

**The Science Behind the Issue:**

**Adolescent Brain Development**

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# Agenda

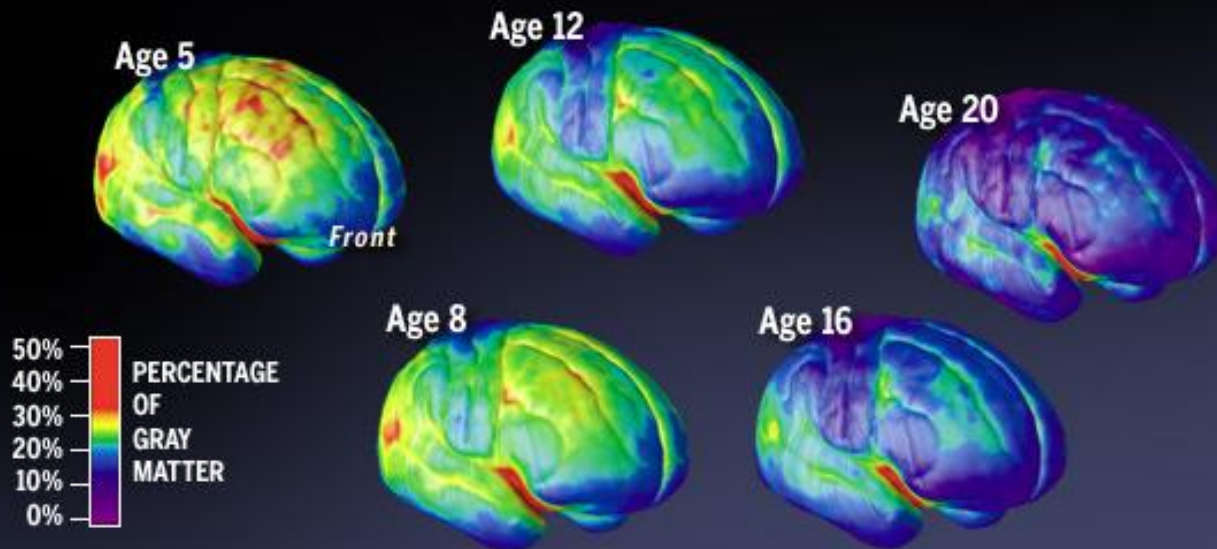
- What we know about adolescent development, capacities, decision making, behavior, and treatment needs and amenability
- The Neuroscience of Adolescence
- The Application of Neuroscience to Rehabilitation, Intervention and the Justice System

# What do we know about Brain Development?

# Brain Development

## Time-Lapse Brain

- Gray matter wanes as the brain matures. Here 15 years of brain development are compressed into five images, showing a shift from red (least mature) to blue.



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# Brain Development

## Child Brain Development



**GOOD NUTRITION LEADS TO MORE STABLE MOODS, INCREASES IN ABILITY TO PAY ATTENTION, AND IMPROVED MEMORY.**



**LOVING AND CONSISTENT CARE-GIVING LEADS TO A BRAIN THAT HAS AN ABILITY TO LEARN TO DELAY GRATIFICATION, PROBLEM SOLVE, AND HAVE EMPATHY FOR OTHERS.**

Brain

at birth, the brain has **200 billion** brain cells (called neurons)

the brain grows **1.7 grams a day** during baby's first year

**60%** of an infant's energy intake from food is used for **brain growth**

Nutrition

Social/  
Emotional

babies need loving interaction, touch, and parents that are tuned into their needs, **as much as they need nutrition**

by age one, infants typically understand about **70 words**, but speak only a handful of them

0-1  
years

communication across different regions of the developing brain occurs **most rapidly** during the first two years of life

by age two, the brain reaches about **75%** of adult weight

DHA, an omega-3 fatty acid, and choline, an essential nutrient, are **critical building blocks** for the developing brain

at this age, toddlers become **increasingly independent** and interested in new things.

1-2  
years

at 18 months, a toddler's spoken vocabulary starts to explode. **they add one new word every two waking hours.**

toddlers have more than **100 trillion** cell connections (called synapses) at age two, the most they'll ever have in their life.

by age two, the brain structure has the overall appearance of an **adult brain**

Calcium and vitamin D, which promotes calcium absorption, **help strengthen bones and teeth.**

toddlers **imitate behavior of others**, especially adults and older children

by two years, most toddlers have a **300-word vocabulary** and are putting together simple two word sentences.

A B C

2+  
years

# Brain Development

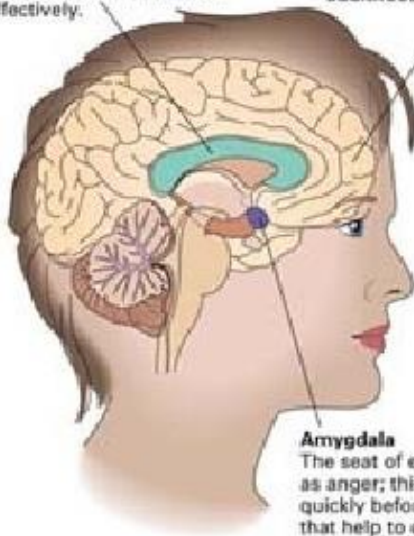
## BRAIN DEVELOPMENT ADOLESCENCE (12 – 19 YEARS)

### Corpus callosum

These nerve fibers connect the brain's two hemispheres; they thicken in adolescence to process information more effectively.

### Prefrontal cortex

This "judgment" region reins in intense emotions but doesn't finish developing until at least emerging adulthood.



### Amygdala

The seat of emotions such as anger; this area develops quickly before other regions that help to control it.

### Brain undergoes structural changes

#### Age 12 - Parietal Lobe mature

- **Corpus callosum**

- nerve fibers connect the brain's left and right hemispheres
- thickens, improves adolescents' ability to process information

- **Amygdala** - matures earlier than the prefrontal cortex

- **Synapses** – at adult density

#### 18 – 25 years: Frontal Lobe/ Prefrontal cortex matures

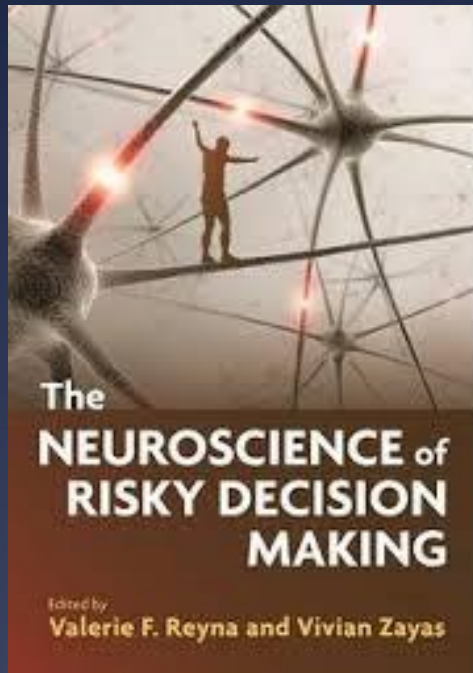


Because of structural and chemical changes in the brain, we know that....

Adolescence extends to young adulthood.

Adolescents do not process information as efficiently as adults

Older adolescents may be as capable as adults of making decisions in some contexts



Adolescents are more sensitive to emotion and social evaluation

Adolescents' capacities to weigh risks and long-term consequences are relatively impaired



Adolescents have different needs than children or adults

- Sleep
- Physical activity
- Exposure to range of activities & risks
- Active teaching of thinking

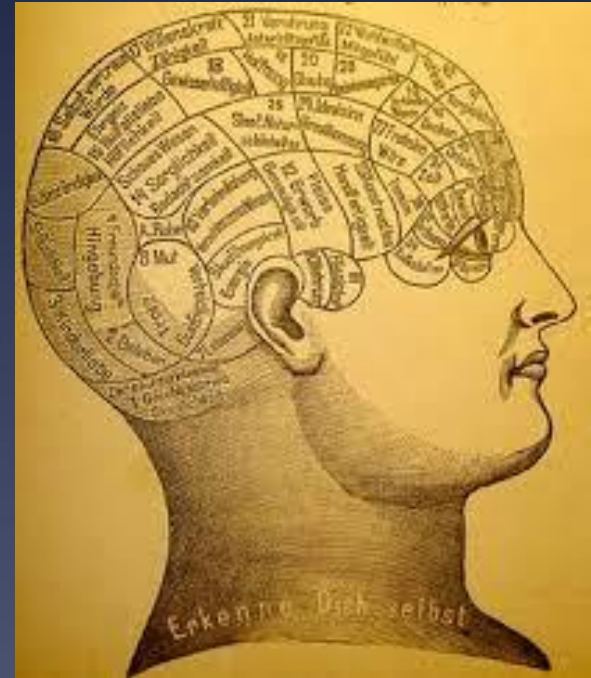
Because of physical and chemical changes in the brain, we know that....

Adolescents are particularly susceptible to the environment

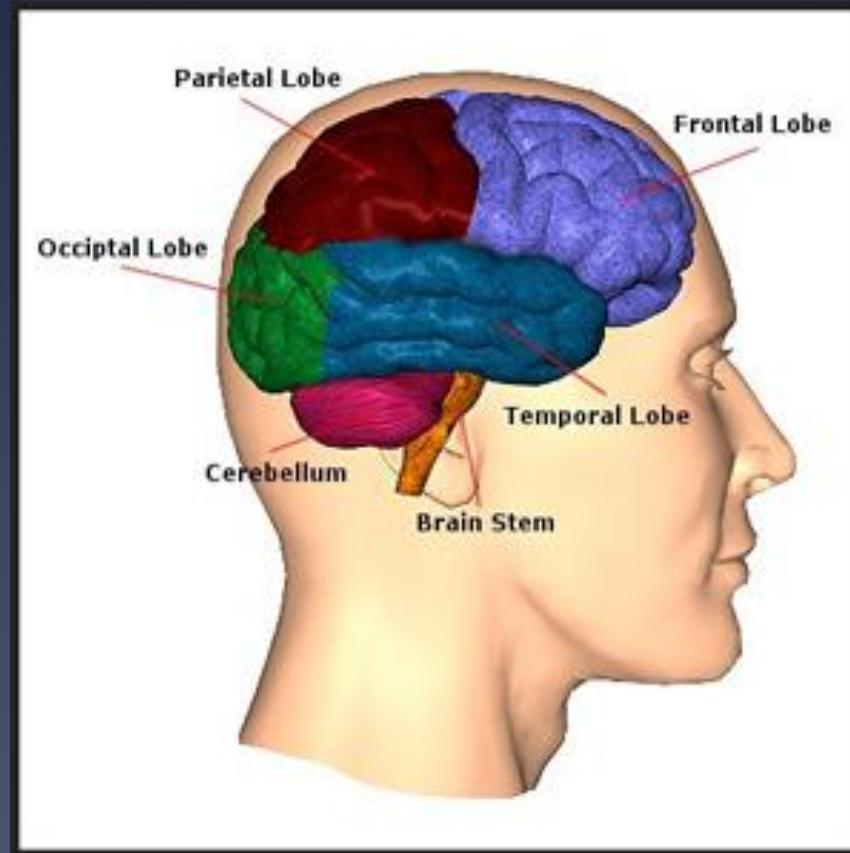


Adolescence is a time of increased vulnerability and opportunity

# The Science of Adolescent Brain Development



# Brain Structures



# Frontal Lobe

**Frontal Lobe:**  
Thinking,  
Planning

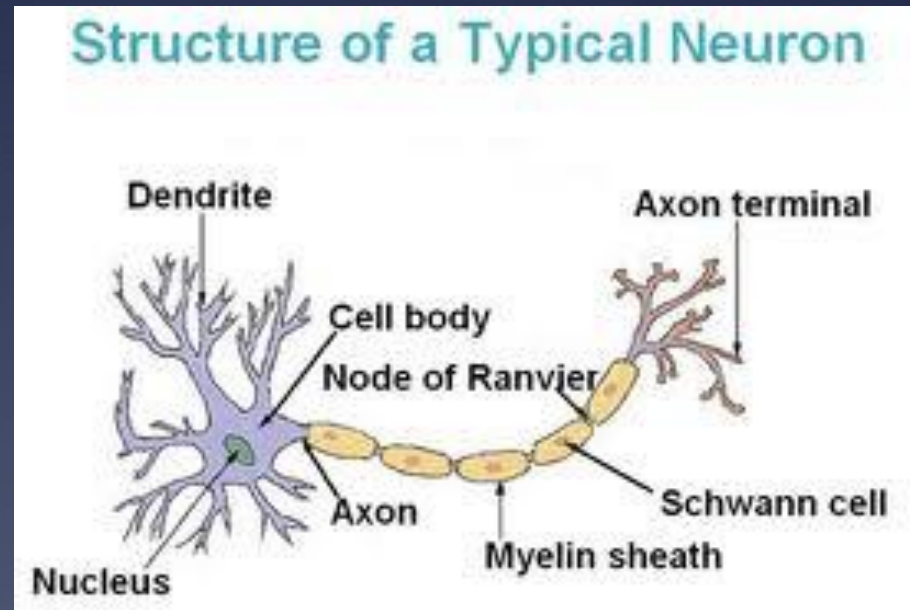
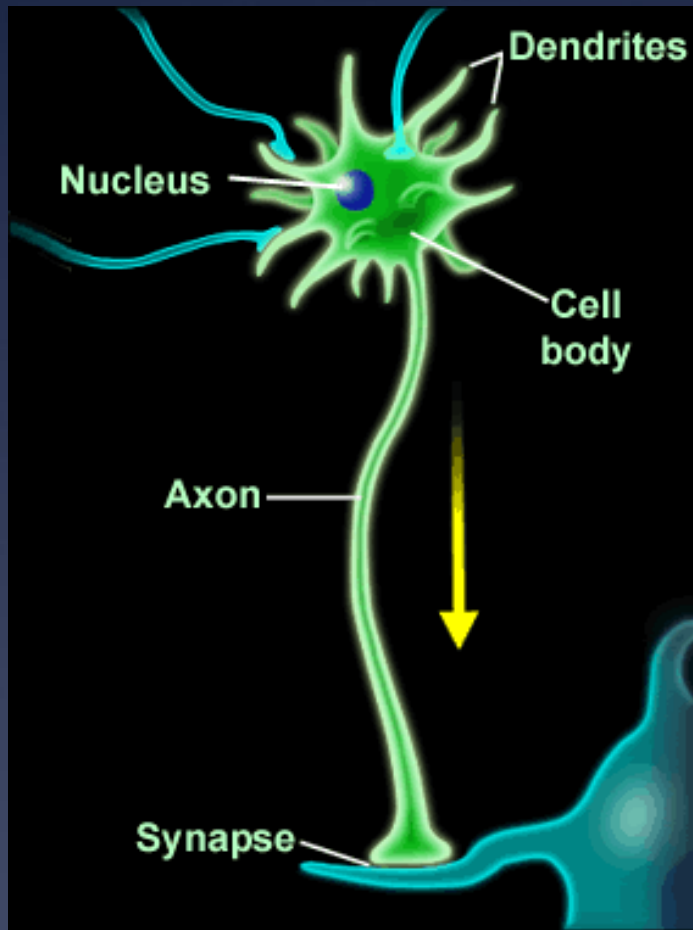
**Parietal Lobe:**  
Perception

**Temporal Lobe:**  
Memory,  
Language

**Occipital Lobe:**  
Vision



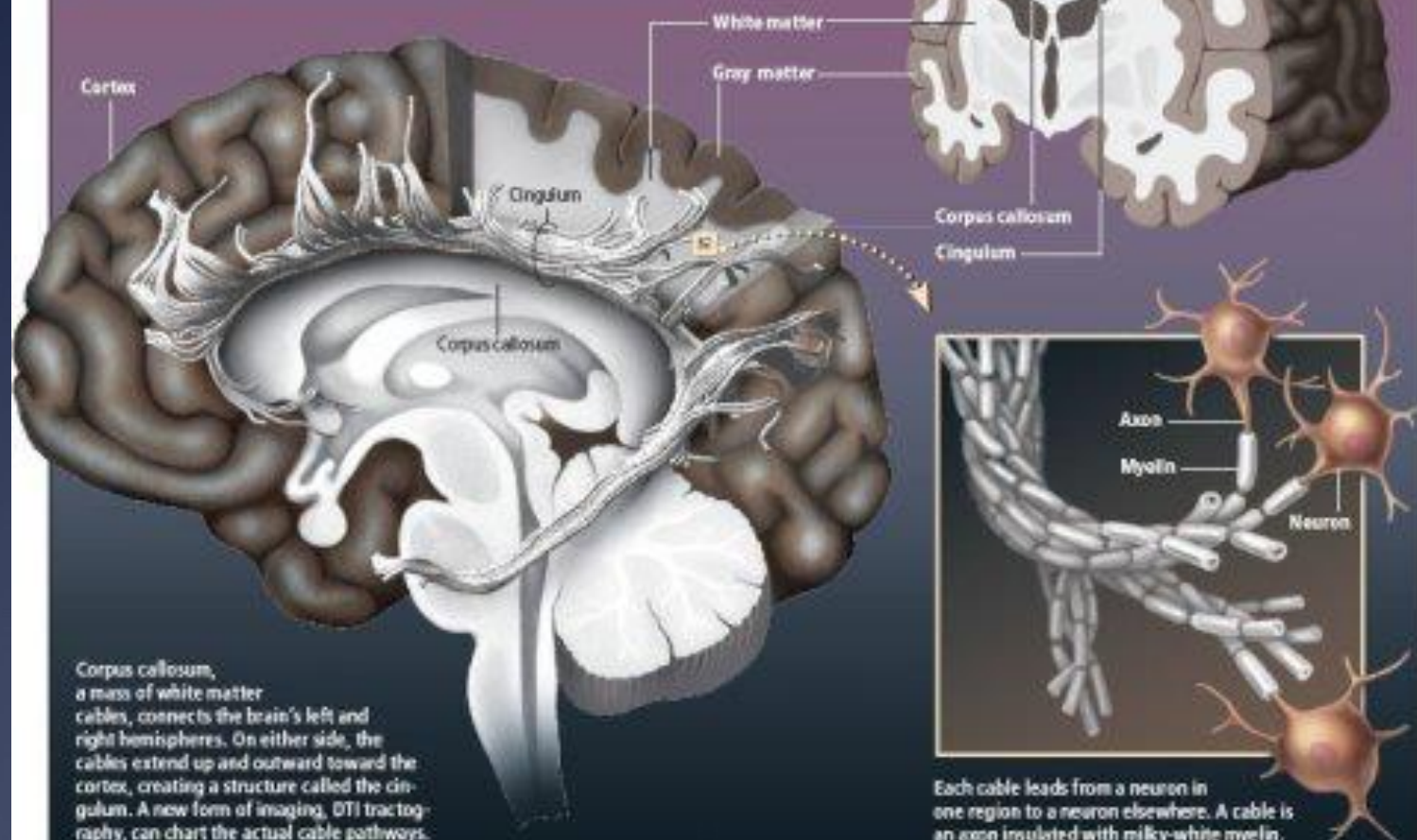
# The Neuron: Transmitter of Information



[BASICS]

## WHAT IS WHITE MATTER?

White matter fills nearly half the brain. It consists of millions of cables (*white*) that connect individual neurons (*gray matter*) in different brain regions, like trunk lines connecting telephones across a country.

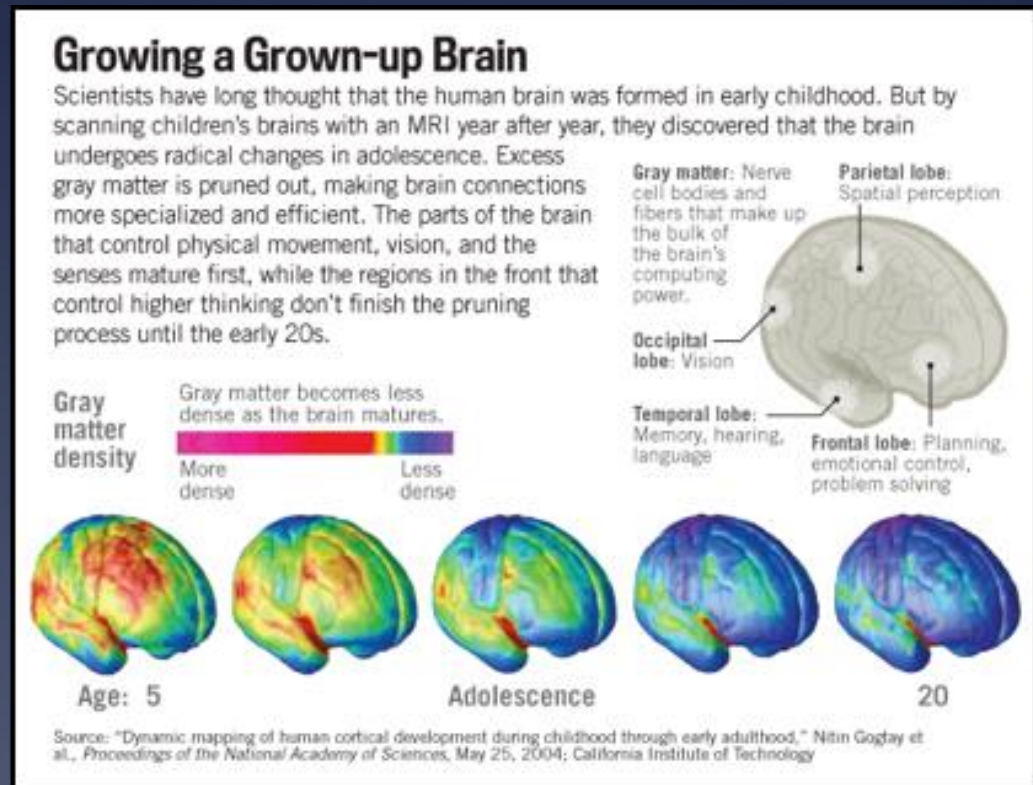


Corpus callosum, a mass of white matter cables, connects the brain's left and right hemispheres. On either side, the cables extend up and outward toward the cortex, creating a structure called the cingulum. A new form of imaging, DTI tractography, can chart the actual cable pathways.

Each cable leads from a neuron in one region to a neuron elsewhere. A cable is an axon insulated with milky-white myelin.

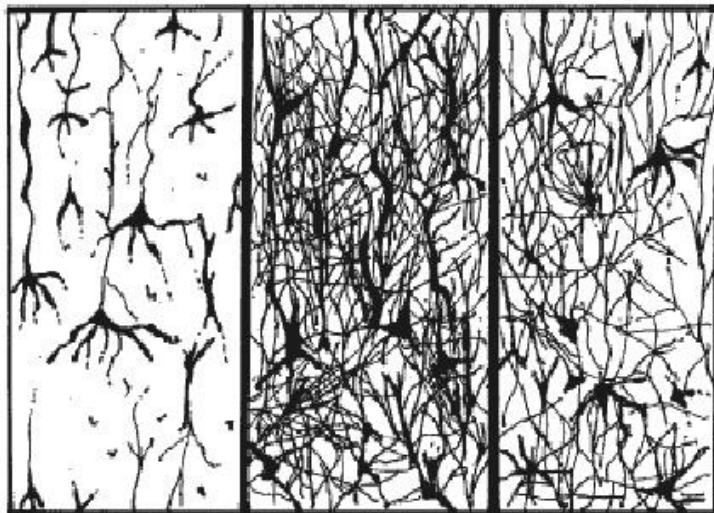
# Changes in the Brain

- \* White matter increases (linear) during myelination
- \* Gray matter increases and then begins to decrease as pruning occurs.





# Synaptic Pruning



at a child's birth

at 7 years of age

at 15 years of age

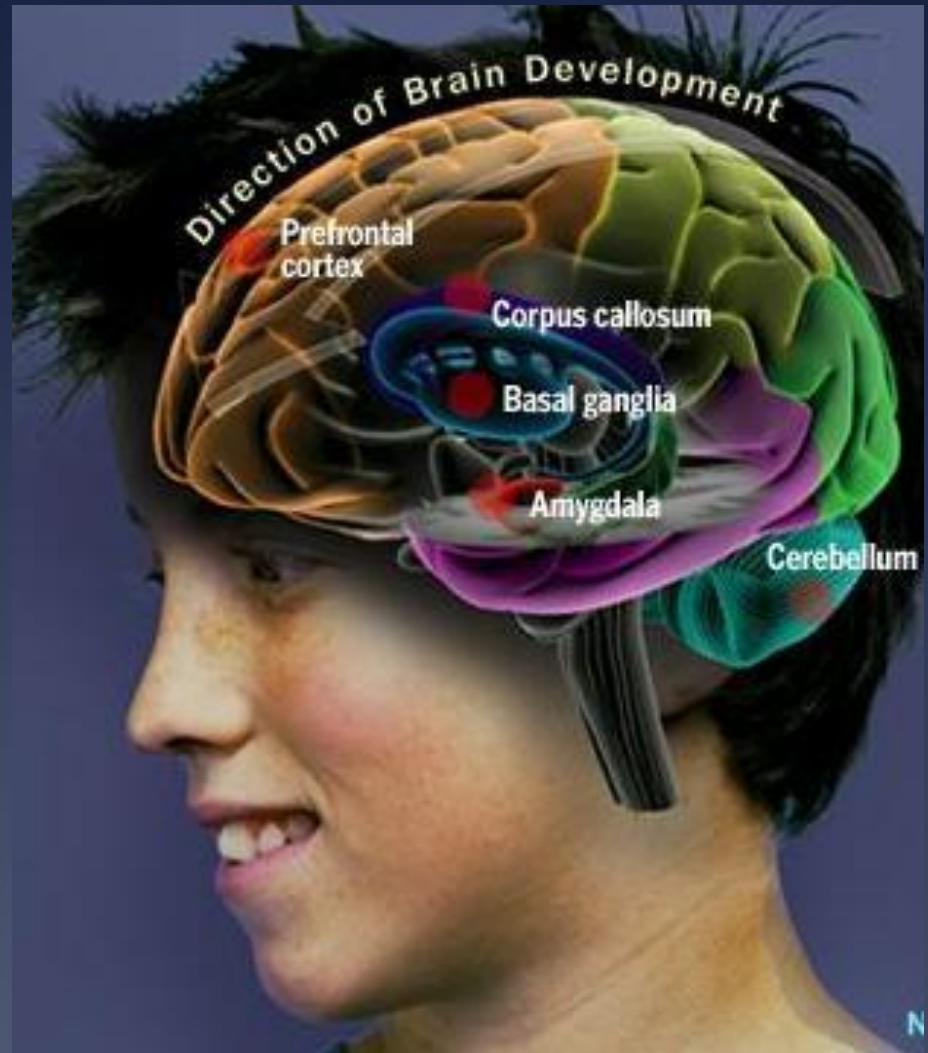
The first change after this synaptic growth spurt is a selective pruning which takes place.

In adolescence, most of this pruning is taking place in the frontal lobes.

The adolescent loses approximately 3 percent of the gray matter in the frontal lobes.

# Adolescent Brain Development

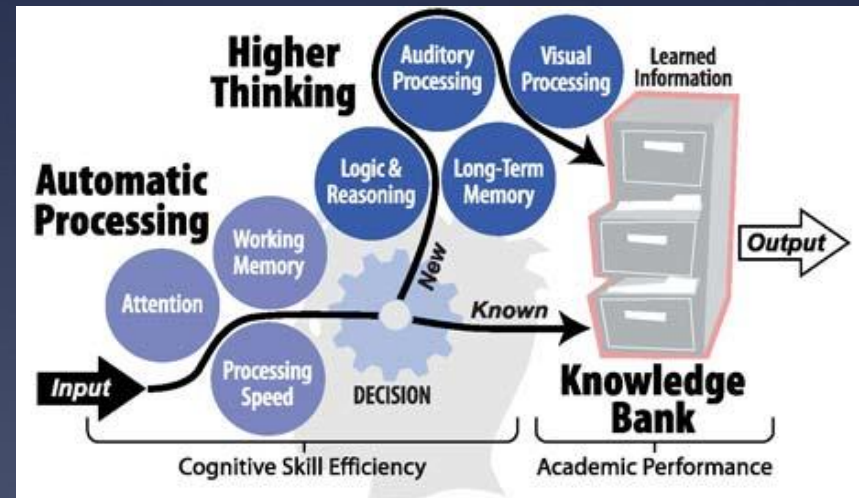
- Changes in gray and white matter
- Location and direction of change



Ken Winters, Ph.D. University of Minnesota  
<http://pruegill.wordpress.com/>

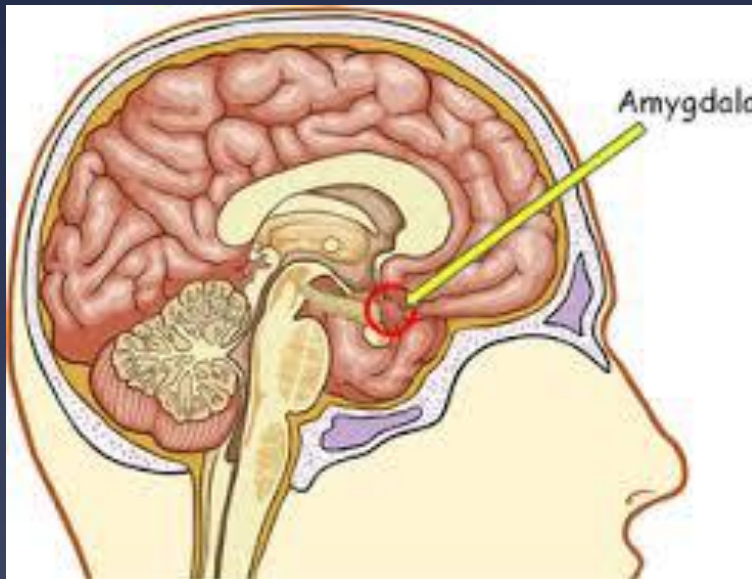
# Cognitive Skill Development Improvements in

- \* Information processing speed, memory
- \* Planning, reasoning about hypothetical situations, reflection, introspection
- \* “Executive functioning” – regulation of lower processes, inhibition, planning, goal-setting



# The Amygdala

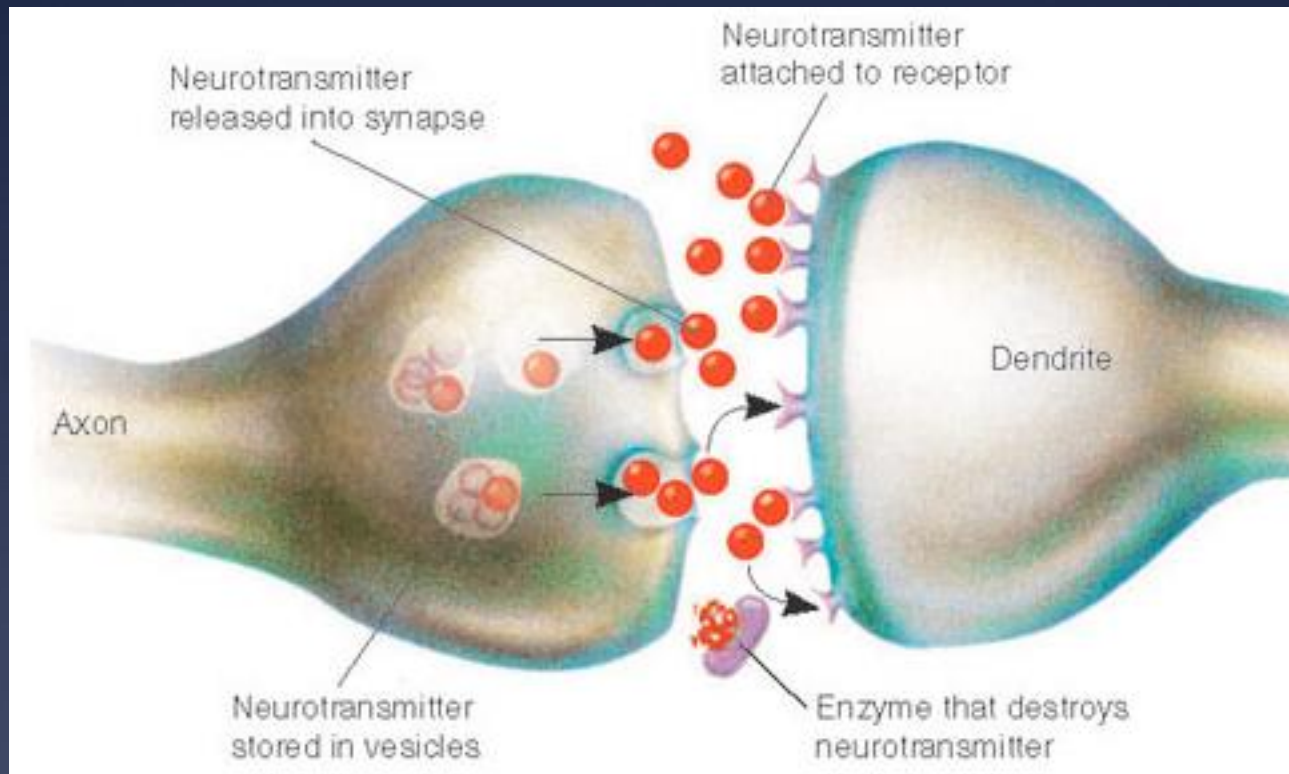
and connections to other regions



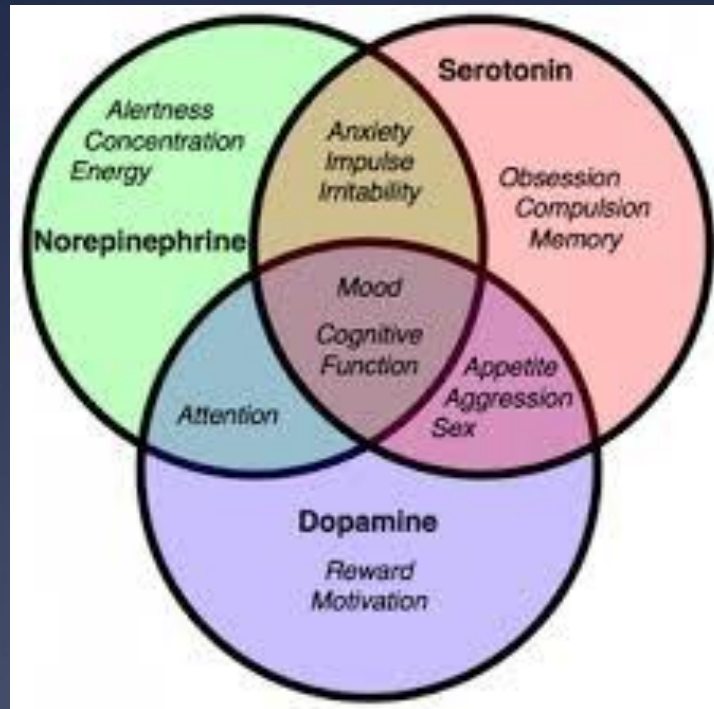
Processing Emotions  
and signals of  
emotion

Planning Defensive  
responses

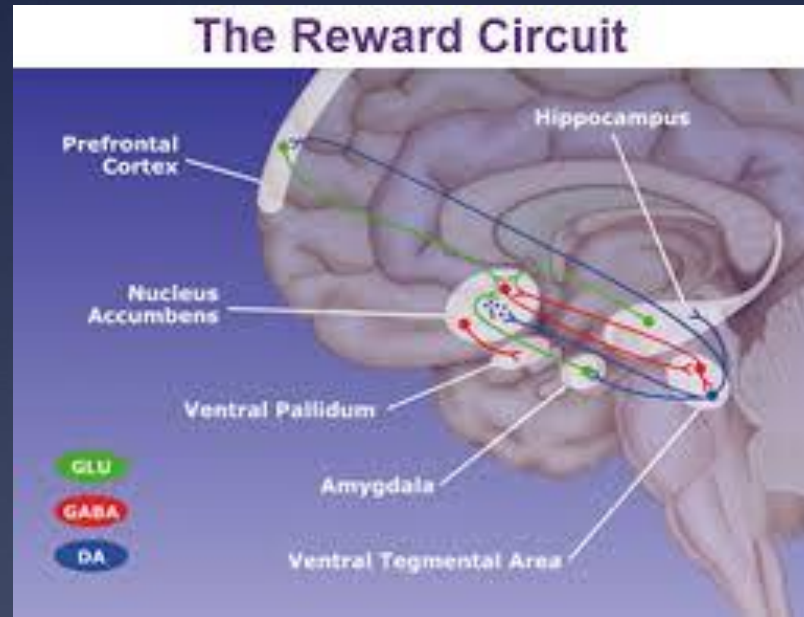
# Neurotransmitters



# Neurotransmitters



# Dopamine



During adolescence there is an increase in the activity of the neural circuits using dopamine, a neurotransmitter central in creating our drive for reward.

# Dopamine

Enhanced dopamine release/reactivity causes....

- Thrill seeking behavior
- Selective focus on rewards rather than risks
- Increased susceptibility to alcohol/substance abuse

Research even suggests that the baseline level of dopamine is lower—but its release in response to experience is higher—which can explain why teens may report a feeling of being “bored” unless they are engaging in some stimulating and novel activities.



# Effect of Adolescent Brain Development on Behavior

Ineffective levels of neurotransmitters



Moody, less attentive, ineffective problem solving, & more risky behaviors

Less reliance on frontal lobes in decision making



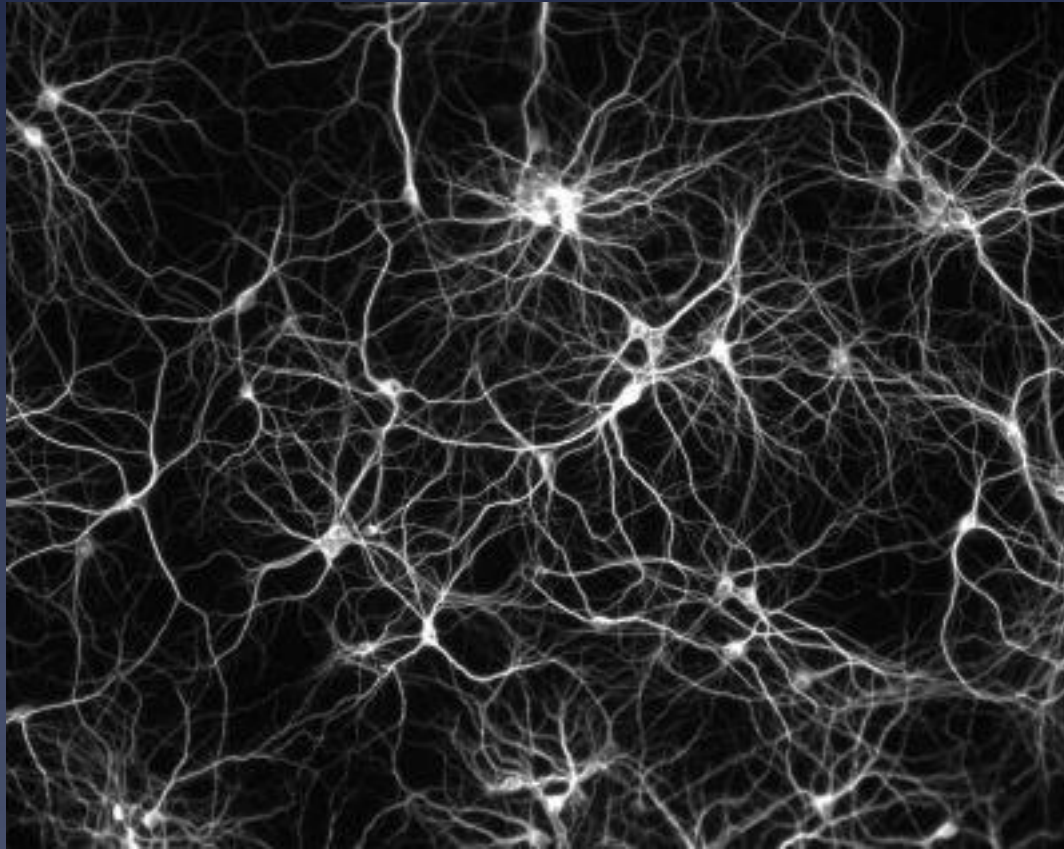
Impulsivity, “gut” reactions; problems ignoring distractions

Less efficient connections, such as those to and from memory centers of the brain



Less reliance on experience and memory in decision making

# Implications for Intervention



# Implications

## Intervention

Increasing family, social, and community support can minimize psychosocial stress during adolescents

Adolescents learn better when responding to rewards rather than through punishment (or removal of rewards).

Adolescents benefit from treatment and skills-development, both behaviorally and through structural changes in the brain

# Summary

## Cognitive Functioning

- Decision Making, Problem Solving
- Reasoning Ability
- Planning
- Weighing Consequences

## Emotional Functioning

## Behavioral Impulsivity and Risk Taking

## Increased Vulnerability and Unique Needs

## Treatment Amenability

# Summary of Findings and Implications

In some situations, adolescents make decisions as well as adults

Adolescents are less efficient in processing information pertaining to social cognition

Adolescents are more sensitive to the effects of emotion and social evaluation

Adolescents' emphasis on short-term rewards increases their involvement in risk-taking behaviors

Adolescence is a critical time, both for protection and for intervening and developing life skills.

# Resources & References

National Institute of Mental Health: The Teen Brain: Still Under Construction

- \* L. P. Spear. The Behavioral Neuroscience of Adolescence. W.W. Norton: London (2010).
- \* L. Steinberg, Ph.D. Age of Opportunity: Lessons from the new science of adolescence. 2014
- \* M. K. Jetha, S. J. Segalowitz. 2012. Adolescent Brain Development: Implications for behavior.

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