How Do We Get From To This...

To This?

2006 Times Square panorama with Mariah Carey by Jook Leung
Cells of the Nervous System – It Starts Here

• Neurons (nerve cells)
  – specialized cells that receive information and transmit it to other cells
• Glia (Greek for “glue”)
  – provide physical and functional support to neurons
  – do not transmit information over long distances as neurons often do
  – outnumber neurons in the brain by almost 10:1
  – on average, 1/10th the size of a neuron

Cells of the Nervous System – Structure

Camillo Golgi (1843-1926)  Santiago Ramón y Cajal (1852-1934)

Shared 1906 Nobel Prize
Cells of the Nervous System – Structure

Golgi stain - (developed 1870s) made it possible to see individual neurons

Cajal in his laboratory in Valencia - He used the Golgi Stain to begin to study the fine structure of individual neurons

Advice for a Young Investigator by Ramón y Cajal

“As with the lover who discovers new perfections every day in the woman he adores, he who studies an object with an endless sense of pleasure finally discerns interesting details and unusual properties...”
Golgi-stained hemisphere of a mouse brain

Golgi-stained CA1 Pyramidal Neurons

Nissel-stained section of a monkey brain

Nissel stain of visual cortex
Features of a Typical Neuron

The Major External Features of a Typical Neuron
The Major Internal Features of a Typical Neuron

Flow of Information in Neurons
Flow of Information: Afferent to Efferent

Within an individual neuron, or in relationship to the brain and spine: “A” before “E”:

Representative Types of Neurons (based on structure)
Representative Types of Neurons  
(based on structure)

Bipolar neurons - found primarily in sensory systems (ex. vision and audition)

Unipolar neurons - found in the somatosensory system (ex. touch and pain)

The Structure of a Neuron is Related to Its Function

- The shape of a neuron determines its connects with other neurons, and thus how it contributes to overall function of the system
- Widespread dendritic branches  
  – good for integrating large amounts of incoming information
- Short branches on dendrites  
  – pool input from only a few sources
Representative Types of Neurons (based on function)

Sensory Neurons:

Neurons specialized to receive information from the environment about what’s out there - light, sound, pain, temperature, pressure, taste, smell, etc. - and to send this information to the brain

AFFERENT NEURONS (<L “to carry toward”)

Representative Types of Neurons (based on function)

Interneurons (<L “within”)

Neurons that handle local information

EX. = connect sensory to motor information in the spinal cord (withdrawal reflexes)

EX. = some cells are contained completely within the cerebral cortex for intracerebral cortex communication

Note: Can also be called projection neurons.
Representative Types of Neurons
(based on function)

Motor neurons

Neurons specialized to cause movement (contraction/relaxation of muscles)
They receive information ("instructions") from the brain (controls voluntary movement) and from the body (withdrawal reflexes, for example)
EFFERENT NEURONS (<L "to carry away")

The Synapse (Greek “to join together”)

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Types of Synapses (Sometimes classified based on structure):

- Axo-dendritic
- Axo-somatic
- Axo-axonic

Types of Synapses (Sometimes classified based on function and or neurotransmitter used):

- Examples:
  - Excitatory - Glutamate
  - Inhibitory - GABA
  - Modulatory - Adrenergic
Glia: Supporting cells of the Nervous System

- **Oligodendrocytes**: form myelin sheath in the central nervous system
- **Schwann cells**: form myelin in the peripheral nervous system
- **Astrocytes**: provides structural support for neurons of the central nervous system; provide pathways for movement of nutrients between blood vessels and neurons; regulate the chemical composition of extracellular fluid; contribute to healing damaged brain tissue (glial scar)
- **Microglia**: act as phagocytes to protect the brain from invading microorganisms
- **Ependyma**: line the ventricles and other cavities around the brain, act as a barrier
  - may secrete small amount of cerebrospinal fluid

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Oligodendrocytes and Schwann Cells
Oligodendrocytes and Schwann Cells

Oligodendrocyte forms myelin around axons of brain and spinal neurons

Schwann cell wraps around peripheral nerves to form myelin

Multiple Sclerosis

- Characterized by a loss of myelin
  - In the brain
  - On pathways bringing sensory information to the brain
  - On pathways taking commands to muscles
  - Loss occurs in patches
  - Scarring frequently left in affected areas
Astrocytes in the Brain

Extensions attach to blood vessels and neurons:
- support
- move nutrients between vessels and neurons
- secrete trophic chemicals
- stimulate dilation of blood vessels
- contribute to healing
- help to form the blood-brain barrier

The Blood-Brain Barrier

*A semi-permeable barrier between the blood and the brain produced by cells in the walls of the brain's capillaries and astrocytes*
The Blood-Brain Barrier

- Regulates the chemicals that can enter the CNS from the blood
- Is weak in a region of the brain called the area postrema - poisons can be detected there and vomiting initiated

The Blood-Brain Barrier

BBB is selectively permeable
- Small uncharged molecules (Ex. oxygen and carbon dioxide), and molecules that can dissolve in the fats of the capillaries wall (most psychoactive active drugs are fat soluble) cross the barrier passively
- Other molecules must be actively transported from blood into brain (glucose etc.)
- Examples of what DOES cross from blood into the brain:
  - Glucose; nicotine; alcohol; oxygen; heroin (10X more readily than morphine)
- Examples of what DOES NOT cross from blood into the brain:
  - Dopamine; most viruses and bacteria; penicillin
Astrocytes in the Brain

May help to synchronize associated axons
- They wrap presynaptic terminals of several axons (a functionally related group?)
- Take up chemicals released by axons and release them later
- Helps to synchronize activity of the axons, enabling to send messages in waves

Microglia in the Brain

Act as phagocytes to protect the brain from invading microorganisms and remove damaged tissue
Ependymal Cells

- Line the ventricles and other cavities around the brain
- Act as a barrier between CSF and brain

Brain Tumors

Most primary brain tumors grow from glia or other supporting cells
- Gliomas (from glial cells)
- Meningiomas (attach to the covering of the brain)
Metastatic (start with cells from another location)
Brain Tumors

Treatment:

- Usually surgery
- Radiotherapy
- Chemotherapy

. Often less successful in treating brain tumors - difficult to get the chemicals across the blood brain-barrier