# How Minds Work

# Neuroscience

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# Nervous Systems

- “Wetware” underlying minds in animals
- Control sense-process-act cycles
- Composed of Neurons
- Ganglia are groupings of neurons

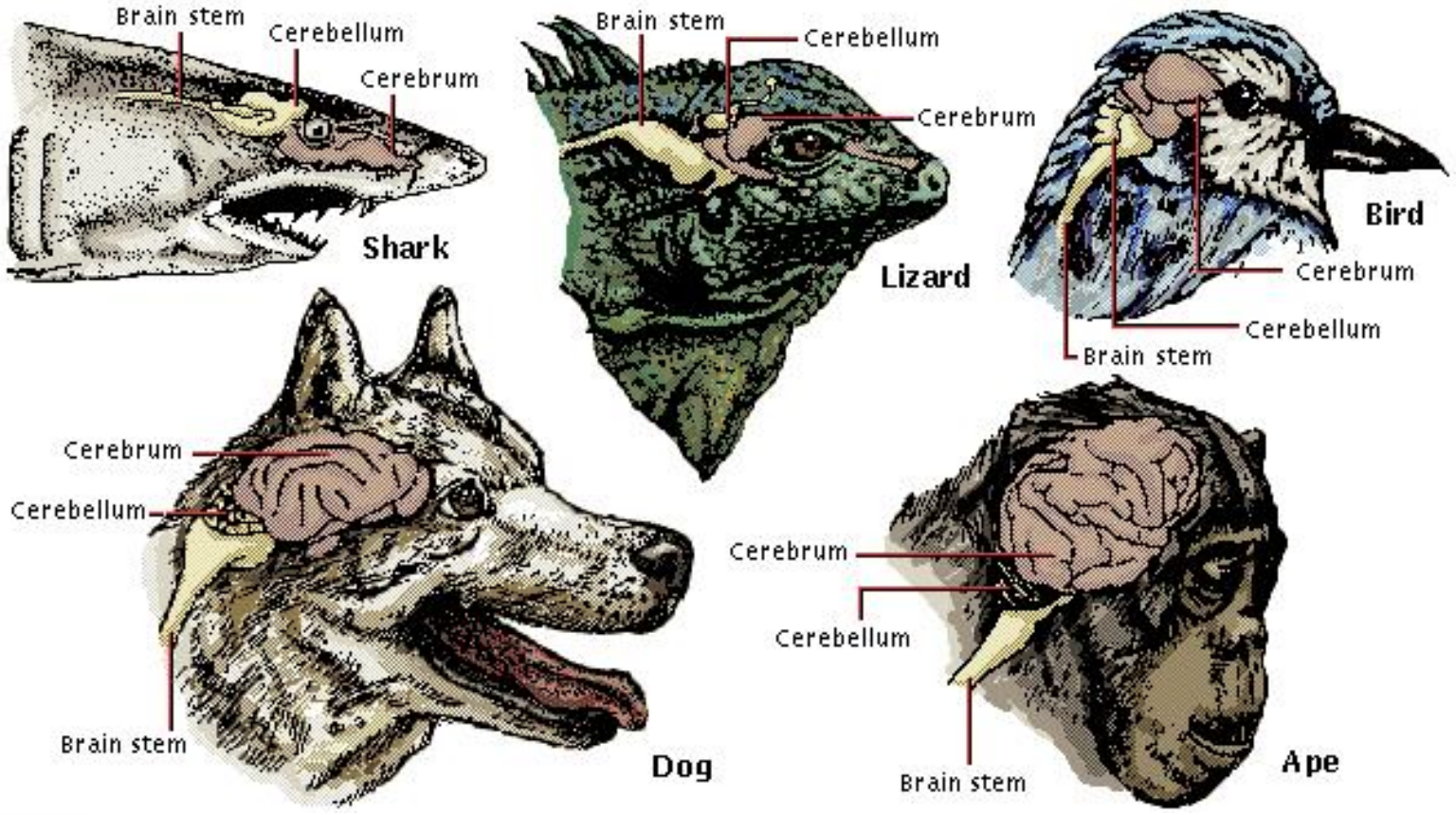
# Nervous System Ontology

- Microscopic—neurons–axons, synapses, ion channels, action potentials, etc.
- Mesoscopic—neuronal populations–ganglia, cell assemblies, neuronal groups
- Macroscopic—anatomical modules–hippocampus, occipital lobe, frontal cortex, cyngulate gyrus, thalamus, etc.

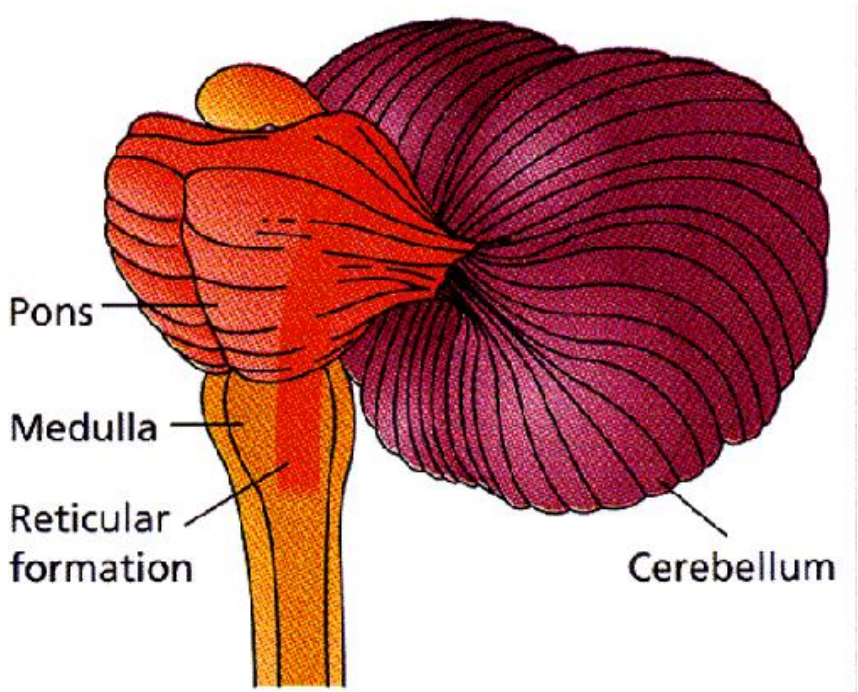
# Invertebrate Nervous Systems

- Sponge—multicelluar animal with no nervous system–touch causes contraction
- Jellyfish—nerve net but no ganglia–sense light, balance, chemicals, touch
- Snail—nervous system of six ganglia
- Earthworm—segmented ganglia & tiny “brain”
- Grasshopper—simple brain between the eyes–can jump and walk without it
- Octopus—complex brain with 300m neurons–can learn and remember

# Vertebrate Brains



# Brain Stem & Cerebelum



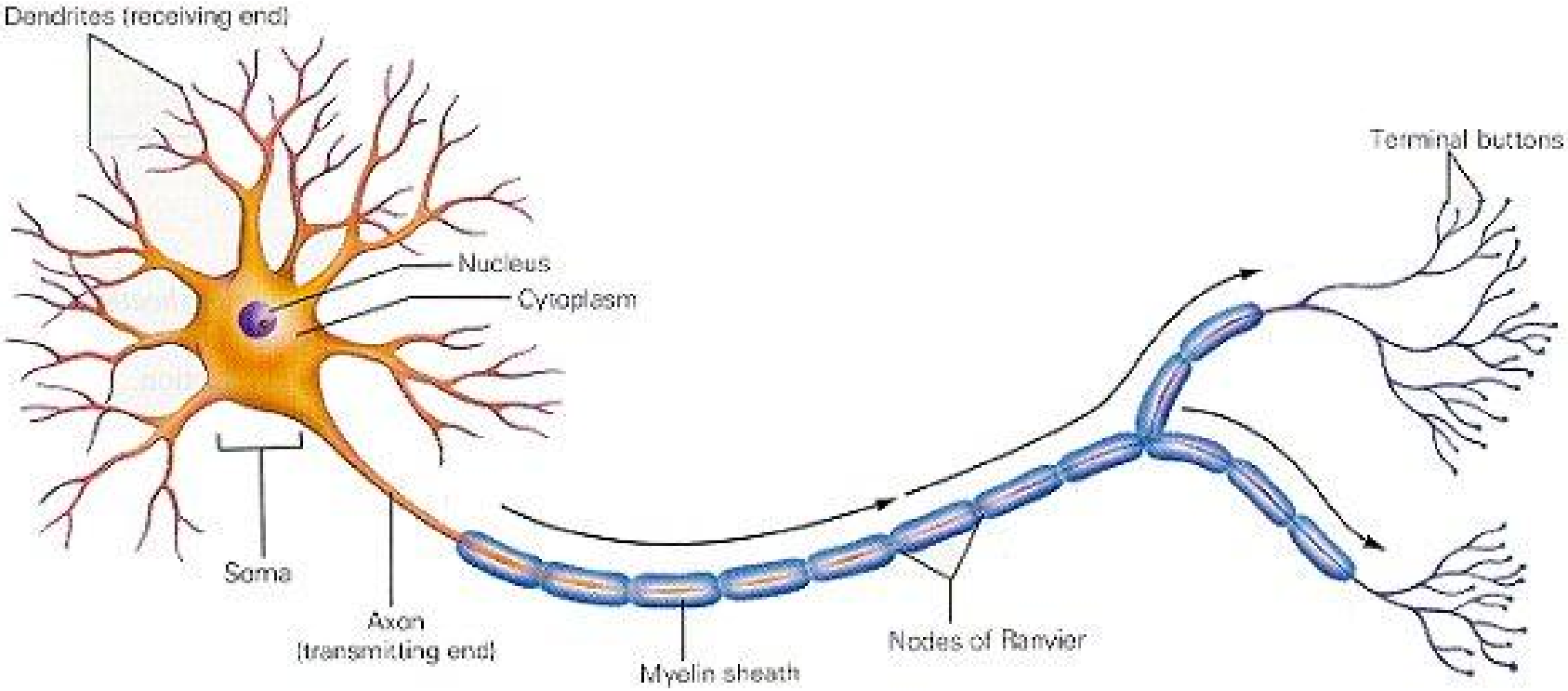

- Pons—respiratory center, facial muscles
- Medulla—cough, gag, swallow, vomit
- Reticular formation—arousal, attention, cardiac reflexes, motor functions, awareness, sleep
- Cerebellum—control & coordinate voluntary movement

# Role of the Cerebrum

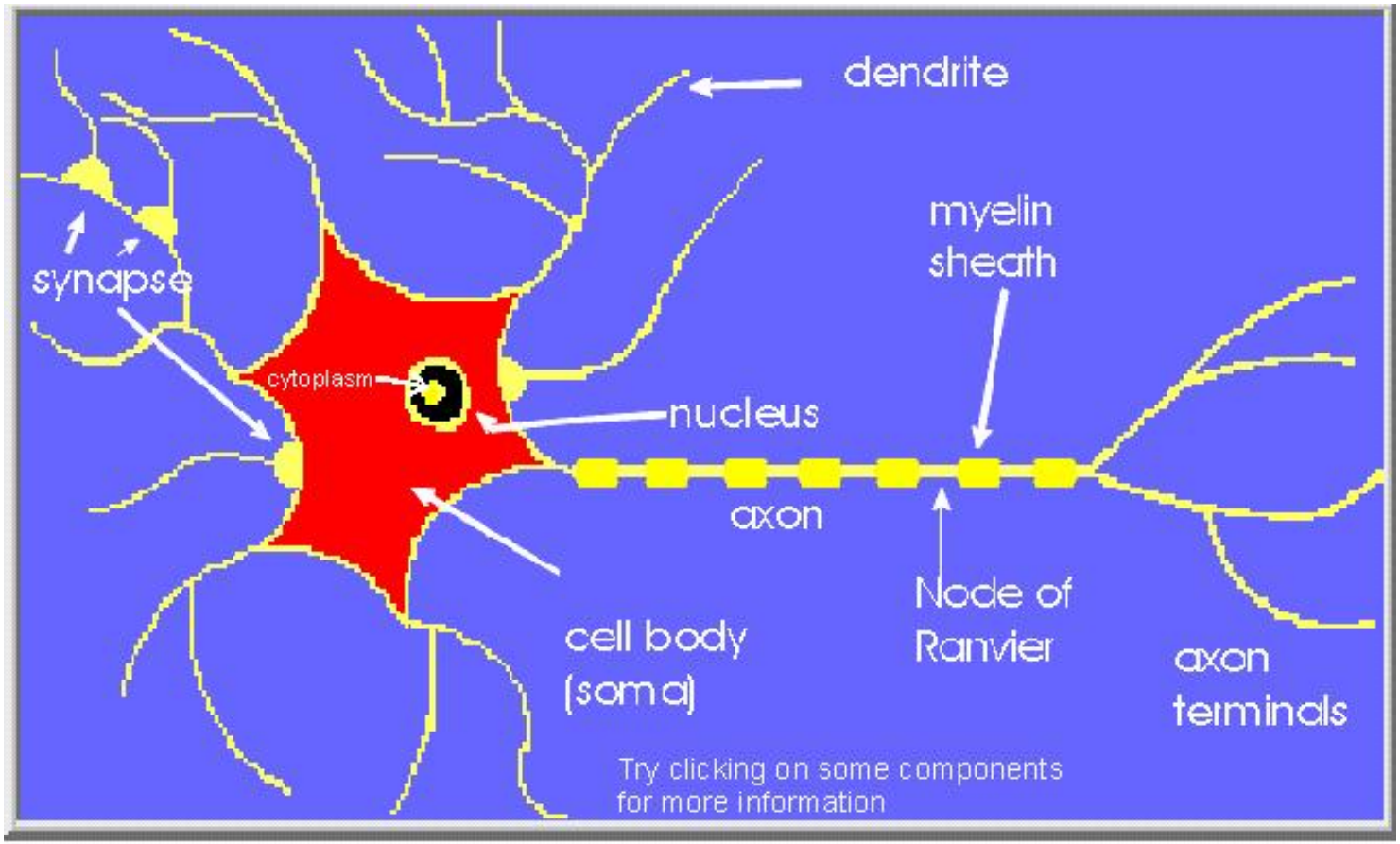
- Fish—dwarfed by the rest of the brain–serves to process sensory input
- Reptiles & amphibians—proportionally larger–connects and forms conclusions about sensory input
- Birds—well-developed optic lobes, making the cerebrum even larger
- Mammals—dominates the brain
- Primates—cognitive ability is the highest

## *The Major Structures of the Neuron*

The neuron receives nerve impulses through its dendrites. It then sends the nerve impulses through its axon to the terminal buttons where neurotransmitters are released to stimulate other neurons.



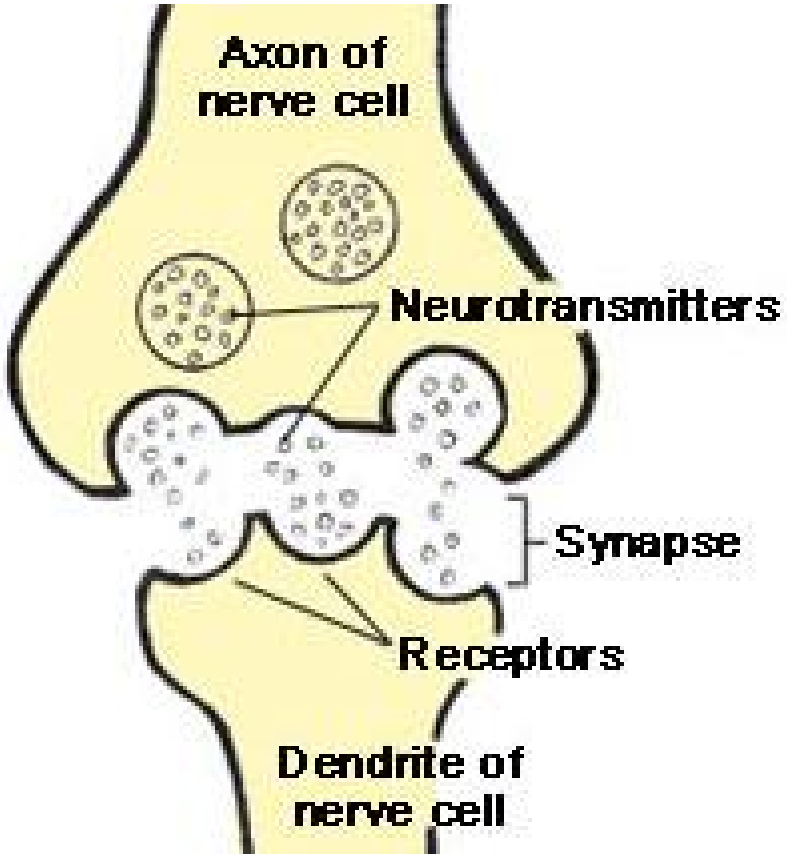
# Neuron




Cartoon of a generic neuron

# Synapses

- Pulse - chemical - wave
- Excitatory or inhibitory
- Neurotransmitter reuptake
- Signal vs modulator
- Learning via strengthening
- Decay with disuse



# Neurons in Action

- Neurotransmitters cross synaptic clefs changing the voltage of the neuron
- Internal voltage exceeds threshold
- Triggers pulse down the axon
- Releases neurotransmitter at each synaptic clef

# Neurotransmitters

- Acetylcholine—most widely used– skeletal muscles, memory and learning
- Norepinephrine—heart & blood vessels, focusing attention
- Dopamine—rewarding effects of drugs and natural stimuli
- Serotonin—mood, sleep, food intake, aggressive behaviors, pain sensitivity
- Others—Glutamic acid, GABA, Aspartic acid, Glycine, etc.

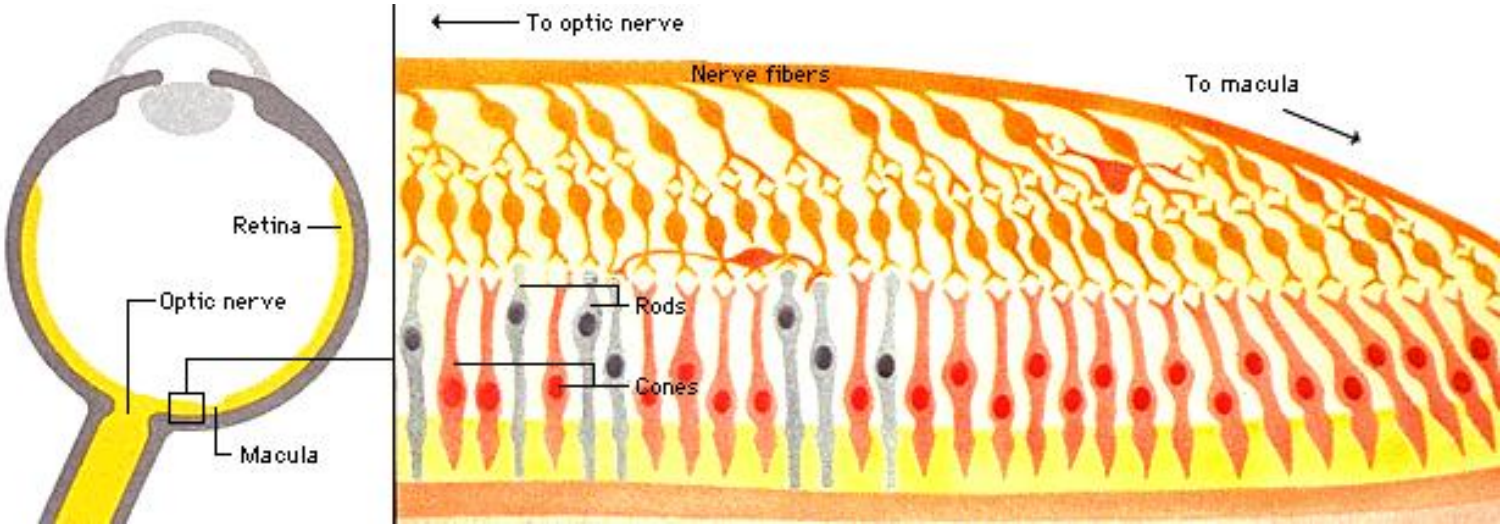
# About Neurons

- Little used neurons tend to die
- Learning by
  - Strengthening synapses
  - Adding new synapses
  - adding new neurons
- Interneurons vs projection neurons

# Receptive Field

- Sensory receptor—eg retinal rod or cone
- Sensory neuron—eg a retinal ganglion cell–each with a particular content preference
- Receptive field—retinal area in which stimulation leads to response by neuron

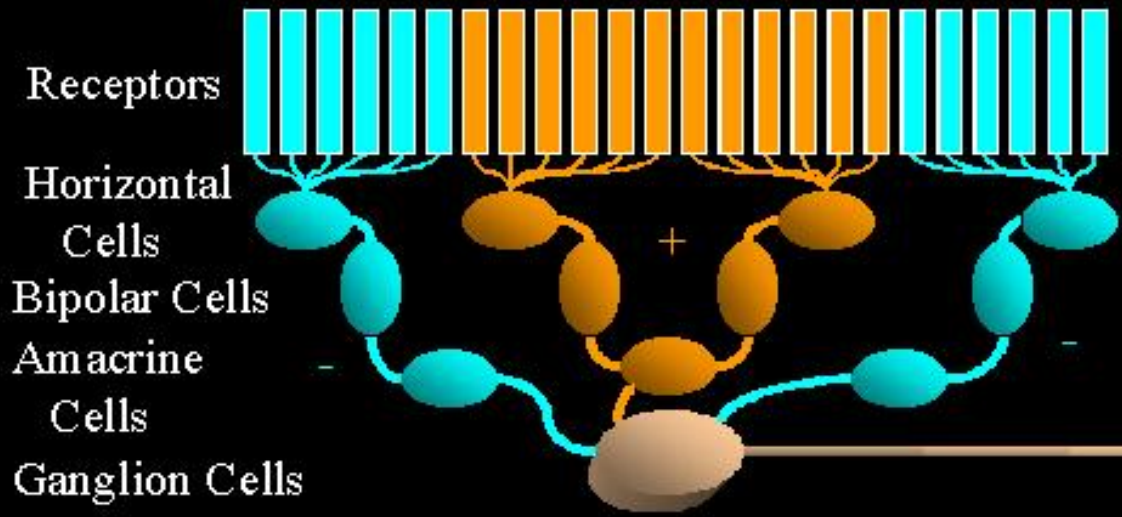
# Retinal Anatomy




- Light passes through nerve fibers to rods & cones
- Ganglion cells reactive to their receptive fields
- Signal then passes through optic nerve to brain

# Schematic Retina Showing a Receptive Field

Orange are excitatory inputs into the receptive field.
Blue are inhibitory inputs into the receptive field.

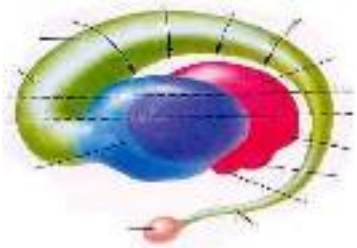


# Sensory Neurons as Feature Detectors

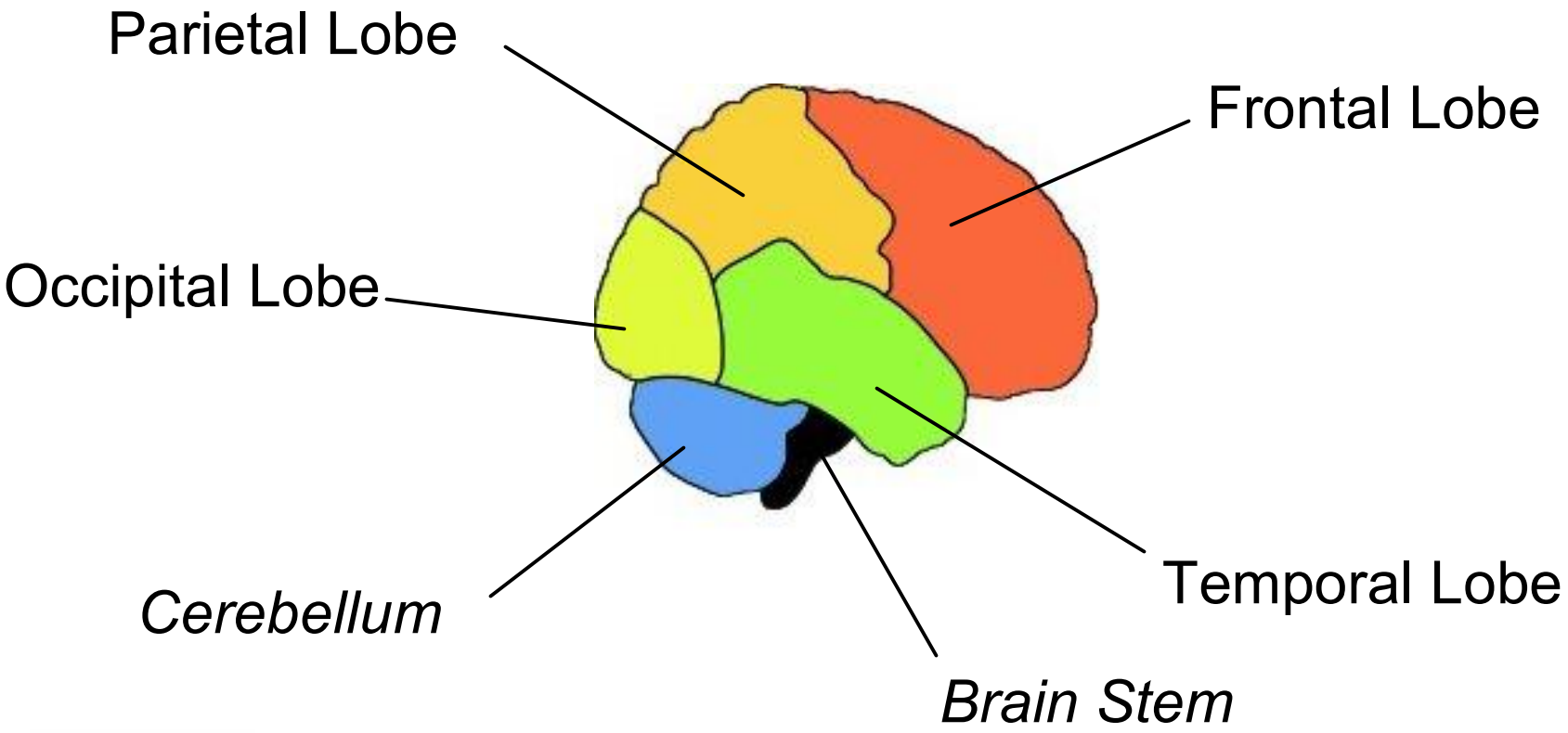
- Edge detector—edge at particular angle
- Motion detector—responds to movement
- Color detector—responds to particular colors
- Responds incrementally to variations
- Complex feature detectors built of primitive feature detectors.

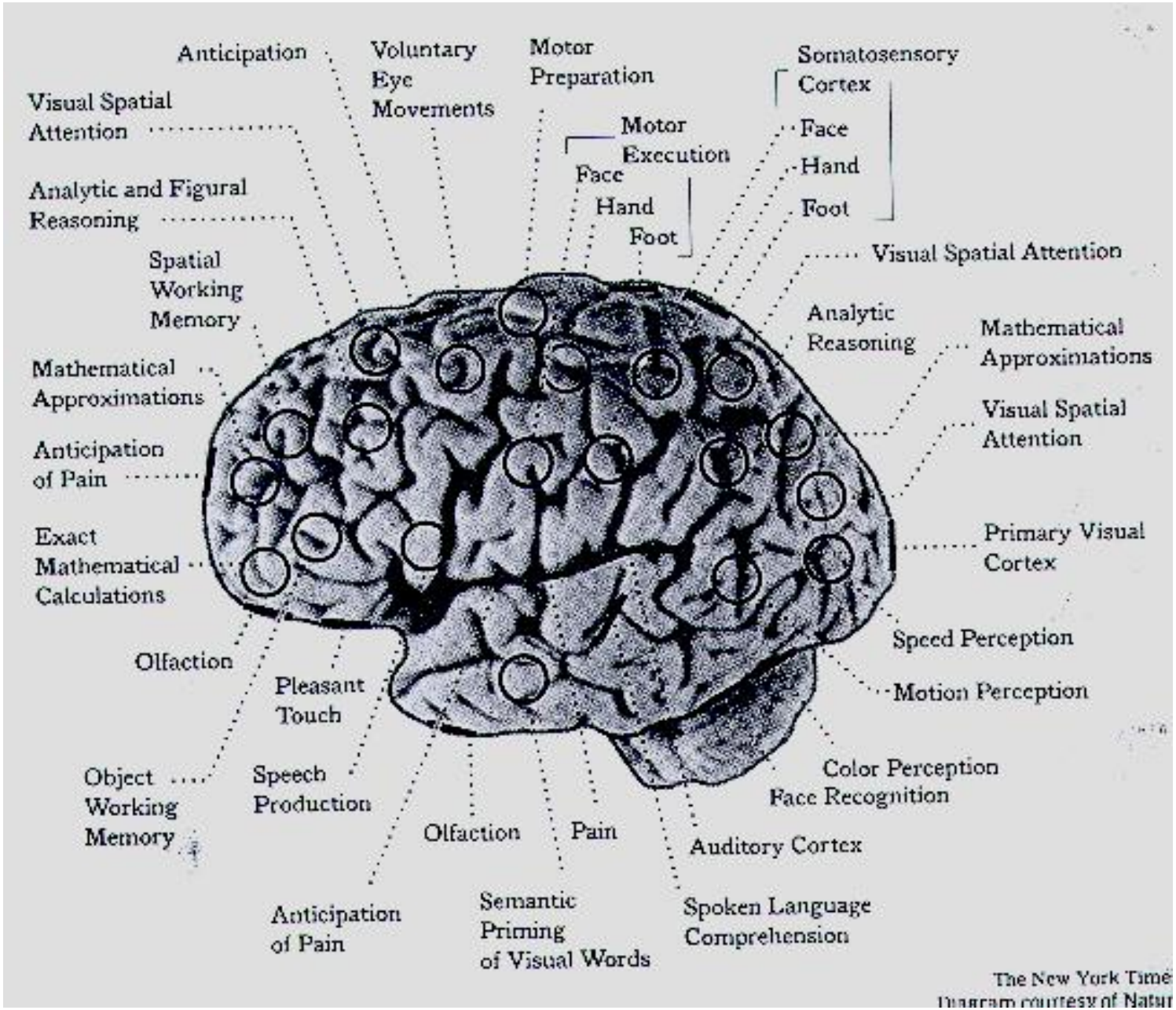
# The Triune Brain

- Reptilian brain
  *snakes, lizards – hunger, temperature control*
- Limbic system
  *cats, rats – mood, memory*
- Neocortex
  *primates – social, planning*

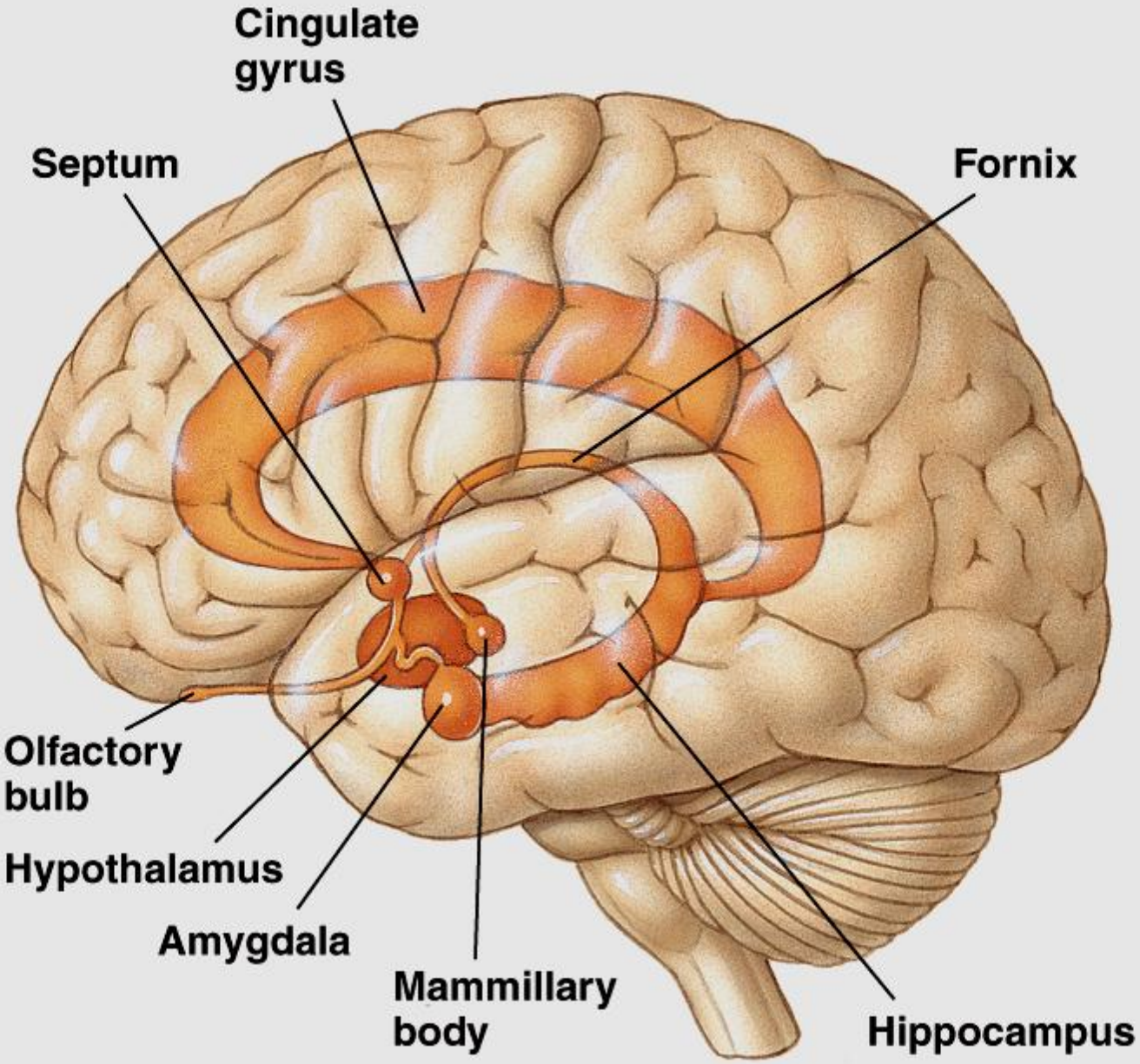


# Lobes of the Human Neo-cortex

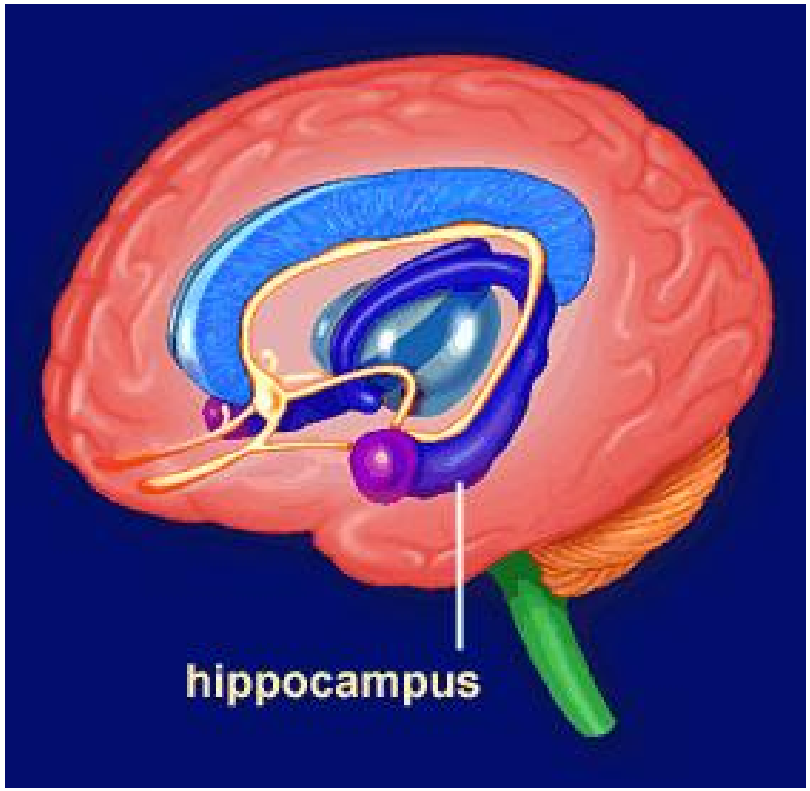



Anticipation
Voluntary Eye Movements
Motor Preparation
Somatosensory Cortex
Face
Hand
Foot
Visual Spatial Attention
Motor Execution
Face
Hand
Foot
Analytic and Figural Reasoning
Spatial Working Memory
Visual Spatial Attention
Analytic Reasoning
Mathematical Approximations
Mathematical Approximations
Visual Spatial Attention
Anticipation of Pain
Exact Mathematical Calculations
Primary Visual Cortex
Speed Perception
Olfaction
Pleasant Touch
Motion Perception
Object Working Memory
Speech Production
Color Perception
Face Recognition
Olfaction
Pain
Auditory Cortex
Anticipation of Pain
Semantic Priming of Visual Words
Spoken Language Comprehension
The New York Time
Diagram courtesy of Natur

## ► Location of Major Limbic System Structures



# Hippocampus




- Spatial memory
  - Song birds
  - London taxi drivers
- Transient episodic memory
- Consolidate into declarative memory

# Assigned Readings

Sloman, A., and R. Chrisley. 2003. Virtual Machines and Consciousness. *Journal of Consciousness Studies* 10:133-172.

Your "3-Brains-in-One" Brain http://www.psycheducation.org/emotion/triune%20brain.htm (take the tour)

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