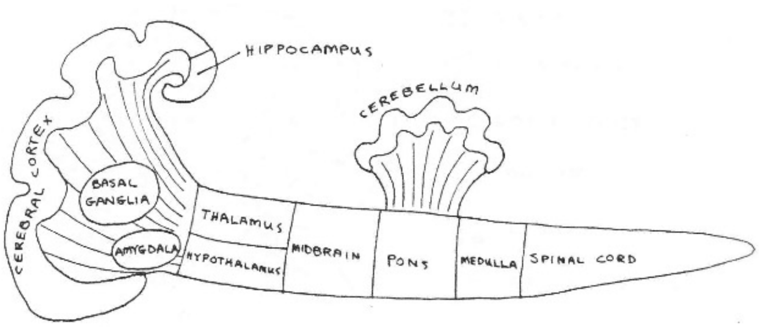
MOVEMENT

1. spinal cord
2. cerebellum
3. various brainstem nuclei
4. ventrolateral nucleus
5. basal ganglia
6. motor cortex



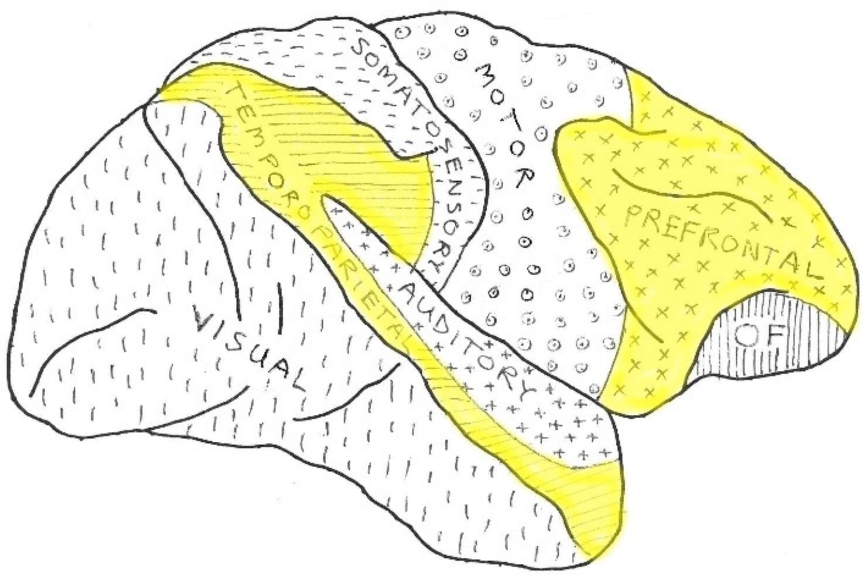
VISCERO-HOMEOSTATIC

1. visceral sensory ganglia
2. visceral sensory nuclei
3. hypothalamus
4. visceral motor nuclei
5. autonomic ganglia
6. blood
7. amygdala
8. orbitofrontal cx

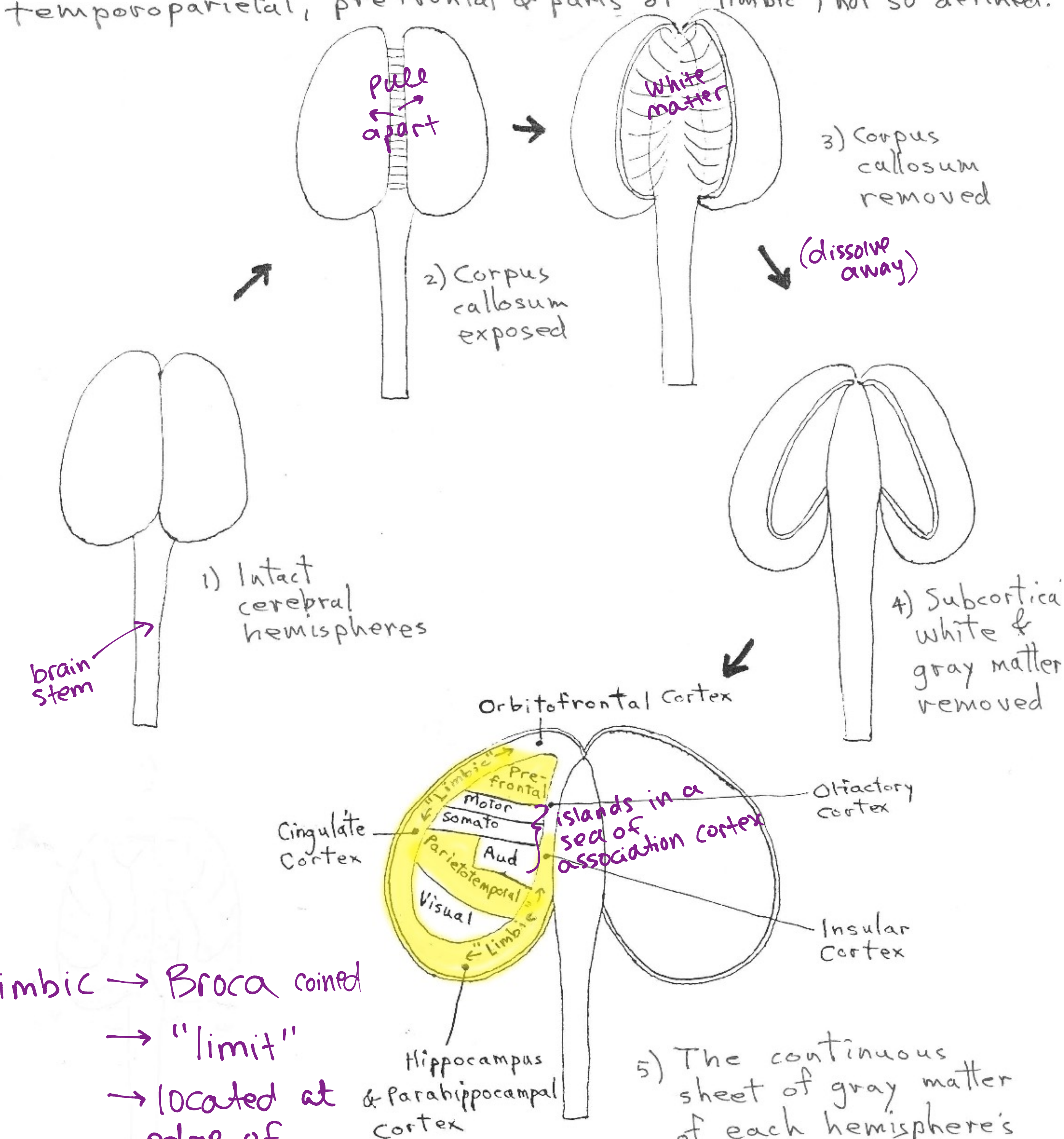


the major functionally defined districts in the cortex of the right cerebral hemisphere of a macaque.

there are some parts of cortex that can't be identified (no ascending pathways)



Arrangement, within the cortical sheet, of districts defined by their connections to functionally identified subcortical systems and of other districts (including temporoparietal, prefrontal & parts of "limbic") not so defined.

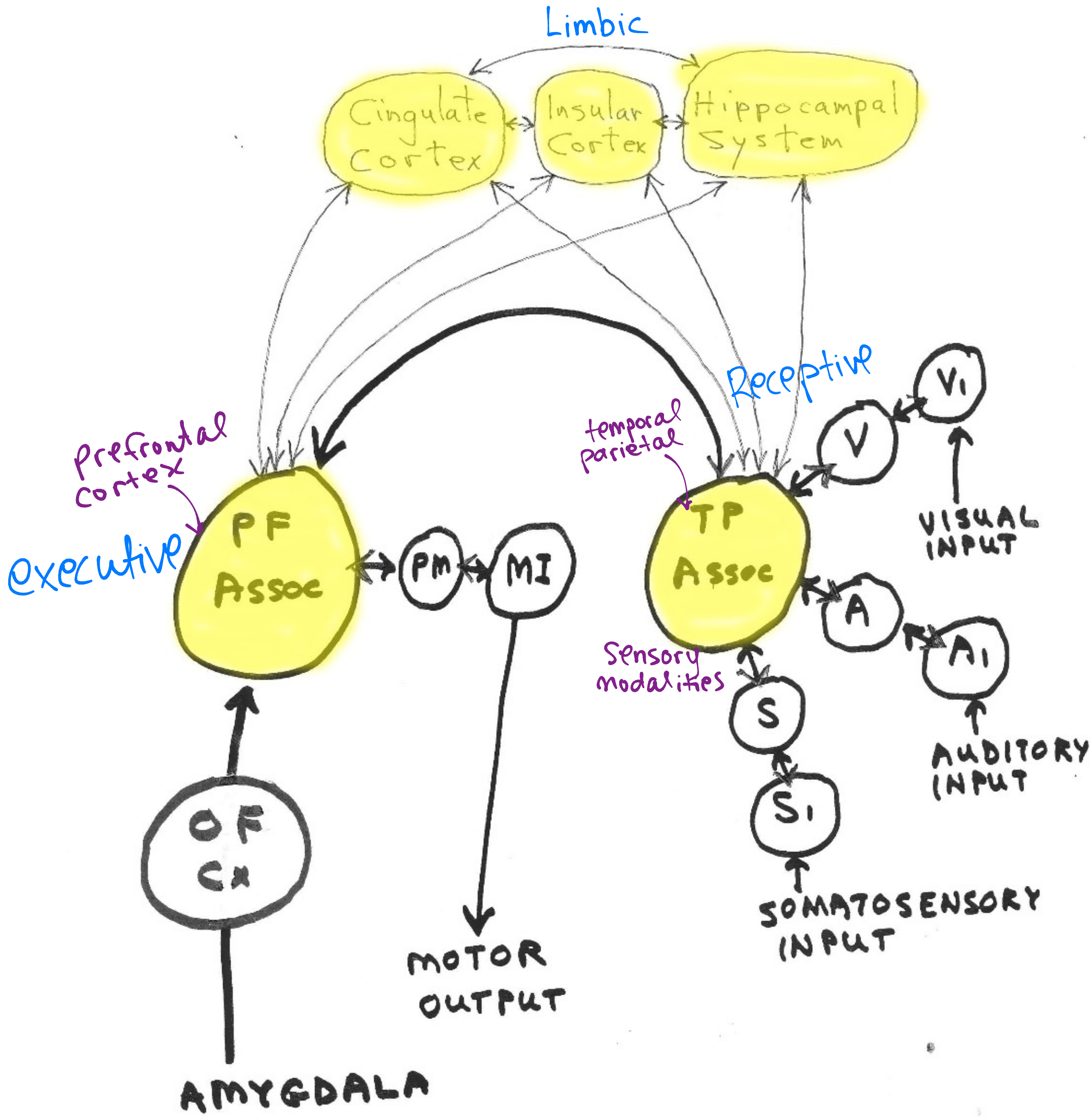


Limbic → Broca coined

→ "limit"

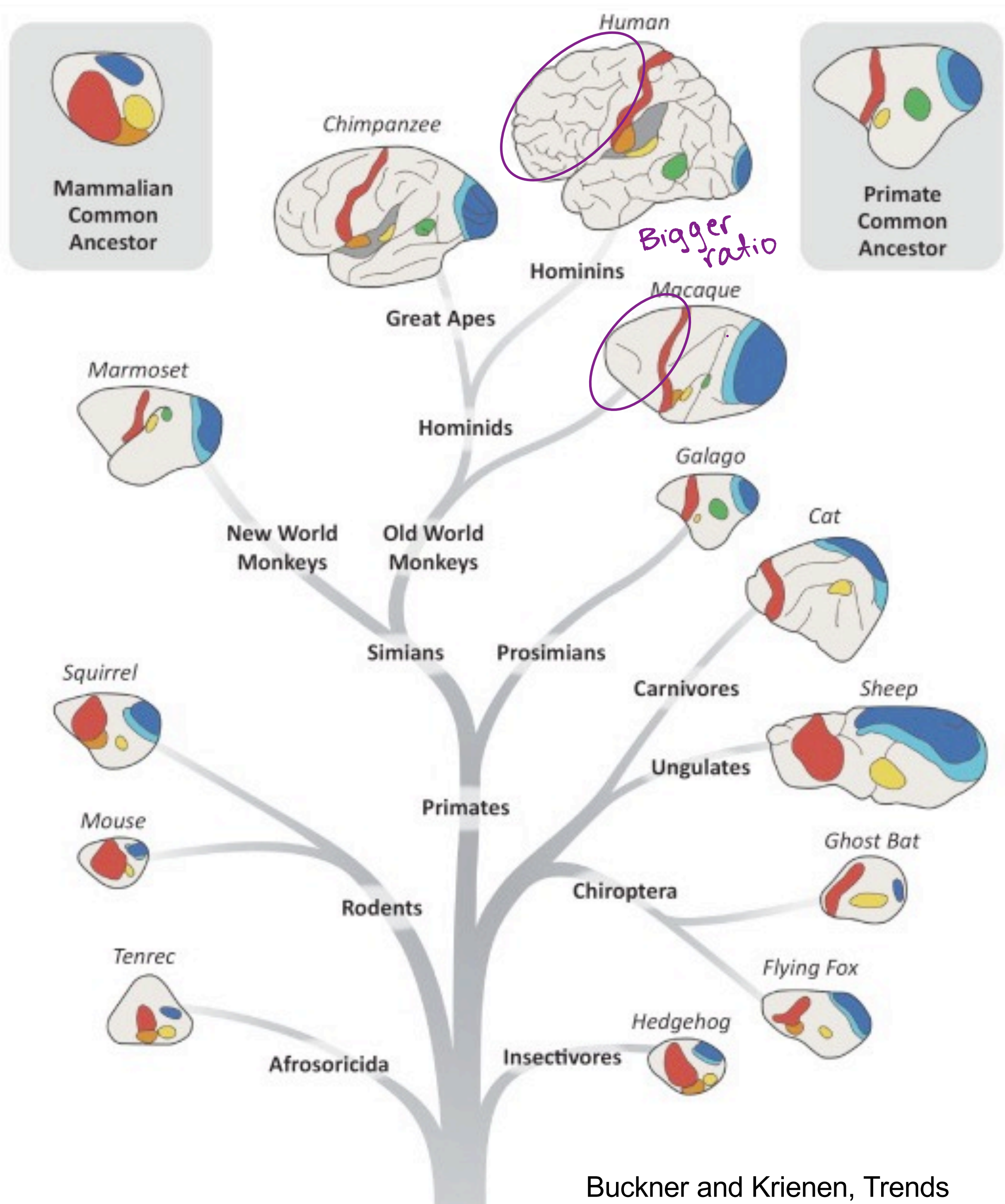
→ located at edge of cortical mantle

5) The continuous sheet of gray matter of each hemisphere's cortex is flattened against the page, with its outer surface against the page



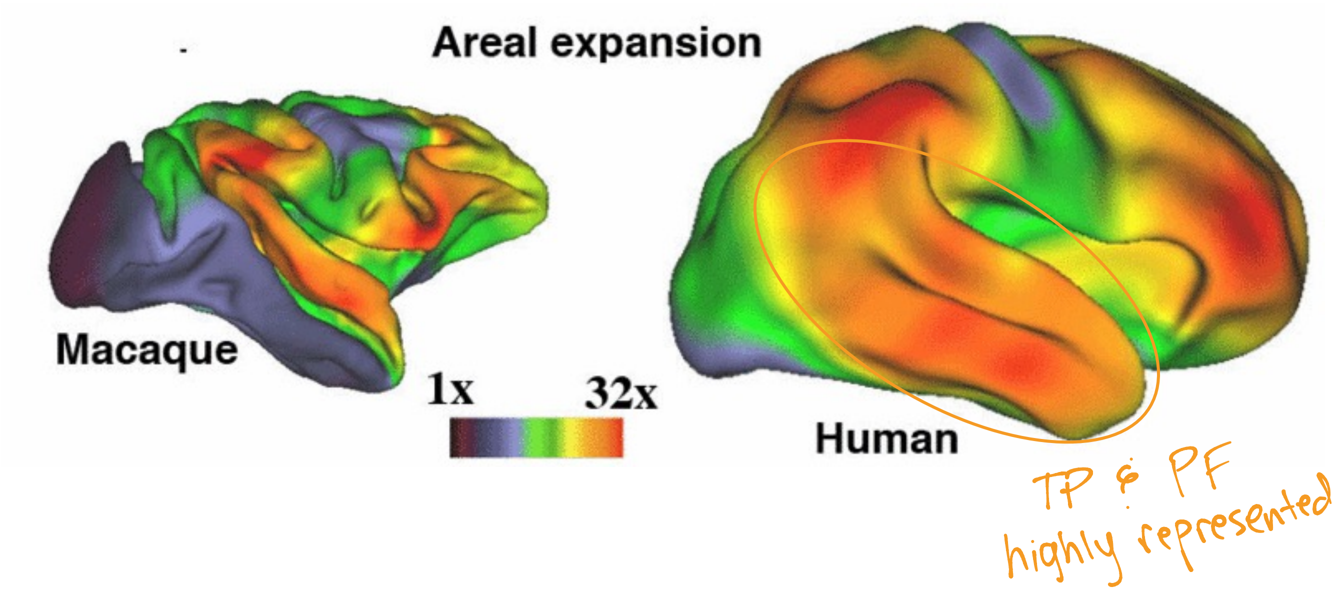
Distinguish us from other species (even monkeys)

The cortical areas identified most strongly with cognitive functions are those which lie at the greatest connectional remove from functionally identified subcortical sensory, motor and visceral systems



Buckner and Krienen, Trends
in Cognitive Sciences 17: 648-665 (2013)

The fraction of the cerebral hemisphere dedicated to association cortex has expanded over the course of the evolutionary process leading to humans. In this diagram, the colored regions represent low-order sensory areas. The surrounding sea of gray corresponds roughly to the association cortex.



Using cytoarchitectural landmarks, David Van Essen and colleagues have identified putative homologous regions in macaque monkey and human cerebral cortex. Then they have asked, for each region, how much it is expanded in the human compared to the monkey brain. The regions with hot coloring in this slide (rendered as pale in the black and white handout) exhibit the greatest degree of expansion in humans. They include specifically the parietotemporal and frontal association cortex.

Van Essen and Dierker, Surface-Based and Probabilistic Atlases of Primate Cerebral Cortex, Neuron 56: 209-225 (2007).