IIIT-H

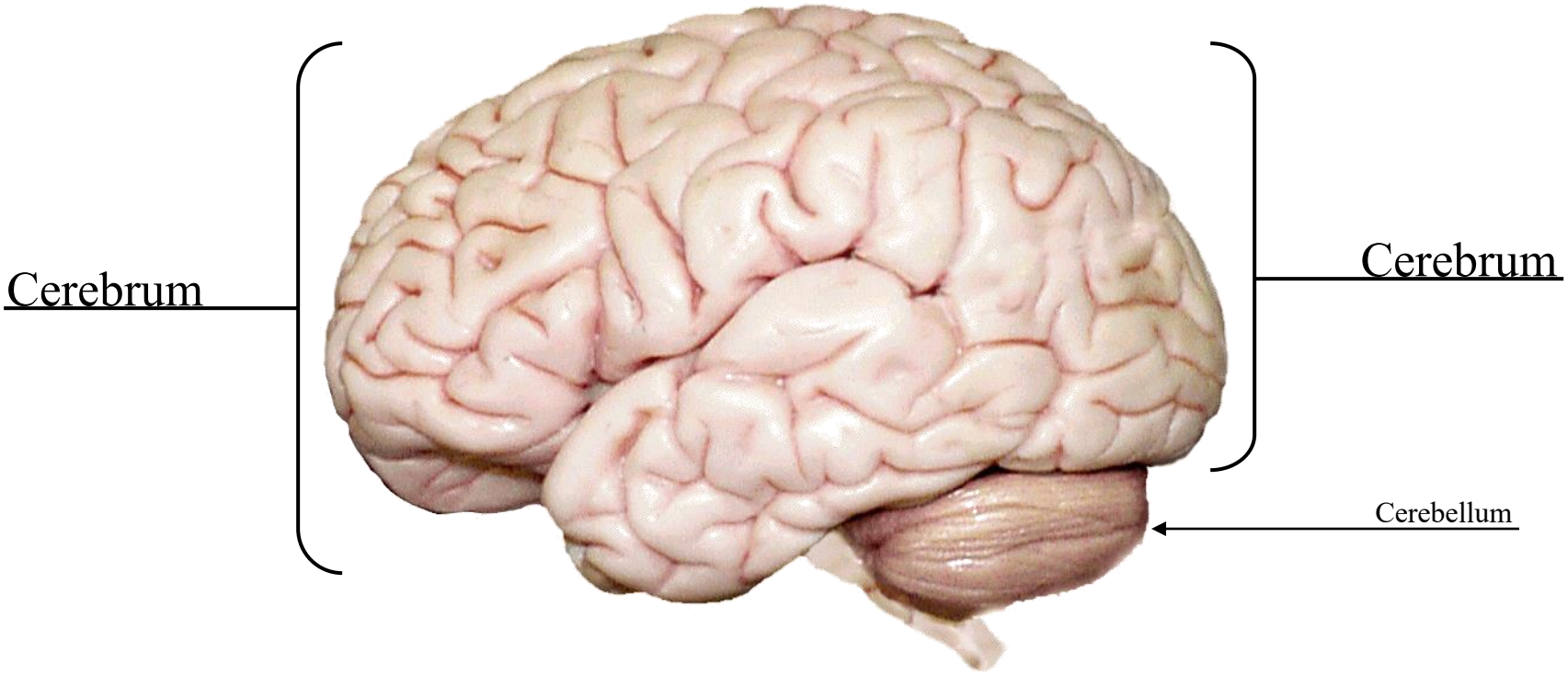
Introduction to Brain and Cognition

S. Bapi Raju

raju.bapi<at>iiit.ac.in

The Brain

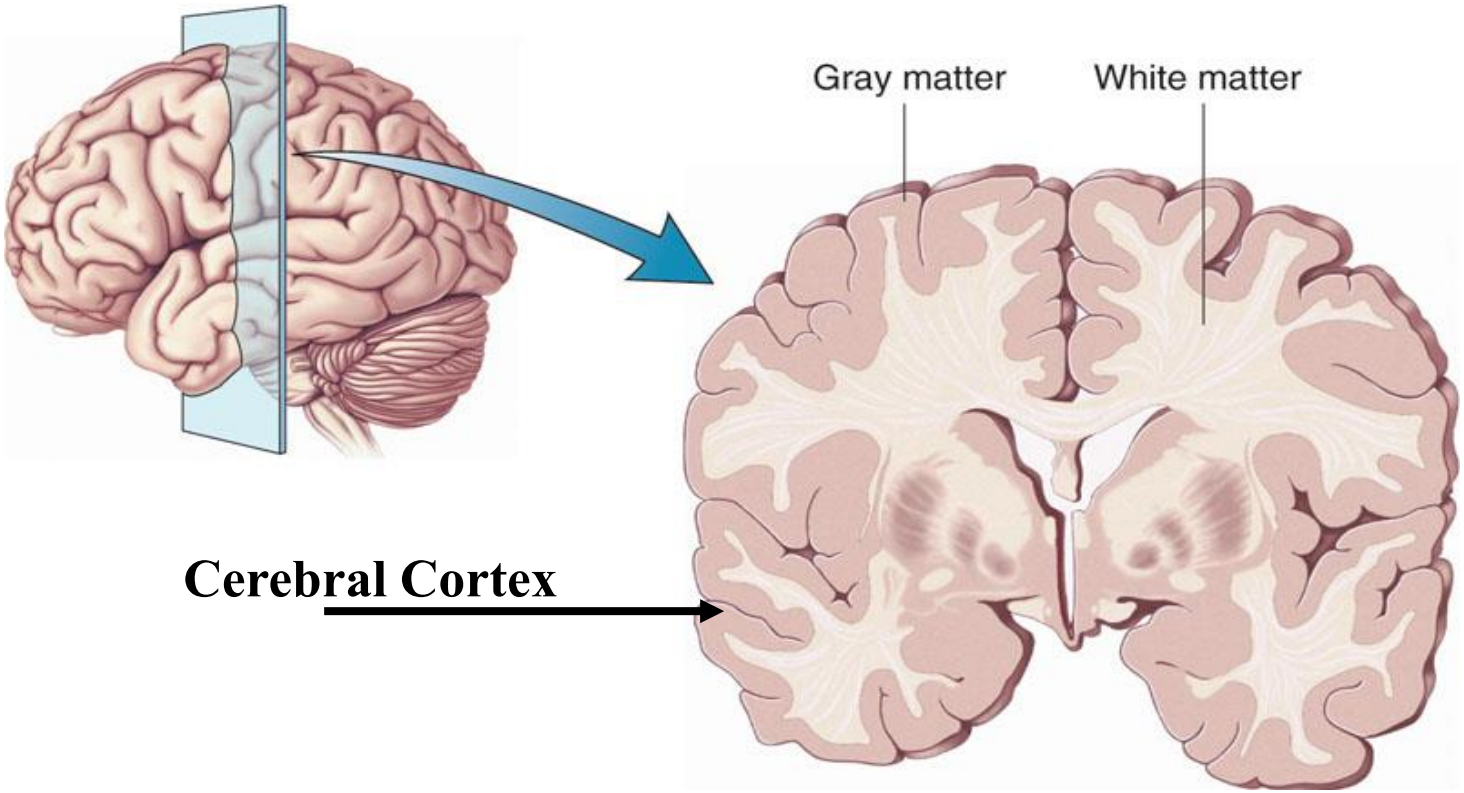
Cerebrum -The largest division of the brain. It is divided into two hemispheres, each of which is divided into four lobes.



http://williamcalvin.com/BrainForAllSeasons/img/bonoboLH-humanLH-viaTWD.gif

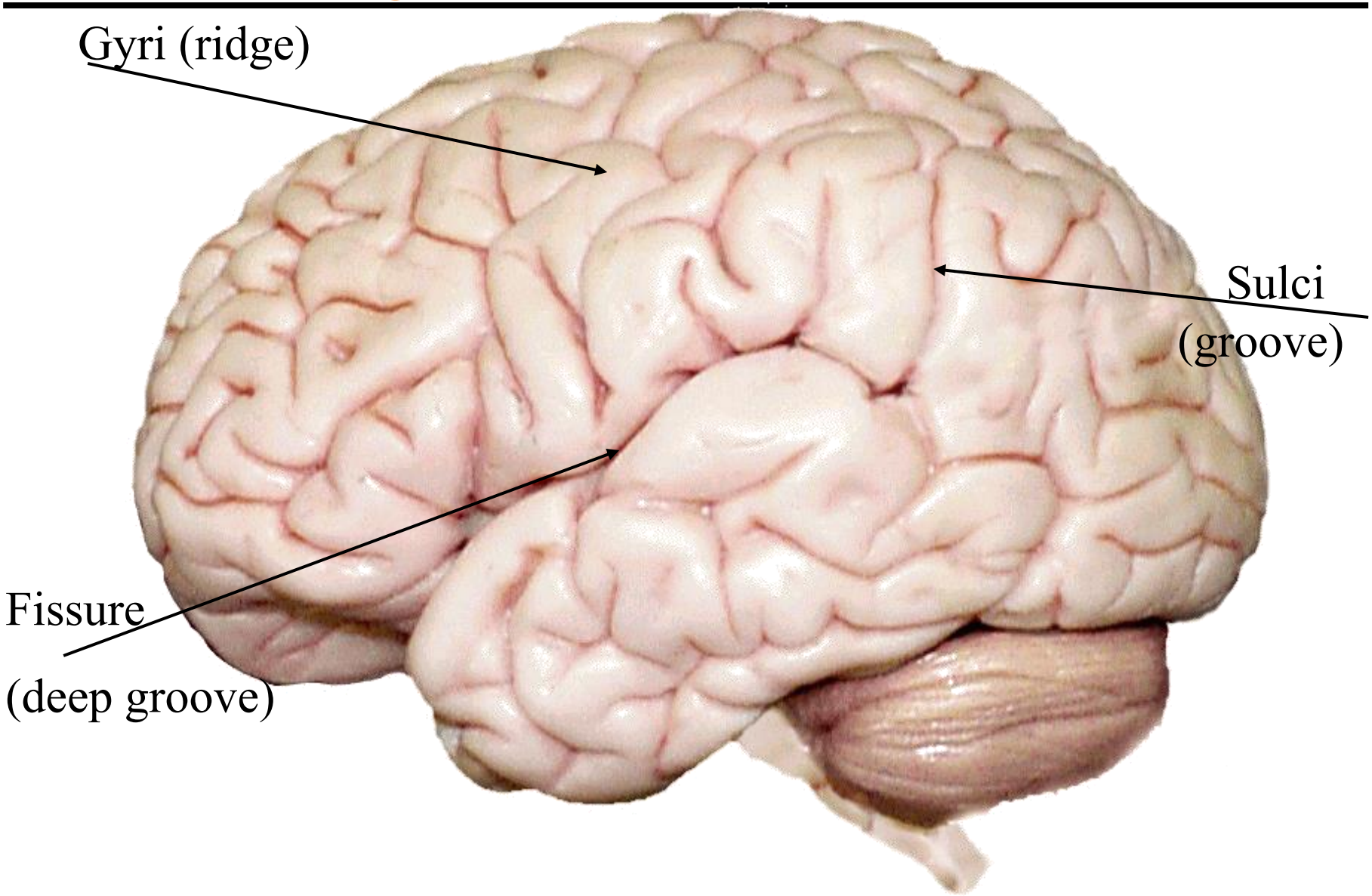
The Brain

Cerebral Cortex - The outermost layer of gray matter making up the superficial aspect of the cerebrum.



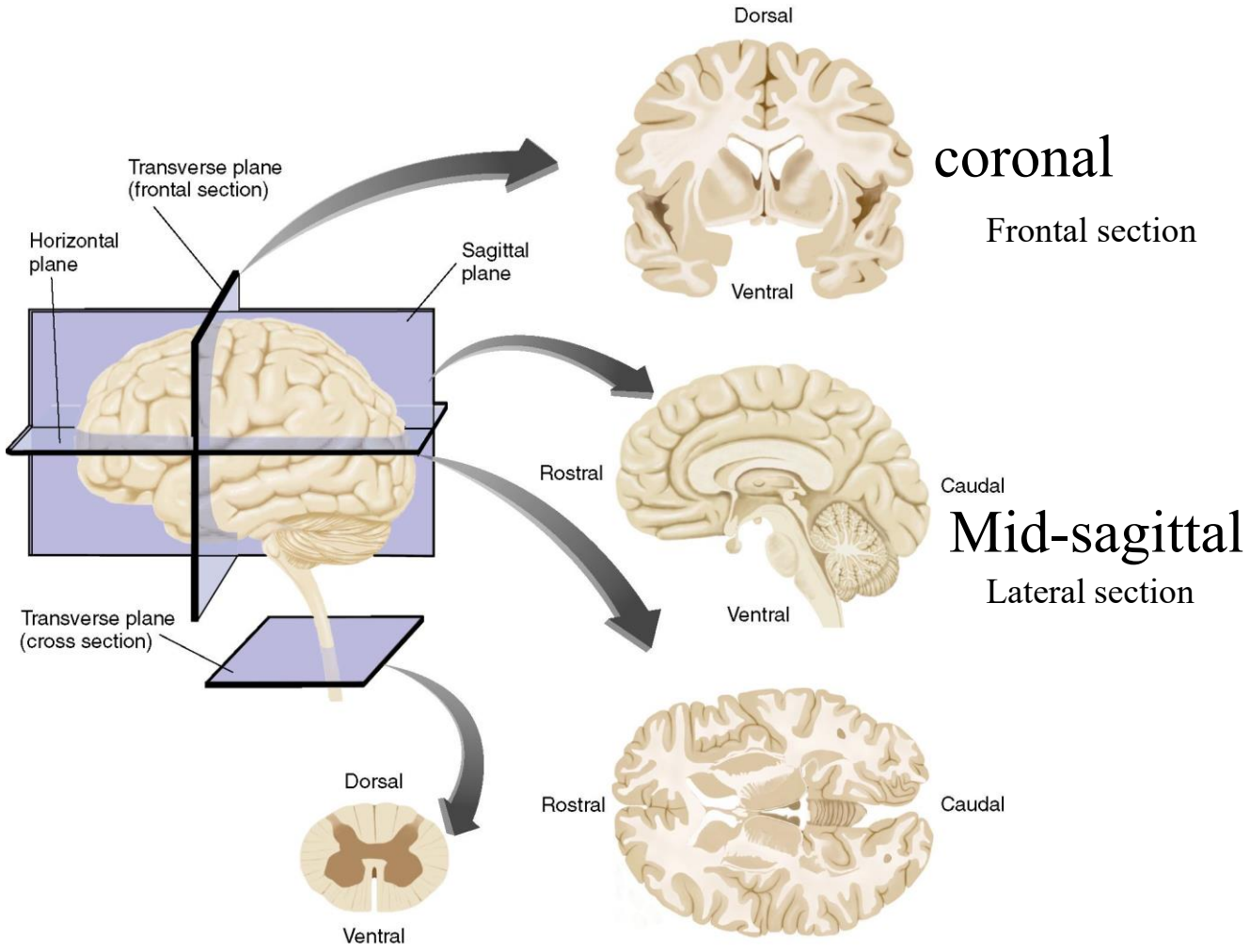
http://www.bioon.com/book/biology/whole/image/1/1-6.tif.jpg

Landmarks



http://williamcalvin.com/BrainForAllSeasons/img/bonoboLH-humanLH-viaTWD.gif

Sections of the brain



coronal

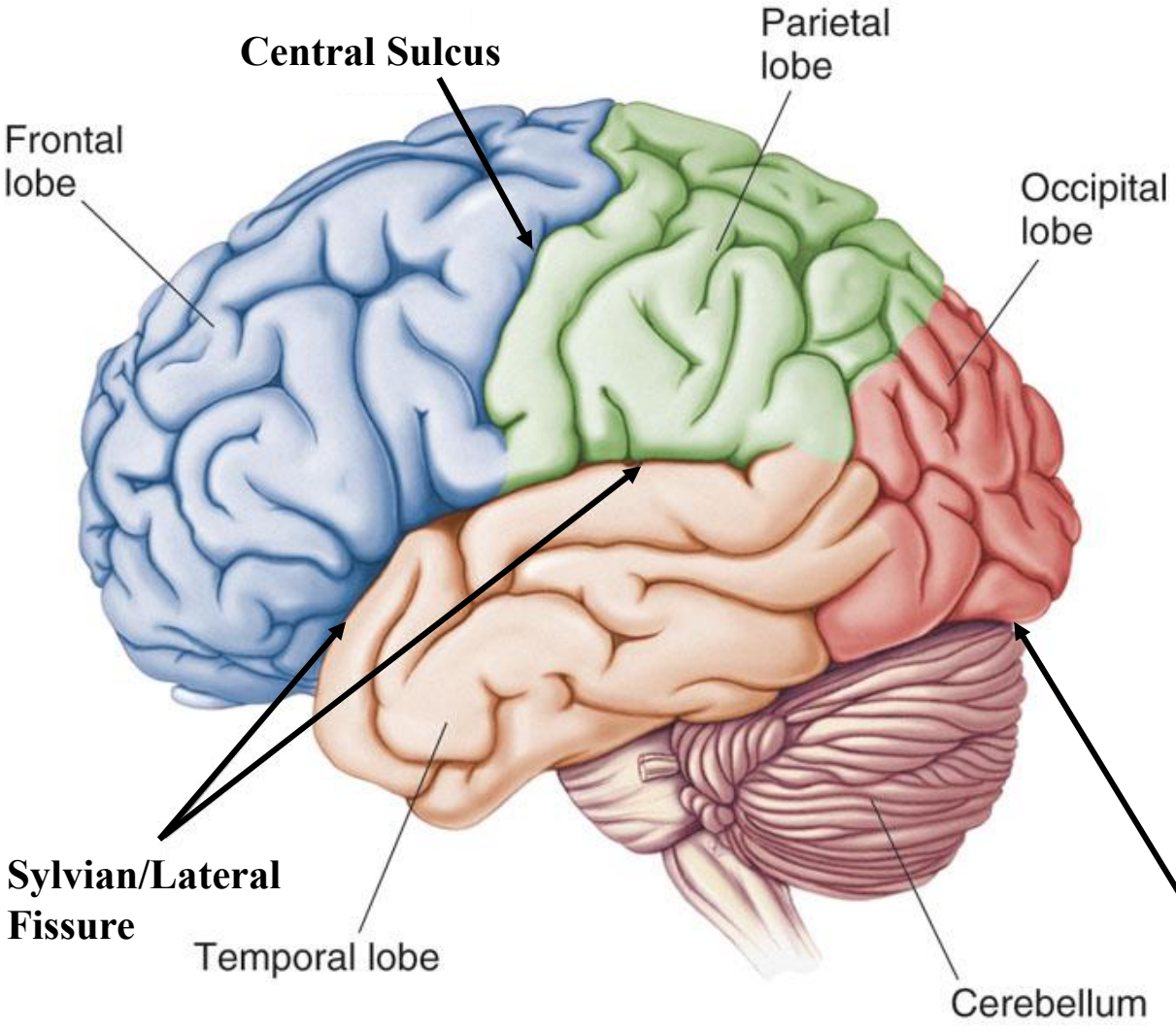
Frontal section

Mid-sagittal

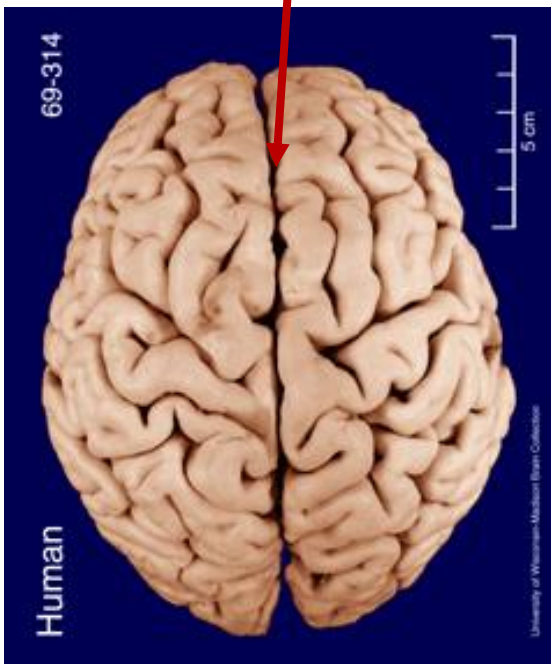
Lateral section

horizontal

Landmarks & Lobes



Longitudinal Fissure



http://www.bioon.com/book/biology/whole/image/1/1-8.tif.jpg

http://www.dalbsoutss.eq.edu.au/Sheepbrains_Me/human_brain.gif

Human Brain

- 2% of the body weight, 3 pounds approx.
- 25% of body's oxygen
- 70% of glucose
- Never rests and its metabolic rate in both day and night is more or less the same.
- In dreams in fact, the metabolic rate increases slightly

Hierarchical Brain

- Represents approx. 500 million years of evolutionary development and fine tuning.
- Core structures of brain are the same in all vertebrates
  - They govern the physiological functions
- Built upon these are newer systems that involve complex functions – sensing, emoting, thinking, reasoning etc.
- Triune brain (Paul MacLean)
  - Reptilian complex
  - Paleomammalian complex (limbic system)
  - Neomammalian complex (neocortex)

Levels of Organization

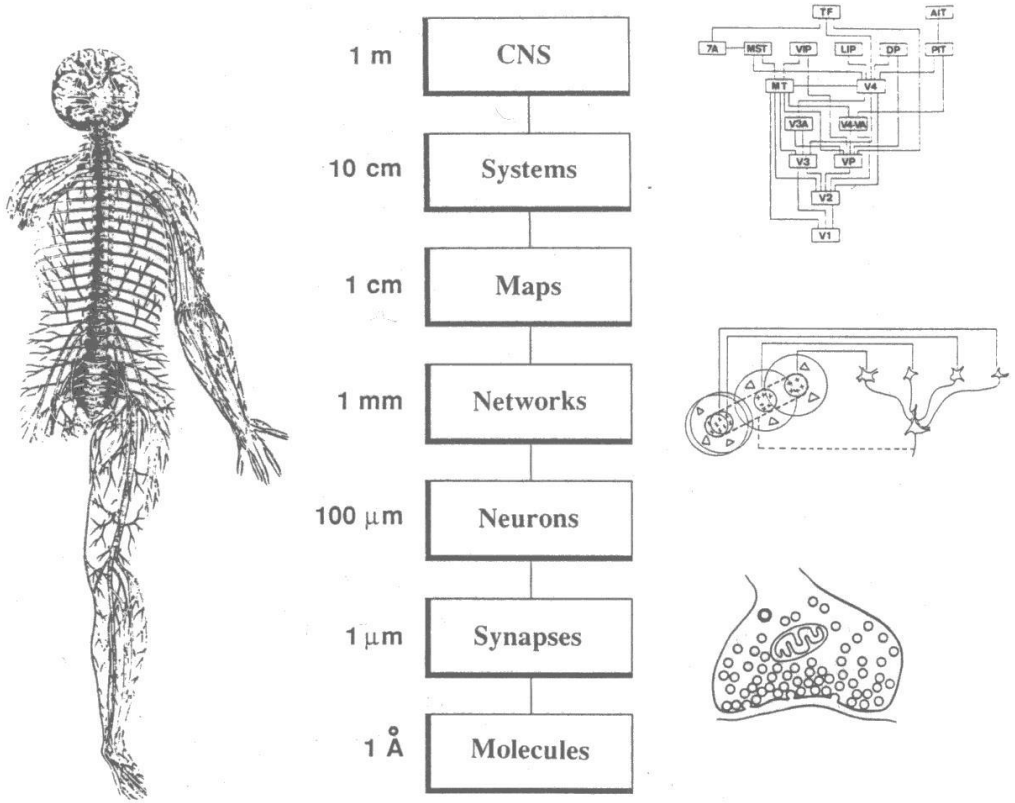


Figure 1.4 Schematic illustration of levels of organization in the nervous system. The spatial scales at which anatomical organizations can be identified varies over many orders of magnitude. Icons to the right represent structures at distinct levels: (top) a subset of visual areas in visual cortex (van Essen and Maunsell 1980); (middle) a network model of how ganglion cells could be connected to simple cells in visual cortex (Hubel and Wiesel, 1962), and (bottom) a chemical synapse (Kandel and Schwartz, 1985). (From Churchland and Sejnowski 1988.)

Churchland & Sejnowski (1992)

Levels of Organization

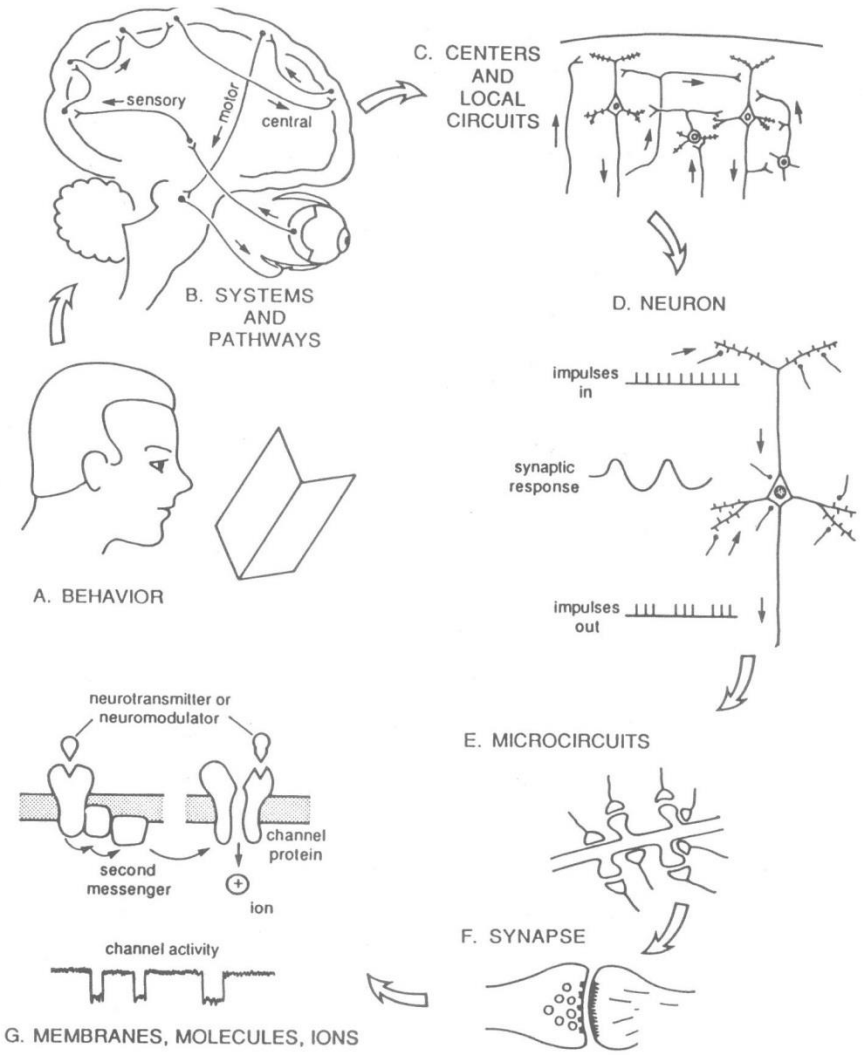
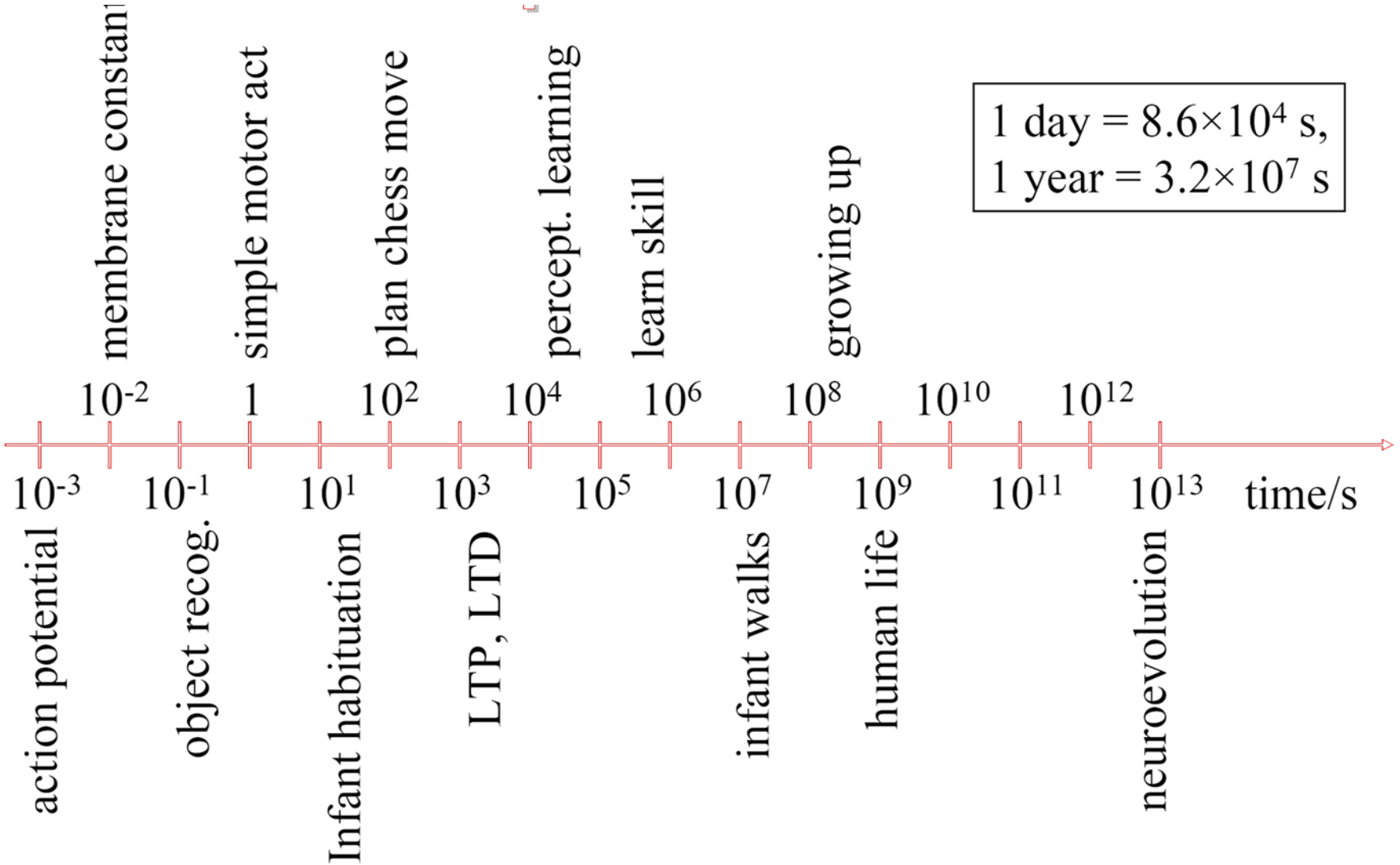


Figure 2.1 Levels of organization in the nervous system, as characterized by Gordon Shepherd (1988a).

Churchland & Sejnowski (1992)

Temporal Scales



Neurons and Action Potentials

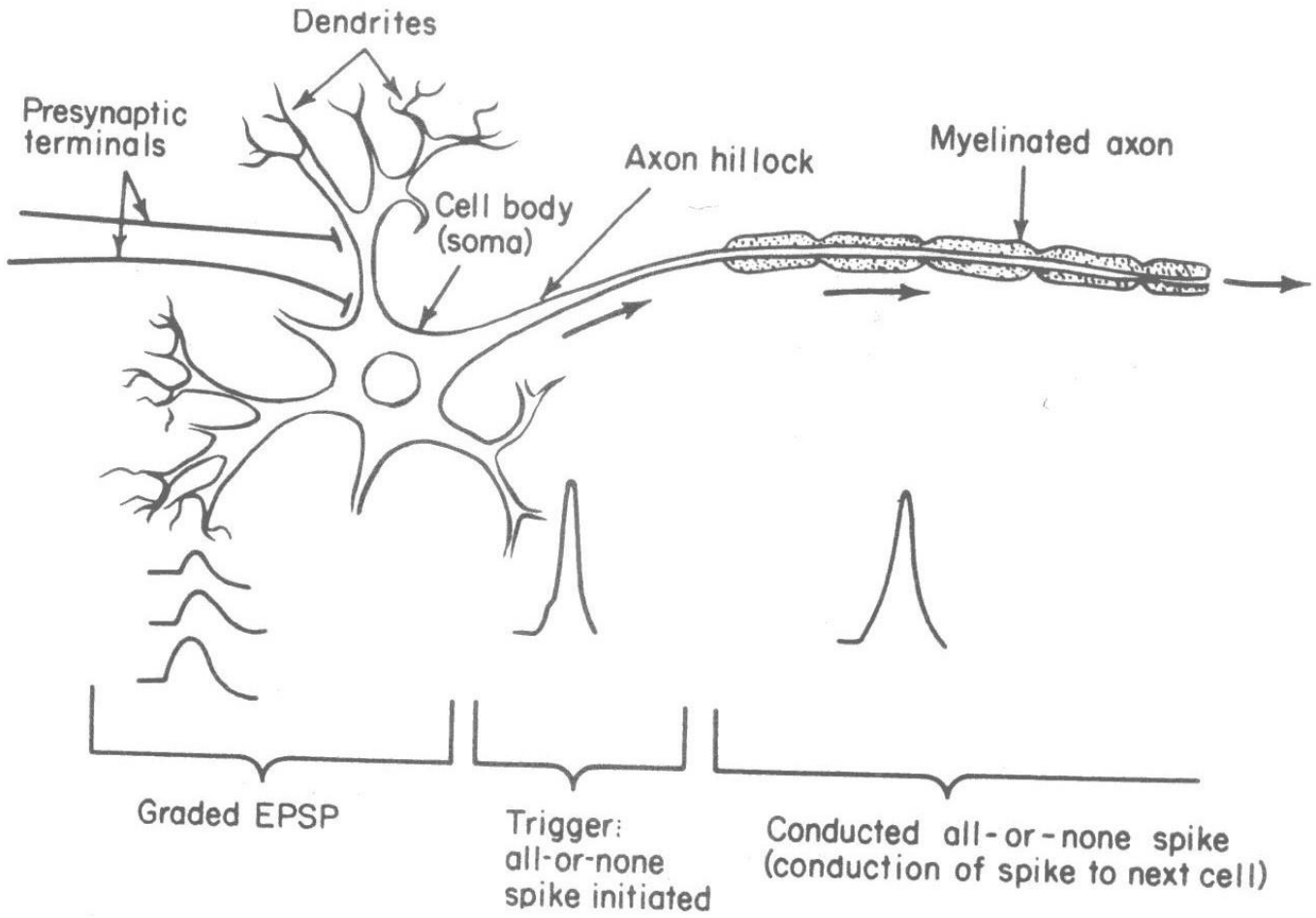


Figure 2.19 Summary diagram showing the location on a motor neuron of various electrical events. In many neurons, dendrites and cell bodies respond with graded EPSPs or IPSPs; the action potential is triggered in the axon hillock and travels undiminished down the axon. (From Thompson 1967.)

Churchland & Sejnowski (1992)

Organizing Principles

- Specialization of function
  - Modular organization of the function: Vision, motor, Language, etc.
- Numbers:
  - Approx. 10^{12} neurons; 10^{15} synapses; 1 mm^3 of cortical tissue has 10^5 neurons 10^9 synapses.
- Input is analog (membrane potential is continuous valued) and Output is discrete (neuron spikes or not)

Churchland & Sejnowski (1992)

Organizing Principles

- Timing:
  - Action Potential (AP) lasts about 1 msec.
  - Synaptic Transmission takes about 5 msec
  - Synaptic potentials last from a millisecond to several minutes
  - Transmission velocity in myelinated axons is ~ 10-100 meters/sec; in unmyelinated axons is < 1 m/sec
    - Reaction times (*the time elapsed from the onset of stimulus to the onset of reaction of the system*) are around 50-60 msec (thus *switching time* of a neuron is order of milliseconds; processing speed is about 1KHz at 1 msec per operation!!)

Churchland & Sejnowski (1992)

Organizing Principles

- Receptive field (RF)
  - RF is that *region of the sensory field from which an adequate sensory stimulus will elicit a response*
  - Size:
    - Ex: Somatosensory: Smaller for fingers but Larger for arms
    - High resolution -> Smaller RF; Low resolution -> Larger RF
  - Centre-Surround Organization
- Topographic Organization
- Parallel and Distributed Processing

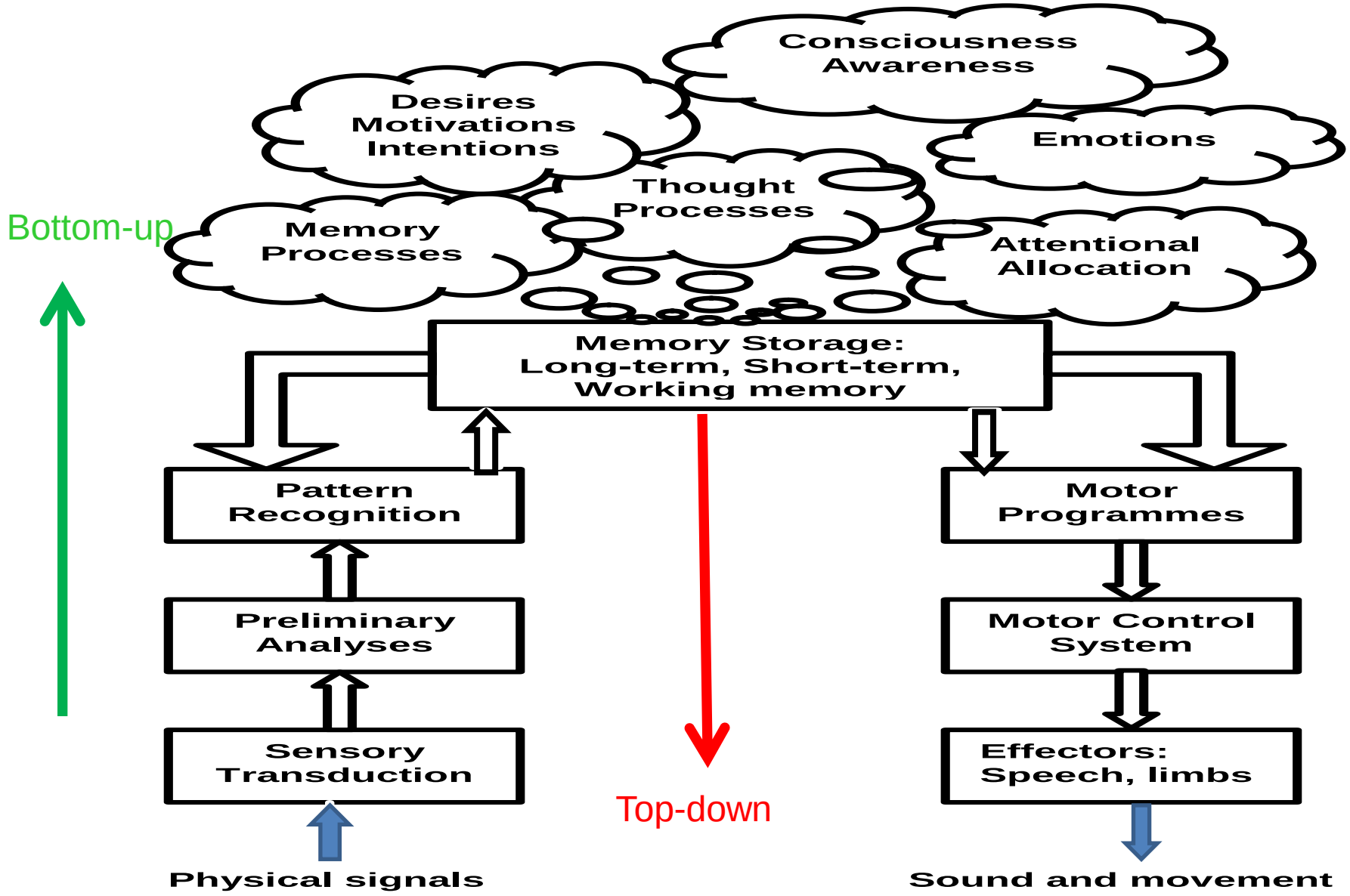
Churchland & Sejnowski (1992)

Von Neumann Computer vs Brain

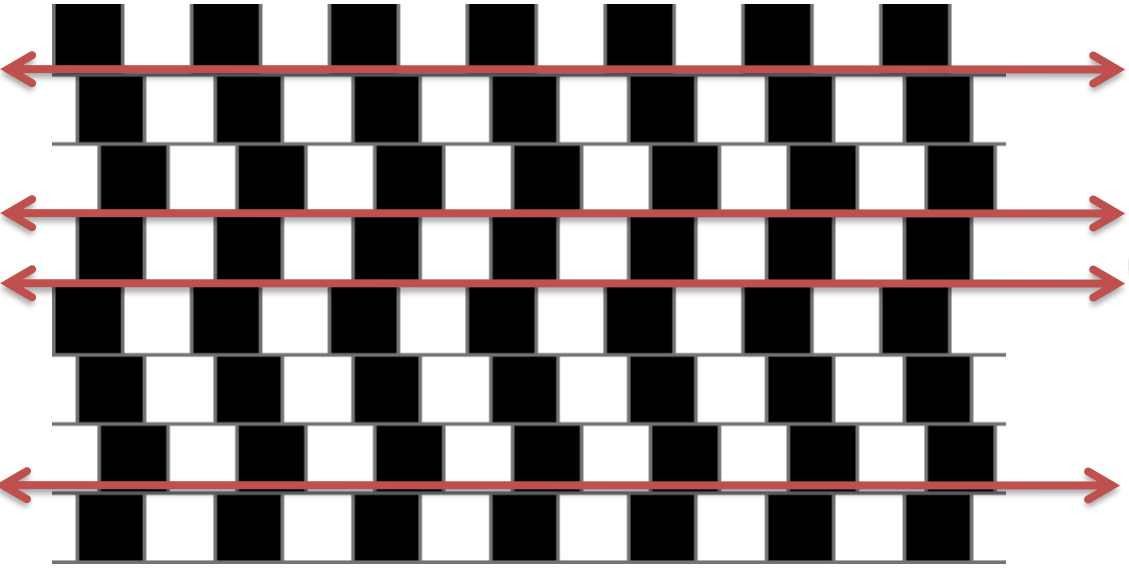
	Von Neumann computer	Biological computer
Processor	complex	simple
	high speed	low speed
	one or a few	large number
Memory	separate from processor	integrated into processor
	localized	distributed
	non-content addressable	content addressable
Computing	centralized	distributed
	sequential	parallel
	stored programs	self-learning
Reliability	very vulnerable	robust
Expertise	numerical and symbolic manipulations	perceptual problems
Operating environment	well-defined, well-constrained	poorly-defined, unconstrained

Jain et al. (1996)

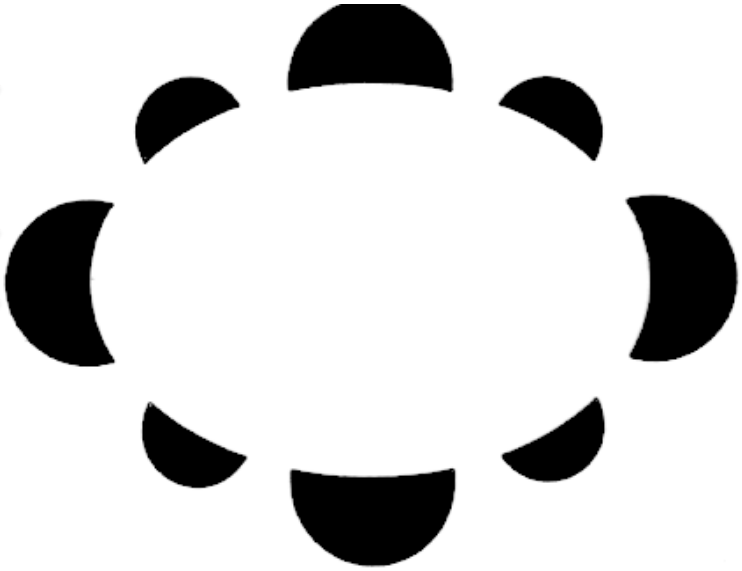
Human Information Processing System



Bottom-up or Top-down Processing?



Bottom-Up √

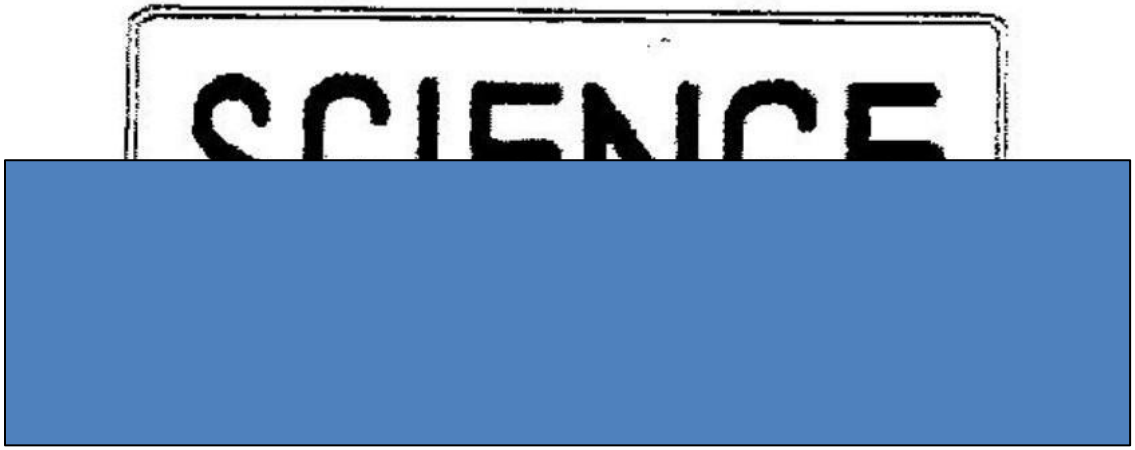


Bottom-Up √

Bottom-up or Top-down Processing?

What do you see?

Now what do you see?



Top-Down √

Course Content

- Learning Outcomes:
  - Broad knowledge and Appreciation of Brain and Cognition
  - **Book**: Daniel Reisberg (2019). *Cognition: exploring the science of the mind*. 7th Edition. W. W. Norton & Company, NY, USA
  - Brief acquaintance with the Research interests of CogSciLab (CSL) faculty!

Learning Assessment

- Quizzes: Best 3 of 4 [3x20 = 60%]
  - Tentative Dates of Quizzes
  - PART 1 (Brain): Jan 16, 2021
  - PART 2 (Vision): Jan 23, 2021
  - PART 3(1) (Memory): Jan 30, 2021
  - PART 3(2) (Memory): Feb 06, 2021

- PROCTORED QUIZ: [30%]
  - COMPREHENSIVE: Feb 13, 2021

- SHORT PAPER SUBMISSION: [10%]
  - Three-A4-Handwritten-One-sided Pages on any topic you found interesting in Brain & Cognition and Your take-aways in the class Scanned PDF to be submitted during Final Week (by Feb 20, 2021)

- Note: Suggested Reading Schedule: (Approx. 20 pages before coming to a class from the Book assigned)