

**Lecture VIII. The Spinal Cord,
Reflexes and Brain Pathways**

Bio 3411
Monday
September 21, 2009

Readings

NEUROSCIENCE 4th ed:
Review Chapter 1 pp. 11-22;
Read Chapter 9 pp. 207-212, 218
Study Box 9A, Figure 9.8 & Refer to Table 9.1;
Read Chapter 16 pp. 399-414
Study figures 16.2, 16.3, 16.4, 16.14
Read Chapter 17 pp. 432-436
Study figure 17.9

THE BRAIN ATLAS 3rd ed:
Read pp. 4-17 on class web site
Look at pp 36, 43, 49, 75-76, 140, 151, 154, 170-171, 182-183, 200-201.

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What the last Lecture was about

- The Initiation of the Central Nervous System
- CNS Growth and Pattern Development
- Bug Brains
- Several Mechanisms for Directing the Show (scripts conserved)
- How did vertebrate and invertebrate patterns arise?
- Reprise and overview the discussions of developmental sequences and mechanisms in the nervous system

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Overview for this Lecture

Spinal Cord
Columns, Horns, Spinal Segments

Spinal Nerves
Dermatomes, Motor Units

Reflexes
"Knee Jerk"- Myotatic or Stretch Reflex
Withdrawal & Crossed Extensor Reflexes

Two Spinal Pathways
Sensory - Dorsal Column/ Medial Lemniscus
Motor - Cortico-spinal Tract

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(The Brain Atlas 3rd ed, p. 8)

Cervical (C) - Neck

Thoracic (T) - Chest

Lumbar (L) - Back

Sacral (S) - Pelvis

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≈ 50 cm

Human spinal cord from side, front and back

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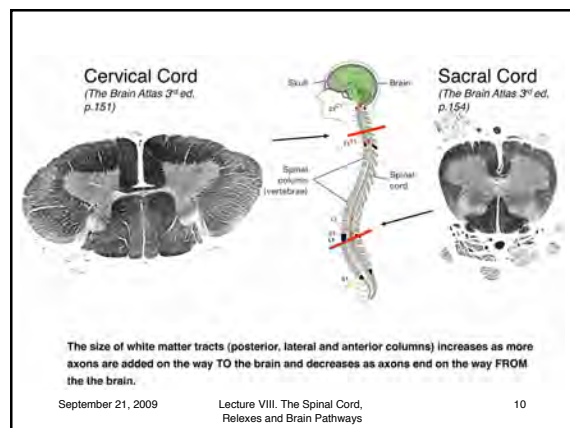
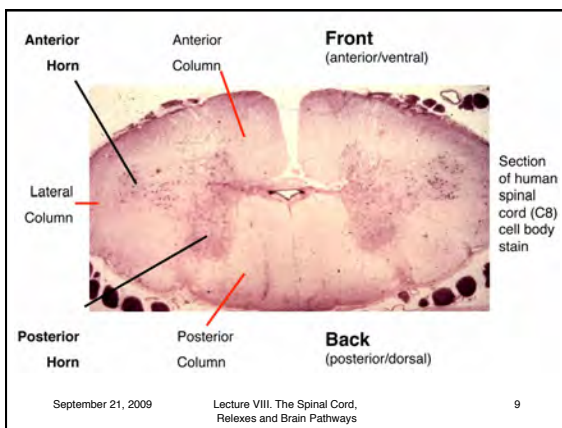
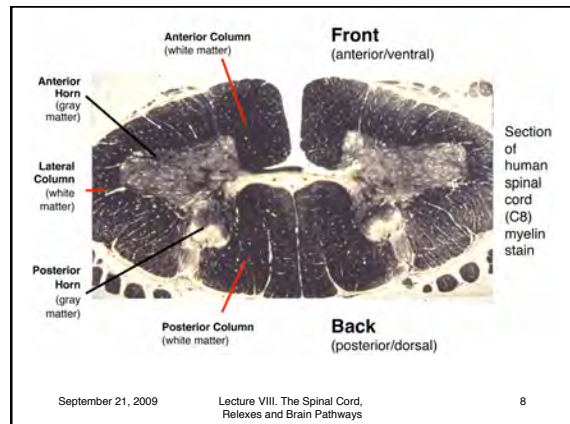
Internal Structure

- **Canal** = tube
- **White Matter** - columns, tracts
anterior up and down to and from brain
lateral down from brain (>>up)
posterior mainly up to brain
- **Gray Matter** - posterior (dorsal) horn "sensory",
anterior (ventral) horn "motor"

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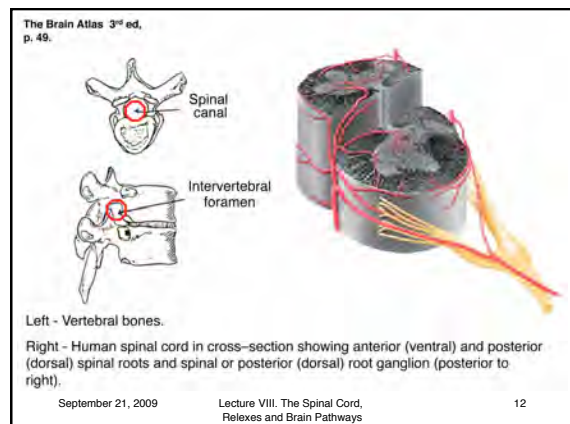
Spinal Nerves

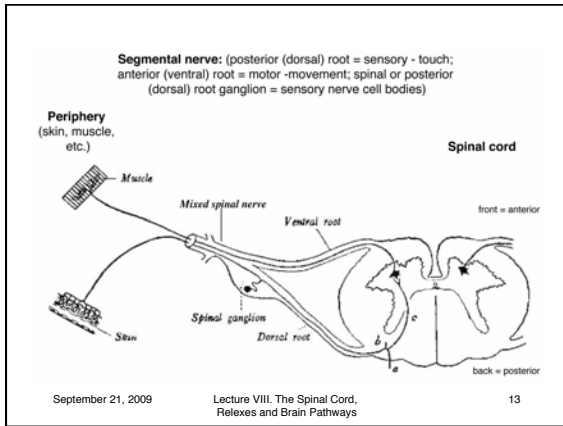
- Intervertebral foramen
- Segmental spinal nerve
- Compound action potential

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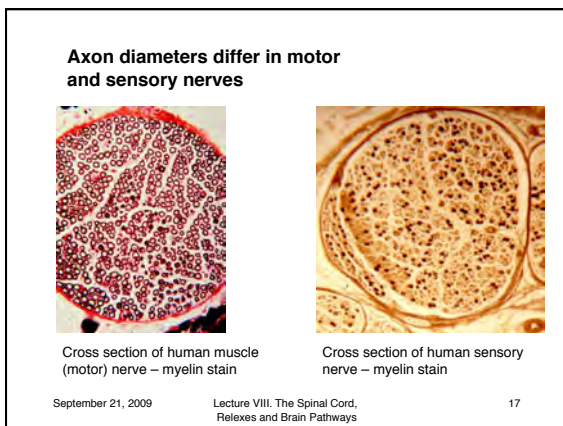
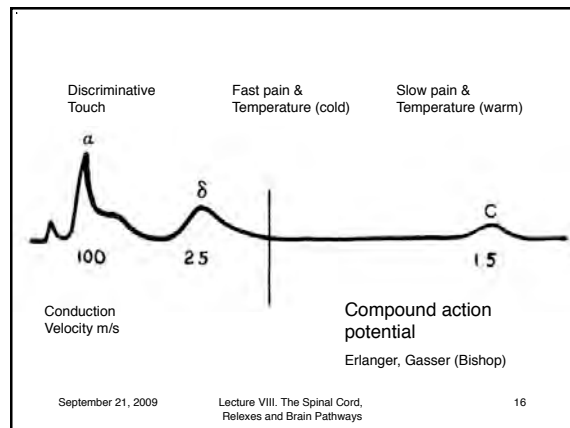
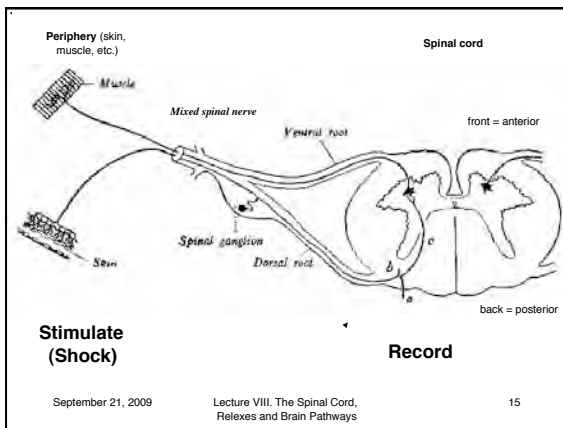


Joseph Erlanger
1874 - 1965
(Prix Nobel 1944)

Herbert Spencer Gasser
1888 - 1965
(Prix Nobel 1944)

George H. Bishop
1889 - 1973

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Afferent Axon Classification*

Cutaneous Axons	Muscle/Tendon Axons	Axon Diameter (μm)	Conduction Velocity (m/s)
A α	Group I	13-20	80-120
A β	Group II	6-12	35-75
A δ	Group III	1-5	5-30
C	Group IV	0.2-1.5	0.5-2

*Myelinated axons include A α , A β , A δ , and Groups I, II, and III. Axons of C fibers and Group IV neurons are unmyelinated.

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Segmental Nerves

Spinal or Posterior (dorsal) Root, Ganglion
Cells & Sensory Nerves

(axons **in** from posterior (dorsal) root ganglia)

Dermatomes

Anterior (ventral) Root & Motor Nerves
(axons **out** from motor neurons)

Motor Units

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Spinal or Posterior (dorsal) Root Ganglion Cells

Pseudo-Unipolar Neurons

(neurons start as bipolar cells and become "unipolar" during
development)

Single sensory endings

light & crude touch, pain, temperature and muscle senses

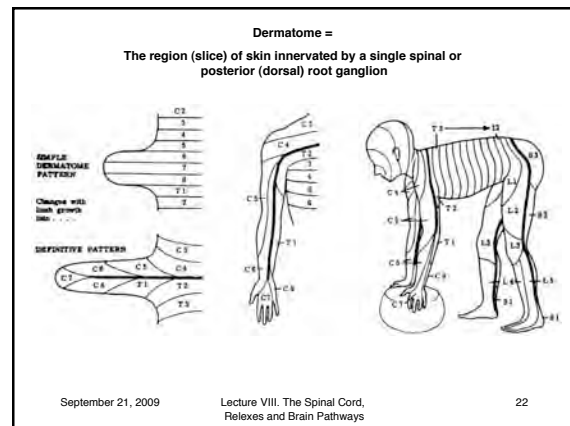
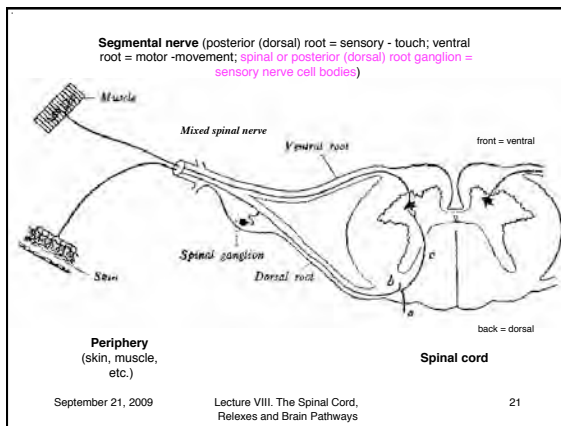
Axons diverge to multiple spinal targets

motor neurons - c, interneurons - c, spinal cord - b, and brain - a

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Motor Units, Motor Neuron Pools & Somatotopy

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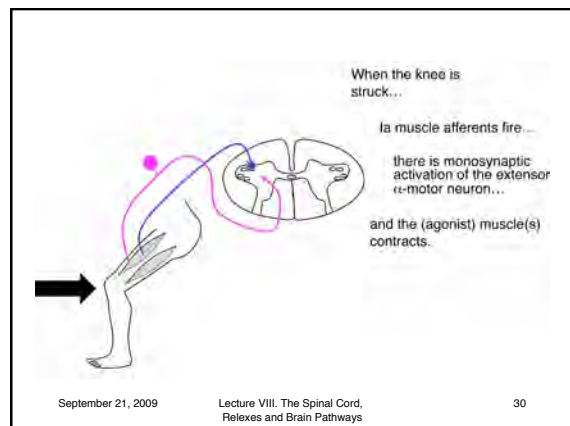
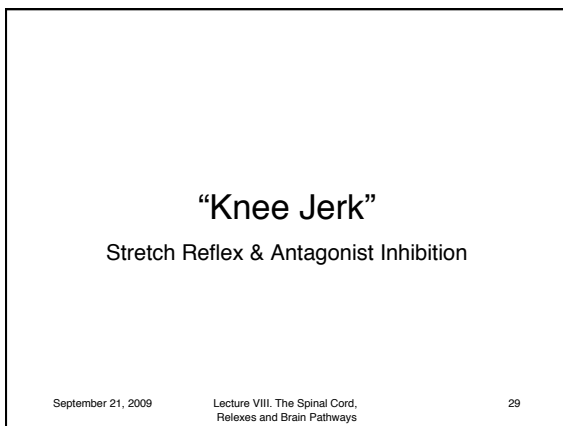
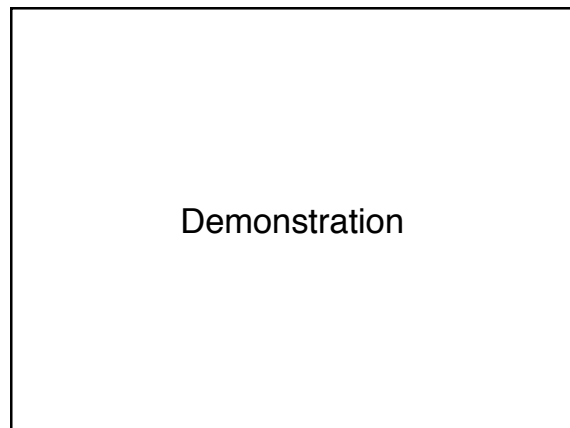
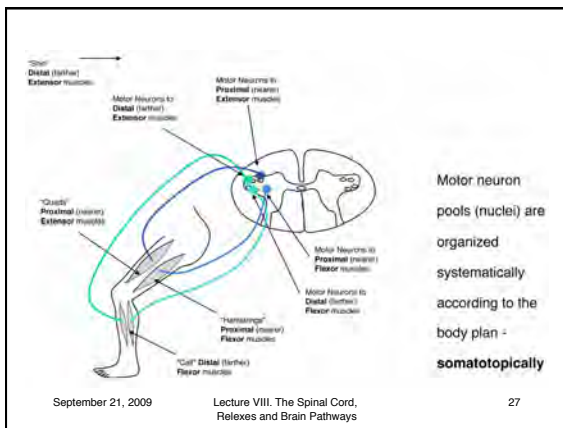
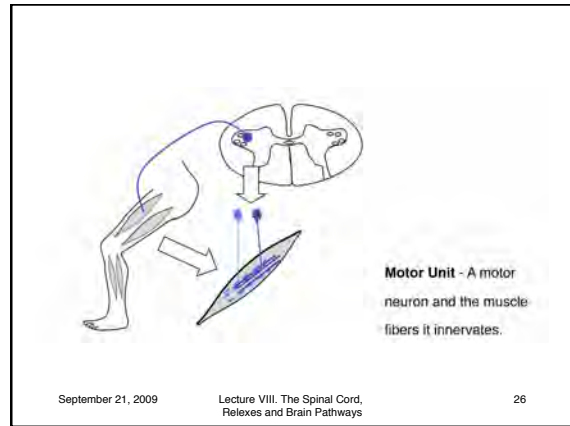
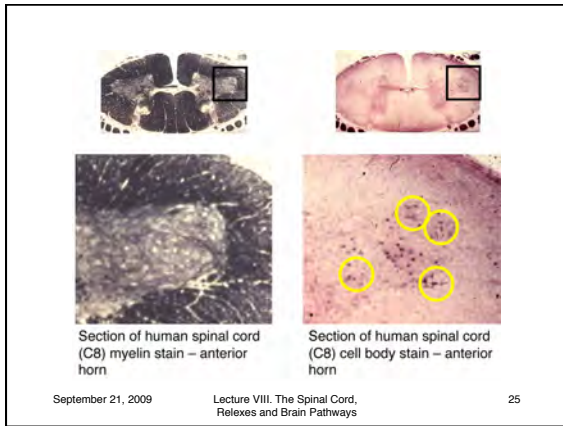
Spinal Motor Neurons

- Multipolar
- Output Diverges to -
several or many muscle cells: *motor unit*
- Input Converges from -
spinal or posterior (dorsal) root ganglion cells
spinal interneurons
long tracts from from brain
- Integrate
- Map
flexors, extensors, proximal, distal

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When the knee is struck...

Ia muscle afferents fire...

there is monosynaptic activation of the extensor α -motor neuron...

and the (agonist) muscle(s) contracts.

The knee extends.

Glycinergic (inhibitory) interneurons are also activated...

...which inhibit motor neurons to the flexor (antagonist) muscle.

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“Stepping on a Nail”

Withdrawal & Crossed Extensor Reflexes

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Stepping on a sharp object activates **pain** afferents in the skin...

activating interneurons in the dorsal horn...

that **excite flexors** and **inhibit extensors**...

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Stepping on a sharp object activates **pain** afferents in the skin...

activating interneurons in the dorsal horn...

that **excite flexors** and **inhibit extensors**...

and the leg **flexes** “withdraws.”

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But the person would fall...

if the crossed **extensors** weren't activated...

and the crossed **flexors** weren't inhibited to **extend** the other (contralateral) leg to stand on.

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Pathways

- Subserve a particular function
- Axons travel together in specific locations (i.e., tracts) in a particular order (topography)
- Always consider: cell body (soma) location, axon course, synapses and side relative to origin and destination
- Nomenclature often origin and target, i.e., **Cortico-Spinal Tract = from cortex to spinal cord**

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Path Finding

- Loss of a particular function after damage (lesion)
- Stimulation (natural/electrical) with recording
- Pathology - degeneration of cells and axons with secondary loss of myelin
- Experiments - special stains and tracers that take advantage of physiological processes

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Pathway Conventions

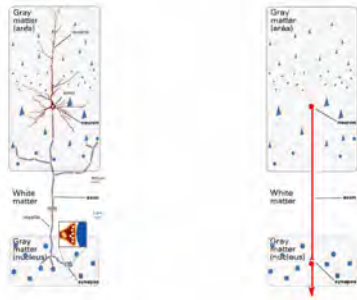
- Related to whole brain through "sections" – gross, histological, imaging
- Related to fiber bundles (fasciculi; i.e., lateral columns, internal capsule, corpus callosum)
- Related to nuclei, ganglia, areas, layers
- Related to transmitters and effects: excitatory, inhibitory, modulatory; fast, slower, slow

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THE BRAIN ATLAS 3rd ed, pp. 5, 7



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Pathways - "Primitive" → "Evolved"
(Synapse & Synapse Number)

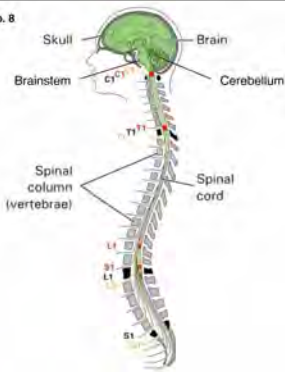


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THE BRAIN ATLAS 3rd ed, p. 8



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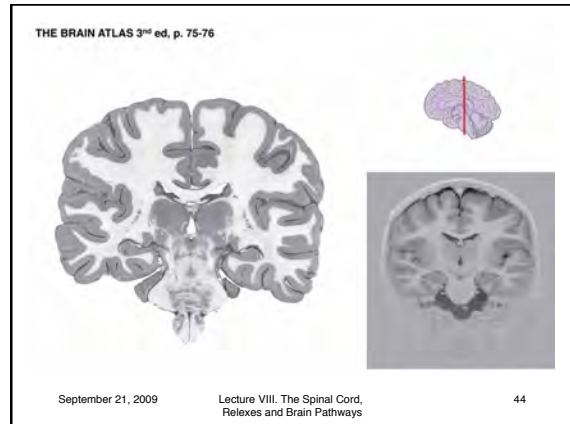
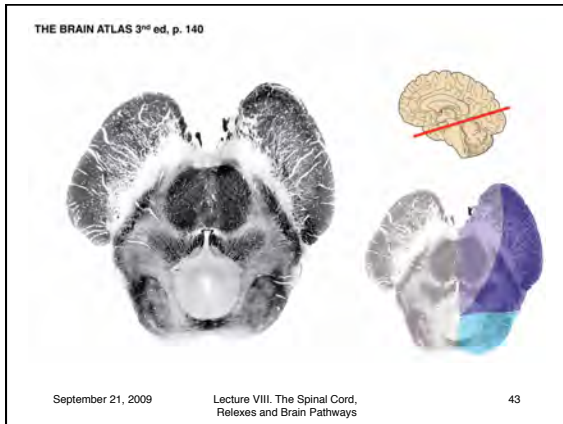
THE BRAIN ATLAS 3rd ed, p. 151



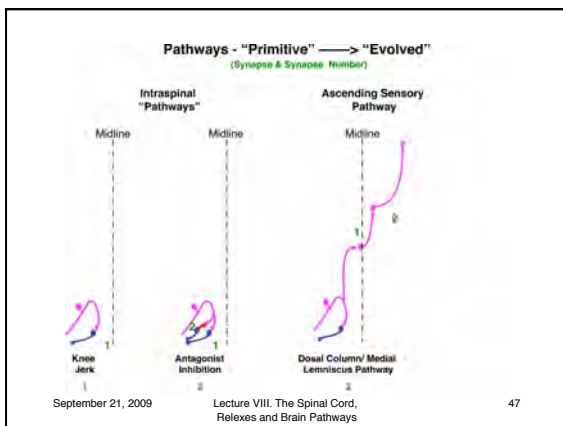
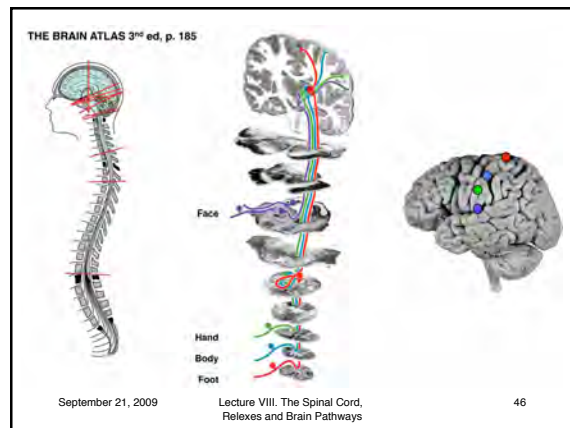
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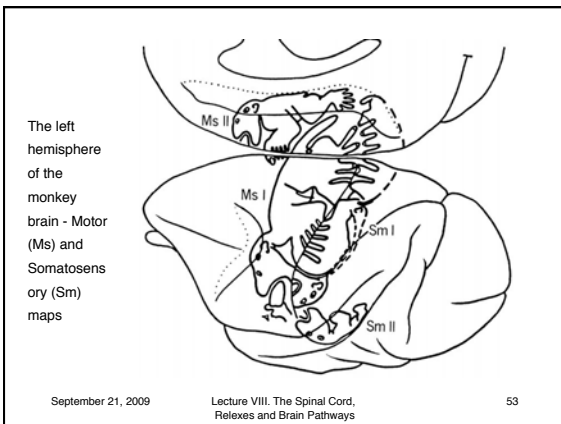
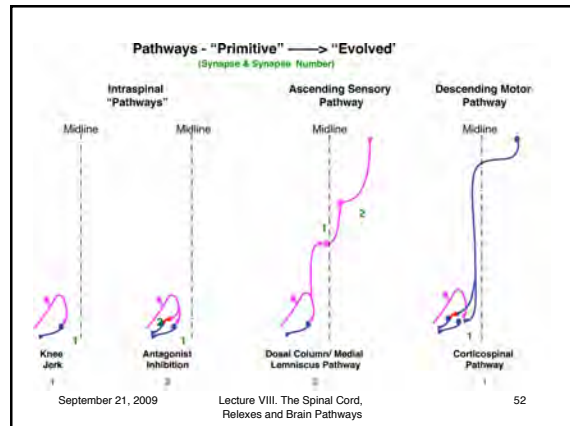
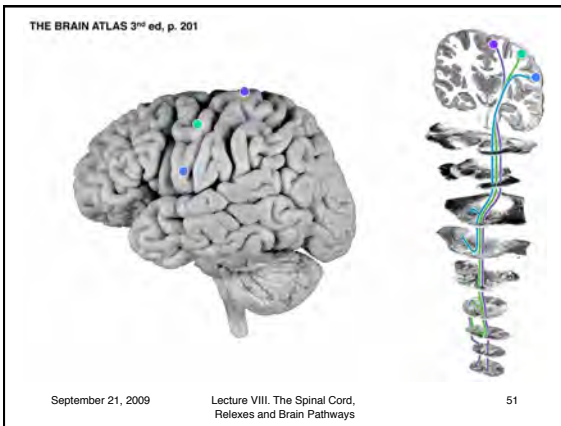
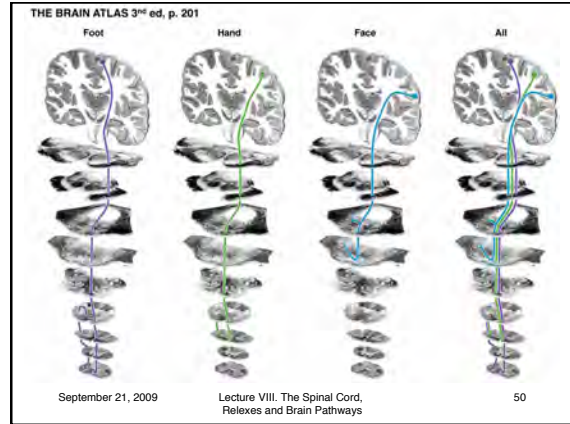
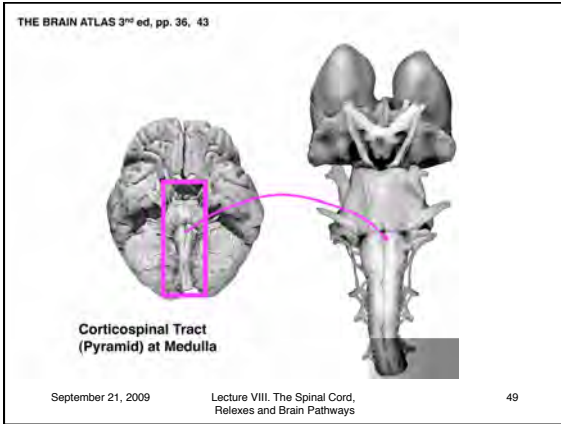
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Dorsal Column/Medial Lemniscus (a ribbon) Pathway
This pathway carries fine discriminative and active touch, body and joint position, and vibration sense.



Corticospinal (Pyramidal) Pathway
This is the direct connection from the cerebral cortex for control of fine movements in the face and distal extremities, e.g., buttoning a jacket or playing at trumpet.



What this lecture was about:

- Spinal Cord** - Segmental organization
- Peripheral Nerves** - Compound action potential
(Erlanger & Gasser Prix Nobel 1944)
- Spinal Nerves** - Dermatomes, motor neuron pools (nuclei) and motor units
- Spinal reflexes** - stretch (knee jerk); withdrawal/crossed extensor
- Introduction to Pathways** - 1 sensory (DC-ML); 1 motor (CST)

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For Review

Use the **Bio 3411 Work Sheet 082809** (handout and posted on the course web site) to get comfortable with the neuroanatomy.

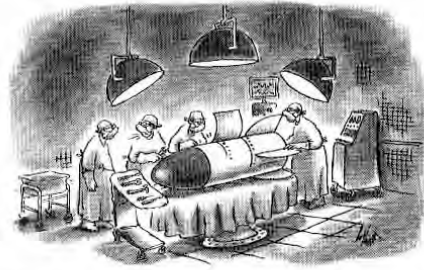
It's neither rocket science nor is it neurosurgery, it just takes a little practice!

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The New Yorker, 7/10-17/2006, p. 110



"Damn it, I'm a brain surgeon, not a rocket scientist!"

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