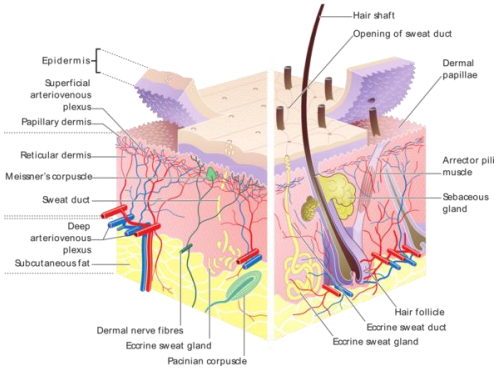
Organization and Function of the Nervous System

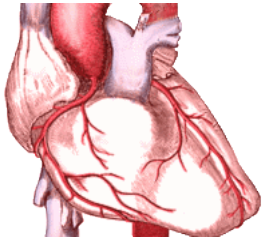
Peripheral Nervous System (PNS)

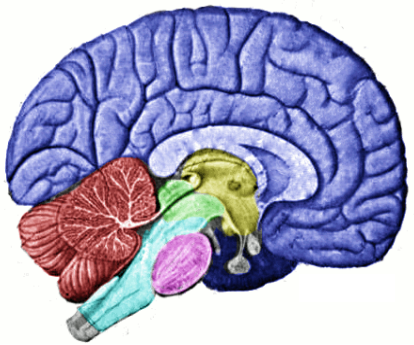
Somatic **Autonomic**

Central Nervous System (CNS)

Brain **Spinal Cord**







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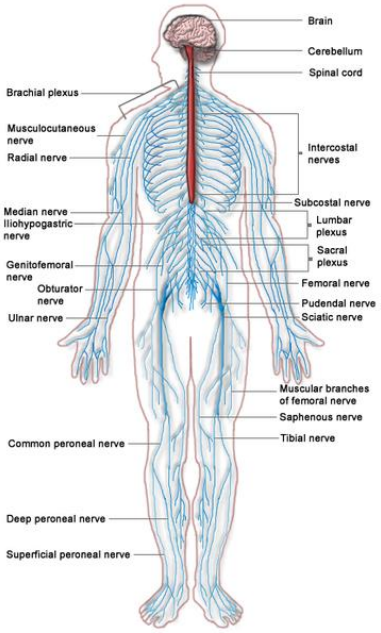
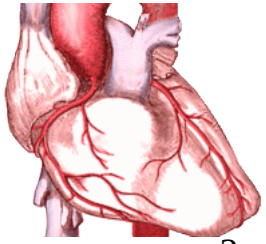
Peripheral Nervous System (PNS)

Somatic: Nerves connecting to voluntary skeletal muscles and sensory receptors

- ***Afferent* Nerve Fibers (incoming)**: Axons that carry info away from the periphery to the CNS
- ***Efferent* Nerve Fibers (outgoing)**: Axons that carry info from the CNS outward to the periphery



Autonomic: Nerves that connect to the heart, blood vessels, smooth muscles, and glands



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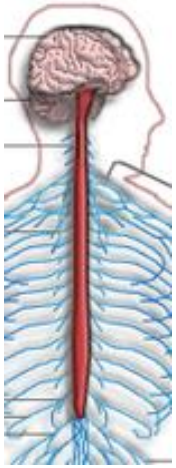
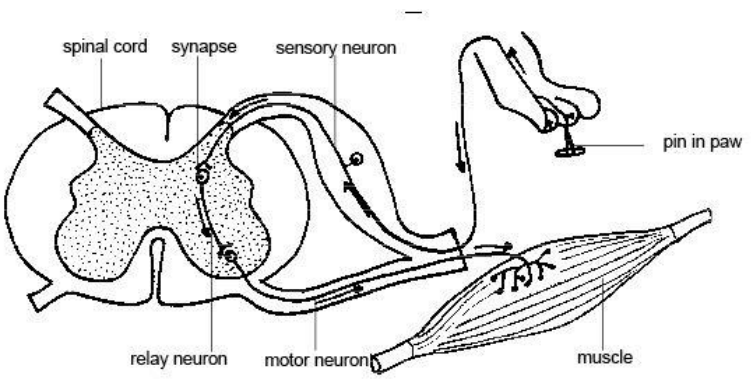
Central Nervous System (CNS)

CNS = Spinal Cord + Brain



Spinal Cord

- Local feedback loops control reflexes ("reflex arcs")
- Descending motor control signals from the brain activate spinal motor neurons
- Ascending sensory axons convey sensory information from muscles and skin back to the brain



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CNS = Spinal Cord + **Brain**

Major Brain Regions: The Hindbrain

Medulla Oblongata

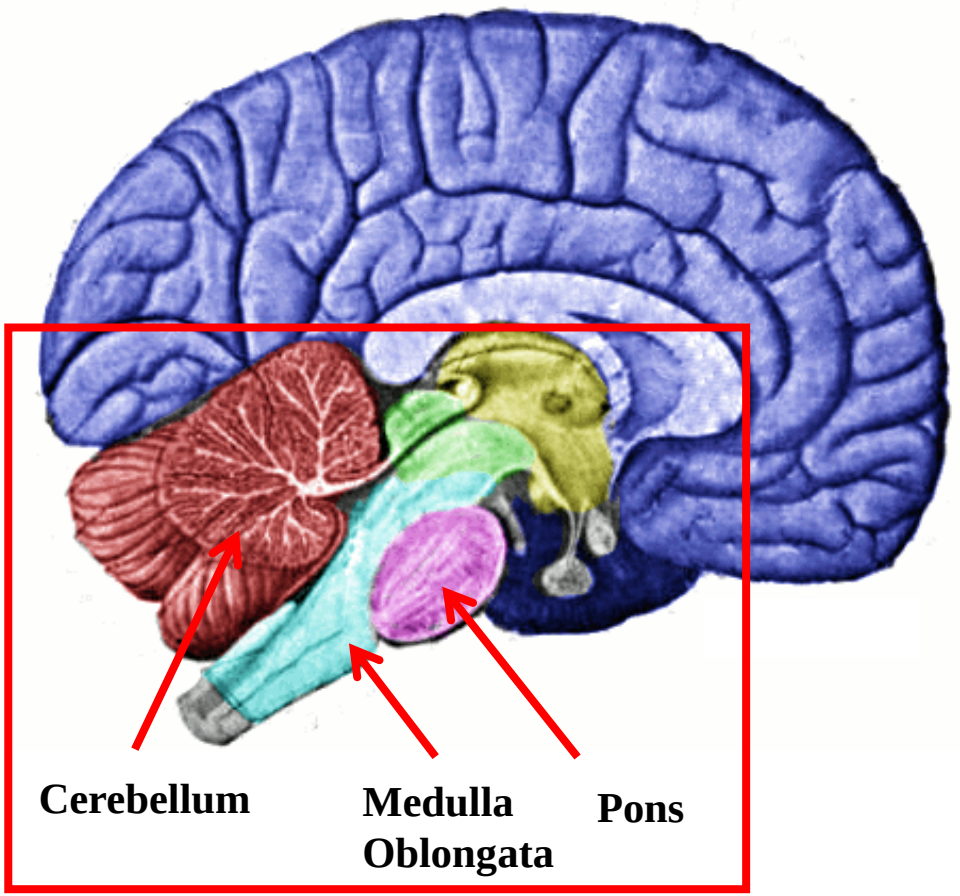
Controls breathing, muscle tone and blood pressure

Pons

Connected to the cerebellum & involved in sleep and arousal

Cerebellum

Coordination and timing of voluntary movements, sense of equilibrium, language, attention,…



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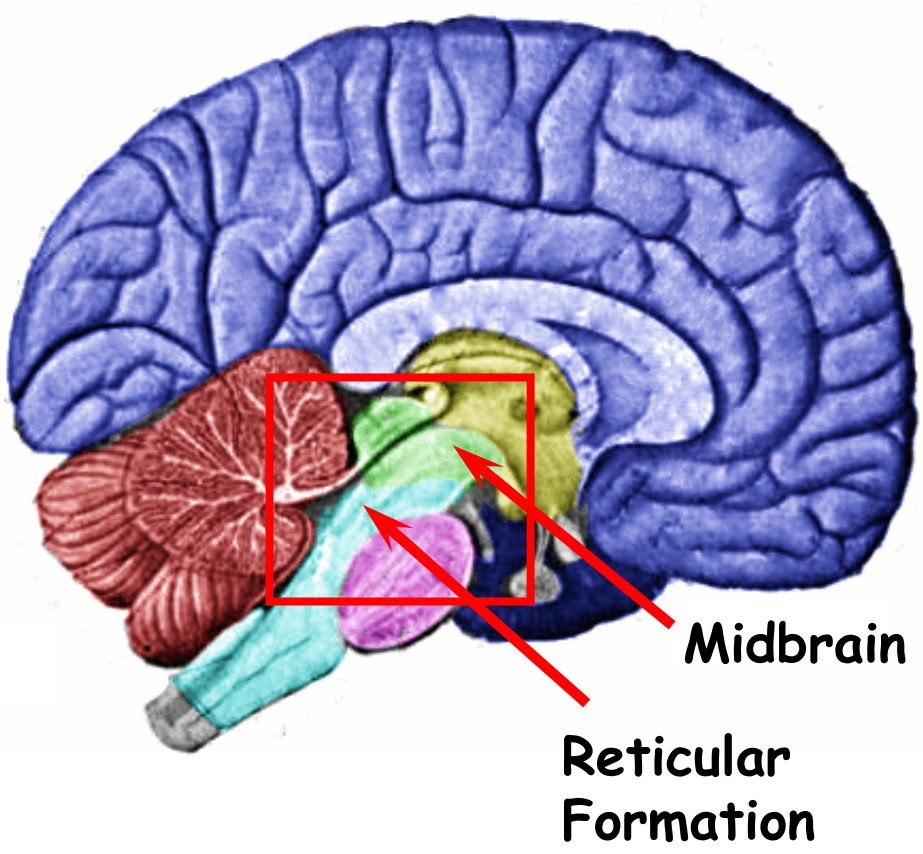
Major Brain Regions: Midbrain & Retic. Formation

Midbrain

Eye movements, visual and auditory reflexes

Reticular Formation

Modulates muscle reflexes, breathing & pain perception. Also regulates sleep, wakefulness & arousal



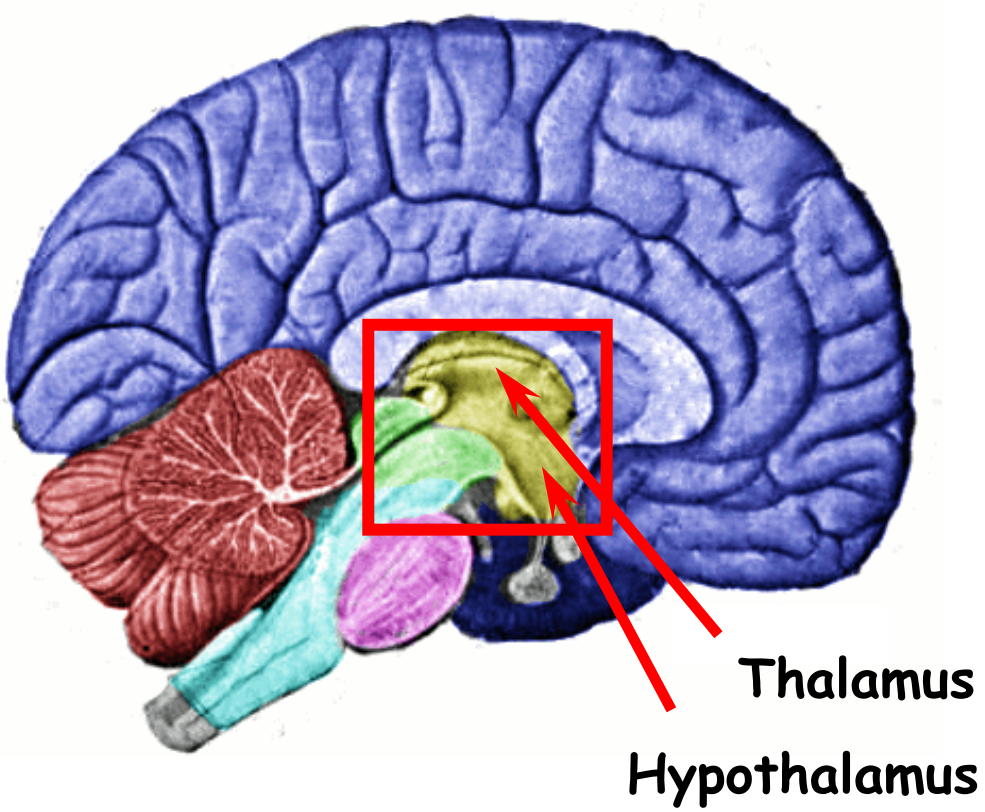
Major Brain Regions: Thalamus & Hypothalamus

Thalamus

"Relay station" for all sensory info (except smell) to the cortex, regulates sleep/wakefulness

Hypothalamus

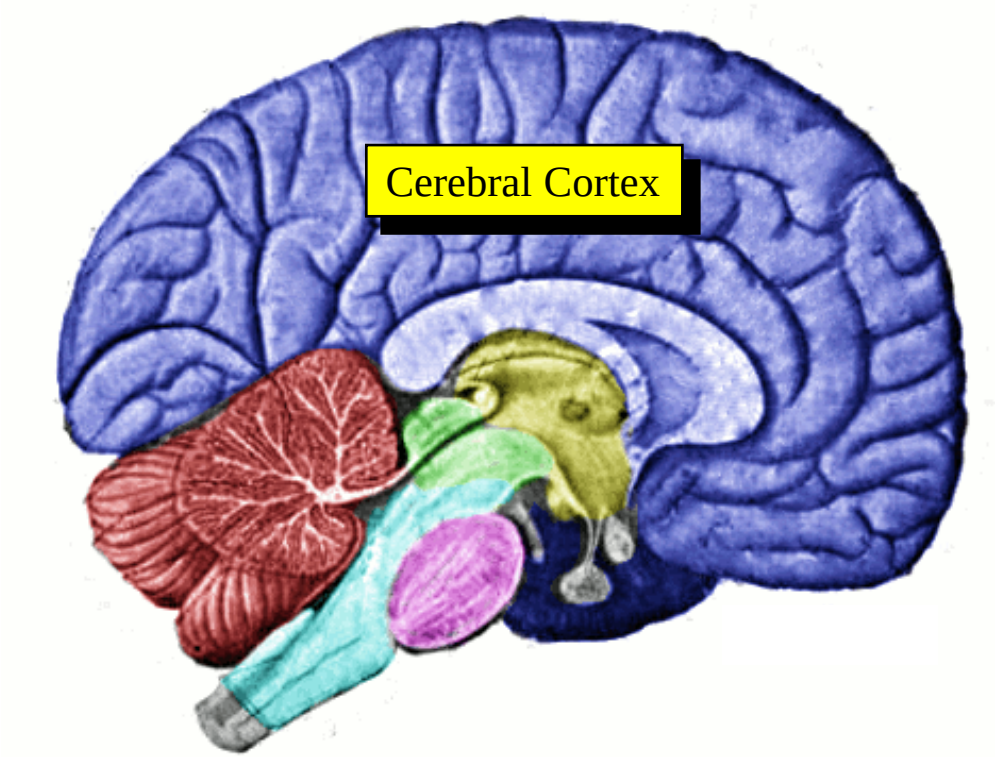
Regulates basic needs Fighting, Fleeing, Feeding, and Mating



Major Brain Regions: The Cerebrum

- Consists of: Cerebral cortex, basal ganglia, hippocampus, and amygdala

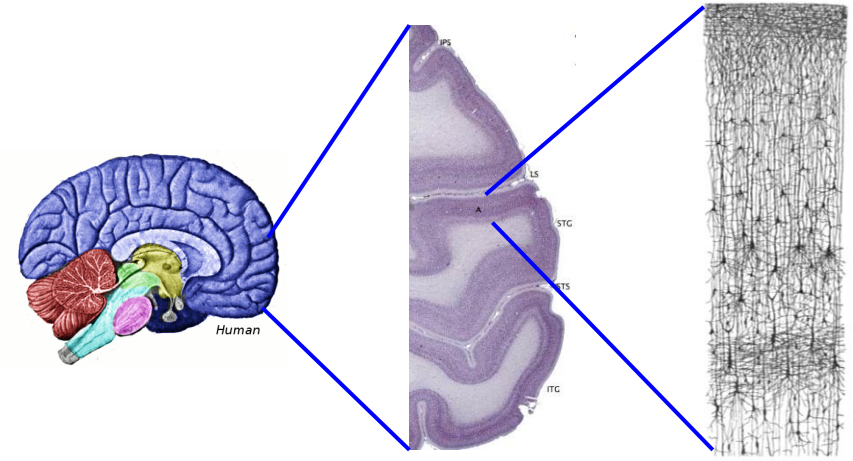
- Involved in perception and motor control, cognitive functions, emotion, memory, and learning



Cerebral Cortex: A Layered Sheet of Neurons

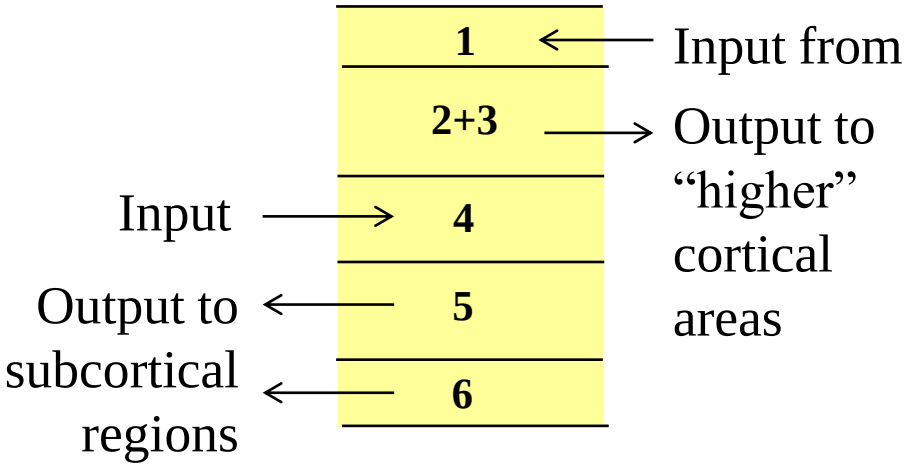
✦ Cerebral Cortex: Convoluted surface of cerebrum, about 1/8th of an inch thick

- Approximately 30 billion neurons
- Each neuron makes about 10,000 synapses, approximately 300 trillion connections in total



✦ Six layers of neurons

- Relatively uniform in structure
- Is there a common computational principle operating across cortex?



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How do all of these brain regions interact to produce cognition and behavior?

Don’t know fully yet!

But inching closer based on:

- electrophysiological,
- optical,
- molecular,
- functional imaging,
- psychophysical,
- anatomical
- connectomic
- lesion (brain damage) studies…

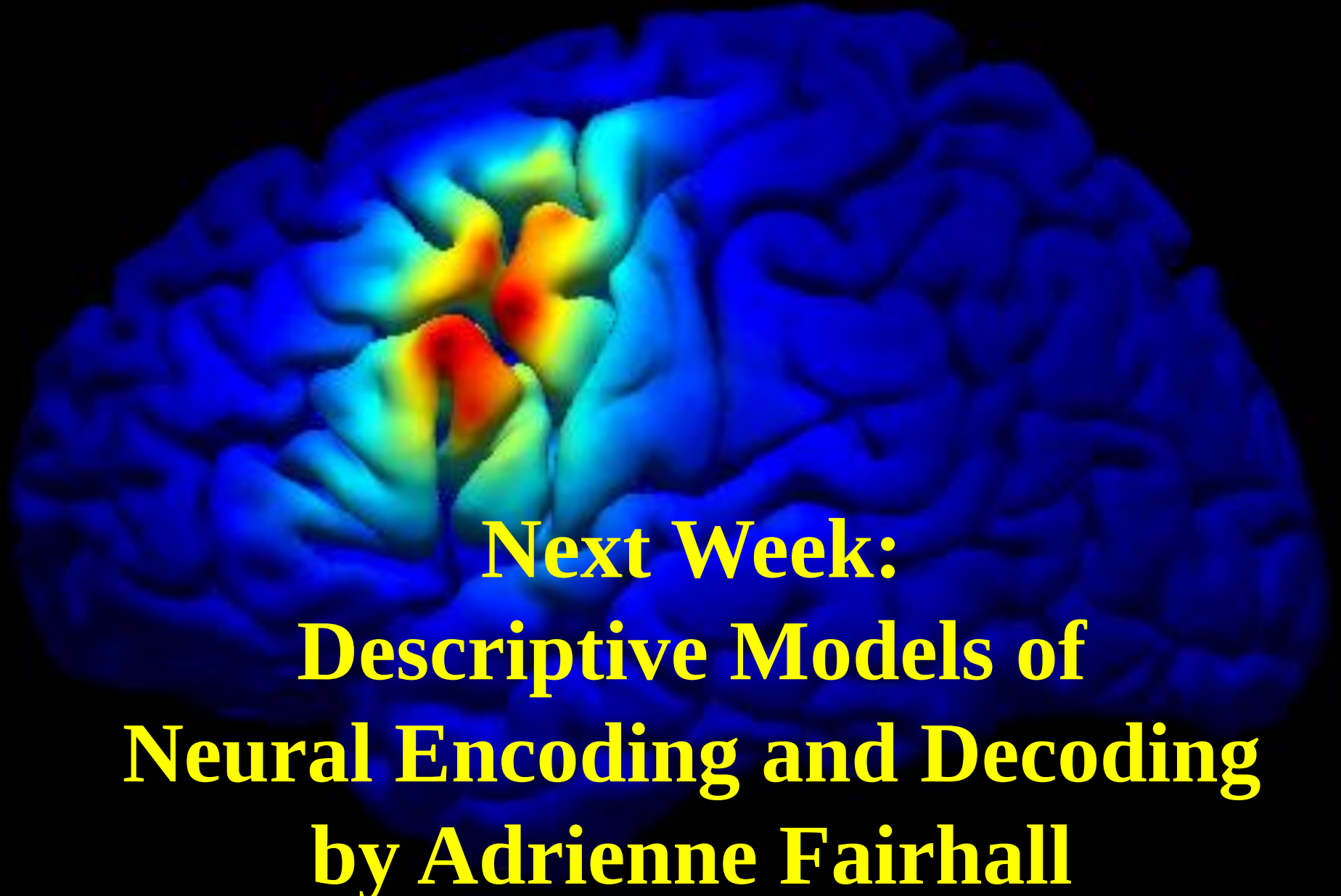
Neural versus Digital Computing

- Device count:
  - Human Brain: 10^{11} neurons (each neuron ~ 10^4 connections)
  - Silicon Chip: 10^{10} transistors with sparse connectivity
- Device speed:
  - Biology has 100μs temporal resolution
  - Digital circuits are approaching a 100ps clock (10 GHz)
- Computing paradigm:
  - Brain: Massively parallel computation & adaptive connectivity
  - Digital Computers: sequential information processing via CPUs with fixed connectivity
- Capabilities:
  - Digital computers excel in math & symbol processing…
  - Brains: Better at solving ill-posed problems (speech, vision)

Conclusions and Summary

- Structure and organization of the brain suggests computational analogies
  - Information storage: Physical/chemical structure of neurons and synapses
  - Information transmission: Electrical and chemical signaling
  - Primary computing elements: Neurons
  - Computational basis: Currently unknown
- In this course, we will try to understand computation in the brain through:
  - Descriptive models
  - Mechanistic models
  - Interpretive models

Computational Neuroscience



Next Week:
Descriptive Models of Neural Encoding and Decoding by Adrienne Fairhall