Lecture 4

BRAIN DEVELOPMENT

BRAIN DEVELOPMENT

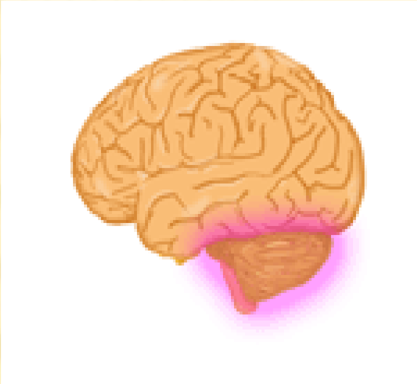
- The brain is part of the central nervous system, and plays a decisive role in controlling many bodily functions, including both voluntary activities (such as walking or speaking) and involuntary ones (such as breathing or blinking).
- The brain grows at an amazing rate during development. At times during brain development, **250,000 neurons** are added every minute!
- At birth, almost all the neurons that the brain will ever have are present. However, the brain continues to grow for a few years after birth. By the age of 2 years old, the brain is about 80% of the adult size. The adult human brain is believed to consist of at least one hundred billion neurons (nerve cells).

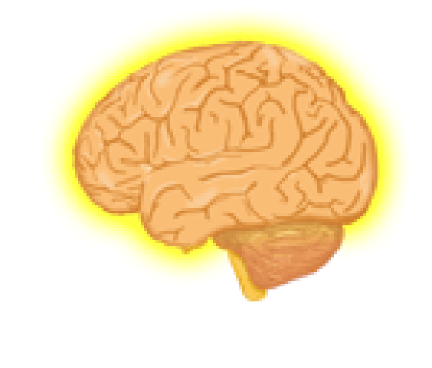
PARTS OF THE BRAIN

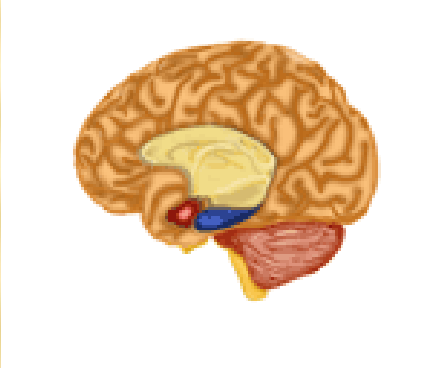
- There are four major parts of the brain: the brain stem, the cerebellum, the limbic system, and the cerebral cortex.

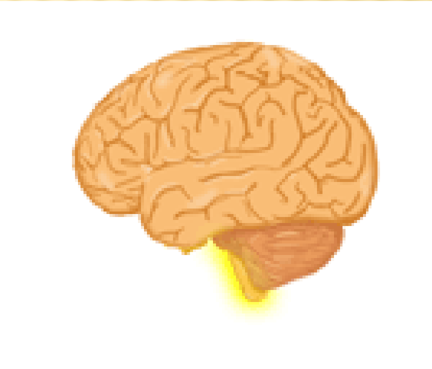
- Brain stem: responsible for basic survival functions such as breathing and heartbeat.
- Cerebellum: responsible for reflexive movements such as blinking the eyes.
- Limbic system: responsible for processing emotions. (autism)
- Cerebral cortex: responsible for conscious, voluntary actions.

BRAIN PARTS









PARTS OF THE BRAIN

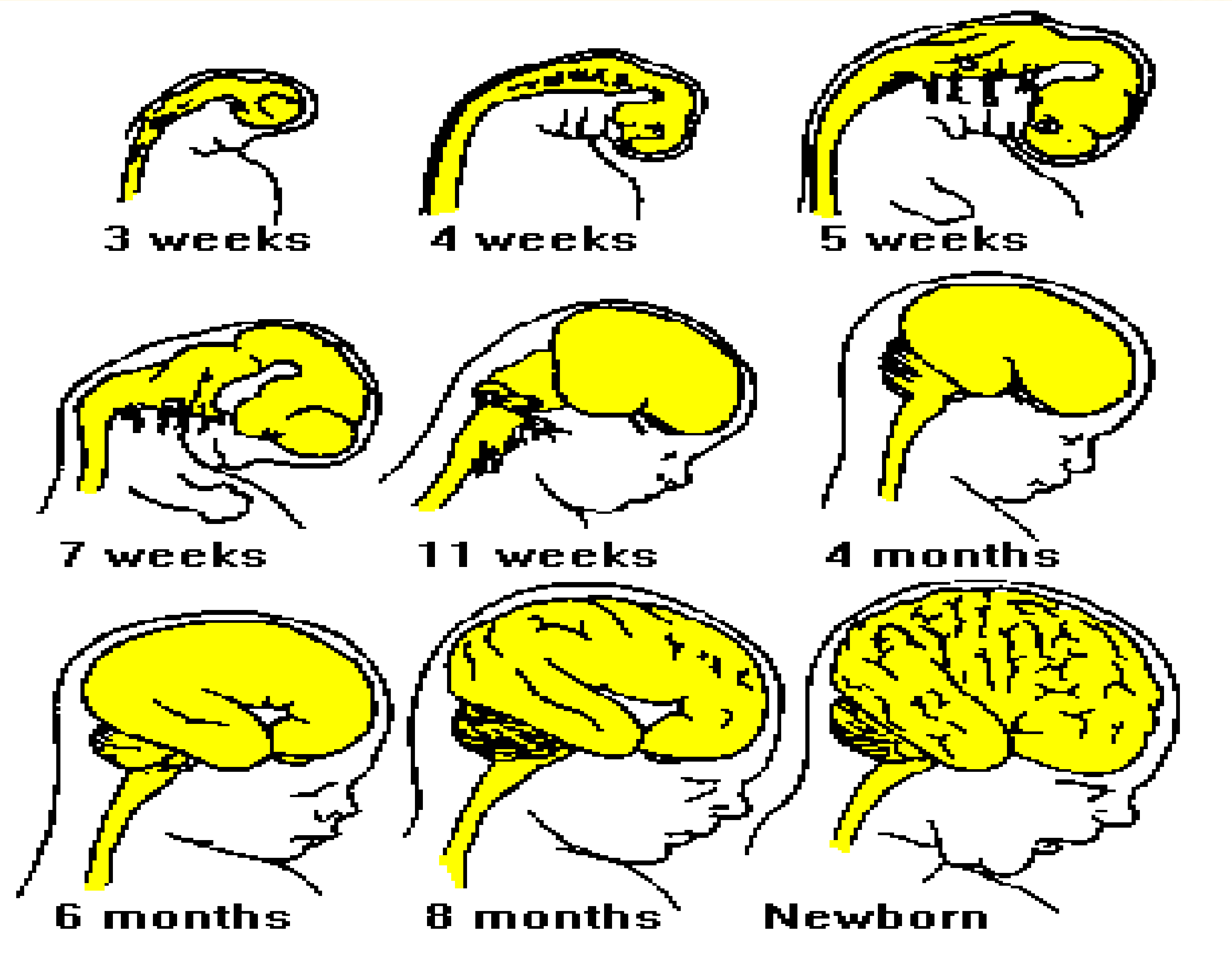
- The brain develops in a specific sequence, from the most basic parts to the most complex ones. The brain stem begins developing first, followed by the cerebellum, the limbic system, and finally the cerebral cortex.

- The fact that the limbic system develops before the cortex is important. The brain can process and store emotional experiences long before the child has the language and memory skills to consciously remember and discuss emotions.

PARTS OF THE BRAIN

- This means that an infant's brain can store and remember a frightening experience, and can use that information to react to similar events later, even if the infant cannot remember or talk about the experience.

- The limbic system is the seat of positive memories as well, and stores the happy experiences that build attachments with adult caregivers.


3 weeks
4 weeks
5 weeks
7 weeks
11 weeks
4 months
6 months
8 months
Newborn

HEMISPHERES OF THE BRAIN

- The brain is divided into halves, called hemispheres. Many of the brain's functions are controlled by both hemispheres. But the right hemisphere and the left hemisphere are also responsible for different types of processing.
- Right hemisphere: controls overall, general impressions; puts together the big picture.
- Left hemisphere: focuses on specific details.
- Corpus callosum: enables the hemispheres to communicate with each other.
- Each hemisphere is divided into four sections called lobes: frontal, temporal, parietal, and occipital.

HEMISPHERES OF THE BRAIN

- The right side of the brain controls muscles on the left side of the body and the left side of the brain controls muscles on the right side of the body.

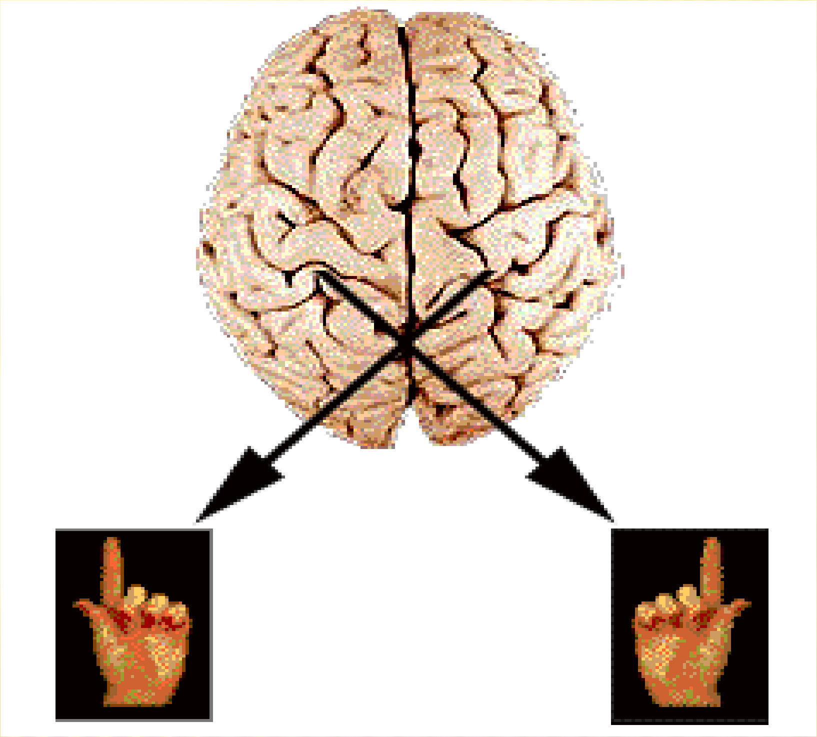
- Also, in general, sensory information from the left side of the body crosses over to the right side of the brain and information from the right side of the body crosses over to the left side of the brain. Therefore, damage to one side of the brain will affect the opposite side of the body.

- In 95% of right-handers, the left side of the brain is dominant for language. Even in 60-70% of left-handers, the left side of brain is used for language. Back in the 1860s and 1870s, two neurologists (Paul Broca and Karl Wernicke) observed that people who had damage to a particular area on the **left side** of the brain had speech and language problems.

DOMINANT FUNCTIONS

- Left Hemisphere:
- Language
- Math
- Logic

- Right Hemisphere:
- Spatial abilities
- Face recognition
- Visual imagery
- Music



LOBES OF THE BRAIN

- The four lobes of the brain process different types of information and control different functions.
- Frontal lobe: controls thinking, planning, and reasoning processes.
- Temporal lobe: processes hearing and some language.
- Parietal lobe: responsible for perception of touch, smell and taste.
- Occipital lobe: brain's vision center.

LOBES OF THE BRAIN

BRAIN CELLS

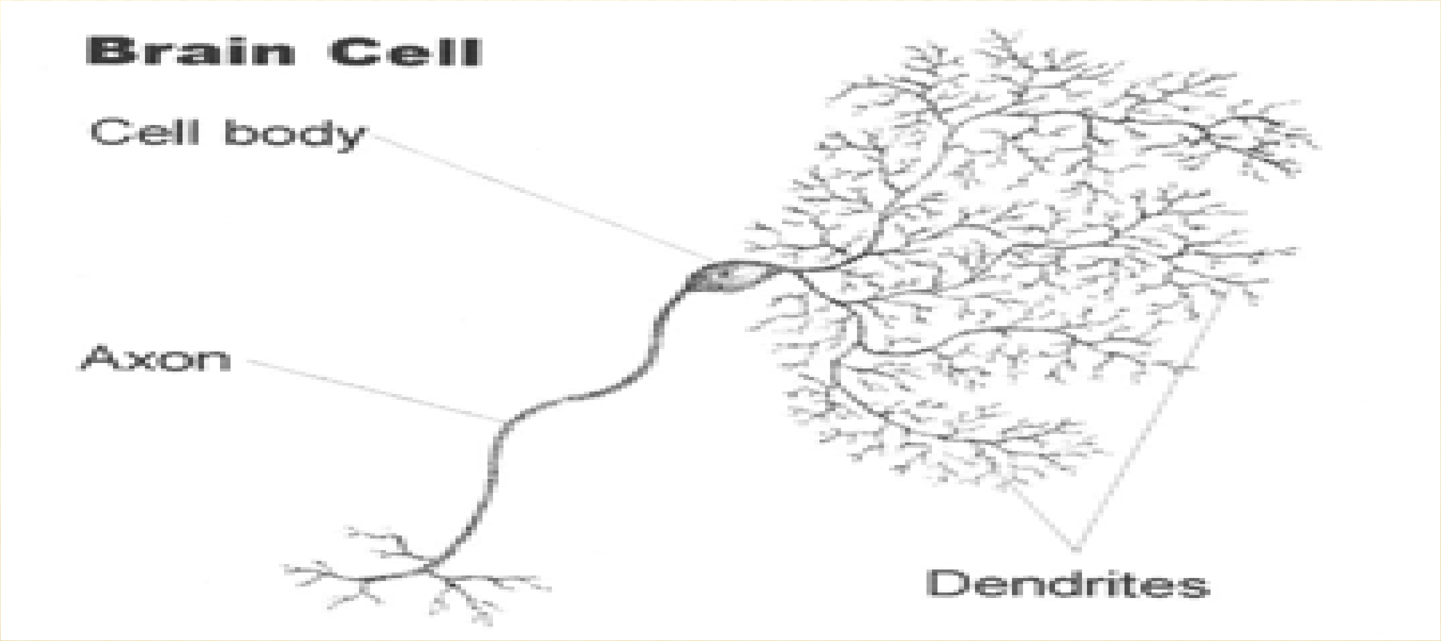
- The basic building blocks of the brain are specialized nerve cells that make up the central nervous system: neurons. The nerve cells proliferate before birth. In fact, a fetus' brain produces roughly twice as many neurons as it will eventually need .
- This is a safety margin that gives newborns the best possible chance of coming into the world with healthy brains. Most of the excess neurons are shed in utero.
- Every neuron has an axon (usually only one). The axon is an "output" fiber that sends impulses to other neurons. Each neuron also has many dendrites short, hair-like "input" fibers that receive impulses from other neurons. In this way, neurons are perfectly constructed to form connections.

BRAIN CELLS

- Neurons are the basic cells considered to be the building blocks of the brain. In fact, most attention in early brain development focuses on neurons since these cells are believed to be the main components of intelligence.
- Neurons have four parts: the dendrites, the cell body, the axon and the synapses. Neurons communicate with each other through electrical signals. Synapses connect neurons into pathways that enable all brain processes to occur.
- Dendrites: bring in electrical signals from other neurons.
- Cell body: command center of the neuron that decides whether or not to send signals on to other neurons.
- Axon: sends electrical signals to other neurons.
- Synapse: microscopic gap between neurons where chemicals can control change brain activity.

BRAIN CELLS

- As a child grows, the number of neurons remains relatively stable, but each cell grows, becoming bigger and heavier. The proliferation of dendrites accounts for some of this growth. The dendrites branch out, forming "dendrite trees" that can receive signals from many other neurons.



BRAIN DEVELOPMENT

- The brain develops in a predictable sequence, from the most basic functions to the most complex ones. The interaction of genetic inheritance and environment determines how the brain will develop.

- There are five basic processes that make up brain development. Many of these processes begin before birth, during the prenatal period. Most are not complete until late adolescence.

BRAIN DEVELOPMENT

- 1. Neurogenesis is the process of forming neurons. This is the first process to occur in brain development, and is completed before a baby is born.

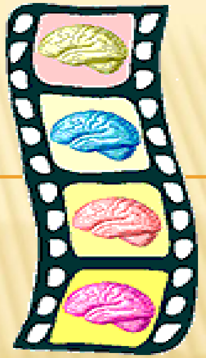
- 2. Neural migration is the process of organizing the brain by moving neurons to specific areas based on the functions these cells will perform. Migration begins prenatally, but continues for at least 8 to 10 months after a baby is born.

BRAIN DEVELOPMENT

- 3. Myelination is the process of coating the axon of each neuron with a fatty coating called myelin, which protects the neuron and helps it conduct signals more efficiently. Myelination begins in the brain stem and cerebellum before birth, but is not completed in the frontal cortex until late in adolescence. Breast feeding contributes to more rapid myelination in the brain.

- 4. Synaptogenesis is the process of forming networks of connections in the brain. Synapses begin forming prenatally, but the process continues throughout life.

BRAIN DEVELOPMENT



- 5. Pruning is the process of weeding out unnecessary connections and strengthening the important ones, based on the child's experiences. Some pruning begins very early in development, but the most rapid pruning happens between about age 3 and age 16. Different areas of the brain undergo pruning during different sensitive periods..

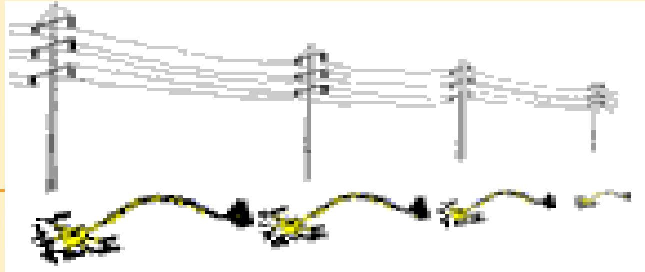
- Pruning is a process that is more important than was once believed. Experiences during infancy and childhood form the connections that shape the development of the brain. Pruning is a key part of brain development because it eliminates the connections that are not used often enough. Pruning provides room for the most important networks of connections to grow and expand, making the brain more efficient.

BRAIN CONNECTIONS

- At birth, the human brain is in a remarkably unfinished state. Most of its 100 billion neurons are not yet connected in networks.

- Forming and reinforcing these connections are the key tasks of early brain development. Connections among neurons are formed as the growing child experiences the surrounding world and forms attachments to parents, family members and other caregivers.

BRAIN CONNECTIONS



- In the first decade of life, a child's brain forms trillions of connections or synapses. Axons hook up with dendrites, and chemicals called neurotransmitters facilitate the passage of impulses across the resulting synapses.

- Each individual neuron may be connected to as many as 15,000 other neurons, forming a network of neural pathways that is immensely complex.

- This elaborate network is sometimes referred to as the brain's "wiring" or "circuitry." If they are not used repeatedly, or often enough, they are eliminated. In this way, experience plays a crucial role in "wiring" a young child's brain.

BRAIN DEVELOPMENT

- Brain cells are “raw” materials much like wood is a raw material in building a house. Heredity may determine the basic number of “neurons” (brain nerve cells) children are born with, and their initial arrangement, but this is just a framework.

- A child’s environment has enormous impact on how these cells get connected or “wired” to each other. Many parents and caregivers have understood intuitively that loving, everyday interactions such as cuddling infants closely or singing to toddlers help children learn.

BRAIN DEVELOPMENT

- And the same processes that wire the brain before birth also drive the very rapid growth of learning that occurs immediately after birth. At birth, a baby's brain contains 100 billion neurons, roughly as many nerve cells as there are stars in the Milky Way.

- Before birth, the brain produces trillions more neurons and "synapses" (connections between the brain cells) than needed. During the first years of life, the brain undergoes a series of extraordinary changes, the brain eliminates connections that are seldom or never used.

SENSITIVE PERIOD

- There are optimal times when certain areas of the brain are most ready to develop. Researchers refer to this time of readiness as a sensitive period in development.

- Sensitive periods open a window of opportunity where experiences have a greater impact on certain areas of brain development. During sensitive periods, the brain is most likely to strengthen important connections and eliminate unneeded ones in a specific part of the brain.

- Growth in that area is still possible after the sensitive period, but it is not as easy or automatic. Our brains are flexible and adaptable, and many abilities can develop later in life if important experiences are missed in the early years. Making up for lost experiences, however, is much more difficult, takes much longer, and can require intensive intervention.

BRAIN DEVELOPMENT

- “Windows of opportunity” are critical periods in children’s lives when specific types of learning take place.
- For instance, scientists have determined that the neurons for vision begin sending messages back and forth rapidly at 2 to 4 months of age, peaking in intensity at 8 months. It is no coincidence that babies begin to take notice of the world during this period.
- Before birth, an infant learns the “melody” of its mother's voice. During the first six years, its brain will set up the circuitry needed to understand and reproduce complex language. A six-month-old can recognize the vowel sounds that are the basic building blocks of speech.

BRAIN DEVELOPMENT

- Babies are born interested in listening to human voices and the tendency to produce babbling sounds. Talking to a baby, especially in the high-pitched, singsong speech style known as "Parentese," speeds up the process of learning new words and helps babies connect objects with words. Using simple but correct words and phrases is helpful in teaching language.

- Language skills are sharpest early on but grow throughout life. Recognition of speech begins at birth through ages 6 or 7; vocabulary starts growing during the second year and continues through adulthood.

BRAIN DEVELOPMENT

- Scientists believe that language is acquired most easily during the first ten years of life. During these years, the circuits in children's brains become wired for how their own language sounds.

- An infant's repeated exposure to words clearly helps her brain build the neural connections that will enable her to learn more words later on. For infants, individual attention and responsive, sensitive caregiving are critical for later language and intellectual development.

BRAIN DEVELOPMENT

- Research does not suggest drilling children in alphabet songs from different languages or using flash cards to promote rote memorization of letters and numbers. Children learn language best in the context of meaningful, day-to-day interactions with adults or other children.

- Schools can take advantage of this window of opportunity to teach language. If children are to learn to speak a second language like a native, they should be introduced to the language by age ten.

BRAIN DEVELOPMENT

- Early stimulation sets the stage for how children will learn and interact with others throughout life. A child's experiences, good or bad, influence the wiring of his brain and the connection in his nervous system. Loving interactions with caring adults strongly stimulate a child's brain, causing synapses to grow and existing connections to get stronger. Connections that are used become permanent. If a child receives little stimulation early on, the synapses will not develop, and the brain will make fewer connections.

- Recent research on one of the body's "stress-sensitive" systems shows how very stressful experiences also shape a child's developing brain. When children are faced with physical or emotional stress or trauma, one of these systems "turns on" by releasing the hormone cortisol.

BRAIN DEVELOPMENT

- High levels of cortisol can cause brain cells to die and reduces the connections between the cells in certain areas of the brain.
- Babies with strong, positive emotional bonds to their caregivers show consistently lower levels of cortisol in their brains. While positive experiences can help brighten a child's future, negative experiences can do the opposite. Too much cortisol in the brain can make it hard for children to learn and to think. And they may have trouble acting appropriately in stressful situations.
- Healthy relationships during the early years help children have healthy relationships throughout life. Deprived of a positive, stimulating environment, a child's brain suffers. Rich experiences, in other words, really do produce rich brains.

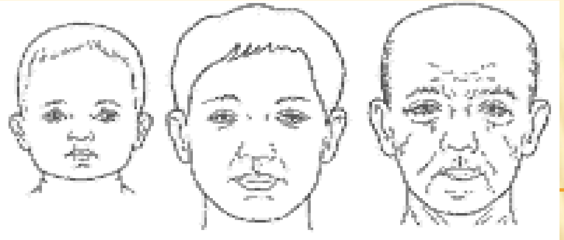
BRAIN DEVELOPMENT

- Every time a child hears the same story, she learns something new. New connections are made in the brain when Daddy reads a story to his child or has a conversation with her. These connections are reinforced through repetition. Repetition is a critical part of a child's learning because it builds the brain's wiring that makes new information permanent.

- Our brains continue to grow and change throughout our lives, based on the experiences we have. Brain development is not complete at birth. The changes in the brain that happen during early childhood form the foundation for a child's later development.

- A child makes brain connections with every experience she has. Connections are important. The more connections a child has, the more ways she has to process information.

BRAIN DEVELOPMENT



- The brain continues to change and mature throughout adolescence. An adolescent's brain reaches its adult weight by about age fourteen, partly because of increased myelination.

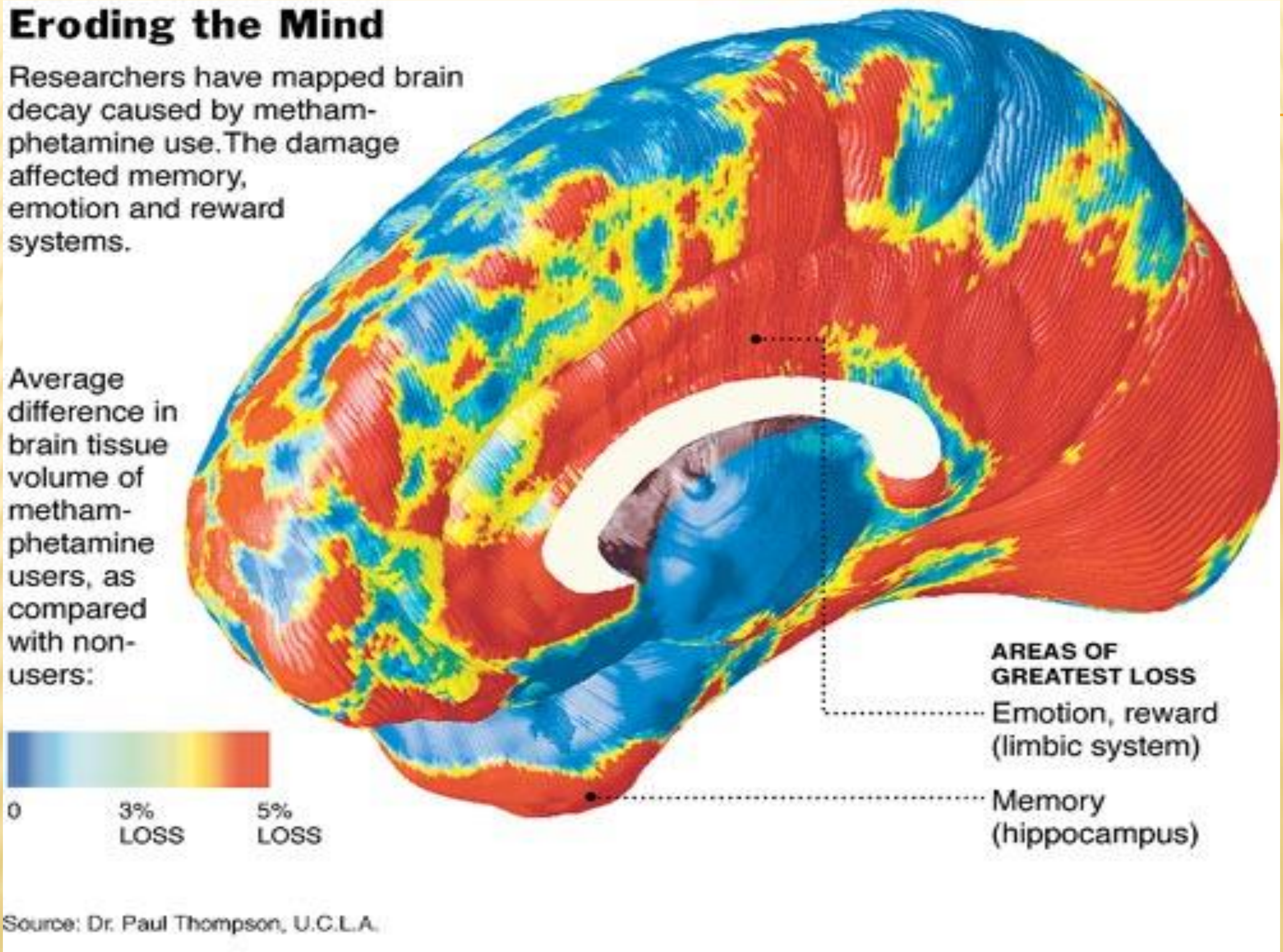
- As myelination and pruning continue during the teen years, adolescents become more capable of insight, judgment, inhibition, reasoning, and social conscience. Increased activity in the frontal lobes enables the adolescent to begin comparing or interrelating several concepts at once.

- Myelination of the frontal lobes is not complete until very late in adolescence. Some researchers estimate that frontal-lobe development continues until age 25 to 30. The regions in the frontal lobe which are responsible for judgment, planning, assessing risks, and decision-making are the last areas to finish developing. (schizophrenia & drugs)

BRAIN DEVELOPMENT

- Even in adulthood, the brain is continuously remodeling itself. The brain continues to develop connections throughout adulthood,but the rate of synapse formation is much slower than in childhood.

  Lifelong activity is important to maintain healthy brain growth. Areas of the brain that are not used regularly may eventually atrophy. Keeping the mind active is a key way to prevent brain atrophy. Activity can be as simple as reading, working crossword puzzles, or spending time talking to others and exercise.


Eroding the Mind
Researchers have mapped brain decay caused by methamphetamine use. The damage affected memory, emotion and reward systems.
Average difference in brain tissue volume of methamphetamine users, as compared with non-users:
0
3% LOSS
5% LOSS
AREAS OF GREATEST LOSS
Emotion, reward (limbic system)
Memory (hippocampus)
Source: Dr. Paul Thompson, U.C.L.A.

DRUG ADDICTION

- Saudi Arabia has a problem with drug addiction. It’s not the worst in the world, but it is serious enough to compel both government and society to look for solutions. In addition to prison, the Saudi government does support various rehabilitation programs, but those programs tend to take a single approach based on the theories of management.

- "Amphetamines are a major nightmare for men and women, especially teenagers, because students take them during exams to improve their performance. However, even though amphetamines increase alertness, they reduce concentration,"

- Amphetamines are highly addictive. "Fifty per cent of those who take it end up drug addicts, and more than 70 per cent end up with psychiatric disorders starting with depression and ending with schizophrenia. Up to one-third commit suicide,"

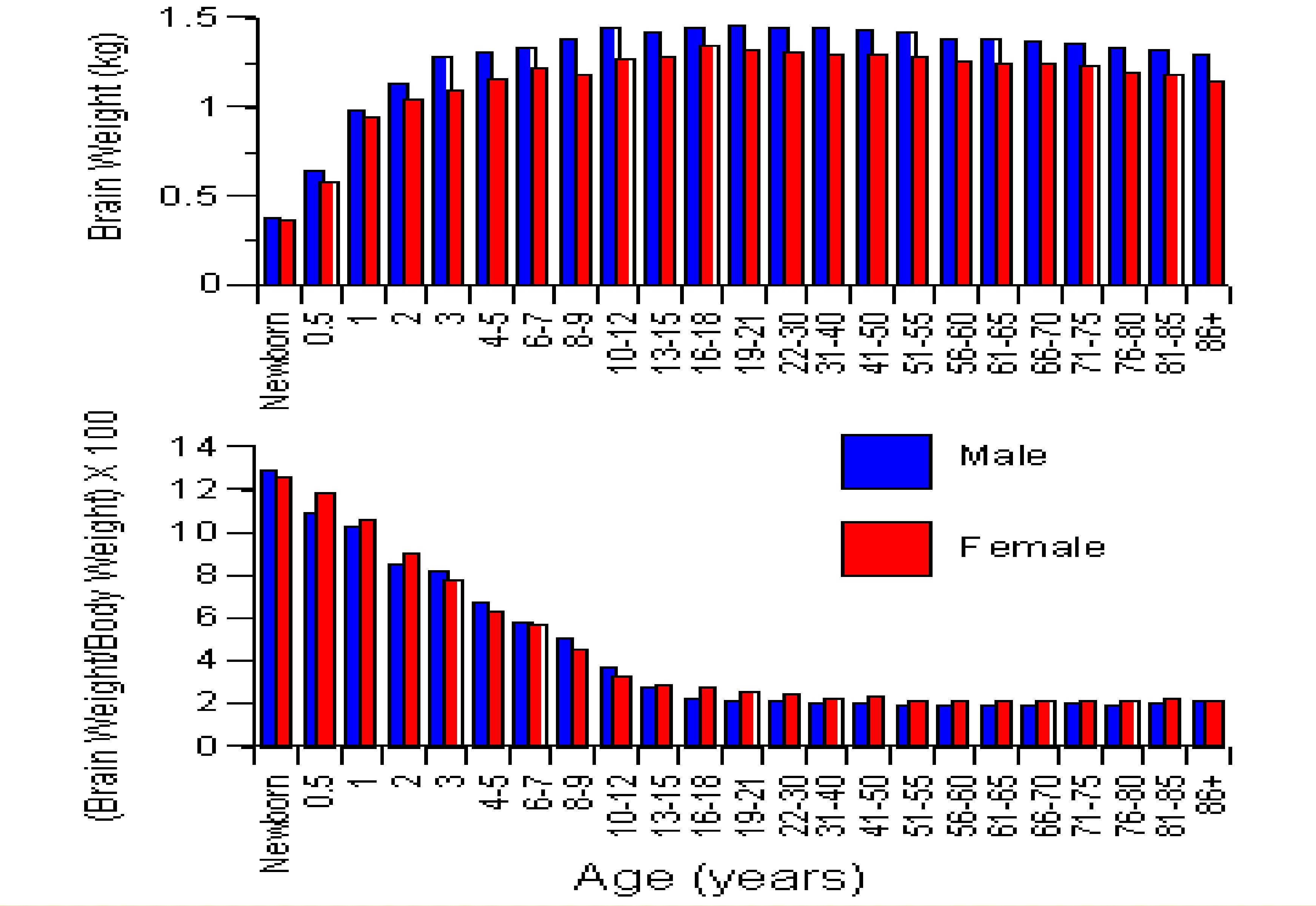
DRUG ADDICTION

- According to the Shoura Council, the number of drug addicts in the Kingdom rose from 109,000 in 2002 to 150,000 in 2005. A study conducted for the Royal Court by King Saud University found that boys as young as 10 years and girls as young as 13 are taking drugs in the Kingdom's public schools.

GRAPH BRAIN WEIGHT

- The top graph on the left shows the brain weights of males and females at different ages. The bottom graph shows the brain weight to total body weight ratio (expressed as a percentage). The adult brain makes up about 2% of the total body weight.

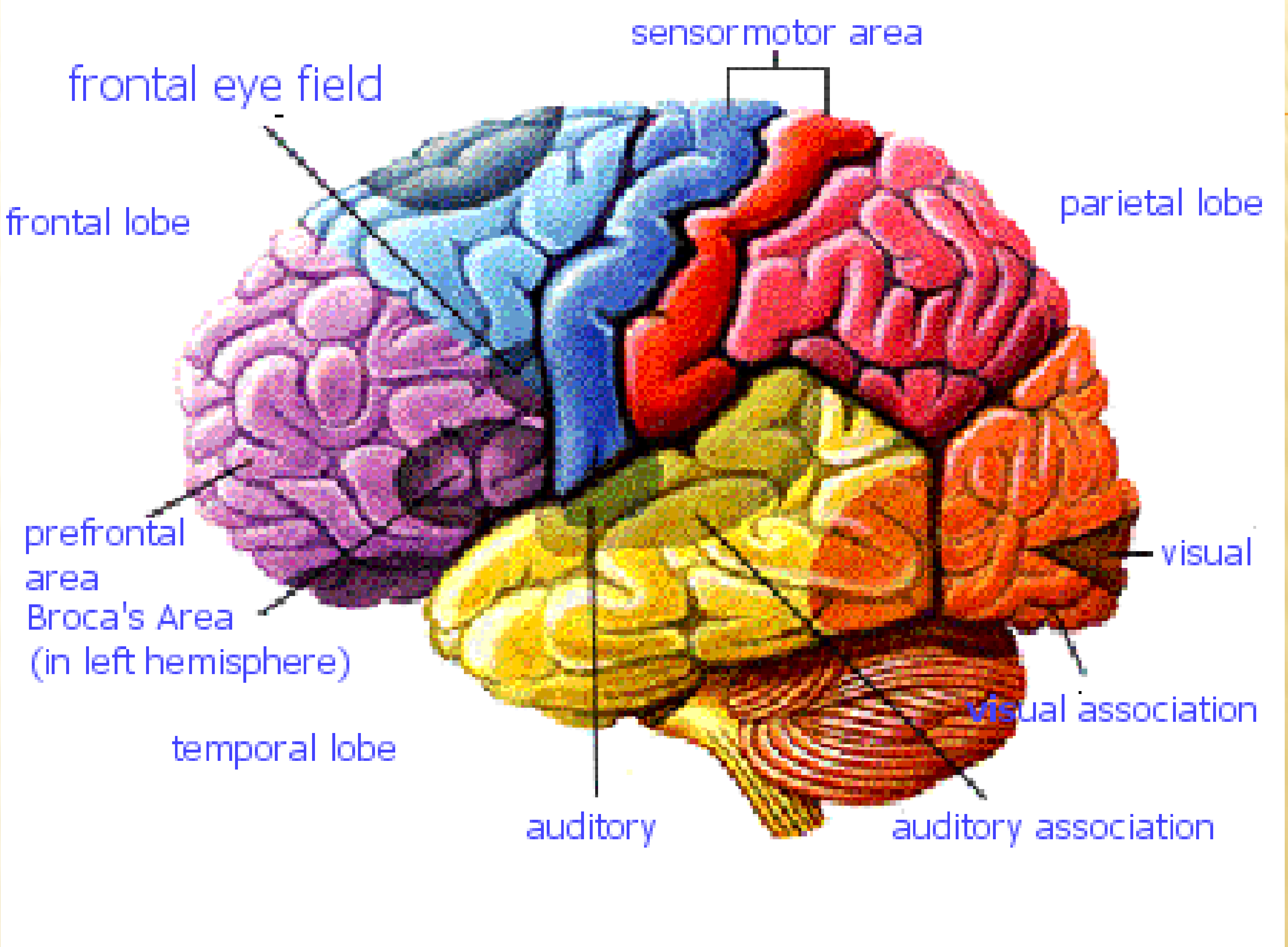
- Data from Dekaban, A.S. and Sadowsky, D., Changes in brain weights during the span of human life: relation of brain weights to body heights and body weights, *Ann. Neurology*, 4:345-356, 1978)



Brain Weight (kg)
1.5
1
0.5
0
Newborn
0.5
1
2
3
4-5
6-7
8-9
10-12
13-15
16-18
19-21
22-30
31-40
41-50
51-55
56-60
61-65
66-70
71-75
76-80
81-85
86+
(Brain Weight/Body Weight) X 100
14
12
10
8
6
4
2
0
Male
Female
Age (years)

LANGUAGE & THE BRAIN

- Left-hemisphere dominance for language
- Language damage far more likely following left-hemisphere damage
- Not so true in left-handers (around 50% show switched dominance)
- Not true in children
  - severe left-hemisphere damage (or loss) early in life: recovery very likely
  - **therefore:** Left Hemisphere specialization isn't fixed at birth … emerges in development
- Not entirely clear in females
  - LH damage: better chance for recovery of language functions than males
  - Recent fMRI evidence suggests that **some but not all** language functions may be less lateralized to the left hemisphere in females


sensor motor area
frontal eye field
frontal lobe
parietal lobe
prefrontal
area
Broca's Area
(in left hemisphere)
visual
visual association
temporal lobe
auditory
auditory association

EFFECTS OF NEGATIVE EXPERIENCES

- Negative experiences can damage brain development by slowing synaptogenesis, pruning, and myelination. Experiences such as poor nutrition, exposure to secondhand smoke, family stress, and child abuse or neglect may have profound, long-term effects on the development of a child's brain.

- For example, when a child has a negative experience such as being yelled at and criticized, her body responds by releasing chemicals that control the brain and activate the survival instinct. When in the survival mode, many of the body's systems slow down. If the body remains in the survival mode for an extended period of time, brain development and physical growth may slow down or even stop.

EFFECTS OF NEGATIVE EXPERIENCES

- The damaging effects of negative experiences depend on three factors:

- **Amount of Exposure.** Brains exposed to a greater amount of a negative experience are more likely to show significant damage.

- **Duration.** Brains exposed to negative stimulation over a longer period of time are likely to sustain more damage.

- **Timing.** Negative experiences during key sensitive periods in development are most likely to damage specific parts of the brain.