Functional Classification of Neurons

•Sensory
–Transmit impulses from sensory receptors toward CNS
–Almost all are Unipolar
–Cell bodies in ganglia in PNS
•Motor
–Carry impulses from CNS to effectors
–Multipolar
–Most cell bodies in CNS (except some autonomic neurons)
•Interneurons (association neurons)
–Are typically found between motor and sensory neurons
–Shuttle signals through CNS pathways
•Most of the brain and spinal cord neurons are interneurons because they connect with each other and relay info
–99% of body's neurons
–Most confined to CNS. However, ENS has some as well.

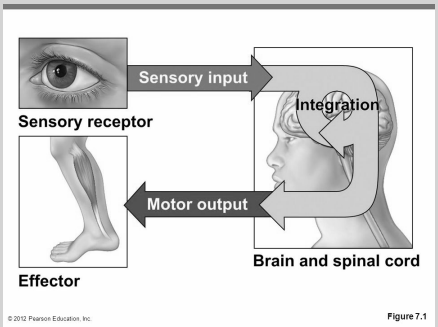
Astrocytes

Astrocytes are the most abundant CNS neuroglia.

Introduction

•Nervous and endocrine systems share responsibility for maintaining homeostasis
–Objective
•Keep controlled conditions within limits that maintain life
–Nervous system
•Rapid response using action potentials
–Endocrine
•Slow response using hormones

Functions of the Nervous System



Peripheral Nervous System (PNS)

•Helpful Mnemonic
•S-A-M-E
–Sensory
–Afferent
–Motor
–Efferent

Peripheral Nervous System (PNS)

•Somatic nervous system (SNS)
–Somatic sensory neurons convey information from somatic receptors in the head, body wall, and limbs to the CNS
•Also includes receptors for senses such as hearing, vision, taste and smell
–Somatic motor neurons conduct impulses from the CNS to skeletal muscles only
•These motor responses can be consciously controlled meaning this part of the PNS is voluntary

Peripheral Nervous System (PNS)

Neurons

•Dendrites (little trees) are the receiving end of the neuron.
–Short, highly branched structures that receive neurotransmitter signals and conduct impulses (voltage changes) toward the cell body.
–They may also contain some organelles.

The Axon: Functional Characteristics

•Main electrical signal conducting region of neuron
•Generates and conveys nerve impulses (action potentials)
–Transmits them along axolemma (neuronal cell membrane) to axon terminal
•Secretory region
–Neurotransmitters (NTs) are released into extracellular space in response to AP
•NTs either excite or inhibit cells with which axon terminals form synapses (chemical or electrical connections)

The Axon: Functional Characteristics (cont)

•A single neuron may carry on many conversations with different neurons at same time through axonal branches
–Splitting of the axon that leads to multiple axon terminals
•Lacks rough ER and Golgi apparatus
–Relies on cell body to renew proteins and membranes
–Efficient transport mechanisms move substances up and down axons
–Axons quickly decay if cut or damaged

Neurons

•Synaptic end bulbs and other varicosities on the axon terminals of presynaptic neurons contain many tiny membrane-enclosed sacs called synaptic vesicles that store packets of neurotransmitter chemicals.
–Many neurons contain two,or even three,types of neuro-transmitters, each with different effects on the postsynaptic cell.

Neurons

•Neurons do not only secrete at the axon terminals, they can also take substances in.
•Many substances that enter the neuron at the axon terminals can move to the cell body by fast retrograde transport.
•These substances include trophic chemicals (such as nerve growth factor)as well as harmful agents (such as tetanus toxin),and the viruses that cause rabies and polio.
•A deep cut or puncture wound in the head or neck is a more serious matter than a similar injury in the leg because of the shorter transit time for the harmful neuropathogenic substance to reach the brain (treatment must begin quickly.)

Histology of Nervous Tissue: Neuroglia

•Astrocytes (CNS)
•Microglial cells (CNS)
•Ependymal cells (CNS)
•Oligodendrocytes (CNS)
•Satellite cells (PNS)
•Schwann cells (PNS)

Microglial Cells

•Small, ovoid cells with thorny processes that touch and monitor health of neurons
•Migrate toward injured neurons
•Can transform to phagocytize microorganisms and neuronal debris in CNS

Main Structures of the Nervous System

•Brain
–Central control center
–~100 billion neurons
•Spinal chord
–Connects the brain to the nerves in the body
–Contains about 100 million neurons
•Nerves
–Bundles of hundreds to thousands of axons
–Each nerve follows a defined path and serves a specific region of the body
•Neuron
–Basic functional unit of the nervous system

Subdivisions of the Nervous System

•Central nervous system (CNS)
–Brain and spinal cord•In dorsal body cavity
–Integration and control center
•Interprets sensory input and dictates motor output
•Peripheral nervous system (PNS)
–The portion of the nervous system outside CNS
•Spinal nerves to and from spinal cord
•Cranial nerves to and from brain

Peripheral Nervous System (PNS)

•The autonomic nervous system (ANS)
–Autonomic sensory receptors and Autonomic sensory neurons convey information from various body regions to the CNS
•However, located primarily in visceral organs
–Ex. Kidneys, liver, heart, lungs, etc.
–Autonomic motor neurons conduct impulses from the CNS to smooth muscle, cardiac muscle, and glands
•Because these structures are not under conscious control, this division is considered involuntary
–Two motor subdivisions of the ANS
•Sympathetic nervous system

Peripheral Nervous System (PNS) (cont)

–Fight or flight
•Parasympathetic nervous system
–Rest and digest

Histology of Nervous Tissue

•Nervous tissue commonly exhibits high cell density with little extracellular space
–Tightly packed
•Two principal cell types
–Neurons (nerve cells)—excitable cells that transmit electrical and chemical signals
–Neuroglia– small cells that support, surround, and wrap delicate neurons

Neurons

•The cell body (Perikaryon, or Soma) has the nucleus surrounded by cytoplasm.
–Like all cells, neurons contain organelles such as lysosomes, mitochondria, Golgi complexes, SER, and Rough ER (in neurons, RER is called Nissl bodies)
– it imparts a striped “tiger appearance”.
–No mitotic apparatusis present.

Neurons

•Axon terminals
–The axon and its collaterals end by dividing into many fine processes called axon terminals (telodendria). Like the dendrites, telodendria may also be highly branched as they interact with the dendritic tree of neurons“downstream”.
–The tips of some axon terminals swell into bulb-shaped structures called synaptic end bulbs.

Neurons

•Electrical impulses,or action potentials (AP),cannot propagate across a synaptic cleft of neuronal synapses. Instead, neurotransmitters are used to communicate at the synapse andre-establish, or inhibit, an AP in the postsynaptic cell.
•This is called a chemical synapse
–Chemical synapse
•The use of neurotransmitters to modify electrical activity in the post-synaptic cell
–Electrical Synapse

Neurons (cont)

•Allowing an electrical impulse to directly modify electrical activity in a post-synaptic cell
•Uses gap junctions to allow the passage of ions between pre and post-synaptic cell

Classifying Neurons

•Neurons display great diversity in size and shape –the longest ones are almost as long as a person is tall, extending from the toes to the lowest part of the brain.
–The pattern of dendritic branching is varied and distinctive for neurons in different parts of the NS.
–Some neurons have very short axons,or lack axons altogether.
•Both structural and functional features are used to classify the various neurons in the body.

Classifying Neurons

•Structural classification is based on the number of processes (axons or dendrites) extending from the cell body.

Astrocytes

•Most abundant, versatile, and highly branched glial (neuroglial) cells
–Star shaped
•Cling to neurons, synaptic endings, and capillaries
•Functions include
–Support and brace neurons
–Play very important role in exchanges between capillaries and neurons
–Guide migration of young neurons
–Control chemical environment around neurons
–Respond to nerve impulses and neurotransmitters
–Influence neuronal functioning
•Participate in information processing in brain

Functions of the Nervous System

•Sensory input
–Sensory receptors detect internal and external changes
–Carried to the brain through the spinal and some cranial nerves

Functions of the Nervous System (cont)

•Integration
–Processing and interpretation of sensory input
–Perception is an important integrated function
•Conscious awareness of stimuli
•Occurs in the brain•Motor output
–Activation of effector organs (muscles and glands) through spinal and some cranial nerves to produce a response
•Causes muscles to contract and glands to secrete

Peripheral Nervous System (PNS)

•Two main functional divisions
–Sensory (afferent) division
•Somatic sensory fibers—convey impulses from skin, skeletal muscles, and joints to CNS
•Visceral sensory fibers—convey impulses from visceral organs to CNS
–Motor (efferent) division
•Transmits impulses from CNS to effector organs
–Muscles and glands
–Three subdivisions of peripheral nervous system
•Somatic nervous system
•Autonomic nervous system
•Enteric nervous system

Peripheral Nervous System (PNS)

•The Enteric Nervous system (ENS)
–ENS is also known as the “brain of the gut”
–Enteric Sensory receptors monitor and communicate the conditions of, and in, the GI tract to the interneurons (integration neurons) of the ENS and to the CNS
–Enteric Motor neurons modify GI propulsion, acid, glandular, and hormonal secretions.–Involuntary
–Enteric Interneurons may process enteric sensory information and decide to modify GI muscle contraction and secretion through enteric motor neurons, if needed.
–Once considered part of the ANS, the ENS consists of over 100 million neurons in enteric plexuses that extend most of the length of the GI tract.
•Some actions of ENS can be modified by ANS

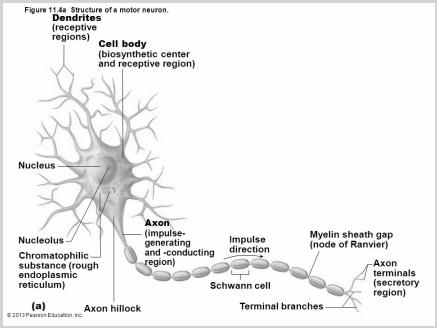
Peripheral Nervous System (PNS) (cont)

•Some sources still list GI control under the ANS
–To be covered in more detail in A and P 2

Neurons

•Though there are several different types of neurons, most have;
–A cell body
–An axon
–Dendrites
–Axon terminals

Neurons



–Neurons gather information at dendrites
•process it in the dendritic tree and cell body.
–Then they transmit the information down their axon to the axon terminals.

Neurons

•Axons conduct impulses "away"from the cell body toward another neuron or effector cell.
–The “axon hillock” is where the axon joins the cell body.
–The “initial segment” is the beginning of the axon.
–The “trigger zone” is the junction between the axon hillock and the initial segment.

Neurons

•The site of communication between two neurons,or between a neuron and another effector cell,is called a synapse.
•The synaptic cleft is the gap between the pre and post-synaptic cells.

Neurons

•Many substances that are synthesized or recycled in the neuron cell body are needed in the axon, or at the axon terminals. Two types of transport systems carry materials from the cell body to the axon terminals and back.
–Slow axonal transport
•conveys axoplasm, mostly,in one direction only – from the cell body toward the axon terminals.
–Fast axonal transport
•moves materials in both directions.
•Anterograde (forward)
–Uses motor proteins to move organelles and synaptic vesicles from the cell body to the axon terminals.
•Retrograde (backward)
–Uses motor proteins to move membrane vesicles and other cellular materials from the axon terminals to the cell body to be degraded or recycled.