The Brain

Raymond Nelson, MA, NCC

The Brain

- Weight is approx 2.5 % of body
- Consumes approx 20% of oxygen intake
  - Brain is over 77% water
  - Grey matter (cerebral cortex) approx 40%
  - Cerebral cortex consumes 94% of oxygen in the brain
- Consumes oxygen and glucose at 10 times the rate of the rest of the body

The Brain - Neurons

- Neurons – found primarily in brain and spinal cord
  - Do not appear to regenerate on a normal programmed basis like other cells
  - "neuron" is Greek for "string"
  - Dendrites (tree) project from neurons
  - Connected to an Axon which is covered in myelin
- Embryonic brain produces 250,000 neurons per minute
  - Neurons are paired (apoptis) to remove bad connections and strengthen good connections
- Electrical signals are carried by neurotransmitter chemicals

The Brain - Neurotransmitters

- Most of the nervous system's important chemicals are produced in the **Brainstem**
- Peptides – Digestion and hormones (amino acids)
- **Acetylcholine** – voluntary and involuntary muscle activity, memory (Alzheimers)
- **Epinephrine / Norepinephrine** – hormone in body, neurotransmitter in brain, produced in adrenal gland and brain, FF response activator, stimulates massive release of glucose to muscles (strength)
- **Cortisol** – stress hormone
- Endorphine (endogenous morphine)
- Dopomine – pleasure, motor functioning (Parkinsons)
- Serotonin – mood, memory, appetite, temperature

The Brain - Brainstem

- Located at the base of the brain
- Damage to brainstem is highly life-threatening
- Three parts
  - Mid-brain (upper part)
  - Pons (center area)
  - Medula oblongata (lower end)
- Primary purpose is survival
- Controls autonomic functions
  - Breathing
  - Heartbeat
  - Blood pressure
- Reticular Formation

The Brainstem – Reticular Formation

- RF Occupies the core of the brainstem
- Monitors information from throughout the body
- Regulates basic life-support functions
- RF neurons and the Thalamus make up the Reticular Activation System

The Brain – Reticular Activation System

- Receives information from body regarding the environment
- Regulates level of autonomic arousal to maintain survival
- Damage to RAS results in permanent coma
- Thalamus filters stimuli from environment
  - decides what is most important (threats)
  - Tunes-out unimportant stimuli

The Brain – Thalamus, Hypothalamus

- Thalamus
  - Directs traffic between cortex and sensory organs
  - Processes all sensory input except smell
  - 99 percent of sensory input is discarded immediately
    - 1 percent of sensory input is considered important
- Hypothalamus (below thalamus)
  - Regulates ANS
  - Temperature and perspiration
  - Sex drive
  - Aggression
  - Pleasure seeking
  - Sleep
  - Fight or Flight Response

Fight or Flight?

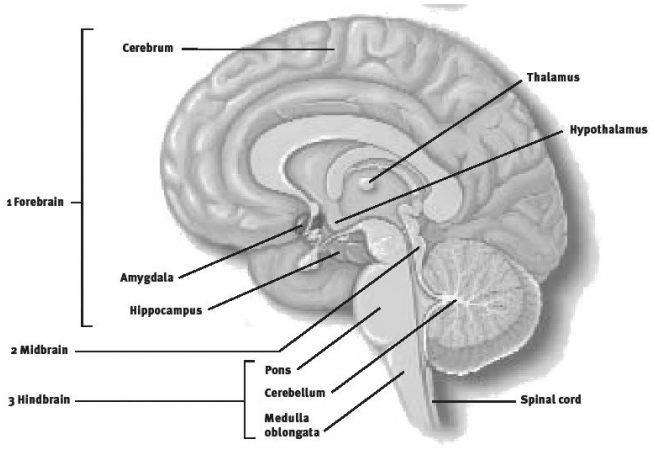
- Massive, diffuse, and global (non-specific) adrenal and endocrine activation during emergency states
- Brain does not distinguish between physical and psychological danger
- Epinephrine and norepinephrine (adrenaline and noradrenaline)
  - Sometimes act as neurotransmitters in the brain
  - In fight or flight they activate endocrine, circulatory, muscular, and digestive systems
- Cortisol (secreted by adrenal glands)
- Endocrine activation

Cortisol

- Emotional hormone component of FF response or stress
- Emotion becomes dominant over cognition
- New learning becomes difficult
- High concentrations of cortisol over long periods of time cause damage
  - Hippocampus (difficulting learning and remembering new things)
  - Immune system compromised
  - Increased risk of disease
  - Retardation of growth
- Stops digestion and other normal metabolic process during FF response (butterflies)
  - Vomiting

The Brain - Hippocampus

- Responsible for working memory
- Over time the hippocampus stores short term memories in long term memory in the Cortex
- Hippocampus not involved in long-term memory retrieval
- Damage to hippocampus results in difficulty learning and storing new memories
  - Chronic gluco-cortical stress response
- Adrenaline enhances memory for the event that stimulated the FF response
  - Emotional stimuli are better remembered than neutral



The Brain - Amygdala

- Small - shaped like and almond
- Alarm system in brain
- Checks with hippocampus to see if stimuli represent a threat
- Triggers hypothalamus if stimuli are potentially harmful
- Some researchers suggest Amygdala forms unconscious emotional memories without dependence upon conscious recollection
  - PTSD inability to deactive through conscious attention to other stimuli

The Brain – Cerebral Cortex

- Grey matter
- Thin layer folder over outside of brain
- Cerebellum (little brain) on lower back
- **Four main lobes** – named after underlying skull bones
  - **Occipital Lobes**
  - **Temporal Lobes**
  - **Parietal Lobes**
  - **Frontal Lobes** (prefrontal cortex)

The Brain - Cerebellum

- Small lobe in back of brain
- Primitive – has changed little over millennia
- Maintains balance
- Muscle tonus
- Posture
- Large – 11% of brain weight
- Almost adult size by age 2
- Depends on Motor Cortex for new skill acquisition
- Motor Cortex depends upon Cerebellum for coordinated movement
- Cerebellum performs complex motor tasks with almost no conscious awareness

The Brain – Occipital Lobe

- Back part of brain (above Cerebellum)
- Visual cortex
- Together with Wernicke's area and Broca's area are referred to as the "Aphasia Cortex"
  - Language skills

The Brain – Temporal Lobes

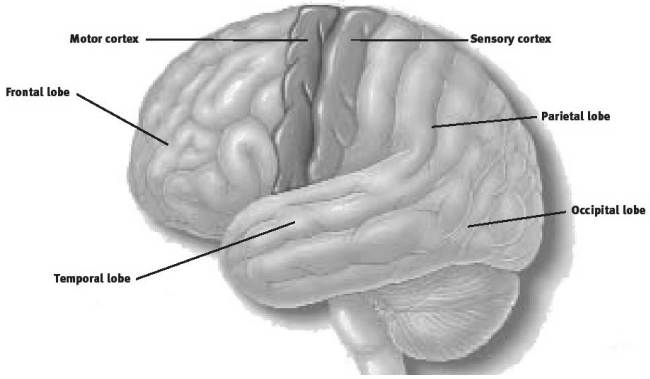
- Located on either side of the brain
- Auditory stimuli
- Various Subdivisions
  - Hearing
  - Memory
  - Language (Wernicke's Area)

The Brain – Parietal Lobe

- On top part of brain
- Somatosensory
  - Touch
  - Temperature
  - Environment
  - Proprioception (awareness of body position)

The Brain – Frontal Lobe

- Front part of brain
- Association cortex
- Human cortex
- Performs most complex functions
- Speech (Broca's area), along with Wernicke's area (language recognition
- Large **Prefrontal Cortex** (different than other mamals)



The Brain – Prefrontal Cortex

- **Executive functioning**
  - Concentration
  - Awareness
  - Emotional self-regulation
  - Behavioral/social self-control
  - Problem solving
  - Lying

Executive Functioning Deficits

- Poor planning and organization
- Difficulties generating and implementing problem solving strategies
- Poor initiation
- Disinhibition / impulsivity / erratic careless behavior
- Rigid or concrete processes-inflexibility in thoughts or attitude
  - Perservation / problems in stopping (deficits in self-monitoring)
  - Inability to correct errors or use feedback
  - Poor self-control
- Deficient self-awareness
  - Limited insight
  - Tendency to be self-satisfied
  - Tend to experience little or no anxiety
  - Fail to appreciate the existence and practical implications of these deficits
- Problems or difficulties with attention
- Deficits in social awareness including rude or insensitive behavior
- Lack of apparent concern about social expectations

(Anderson, 1998; Sami et al., 2003; Lezak, 1993; Pennington, 1997; Stuss & Benson, 1987; Tranel, Anderson, & Benton, 1994; Walsh, 1978)

Development of Executive Functions

- **Three Distinct Stages of Executive Skill Development**
  - Age 6 – Ability to resist distraction
  - Age 10 – Organized search, hypothesis testing, impulse control (sometimes consistent with adult levels
  - Age 12 – Expanded verbal fluency skills, improved motor coordination skills, increased planning (not consistent with adult levels)

(Anderson, 1998; Welsh, Pennington, and Groisser 1991)

Memory, Perception and Attention

- Novelty – the great attention getter
- Habituation – getting used to it (outhouse syndrome)
- Hippocampus – responsible for working (short-term) memory and eventually cedes memories to long term storage in the cortex
  - Hippocampus is independent of long term memory
- Emotional interest enhances attention and memory
  - Information goes first to the Thalamus
  - Amygdala then determines the emotional significance
  - Cortex makes rational sense of stimulus
  - Iconic (brief, visual) / Echoic (auditory – longer)
- 18 second holding pattern (15 to 20 seconds)
  - Cocktail Party Effect
- Perception depends upon meaning (RAS)
  - Why does it matter?