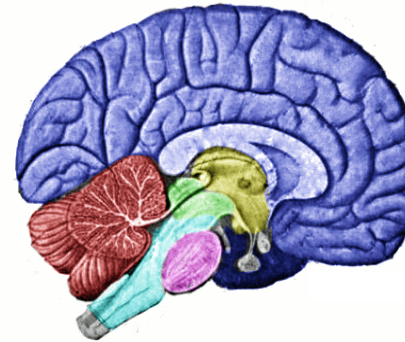
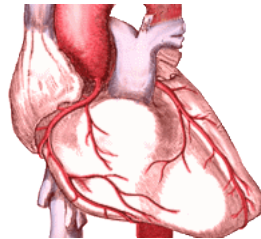
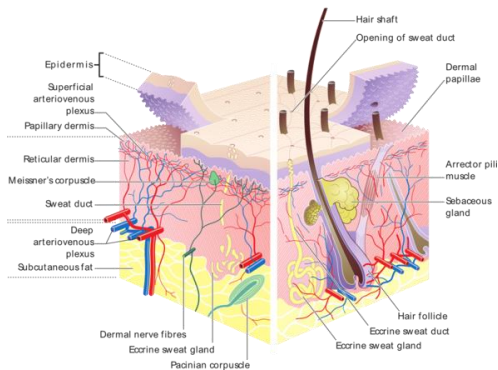


Organization and Function of the Nervous System

**Peripheral
Nervous System (PNS)**
Somatic Autonomic

**Central
Nervous System (CNS)**
Brain Spinal Cord

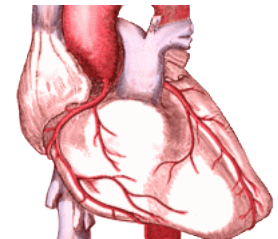
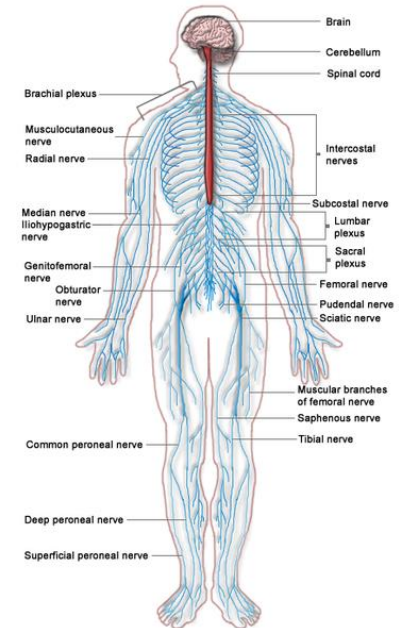


Peripheral Nervous System (PNS)

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

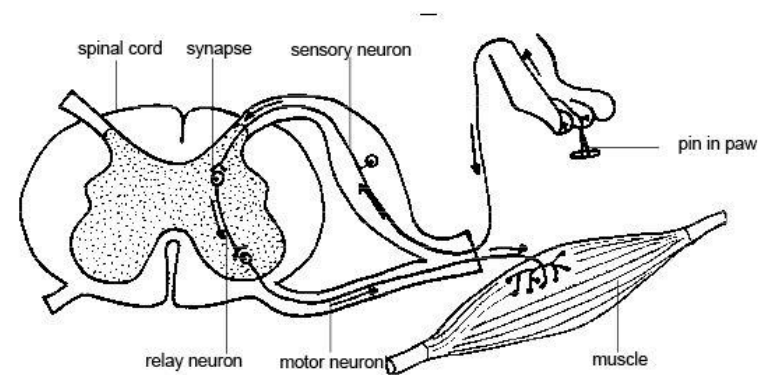


Central Nervous System (CNS)

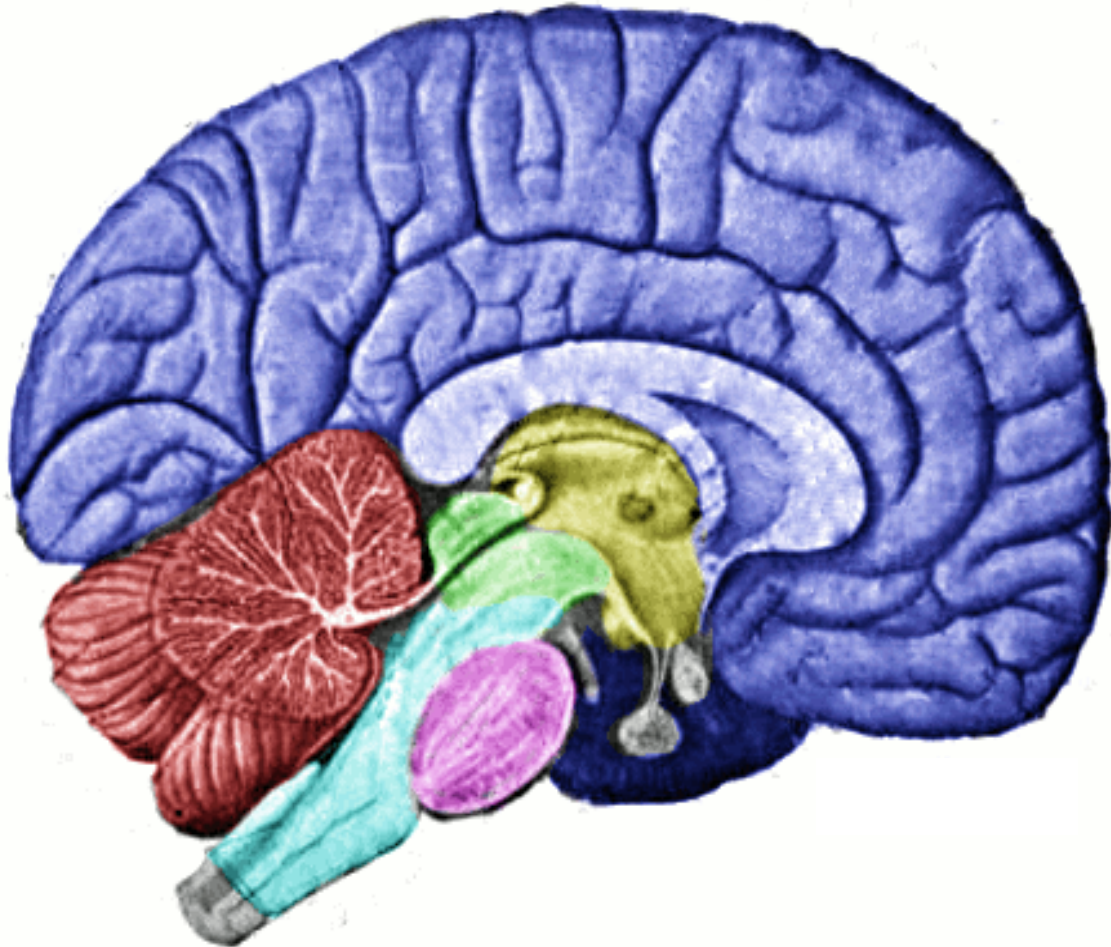
CNS = Spinal Cord + Brain

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



CNS = Spinal Cord + Brain



Major Brain Regions: The Hindbrain

Medulla Oblongata

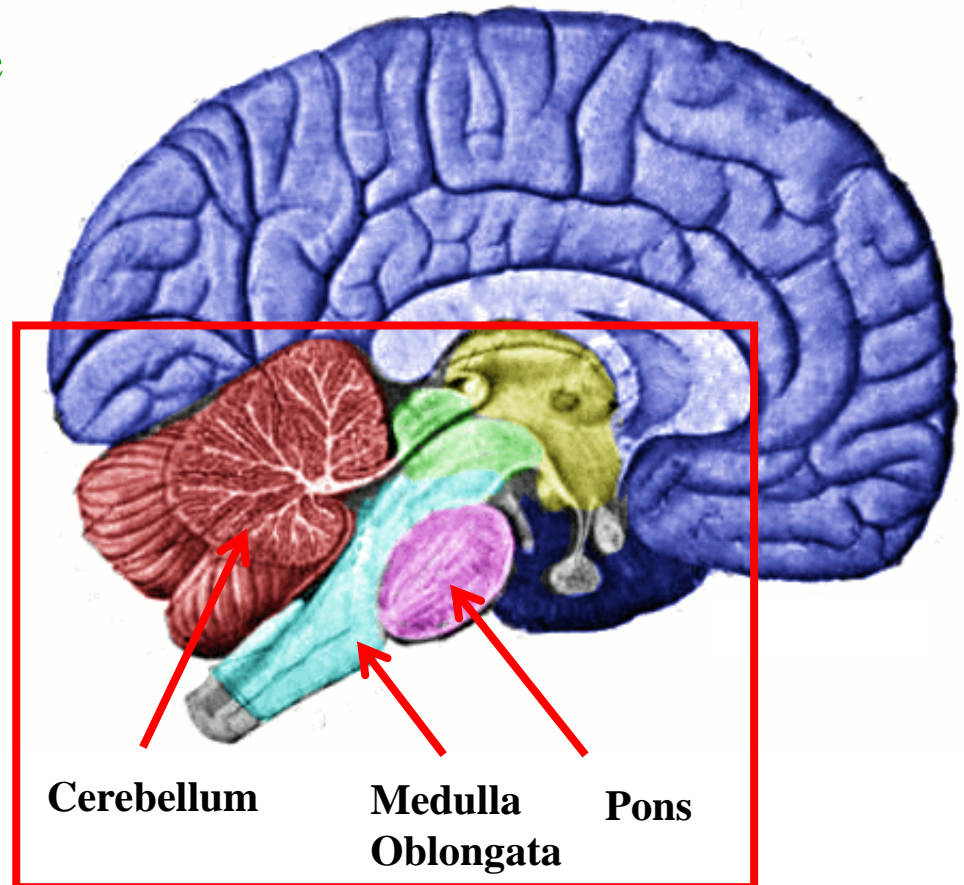
Controls **breathing**, **muscle tone**
and **blood pressure**

Pons

Connected to the
cerebellum & involved
in **sleep** and **arousal**

Cerebellum

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



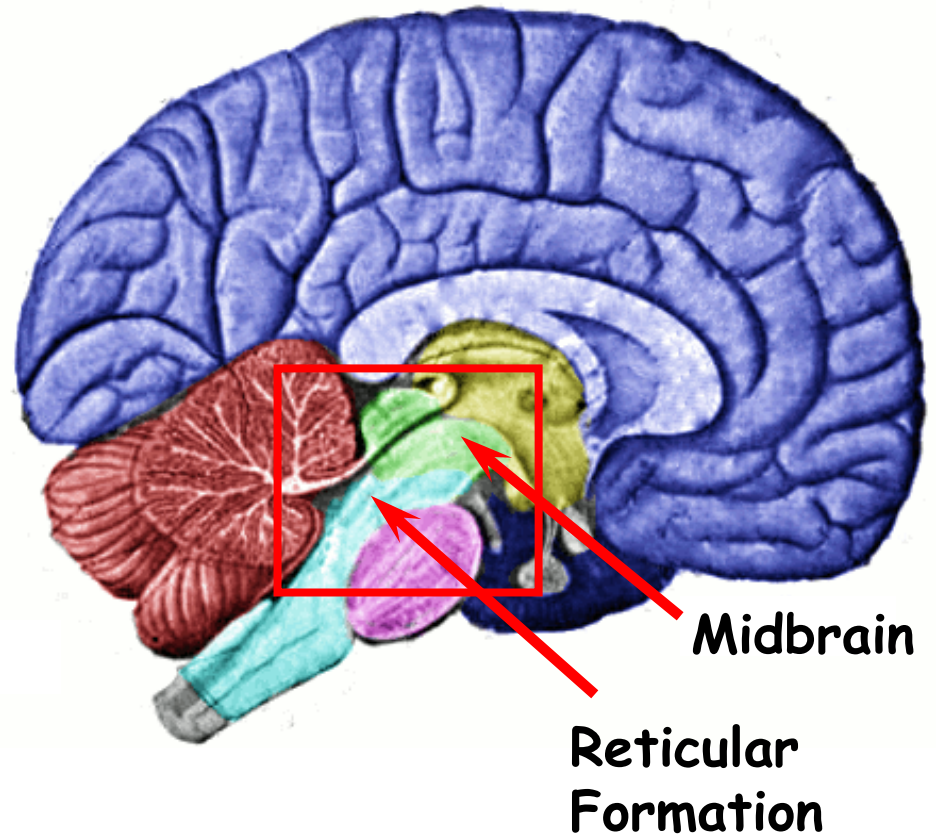
Major Brain Regions: Midbrain & Retic. Formation

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

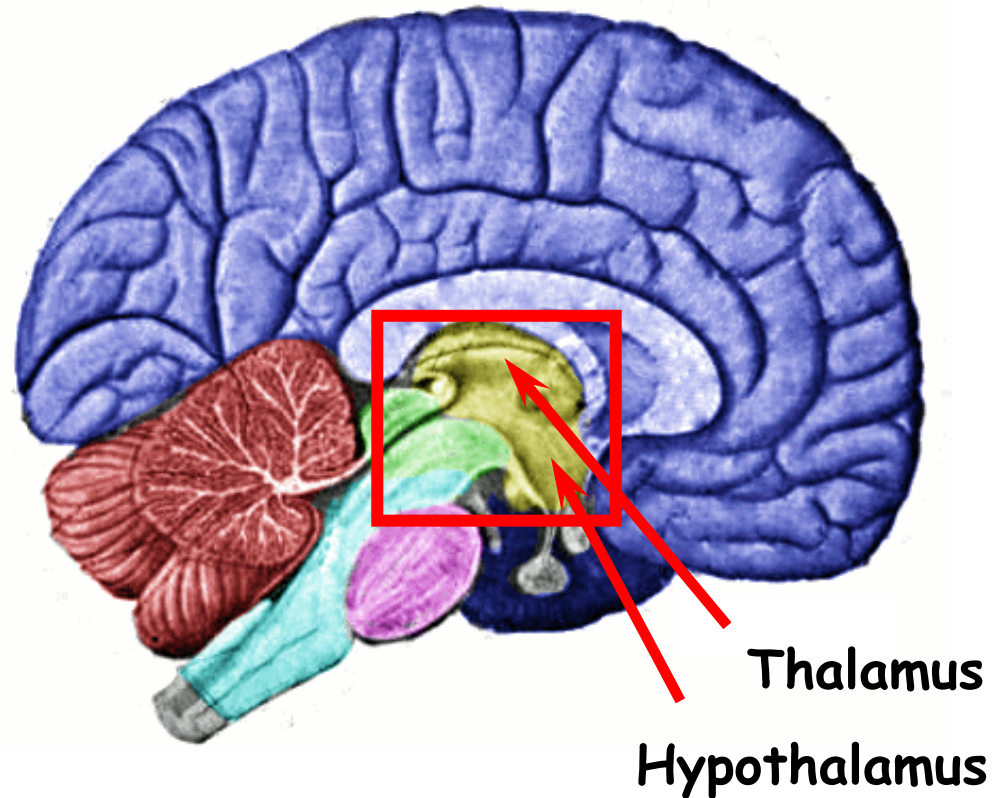
Thalamus

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

Hypothalamus

Regulates basic needs

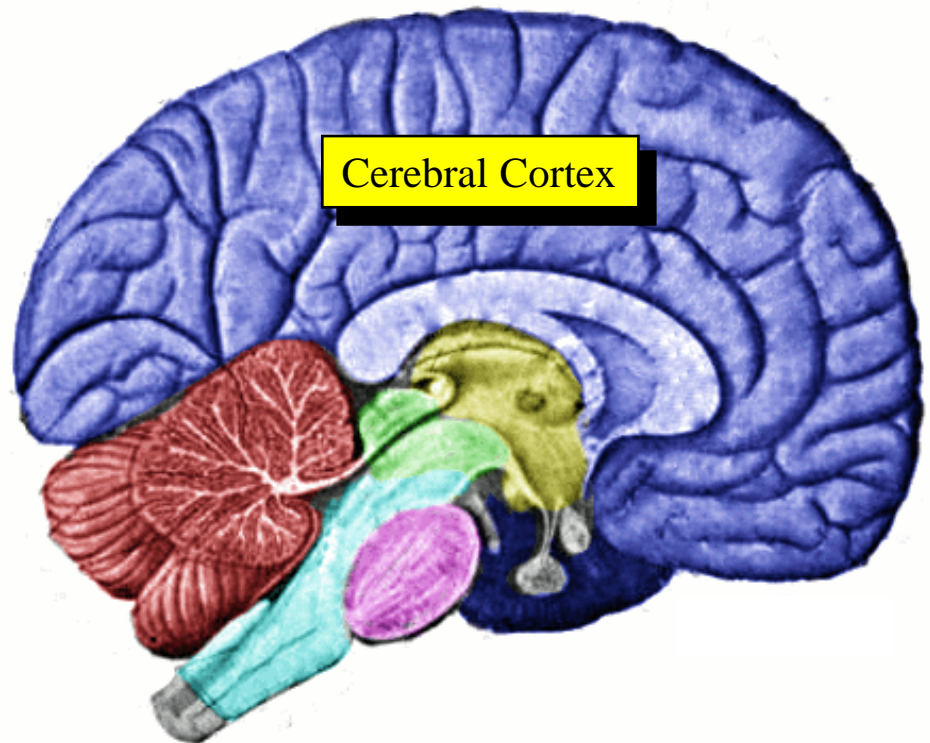
Fighting, Fleeing,
Feeding, and
Mating





Major Brain Regions: The Cerebrum

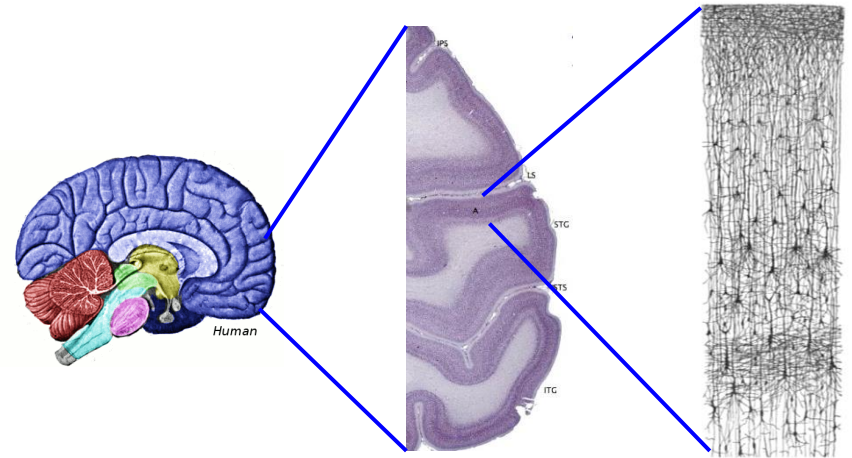
- ◆ Consists of: Cerebral cortex, basal ganglia, hippocampus, and amygdala
- ◆ Involved in perception and motor control, cognitive functions, emotion, memory, and learning



Cerebral Cortex: A Layered Sheet of Neurons

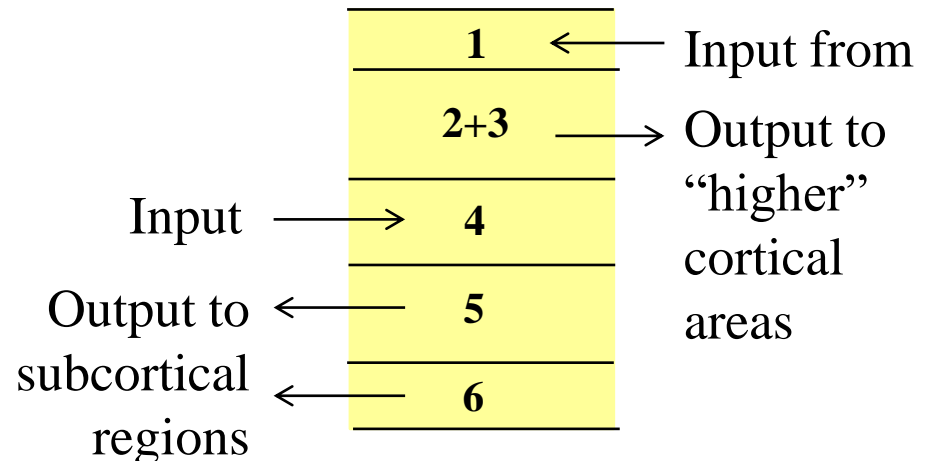
♦ **Cerebral Cortex**: Convoluted surface of cerebrum, about 1/8th of an inch thick

- 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?



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 $\sim 10^4$ connections)
- ⇒ Silicon Chip: 10^{10} transistors with sparse connectivity

◆ Device speed:

- ⇒ Biology has $100\mu\text{s}$ 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