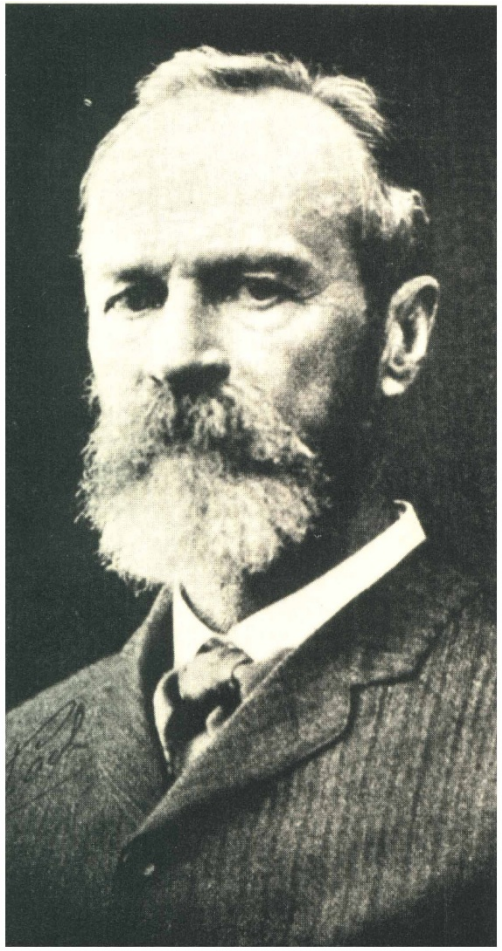
The Organization of the Nervous System

Lecture 2

William James (1842-1910)



R.W. Wozniak

"Psychology is the science of mental life"

Principles of Psychology (1890)

The study of mind includes the study of *mind in body*.

Levels of Biological Organization

The Individual Organism

Cell

Tissue

Organ

System

Organism

Groups of Organisms

Species

Genus

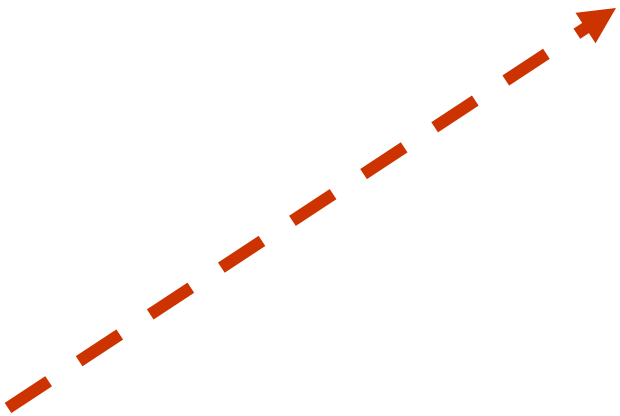
Family

Order

Class

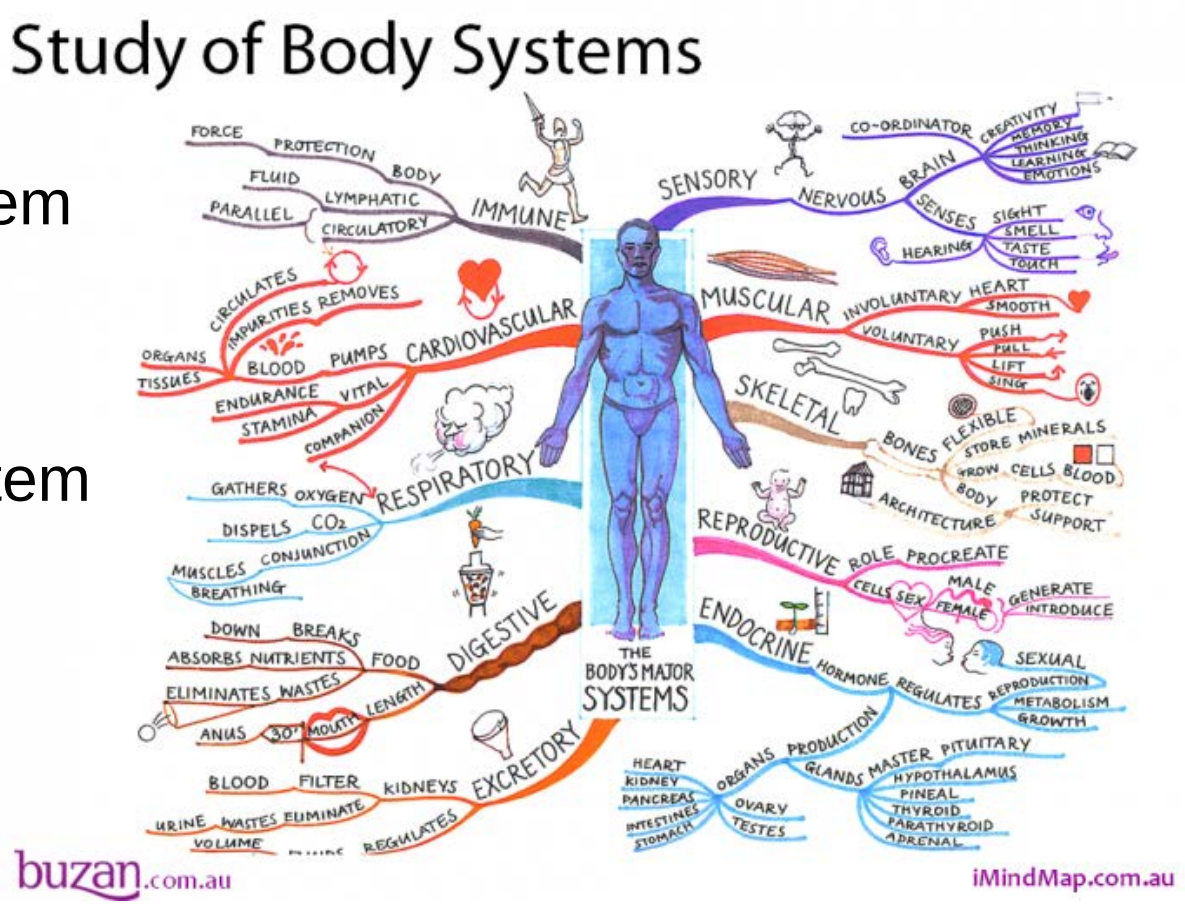
Phylum (Division)

Kingdom (Domain)



Systems of the Body

- **Nervous System**
- Endocrine System
- Integumentary System
- Skeletal System
- Muscular System
- Cardiovascular System
- Lymphatic System
- Respiratory System
- Digestive System
- Urinary System
- Reproductive System
- Immune System



Levels of Neural Organization

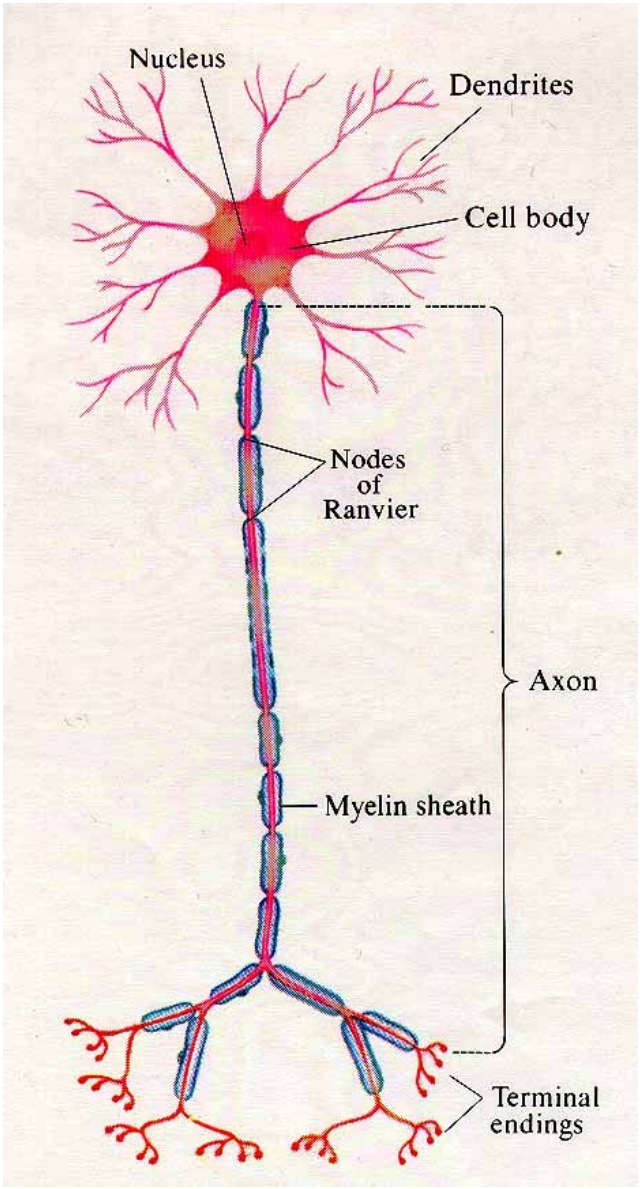
Cell
- Neuron

Tissue
- Nerves, Ganglia, Nuclei

Organ
- Brain, Spinal Cord, Brainstem

System
- Nervous System
  - Central
    - Brain, Spinal Cord
  - Peripheral
    - Somatic (Skeletal), Autonomic

Organism
- Person

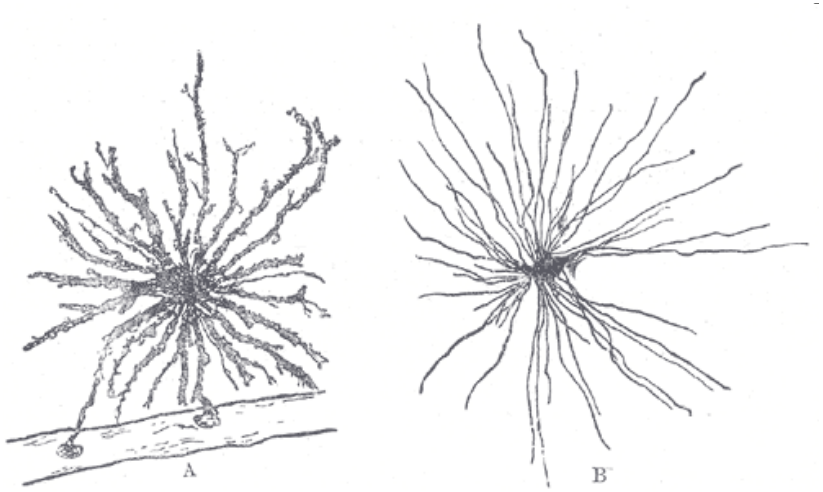


Gleitman 1995

Neurons

- Afferent
  - Sensory
- Efferent
  - Motor
- Interneurons
  - “Central”

Glia Cells (Neuroglia)

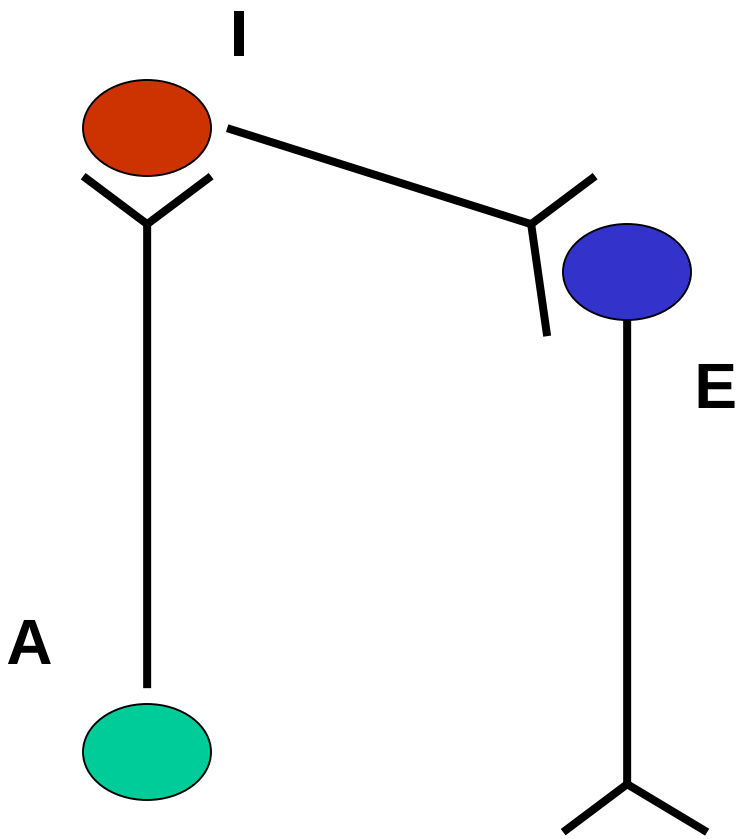


Wikipedia

- Functions
  - Build Myelin sheath
  - Guide Migration
  - Packing Tissue
  - Transfer Nutrients
  - Remove Waste
- Pathology
  - Alzheimer's Disease
    - Plaques and Tangles
  - Brain Tumors

The Reflex Arc

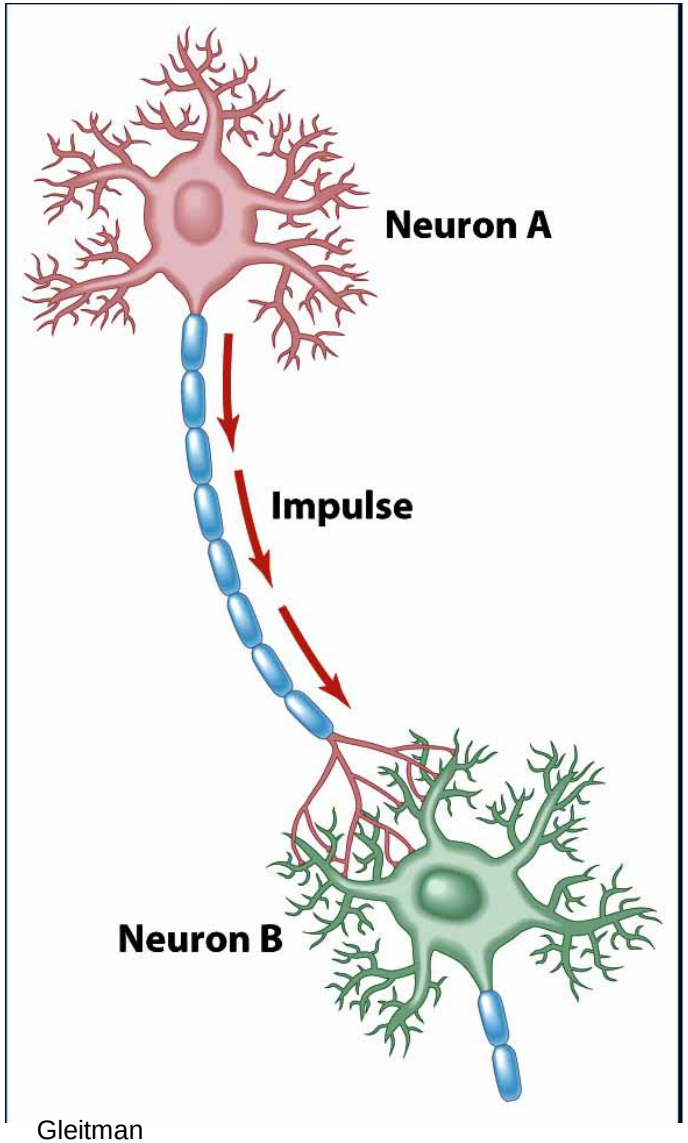
Sherrington (1906)



- Afferent Neuron
  - Sensation
- Interneuron
  - Processing
- Efferent Neuron
  - Response

Depolarization

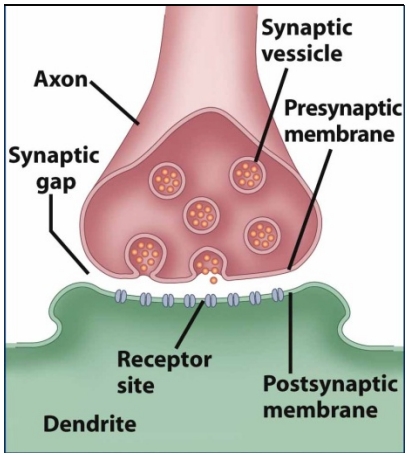
Sherrington (1906)

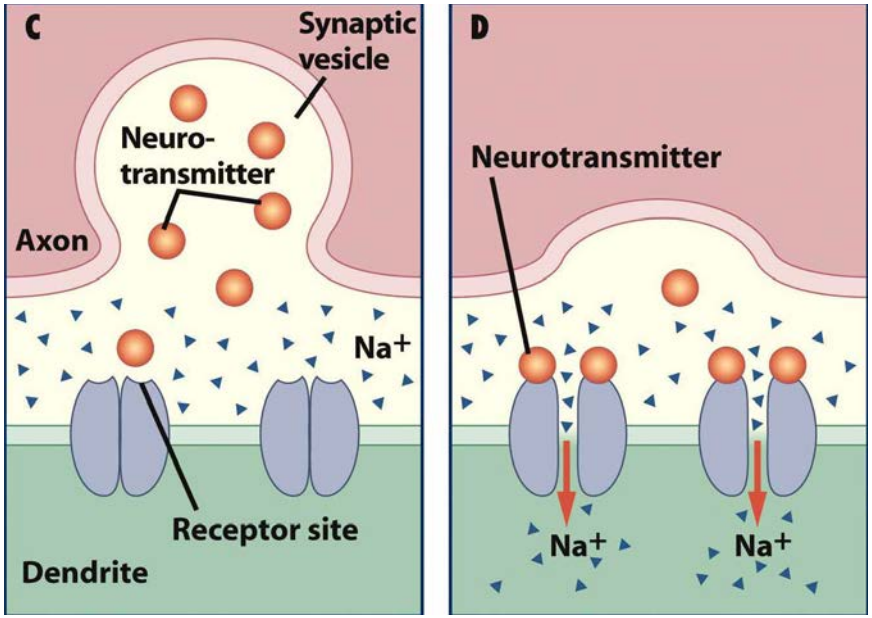


- Resting Potential
  - Negative
- Ion channels
  - Sodium (Na)
  - Potassium (K)
- Depolarization
- Action Potential
  - Positive
- The Synapse

Gleitman

Synaptic Transmission



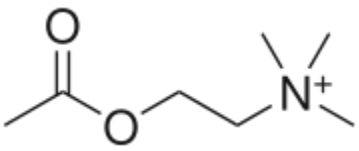


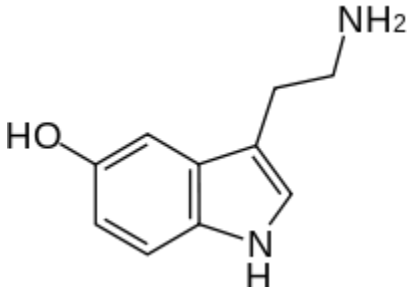
- Neurotransmitters
  - Release
  - Uptake
  - Re-Uptake
- Acetylcholine
  - Botulism
  - Curare
  - Nerve Gas

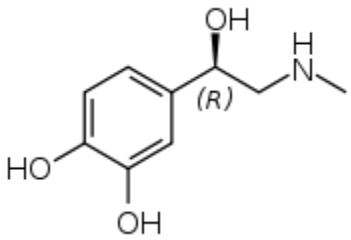
Gleitman

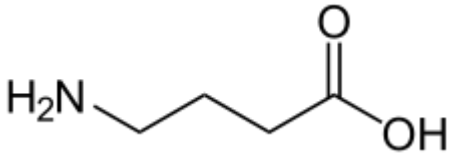
Excitatory and Inhibitory Neurotransmitters

- Amines
  - Acetylcholine (Ach)
- Monoamines
  - Catecholamines
    - Epinephrine (Adrenaline)
    - Norepinephrine (NA)
    - Dopamine (DA)
  - Serotonin (5-HT)
- Amino Acids
  - Glutamate
  - GABA
- Peptides
  - Substance P
  - Beta-Endorphin
  - Corticotropin (ACTH)
  - Oxytocin





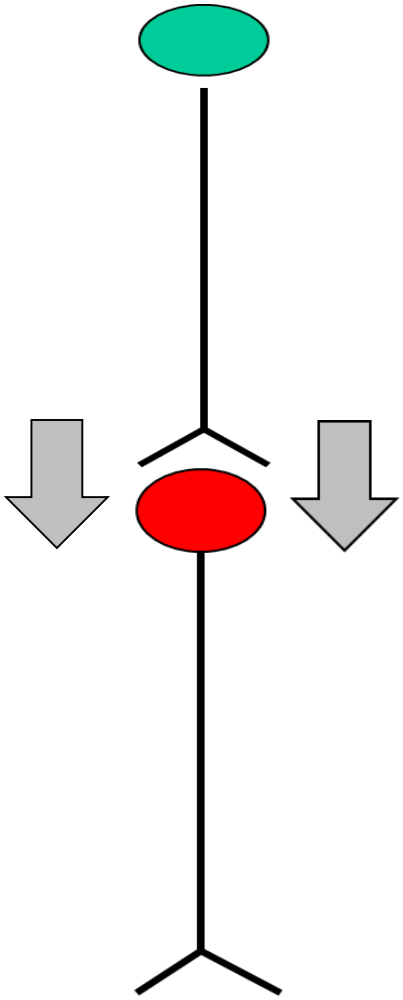


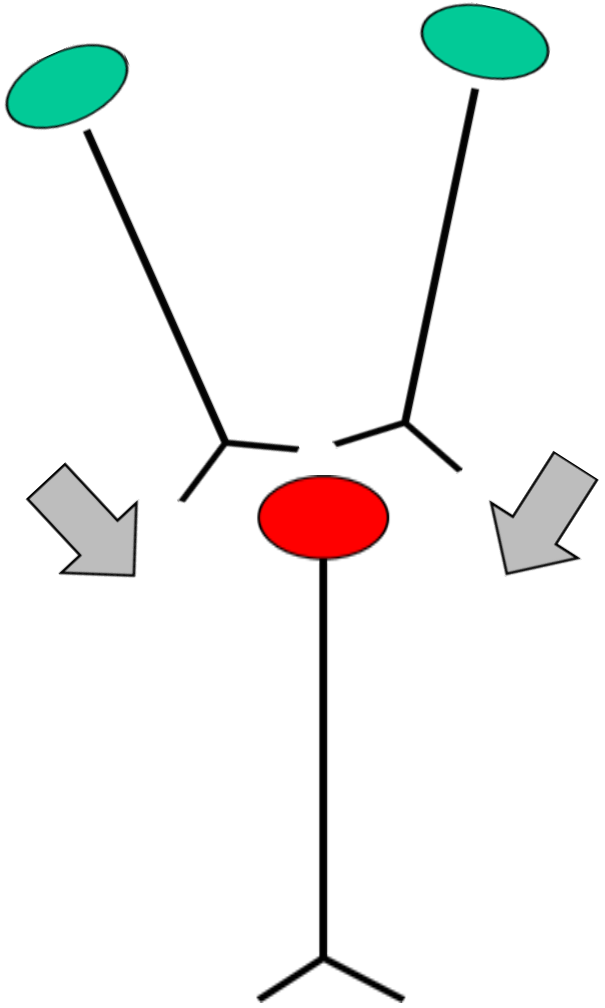


Dynamics of the Neural Impulse

- “All-of-None” Law
- Refractory Period
  - Absolute
  - Relative
- Thresholds
  - Superthreshold
  - Subthreshold

Temporal and Spatial Summation





Nerves, Ganglia, Nuclei

- Nerves
  - Afferent Neurons
    - Ascending Tract of Spinal Cord
  - Efferent Neurons
    - Descending Tract of Spinal Cord
- Ganglia
  - Interneurons Outside Brain, Spinal Cord
- Nuclei
  - Interneurons Inside Brain, Spinal Cord

Major Divisions of the Nervous System

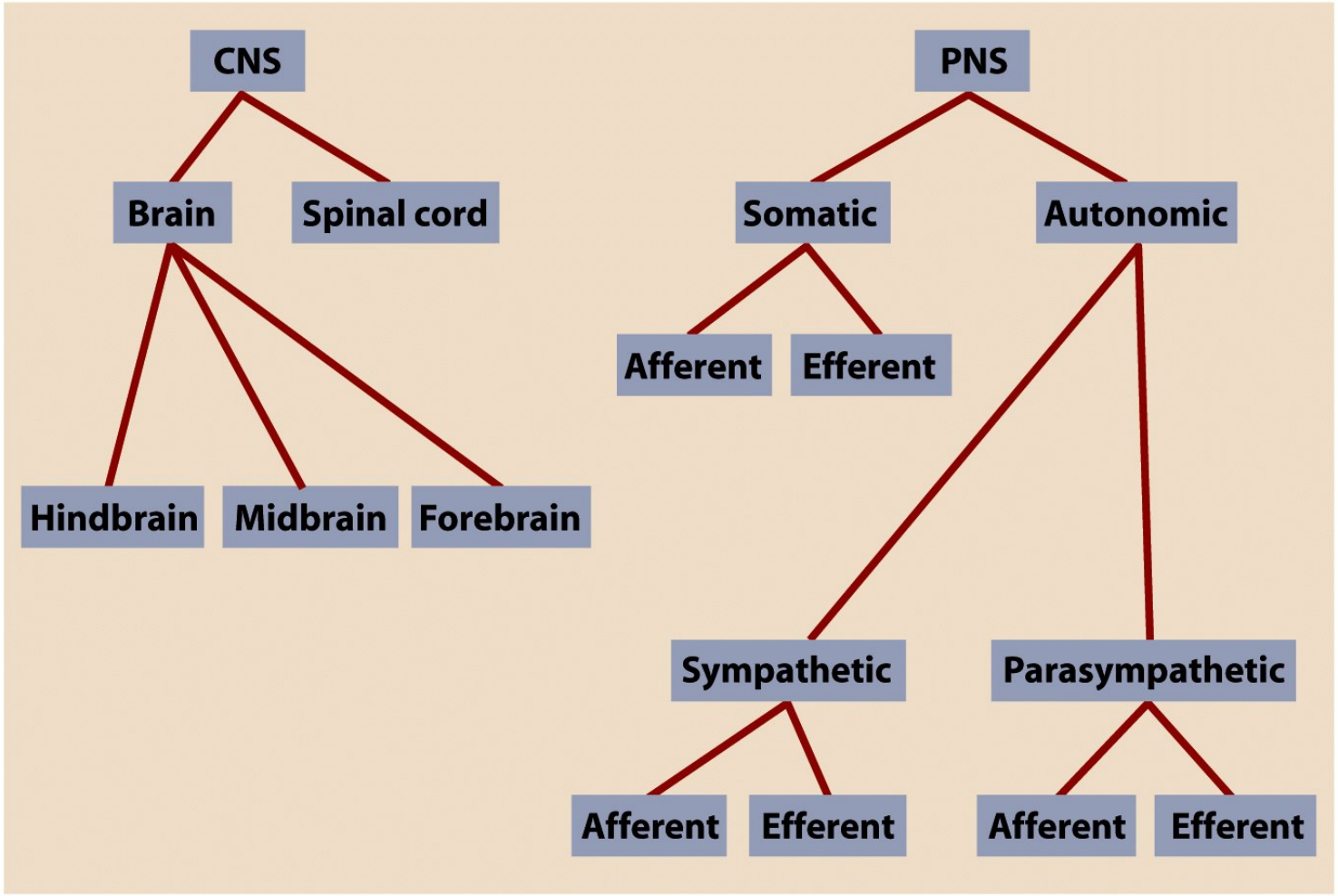
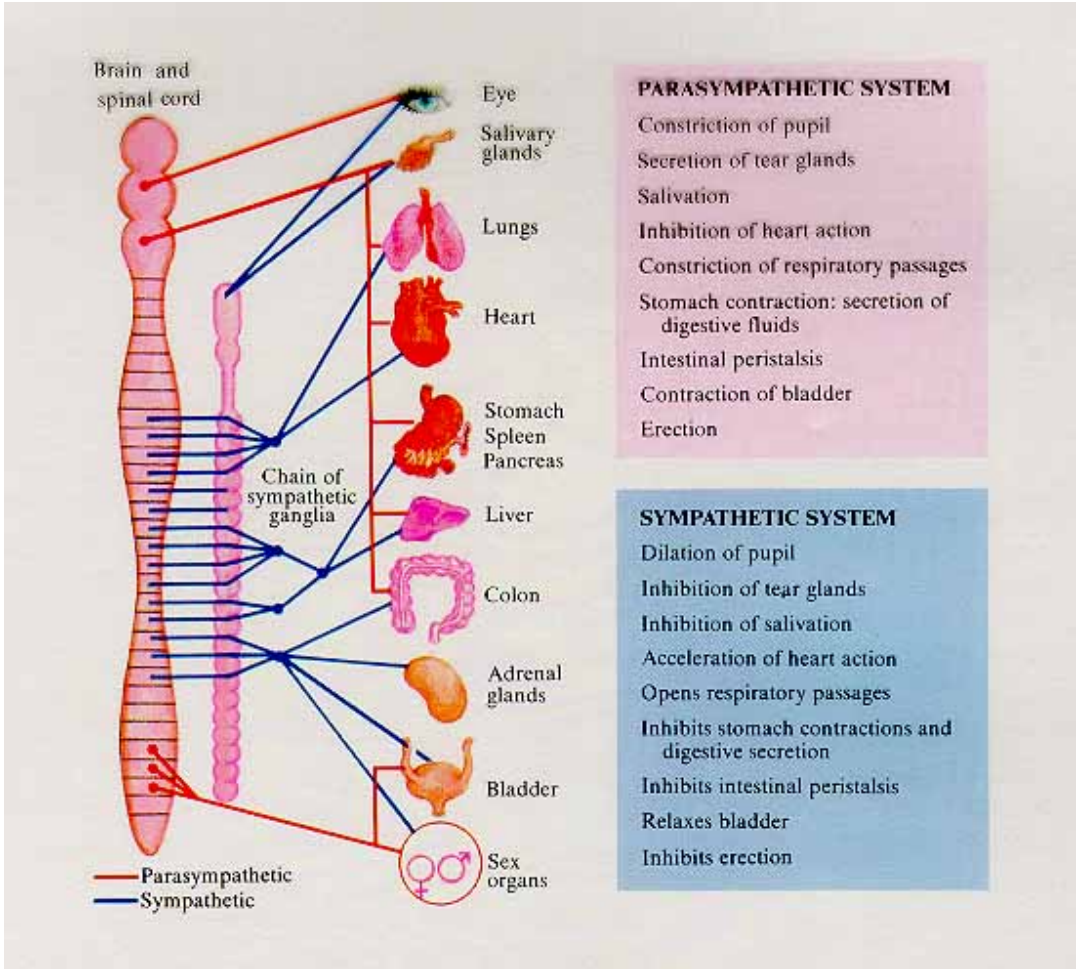


Figure 3-7 Psychology 7/e

Organization of the Autonomic Nervous System

- Sympathetic: Meet Emergencies
  - "Flight, Fight, or Freeze" (Canon, 1915)
    - Emotional Arousal (Adrenaline)
    - Release of Sugar (Noradrenaline)
    - Rechannel Blood Flow
  - "Tend and Befriend" (Taylor et al., 2000)
  - "Choice" Largely Determined by Hormones
    - Testosterone vs. Estrogen
- Parasympathetic: Vegetative Functions
  - Maintain Life

Antagonistic Relationship between Sympathetic and Parasympathetic Nervous Systems



Parasympathetic

Acts Discretely

Slow Onset, Offset

Conserves, Restores Resources

Sympathetic

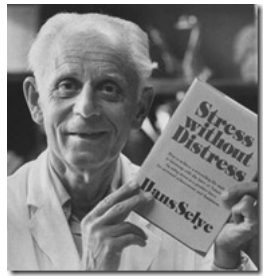
Acts as a Unit

Rapid Onset, Offset

Depletes Resources

The General Adaptation Syndrome

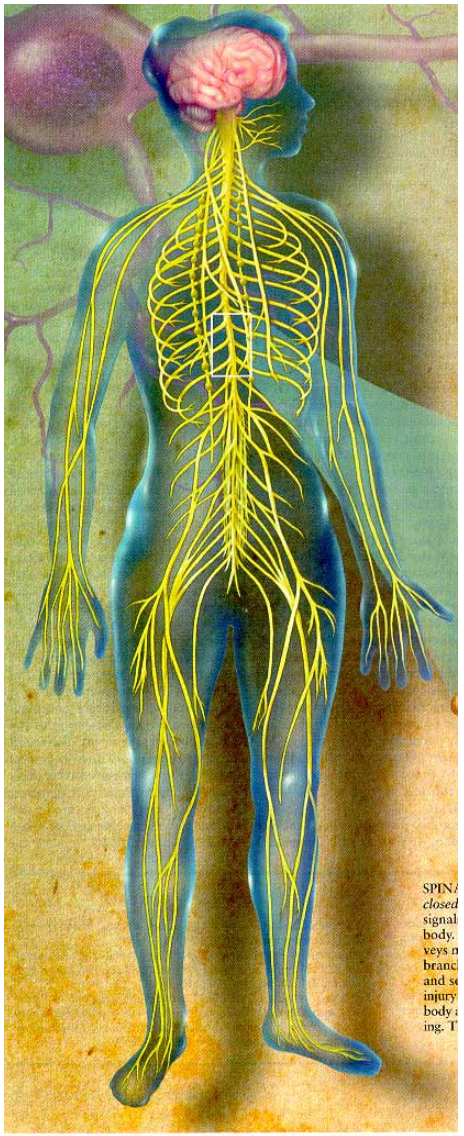
Selye (1956)



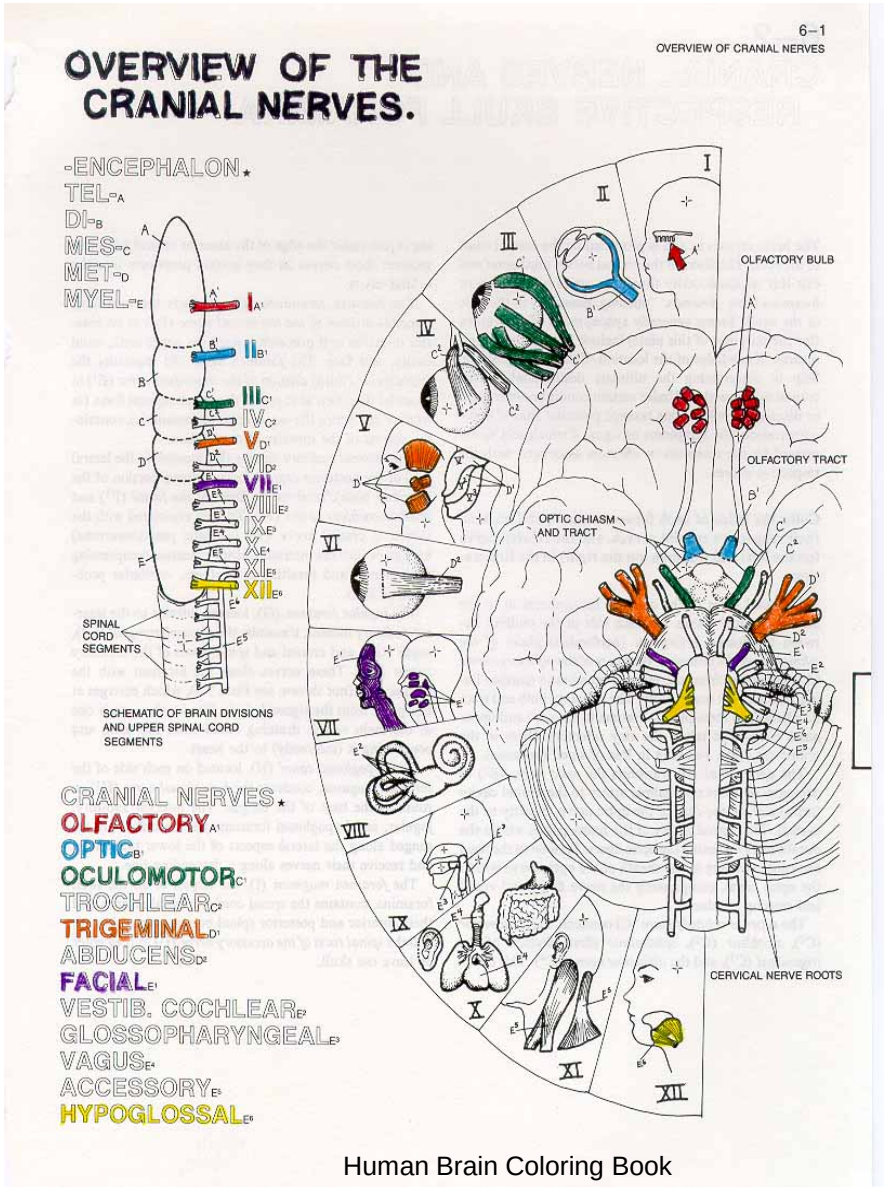
- Gross Emotional Reaction
  - Sympathetic Activation
- Decreased Emotion
  - Parasympathetic Activation
- Exhaustion, Death
  - Depletion of Resources

Organization of the Somatic Nervous System

- 31 Spinal Nerves
  - Spinal Cord
- 12 Cranial Nerves
  - Brain
  - Brainstem



12 Cranial Nerves

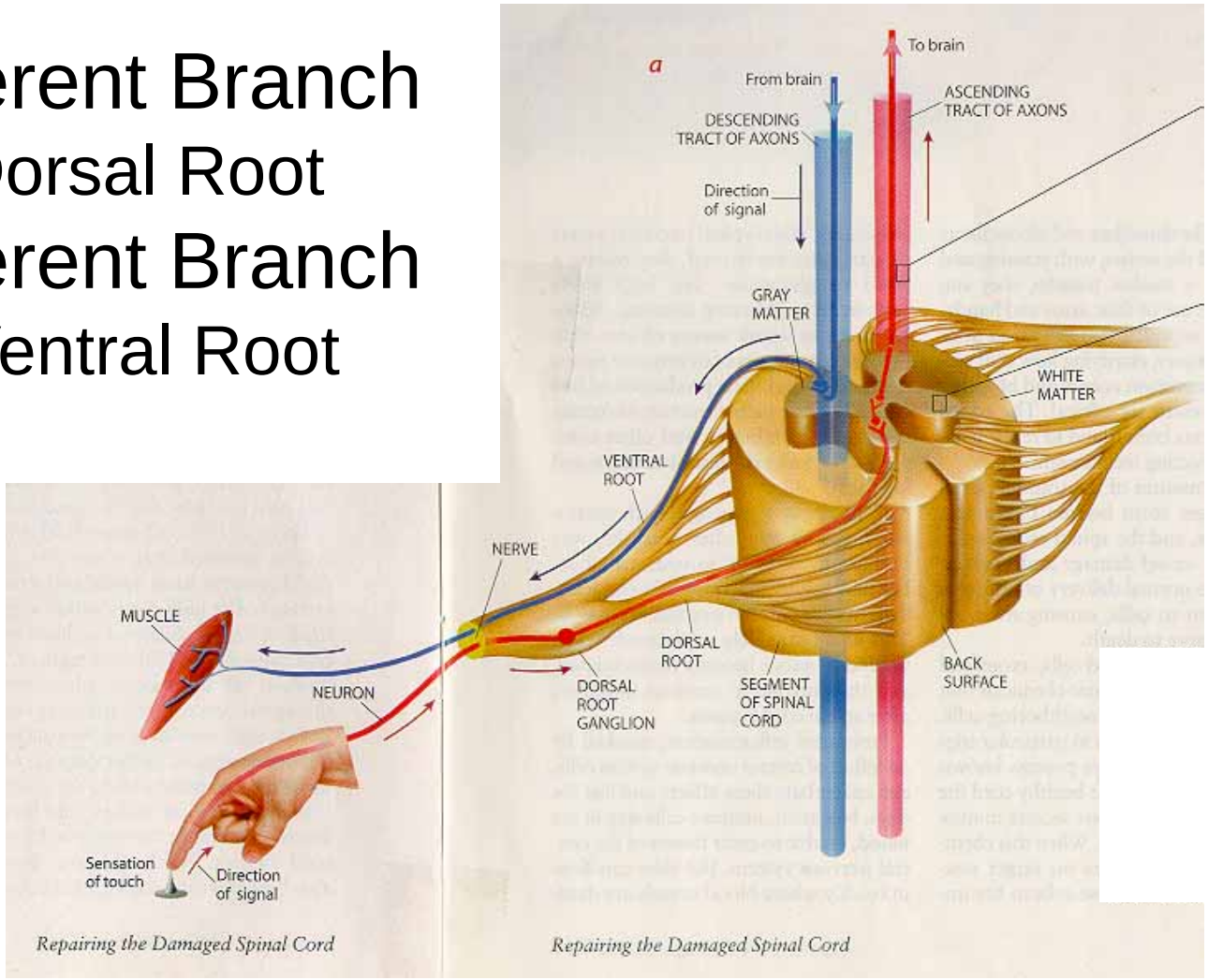


Human Brain Coloring Book

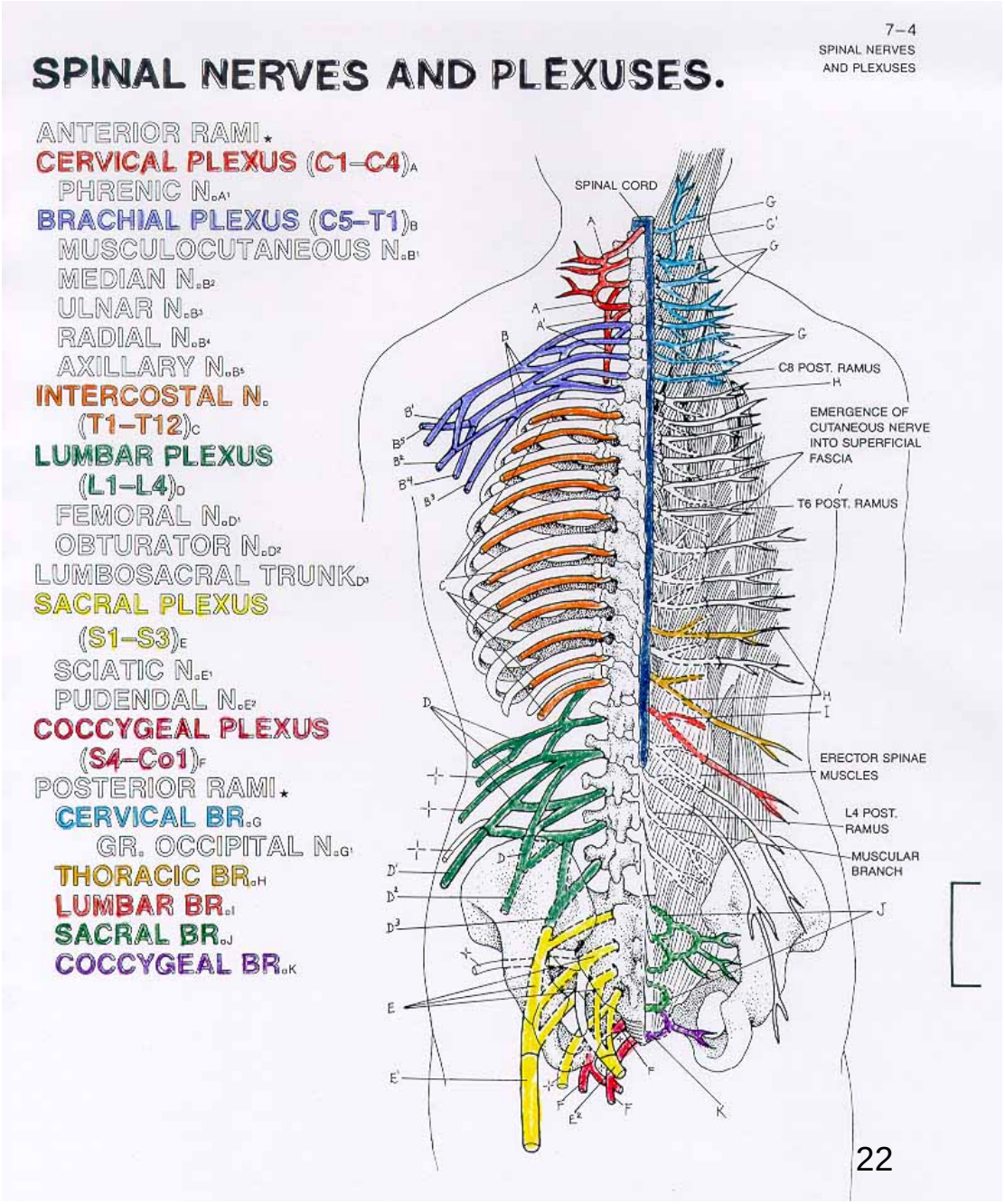
- Afferent
  - **Olfactory (I)**
    - **smell**
  - **Optic (II)**
    - **vision**
- Efferent
  - **Oculomotor (III)**
    - **eyes**
  - **Hypoglossal (XII)**
    - **tongue**
- Mixed
  - **Trigeminal (V)**
    - **touch, chewing**
  - **Facial (VII)**
    - **taste, face**

Spinal Nerves: Combine Afferent and Efferent Functions

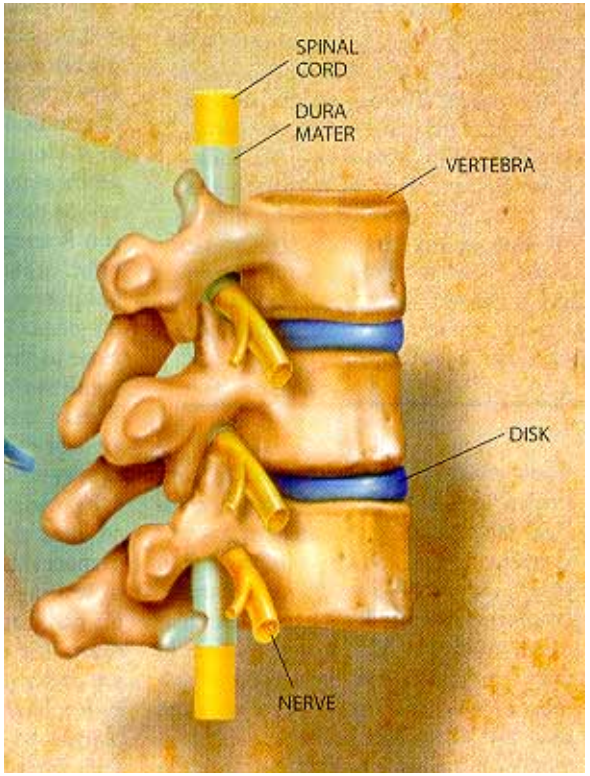
- Afferent Branch
  - Dorsal Root
- Efferent Branch
  - Ventral Root



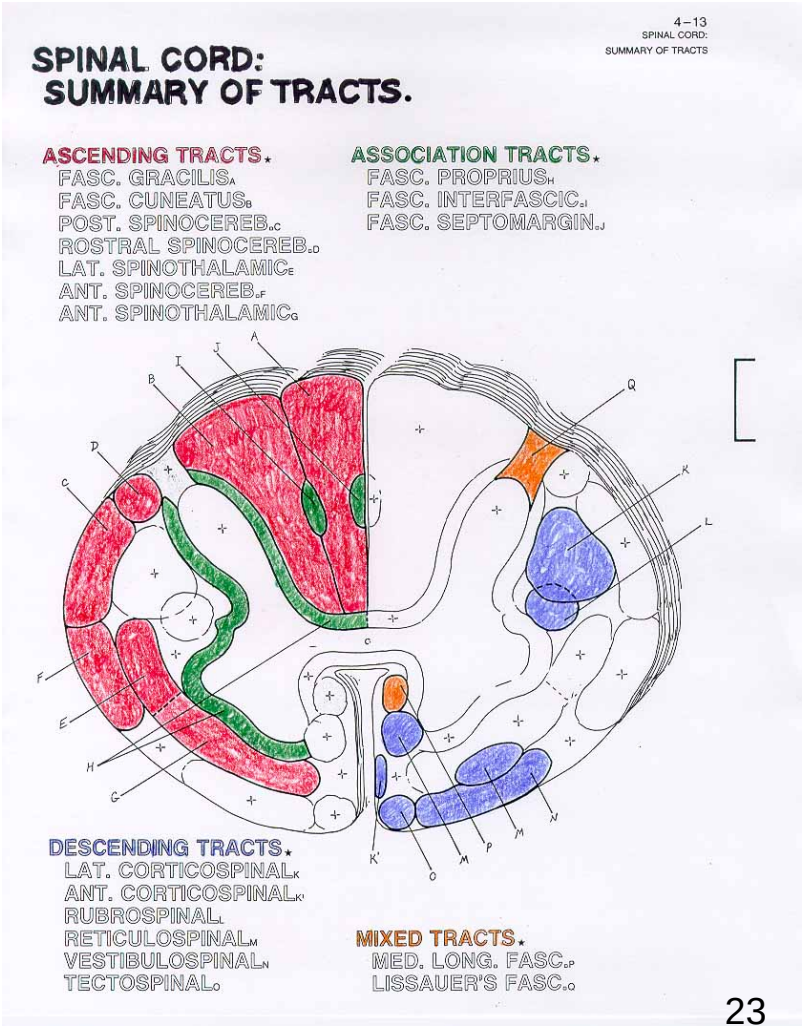
Distribution of 31 Spinal Nerves



Spinal Cord

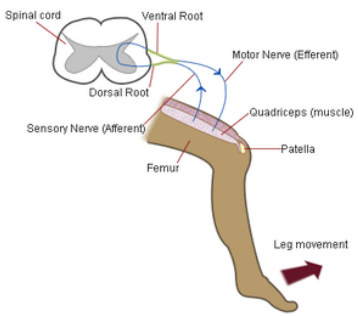


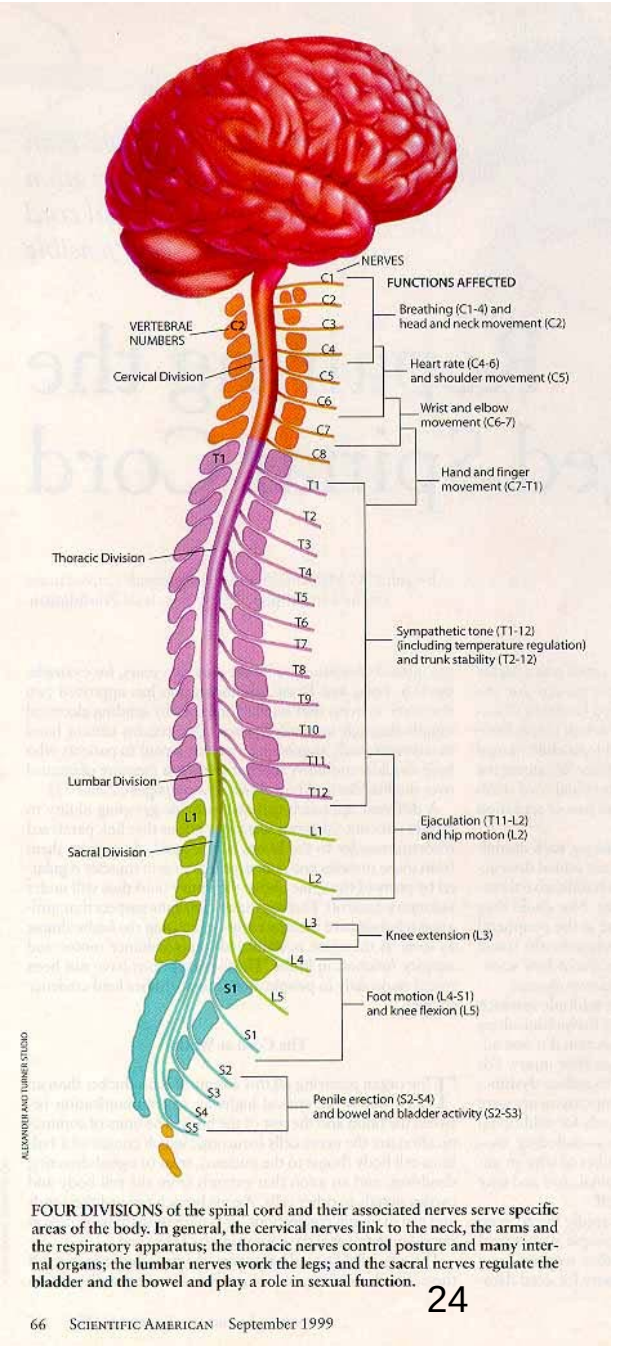
Scientific American



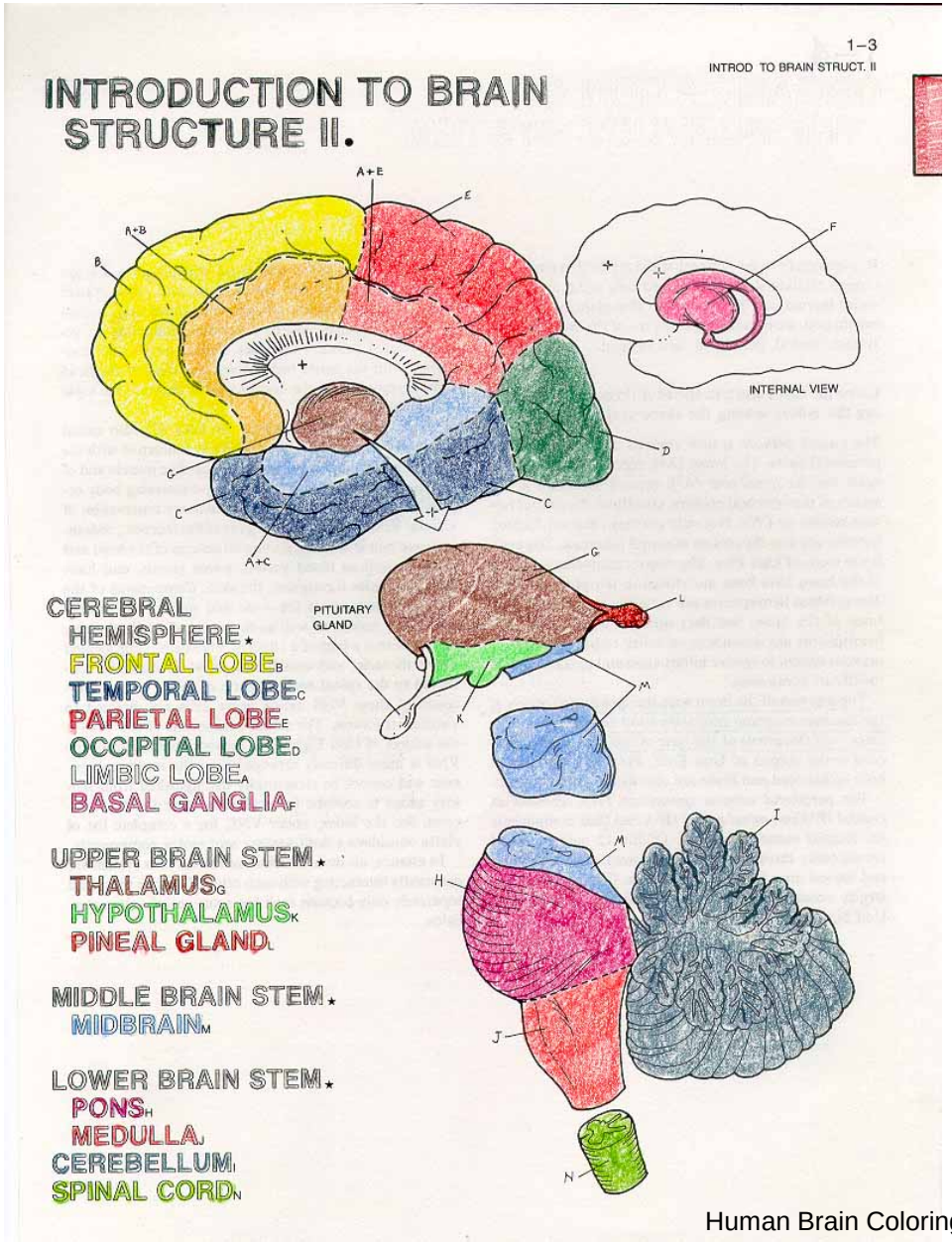
Paraplegia (Quadriplegia)

- Loss of Function
  - Sensation
  - Voluntary Movement
- Vagus Nerve
  - Vital Functions
- Spinal Reflexes
  - Exaggerated
  - Unconscious
  - Involuntary





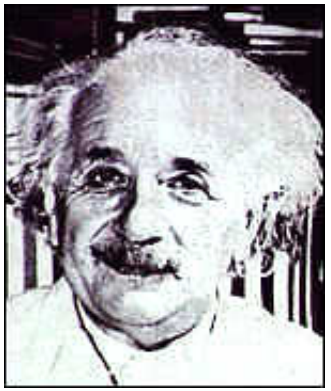
Brainstem and Subcortical Structures

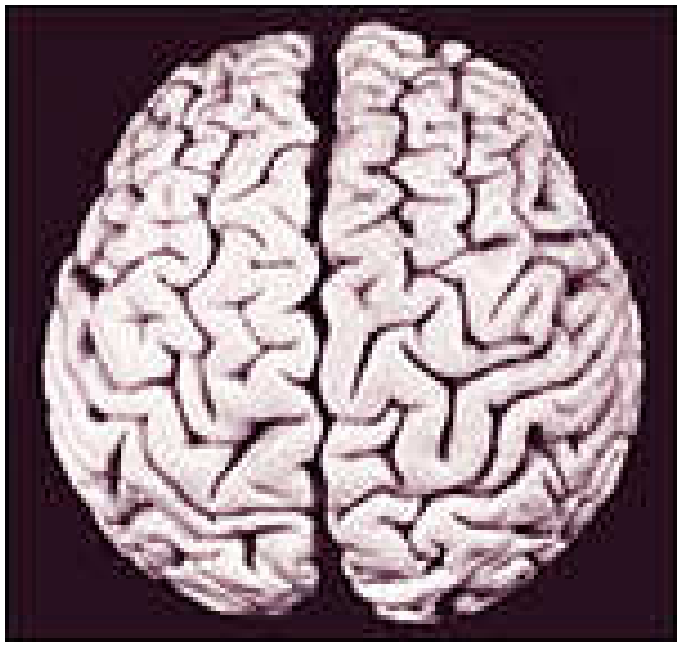


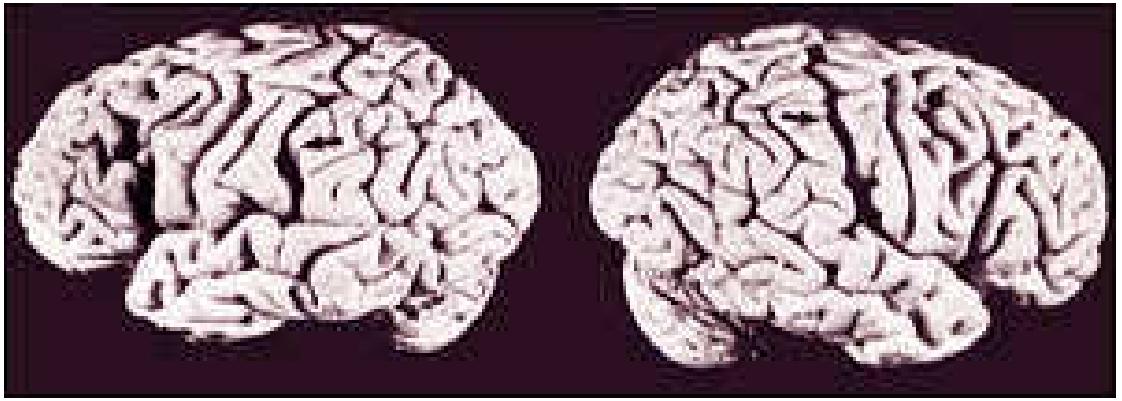
- Forebrain (Diencephalon)
  - Thalamus
    - Sensory Relay Station
  - Hypothalamus
    - Biological Motives
  - Basal Ganglia
    - Coordinate Movement
  - Limbic System
    - Emotional Experience
- Midbrain (Mesencephalon)
  - Reticular Formation
    - Regulates Cortical Arousal
- Hindbrain (Metencephalon)
  - Cerebellum
    - Coordinates Sensation, Action
  - Medulla (Oblongata)
    - Vegetative Functions
  - Pons
    - Regulates Cortical Arousal

Human Brain Coloring Book

The Human Brain

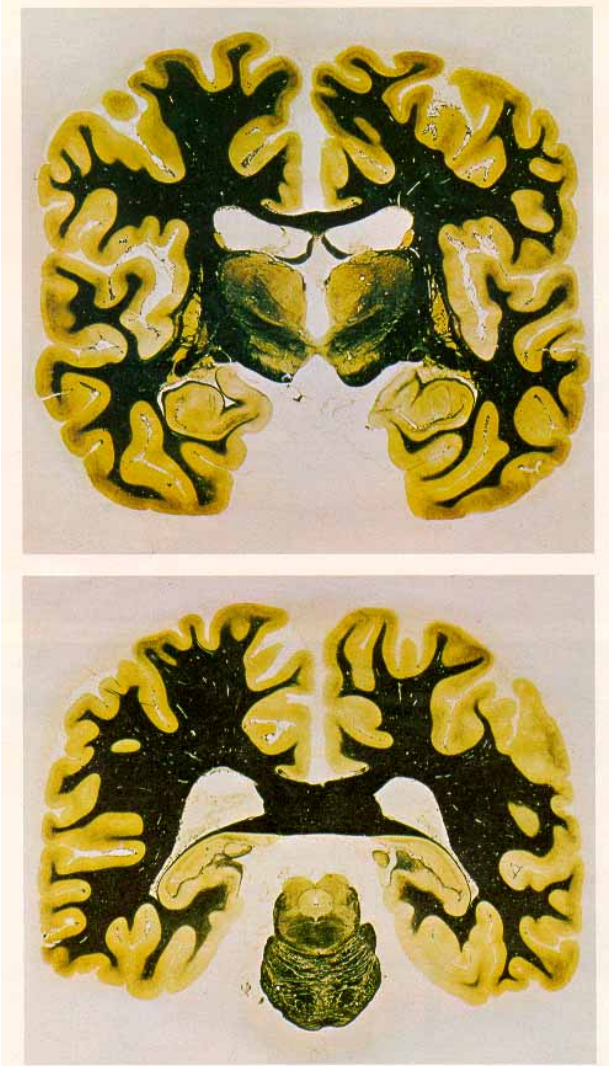




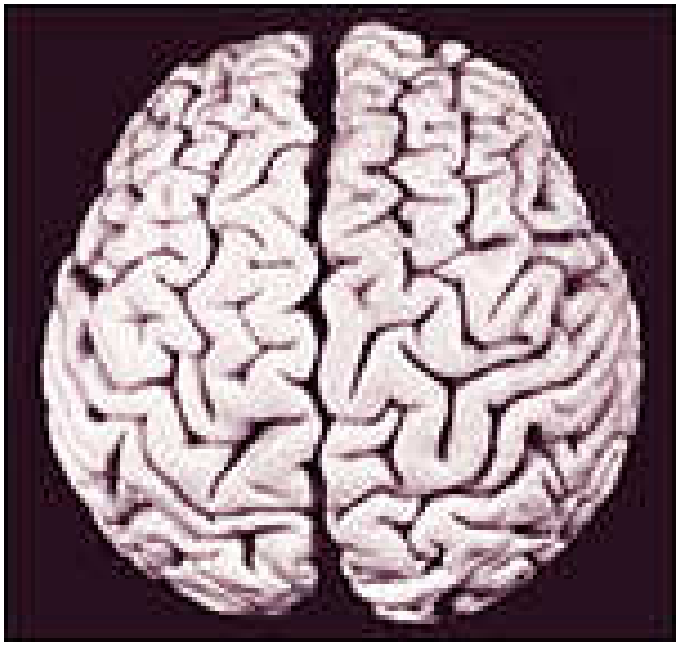


BBC

The Cerebral Hemispheres



TWO SLICES through a fixed human brain perpendicular to its long axis reveal the complexity of the brain's internal anatomy. The thin slices were treated with a stain that selectively blackens the fatty myelin sheath of the nerve fibers. As a result the white matter appears black and the gray matter (which consists primarily of neuronal cell bodies) is more or less unstained. The empty spaces in the slices indicate the location of the ventricles: fluid-filled cisterns deep within the brain. The slice at the top (*a*) was made near the middle of the length of the brain and includes the cerebral cortex, the hippocampus and the thalamus. The slice at the bottom (*b*) was made more to the rear and includes a section through the brain stem. The location of the two slices and the identity of the structures shown are indicated in the view on page 92. Specimens are from the collection of Professor Paul I. Yakovlev at the Harvard Medical School.



Longitudinal Fissure

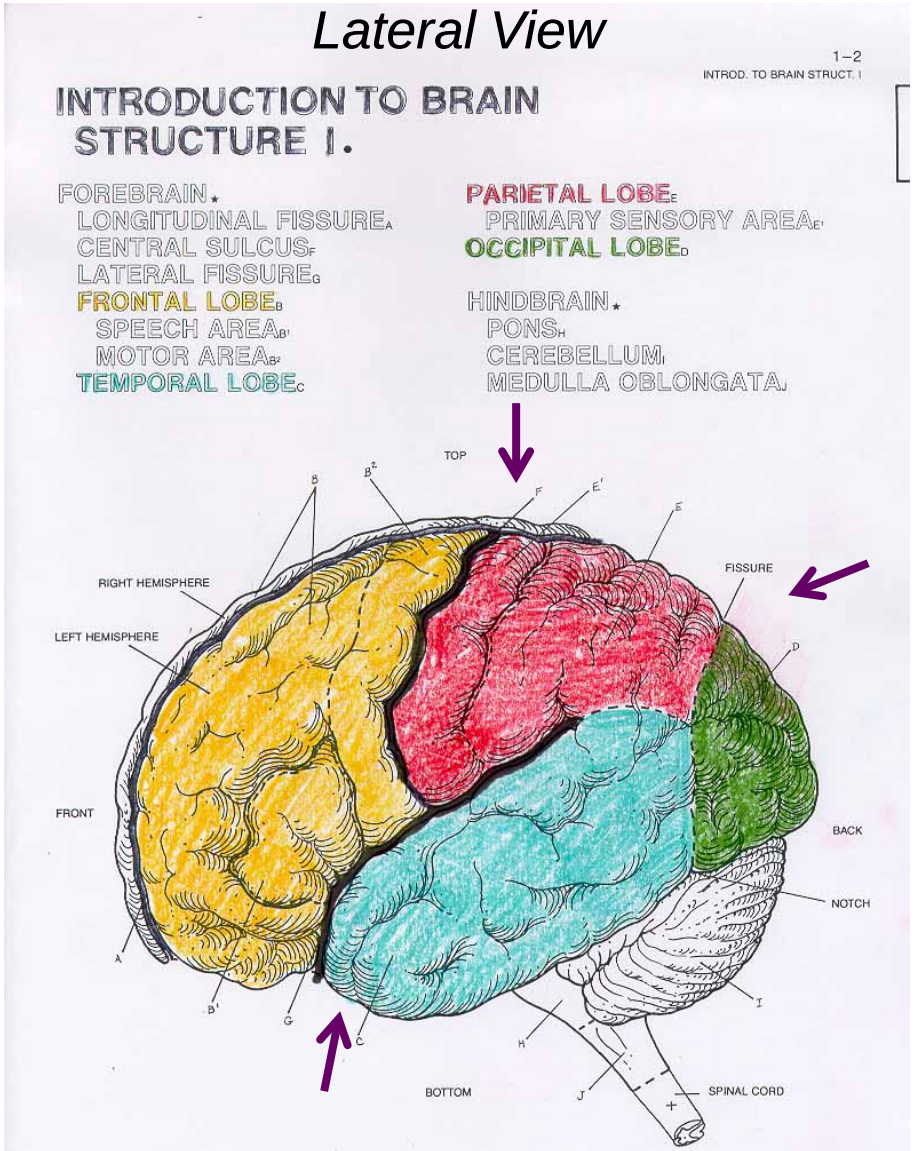
Cerebral Commissures
Corpus Callosum

Scientific American

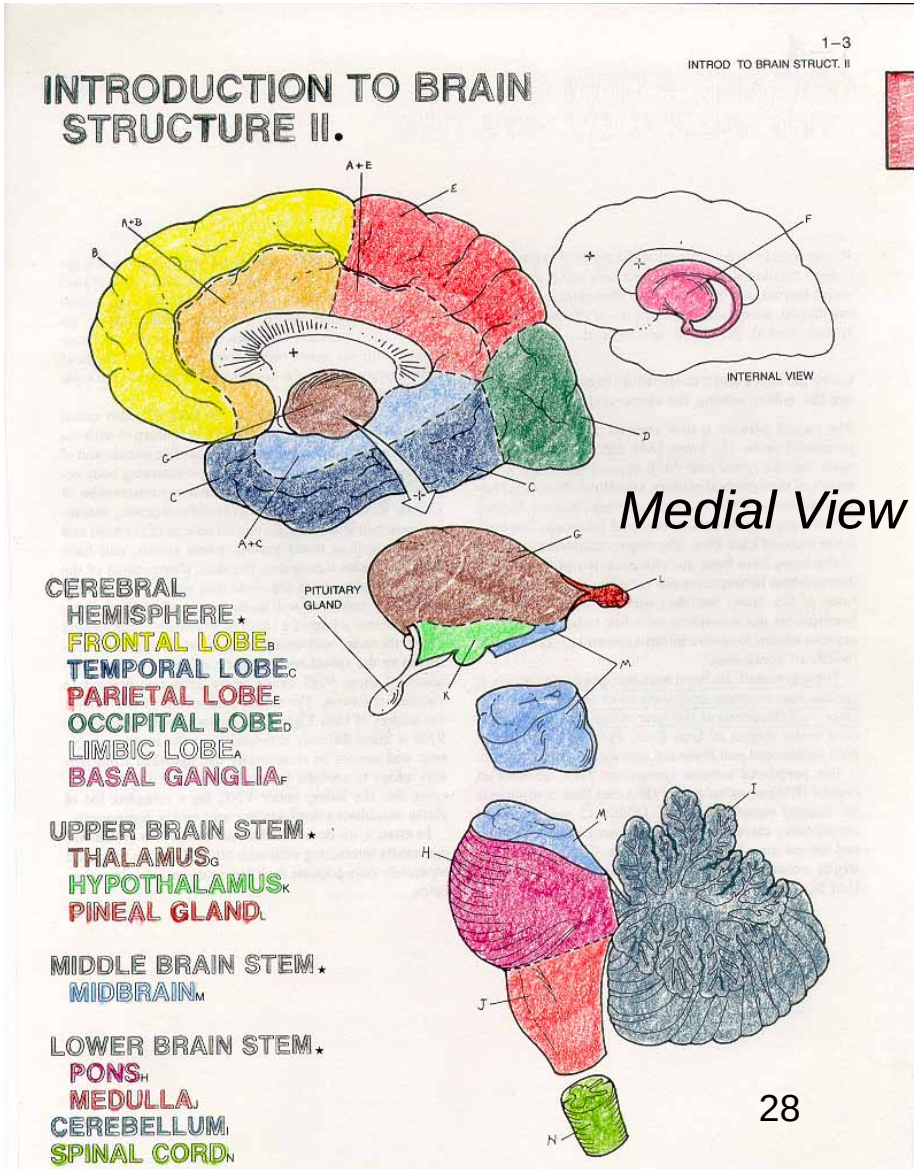
Topography of Cerebral Cortex

(Telencephalon)

Lateral View



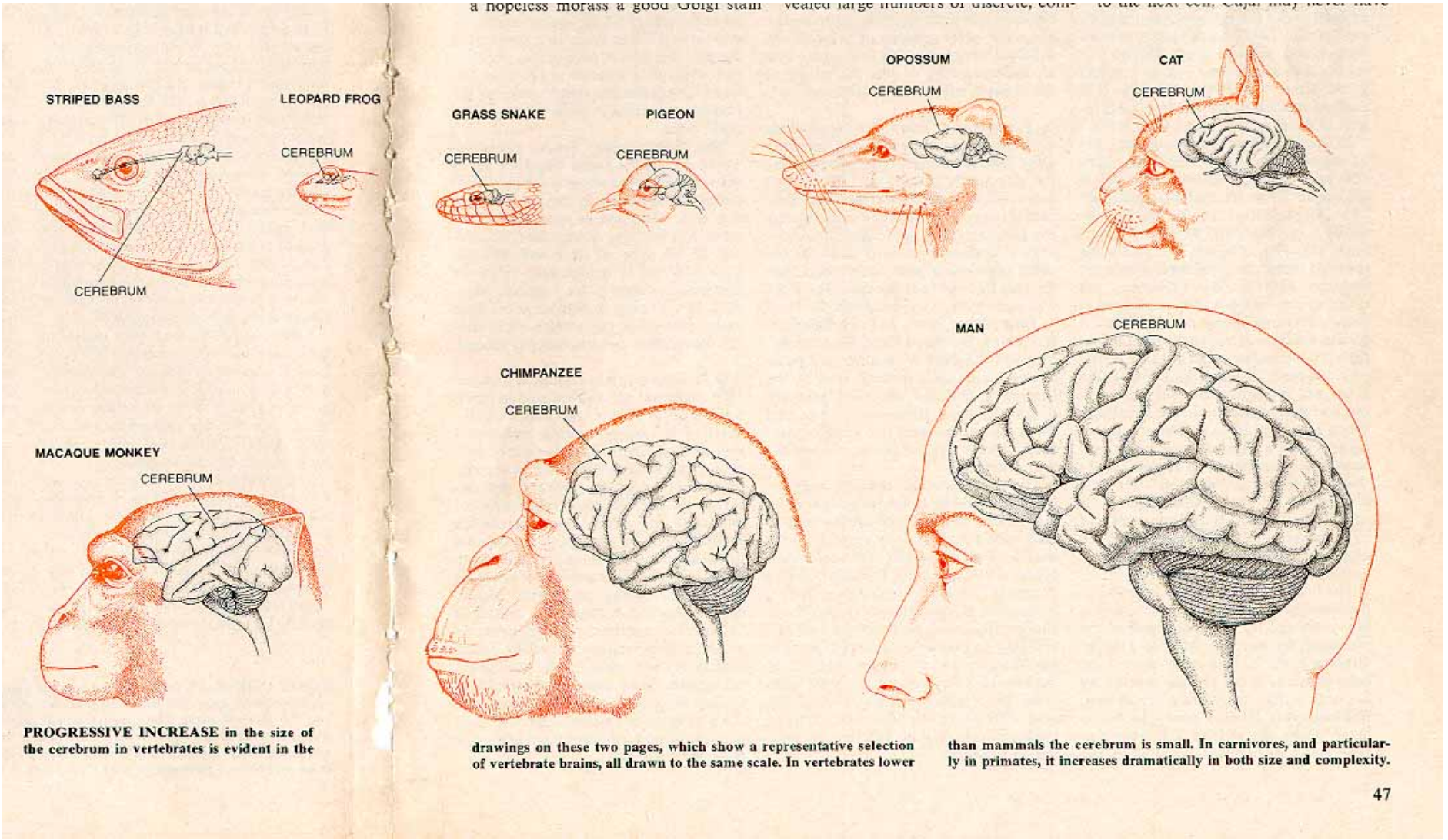
Medial View



Cerebral Cortex as *Neo*cortex

- "New" Phylogenetically
  - Evolution of Species
    - Emerged Relatively Recently in Evolutionary Time
- "New" Ontogenetically
  - Development of the Individual Organism
    - Emerges Relatively Late in Fetal Development

Phylogenetic Comparisons



PROGRESSIVE INCREASE in the size of the cerebrum in vertebrates is evident in the drawings on these two pages, which show a representative selection of vertebrate brains, all drawn to the same scale. In vertebrates lower than mammals the cerebrum is small. In carnivores, and particularly in primates, it increases dramatically in both size and complexity.

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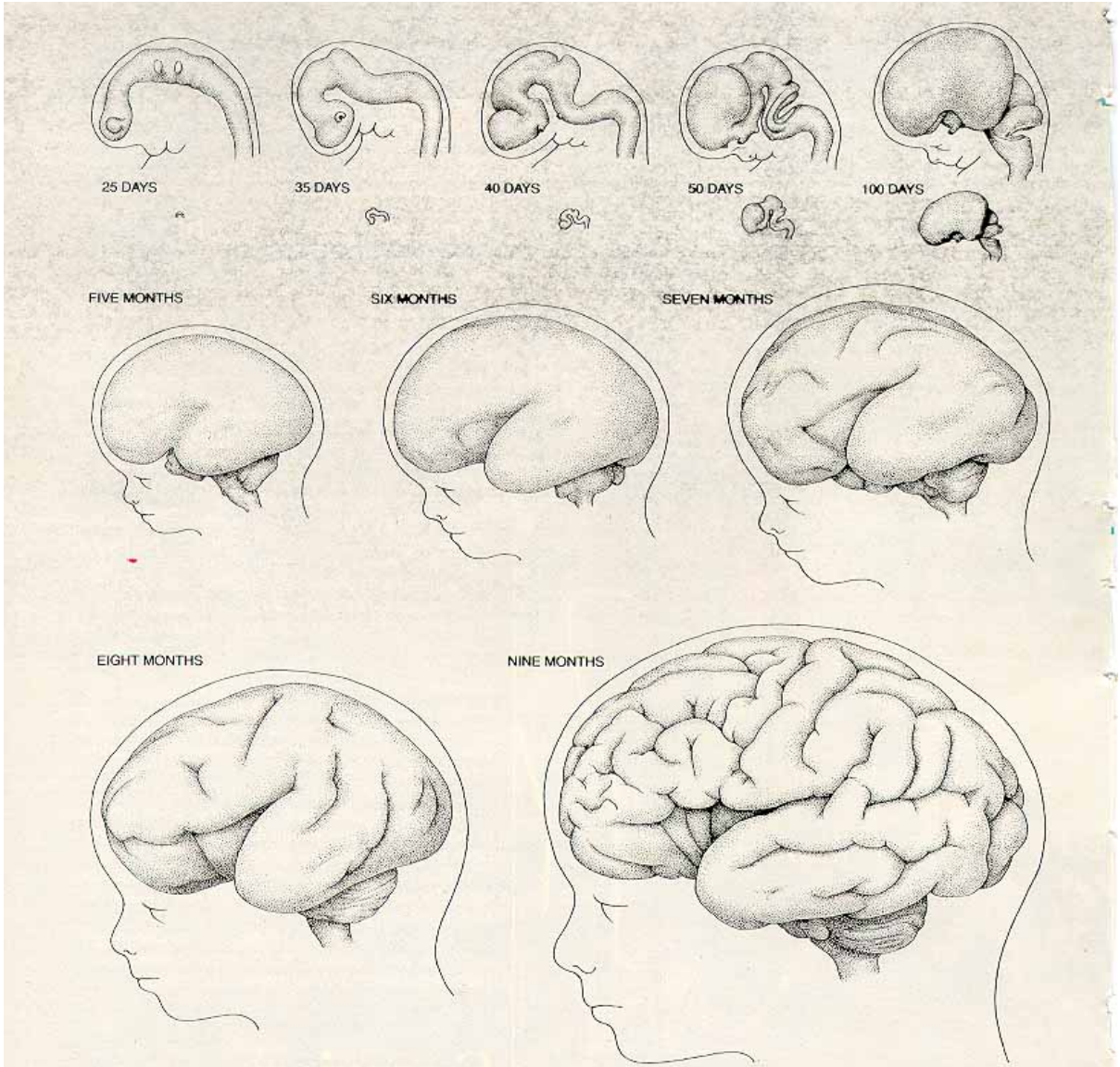
Scientific American



DEVELOPING HUMAN BRAIN is viewed from the side in this sequence of drawings, which show a succession of embryonic and fetal stages. The drawings in the main sequence (*bottom*) are all reproduced at the same scale: approximately four-fifths life-size. The first five embryonic stages are also shown enlarged to an arbitrary common size to clarify their structural details (*top*). The three main parts of the brain (the forebrain, the midbrain and the hindbrain) originate as prominent swellings at the head end of the early neural tube. In human beings the cerebral hemispheres eventually overgrow the midbrain and the hindbrain and also partly obscure the cerebellum. The characteristic convolutions and invaginations of the brain's surface do not begin to appear until about the middle of pregnancy. Assuming that the fully developed human brain contains on the order of 100 billion neurons and that virtually no new neurons are added after birth, it can be calculated that neurons must be generated in the developing brain at an average rate of more than 250,000 per minute.

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Scientific American

Ontogenetic Comparisons

Prefrontal Cortex: Phylogenetic Comparisons

Figure 11.2 The areas of the frontal lobe. The prefrontal cortex includes all of the areas in front of the primary and secondary motor regions. The three major subdivisions of prefrontal cortex are the lateral prefrontal, ventromedial prefrontal, and the anterior cingulate cortex.

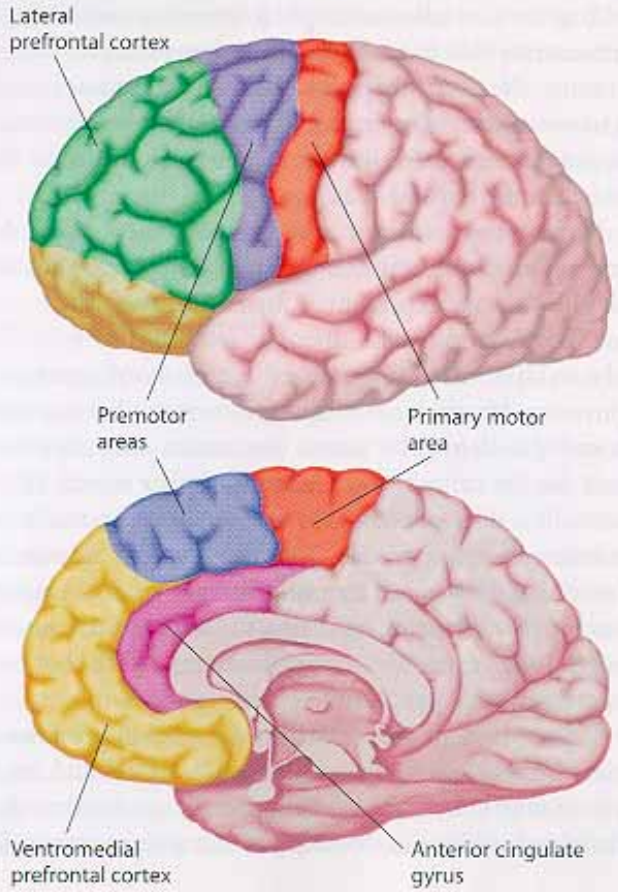
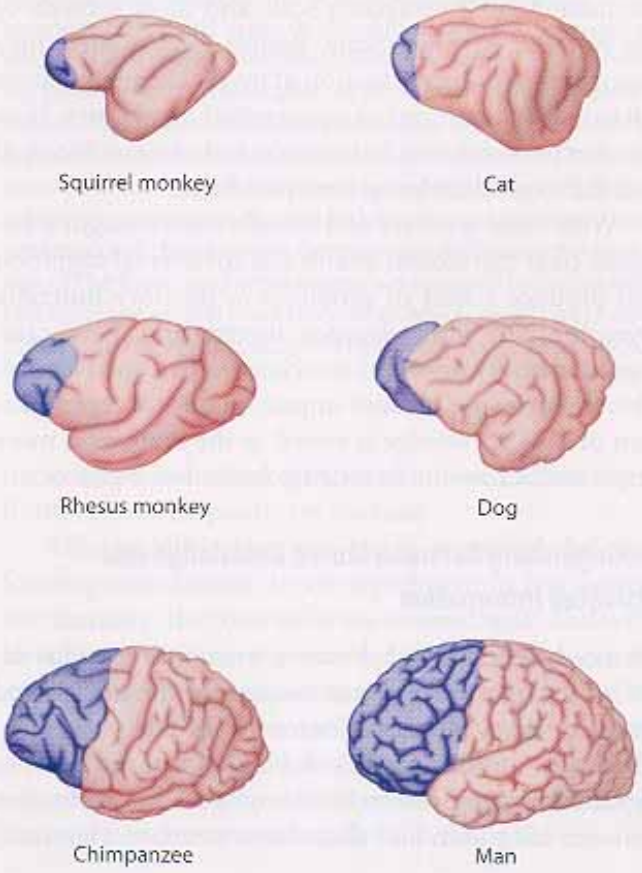
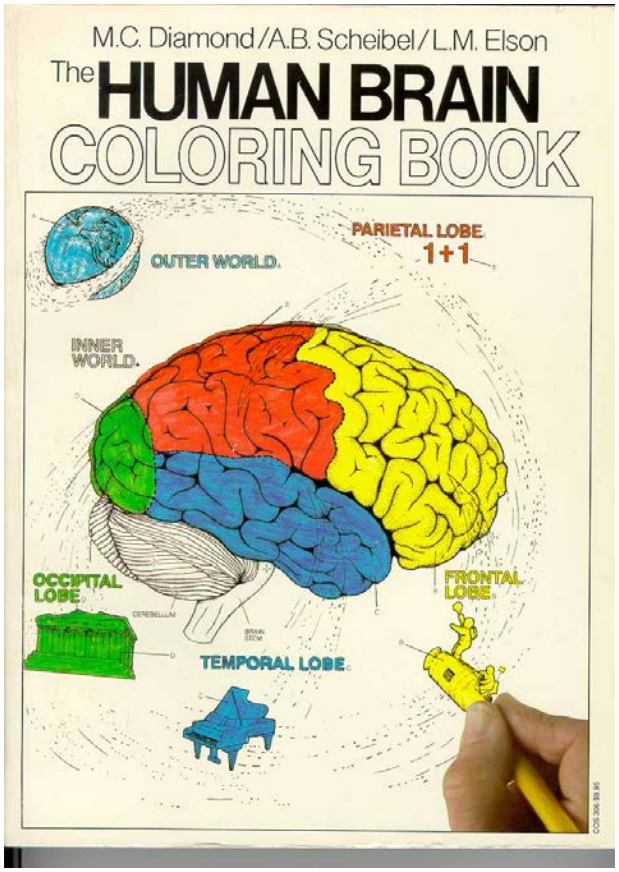


Figure 11.3 The shaded areas show the extent of prefrontal cortex in six species. Note how small this region is in the cat, dog, and squirrel monkey. It is greatly enlarged in humans. The brains are not drawn to scale. Adapted from Fuster (1989).



Learn Your Brain with *The Human Brain Coloring Book*

M.C. Diamond, A.B. Scheibel, & L.M. Elson (1985)



An excellent introduction to neuroanatomy, and basic principles of neuroscience, from which many illustrations in these lectures were taken.