How Does The Body Communicate Internally?

- 2 Communication Systems
  - Nervous System
    - Carries messages in pulses of electrical and chemical energy throughout the body
  - Endocrine System
    - Sends follow-up messages that support and sustain the response initiated by the nervous system
- The brain coordinates these 2 systems
  - Neurons
    - Specialized cells that receive and transmit information to other cells in the body
      - Bundle of neurons forms nerves, hence, nerve cells

Neuron: Building Block of the Nervous System

Types of Neurons

- Sensory or afferent
  - Carry messages from sense organs toward the brain
  - Travel one way
- Motor or efferent)
  - Carry messages away from the brain toward the muscles, organs, and glands
  - Travel one way
- Interneuron
  - Relays messages between nerve cells, especially in the brain and spinal cord

Neuron: Building Block of the Nervous System (2)

Can relay messages from sensory neurons to other interneurons or to motor neurons
Make-up most of the billions of cells in the brain and spinal cord

How Do Neurons Work?

Receiver parts, accept most of the incoming messages

Dendrites, branched fibers extending outward from the cell body

Receive info by direct stimulation and carry it to the central part of the neuron, the cell body or soma

Undergoes subtle modifications when we learn

Soma or cell body is the part of a cell containing the nucleus, which includes the chromosomes

Assesses all the messages the cell receives from the dendrites and directly from other neurons

If excitatory message, will fire!

If inhibitory message, will not t fire

How Do Neurons Work? (2)

Axon

Action Potential, axon fires or not fire

Nerve cells utilize electrical and chemical signals to process and transmit information

An impulse in a single neuron begins when a stimulus or messages from other nerve cells make the soma excited; when the arousal reaches a critical level, an electrical impulse occurs in the axon, and the cell fires.

- Ions are charged chemicals
  - The axon gets its electrical energy from ions
- Resting potential
  - In its normal resting state, the ions within the cell give the axon a small negative charge

How Do Neurons Work? (3)

Action potential

When the cell becomes excited, this temporarily reverses the charge, from negative to positive, and causes an electrical signal to race along the axon, in turn, causing an electrical signal to race from the soma toward the axon ending

Ion pump

Flushes out positive charged ions and restores the neuron to its resting potential

Ready to fire again

How Do Neurons Work? (4)

Synaptic Transmission

Relaying of information across the synapse by means of chemical neurotransmitters

Synapse is the gap between nerve cells

Acts as an electrical insulator, preventing the charge speeding down the axon from jumping to the next cell

Terminal buttons are tiny bulblike structures at the end of the axon, which contain neurotransmitters that carry the neuron's message into the synapse

To pass messages across the synaptic gap, the electrical message morphs into a chemical message that flows across the synaptic cleft or gap between neurons

How Do Neurons Work? (5)

Neurotransmitters are chemical messengers that relay neural messages across the synapse

At the terminal buttons, the electrical impulse causes a rupture in the bubble-shaped vesicles, called sacs, containing neurotransmitters; which are spilled into the synaptic cleft.

The neurotransmitters, which fit the shape of the special receptors in the membrane of the target cell, lock-in, stimulating the receiving neuron and carry the message forward.

Once the neurotransmitters have completed their work, they are broken down by other chemicals and recycled back to the terminal buttons, reassembled and reused

How Do Neurons Work? (6)

Reuptake

Some neurotransmitters are intercepted on their way to the receptor sites as they float within the synapse and drawn back into vesicles to be reused later

Neurotransmitters

Neurotransmitters Identified in Psychological Functioning

Dopamine, produces sensations of pleasure and reward

- Used by CNS neurons involved in voluntary movement, attention, emotion, learning, memory, etcetera
- Associated problems
  - Schizophrenia
    - Too much
  - Parkinson's Disease
    - Too little

Serotonin, regulates sleep and dreaming, mood, pain suppression, aggression, appetite, impulsivity, and sexual behavior, particularly arousal

- Associated problems
  - Depression, OCD, certain Anxiety Disorders

Neurotransmitters (2)

Norepinephrine, used by neurons in the Autonomic Nervous System and by neurons in almost every region of the brain

- Controls heart rate, sleep, dreaming, stress, sexual responsiveness, vigilance, and eating, etcetera
- Associated problems
  - High blood pressure
  - Depression
    - Low level
  - Manic States
    - High levels
- Acetylcholine, primary neurotransmitter used by efferent neurons
  - Involved in some kinds of learning and memory, muscle action, etcetera

Neurotransmitters (4)

Associated problems

Certain muscular disorders, Alzheimer's

GABA, most prevalent inhibitory neurotransmitter in neurons of the CNS; learning; anxiety regulation

Associated problems

Anxiety, Epileptic seizures, Insomnia, too little

Glutamate, primary excitatory neurotransmitter in the CNS

Involved in learning and memory; movement

Associated problems

Release of excessive glutamate causes brain damage after stroke; anxiety, depression, migraines, seizures, too little

Endorphins, pleasurable sensations and control of pain, mood, blood pressure, etcetera

Neurotransmitters (5)

Associated problems

Opiate addiction lowers level

Epinephrine, emotional arousal, glucose metabolism, memory storage

Drugs of abuse either

Mimic

Enhance, acts as an agonist, or

Inhibit, acts as an antagonist, the brain's neurotransmitters

Neuroplasticity

Neuroplasticity is the brain's ability to adapt or reorganize or change its structure and function as the result of experience

- Make new connections or strengthen old ones
- Might also help the Nervous System adapt to physical damage
- Neurogenesis is the process by which new neurons are generated
  - Replace lost cells with new cells
  - How?
    - Neutral stem cells
      - Rare, immature cells that can grow and develop into any type of cell
        - Depends upon the chemical signals they receive

Glial Cells

Glial Cells: A Support Group for Neurons

Provide structural support for neurons

Bind them together

Help in forming new synapses

Form a myelin sheath, fatty insulation around many axons in the brain and spinal cord

Insulates and protects the cell and helps speed the conduction of impulses along the axon

Neurons and glial cells are the two main building blocks of the nervous system

Divisions of the Nervous System

Nervous system is made up of all the nerve cells in the body; functions as a single, complex, and interconnected unit

Two Divisions

- Central Nervous System or CNS
- Peripheral Nervous System or PNS

CNS includes the brain and the spinal cord

- Serves as the body's "command central"
  - Brain occupies about 1/3 of the skull
    - Coordinates body functions
    - Initiates behaviors
    - Makes complex decisions

Divisions of the Nervous System (2)

- Spinal cord
  - Connects the brain with parts of the Peripheral Nervous System extending into the trunk and limbs
    - Simple, swift reflexes, such as knee-jerk reactions that don't involve the brain
      - Involuntary movement or automatic behaviors

- Peripheral Nervous System
  - Connects the CNS with the rest of the body through bundles of sensory and motor axons or nerves
  - Carry messages between the brain and the sense organs, the internal organs, and the muscles
  - Carries incoming messages that tell your brain about sights, sounds, tastes, smells, and textures

Divisions of the Nervous System (3)

Carries outgoing signals that tell your body muscles and glands how to respond

Two major divisions of the PNS

- Somatic Nervous System
  - Carries sensory info to the CNS
  - Sends voluntary messages to the body's skeletal muscles
  - Involves afferent and efferent neurons
- Autonomic Nervous System
  - Autonomic, self-regulating or independent
  - Sends communications between the CNS and the internal organs and glands

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Divisions of the Nervous System (4)

- Carries signals that control internal organs to perform such jobs as regulating digestion, respiration, heart rate and arousal
- Does this unconsciously, without thinking about it

Two major parts or divisions of the ANS

- Sympathetic Division

Arouses the heart, lungs, and other organs in stressful or emergency situations

- Fight or flight response, when feel threatened, attack or flee

Parasympathetic Division

- Returns internal responses to a calm and collected state; put on the neural brakes

Endocrine System

The bloodstream carries information, serving as the communication pathway for the endocrine system

Endocrine system is the hormone system, the body's chemical messenger system, including the endocrine glands, which includes the pituitary, thyroid, parathyroid, adrenals, pancreas, ovaries, and testes

- The glands transmit information by releasing hormones into the bloodstream
  - Hormones are the chemical messengers used by the endocrine system that influence body functions, behaviors and emotions
    - Some serve as neurotransmitters
    - Once secreted into the blood, hormones circulate

Endocrine System (2)

throughout the body until delivered to their target muscles, glands, and organs

Under normal, unaroused conditions, the endocrine system works in parallel with the Parasympathetic Nervous System

In a crisis, the endocrine system shifts into a new mode, supporting the actions of the Sympathetic Nervous System

The hormone, epinephrine or adrenalin, is released into the bloodstream eliciting a fight or flight response

Hormonal Functions of Endocrine Glands

The pituitary gland is the master gland; it produces hormones influencing the secretions of all other endocrine glands, as well as a hormone that influences growth and also a hormone for lactation. It is attached to the brain's hypothalamus, from which it takes its orders.

Glands produce hormones that regulate

Anterior pituitary hormones regulate ovaries, testes, breast milk production, metabolism, reactions to stress

Posterior pituitary hormones regulate water conservation, breast milk secretion, uterus contractions

Thyroid hormones regulate metabolism, physical growth and development

Hormonal Functions of Endocrine Glands (2)

Parathyroid hormones regulate calcium levels

Pancreas hormones regulates glucose or sugar metabolism

Adrenal glands hormones regulate fight or flight response, metabolism, sexual desire, especially in women

Ovaries hormones regulate development of female sexual characteristics, production of ova or eggs

Testes hormones regulate development of male sexual characteristics, sperm production, sexual desire, in men

Pineal hormones regulate sleep cycle and body rhythms

A Tour Through the Brain

Tools for Biological Research

Electroencephalograph or EEG records brain waves, a weak voltage pattern, by placing electrodes on the scalp

- Tells which parts of the brain are most active
- Reveals abnormal waves caused by brain malfunctions

Cell body staining consists of color selected neurons or nerve fibers

Microinjections involve injecting chemicals into specific areas of the brain

Intrabrain electrical recordings record activities of one or a group of neurons inside the brain

By these 3 direct observations, more information is obtained about the structure and function of the brain. The intrabrain recordings allow one to see individual neuron activity.

A Tour Through the Brain (2)

CT scanning, computed tomography, creates a static image of the brain structure via x-rays passed through the brain at various angles

- Detects soft-tissue structures x-rays normally don't reveal
- Reveals effects of strokes, injuries, tumors, and other brain disorders

PET scanning, positron emission tomography, produces an image showing brain activity, not structure, by sensing the concentration of low-level radioactive glucose consumed by active brain cells

- Identify brain areas active during ordinary activities

MRI, magnetic resonance imaging, makes highly detailed 3D pictures from tissue responses to powerful pulses of magnetic energy

A Tour Through the Brain (3)

Identify abnormalities and map brain structures and function

fMRI, functional magnetic resonance imaging, is a faster version of MRI detecting blood flow by picking up magnetic signals from blood

Measures blood flow which indicates areas of the brain that are active and inactive during ordinary activities

dMRI, diffusion magnetic resonance imaging, depicts image of the whole brain

Produces 3-D images of the whole brain's neural pathways

Tracks the movement of molecules as they travel in the brain

Bright colors highlight the axons and dendrites

Three Levels of the Brain

- Hindbrain, lower region of brain
  - Brainstem links the spinal cord with the rest of the brain
    - Serves as a conduit for nerve pathways that carry messages traveling up and down the spinal pathway between body and brain
  - Four components: medulla, pons, reticular formation, cerebellum
    - Medulla, regulates basic body functions, including breathing, blood pressure, and heart rate
      - Operates unconsciously
    - Pons, regulates the sleep and dreaming cycle
      - located just above the medulla
        - Connects brain to cerebellum

Three Levels of the Brain (2)

Reticular formation, keeps the brain alert and awake

Monitors incoming sensory information and directs attention to novel or important messages

Runs through the hindbrain, midbrain and brainstem

Cerebellum, referred to as the little brain, works with the brain stem and higher brain centers to control automatic complex movement, such as walking, dancing, drinking from a glass

Involved in sequential order, habitual responses

The brainstem and cerebellum control the most basic functions of movement and of life

Three Levels of the Brain (3)

- Midbrain
  - Responsible for coordinating movement patterns, sleep, and arousal
  - Helps us to orient our eyes and body movements to visual and auditory stimuli
  - Contains the substantia nigra, which secretes the neurotransmitter dopamine
    - Deterioration of neurons in the substantia nigra is indicative of Parkinson's Disease
- Forebrain, upper-level structures
- Includes
  - Thalamus, hypothalamus, limbic system, cerebral cortex

Three Levels of the Brain (4)

Thalamus, directs nearly all the brain's incoming and outgoing sensory and motor traffic

- Receives information from all the senses, except smell, and distributes it to appropriate processing circuits throughout the brain, the cerebral cortex
- Has a role in focusing attention
- Located atop the brain stem, near the geographic center of the brain
- Attached to the pituitary gland
- May tell pituitary to release certain hormones to regulate certain body functions, such as heart rate, blushing, sweating, goose bumps
- Considered to be the master control center for emotions and many basic motives, such as hunger, thirst, sex, aggression, to name a few

Three Levels of the Brain (5)

Hypothalamus, constantly monitors the blood to determine the condition of the body, including body temperature, fluid levels, nutrients, etcetera

Limbic System

- Houses modules that process memories and regulate complex motives and emotions
- Involved in feelings of pleasure and pain
- Produces fear, rage, and ecstasy

Components of the limbic system

- Hippocampus, regulates memory
  - One on each side of the brain
  - Connects your present with your past

Three Levels of the Brain (5)

- Helps you remember locations of things in space
- Amygdala, regulates memory and emotion
  - Involved in aggression and fear
  - Helps us to remember emotionally charged events, such as 9/11, Hurricane Katrina, Hurricane Harvey
- Limbic system contains several pleasure centers
  - Good feelings accompanying eating, sex, and other rewarding activities
  - Certain street drugs generate wild rushes of pleasure and stimulate the pleasure centers; involves dopamine
- Cerebral Cortex is the thin gray-matter covering the cerebral hemispheres, which are the 2 halves of the brain

Three Levels of the Brain (6)

- Consists of ¼ inch layer dense with cell bodies of neurons
- Carries on the major portion of our higher mental processing, including thinking and perceiving

Cerebral cortex and its supporting structures account for 2/3 of the brain's total mass

- About 1/3 is visible on the brain's surface

Four Lobes of the Cerebral Cortex

- Localization of function
- Different regions of the brain perform different tasks

Frontal Lobes, cortical regions at the front of the brain that are especially involved in movement and thinking

- Perform higher functions, such as planning, deciding, perceiving

Three Levels of the Brain (7)

Components of personality and temperament

Motor cortex is the narrow, vertical strip found in the back of the frontal lobe

Controls the body's motor movement by sending messages via the motor nerves to the voluntary muscles

movement, speech, abstract thought

Parietal Lobes, cortical areas lying toward the back and top of the brain

Processes sensation

Somatosensory cortex, a special parietal strip, has 2 functions:

Primary processing area for the sensations of touch,

temperature, pain, and pressure from all over the body

Three Levels of the Brain (8)

Relates this info to a “mental map” of the body to help locate the source of these sensations

Keeps track of the position of body parts

Allows us to locate, in 3-dimensional space, the positions of external objects detected by our senses (right lobe)

Specializes in locating the source of speech sounds; extracts meaning from speech and writing (left lobe)

Sensations of touch, body positioning, hearing

Occipital Lobes, cortical regions at the back of the brain housing the visual cortex

Receives stimulation relayed from the eyes to the visual cortex, which constructs our moving picture of the outside world

Three Levels of the Brain (9)

The brain divides up the incoming visual input and sends it to separate cortical areas for the processing of color, shape, movement, and shading

Work in association with areas in the parietal lobes and the temporal lobes

Temporal Lobes

Houses the auditory cortex

Processes speech sounds

Stores long-term memory

Hippocampus lies directly beneath temporal lobe

Hearing, smell, vision

Three Levels of the Brain (10)

There are no single brain centers for any major functions of the mind including attention, consciousness, learning, memory, thinking, language, emotion, or motivation; every mental and behavioral process involves the coordination and cooperation of many brain networks.

- Association areas are cortical regions throughout the brain that integrates and interprets info gathered from the sensory parts of the brain
  - Interpret sensations
  - Lay plans
  - Make decisions
  - Prepare us for action

Three Levels of the Brain (11)

Corpus callosum is a bundle of nerve cells that connects the two cerebral hemispheres transferring information between the two hemispheres

Cerebral Dominance is the tendency of each brain hemisphere to exert control over different functions

- However, they work together to produce our thoughts, feelings, and behaviors
- Each hemisphere makes different contributions to the same task
  - Different processing styles
    - Left hemisphere is analytic and sequential
    - Right hemisphere interprets experiences holistically and spatially

Three Levels of the Brain (12)

- The Split Brain
  - Severing of the corpus callosum, brain surgically split
    - Used in treating patients with epilepsy
      - To prevent abnormal electrical rhythms from echoing back and forth between the hemispheres and developing into a full-blown seizure
    - Findings
      - Duality of consciousness
        - When different stimuli were presented to opposite sides of the brain, the two hemispheres could respond independently