Adolescent Brain Development

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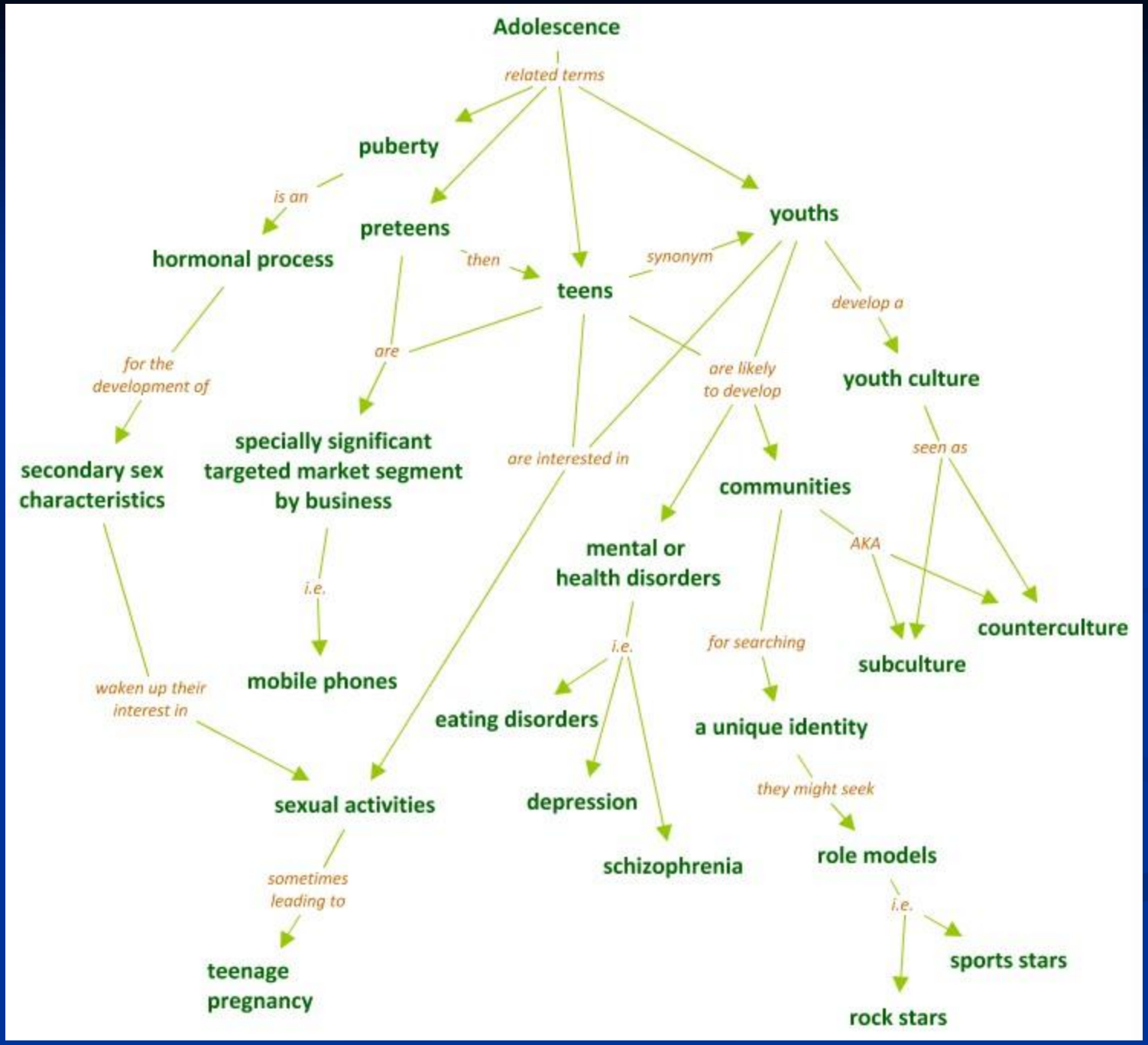
Adolescence

The period of life, from about **age 13 to early 20s**, during which a young person is **no longer physically a child**, and **not yet a full adult**

Puberty

Physical changes that occur in the body as **sexual development** reaches its peak

- **Primary sex characteristics**
  - Sex organs
- **Secondary sex characteristics**
  - Other body changes


Adolescence
related terms
puberty
is an
hormonal process
preteens
then
teens
synonym
youths
develop a
youth culture
for the development of
secondary sex characteristics
are
specially significant targeted market segment by business
i.e.
mobile phones
waken up their interest in
are interested in
sexual activities
are likely to develop
communities
seen as
AKA
counterculture
subculture
mental or health disorders
i.e.
eating disorders
depression
schizophrenia
for searching
a unique identity
they might seek
role models
i.e.
sports stars
rock stars
sometimes leading to
teenage pregnancy

Adolescence

- Cognitive changes
- Emotional changes
- Social changes.

Psychosocial Development

- Who am I?
- What are the things that are important to me?
- What do I want to become?
- What are the values that I believe in?

Search for a consistent sense of self

Psychosocial Development

Parent-Teen Conflict

- A **certain amount of rebellion and conflict** is **necessary to break away** from childhood dependence on parents and **become a self-sufficient adult**

Adolescent Psychosocial Development

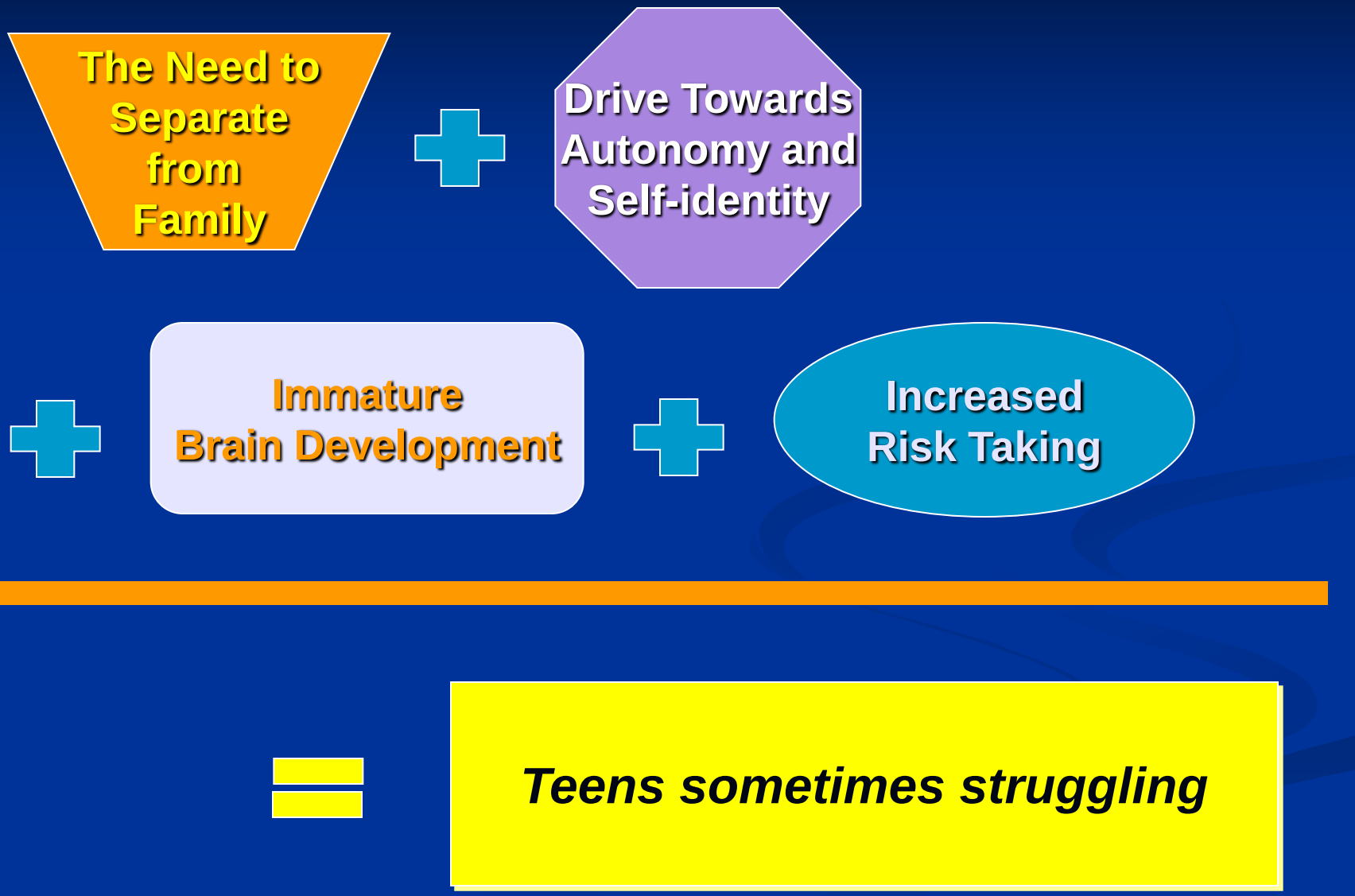
- Internal Influences
  - **Adolescent Cognitive Development**
- External Influences
  - **Adolescent Social Development**

Adolescent Social Development

- Key social developmental task
  - establishment of own identity
  - to separate from the family

Adolescent Cognitive Development

- The hormone-brain relationship contributes to increased risk-taking at a time when the center of the brain that puts on the brakes is still under construction.
  - How will knowing this affect how you work and talk with teens?


The Need to Separate from Family
Drive Towards Autonomy and Self-identity
Immature Brain Development
Increased Risk Taking
Teens sometimes struggling

Adolescent Social Development

- Teens are influenced by:
  - Family
  - Peers
  - School
  - Community norms
  - Cultural norms
- Teens are influenced by personal experiences

Relationship Tasks

- To navigate their world, teens need to develop:
  - biologically (brain)
  - emotionally (maturity) or
  - socially (self-identity vs. peer pressure)

Cognitive changes

- At the middle to late adolescence capable of doing extremely sophisticated intellectual tasks

Cognitive development

- High ability at abstract thinking---- deal with complex and difficult educational challenges

- Formal operational thinking and the ability to store information in the memory after perceiving it

Cognitive development

- The new information available to adolescent, along with more sophisticated ways of analysis, often make him or her to be a rebel, a complainer or accuser

Cognitive development

- Thinking becomes abstract and future-oriented
- Show remarkable creativity
  - Writing, music, art, poetry
- Interest in the world of ideas
  - Humanitarian issues, morals, ethics and religion
- Keep a personal diary
- Major task: Achieve a secure sense of self
- Identity crisis partly resolved by the move from dependency to independence

Cognitive Development

Adolescents move into the **formal operations** stage in which **abstract thinking** becomes possible

- Final development of the **frontal lobes**, responsible for organizing, understanding and decision-making

What are the cognitive abilities of adolescents?

Cognitive Development

Egocentrism

- Adolescents tend to be **deeply pre-occupied with their own thoughts** and the importance of their own thoughts to other people

"Everything is about me."

Cognitive Development

Personal Fable

- Adolescents feel that **they are special and unique**, that no one else have ever had the same thoughts and feelings that they have

"I am different. You just don't understand me."

Cognitive Development

Personal Fable

- Adolescents may **feel that they are protected from risk and harm** because of their uniqueness, thus **failing to take the necessary precautions**

"I am special. That won't happen to me. Not me."

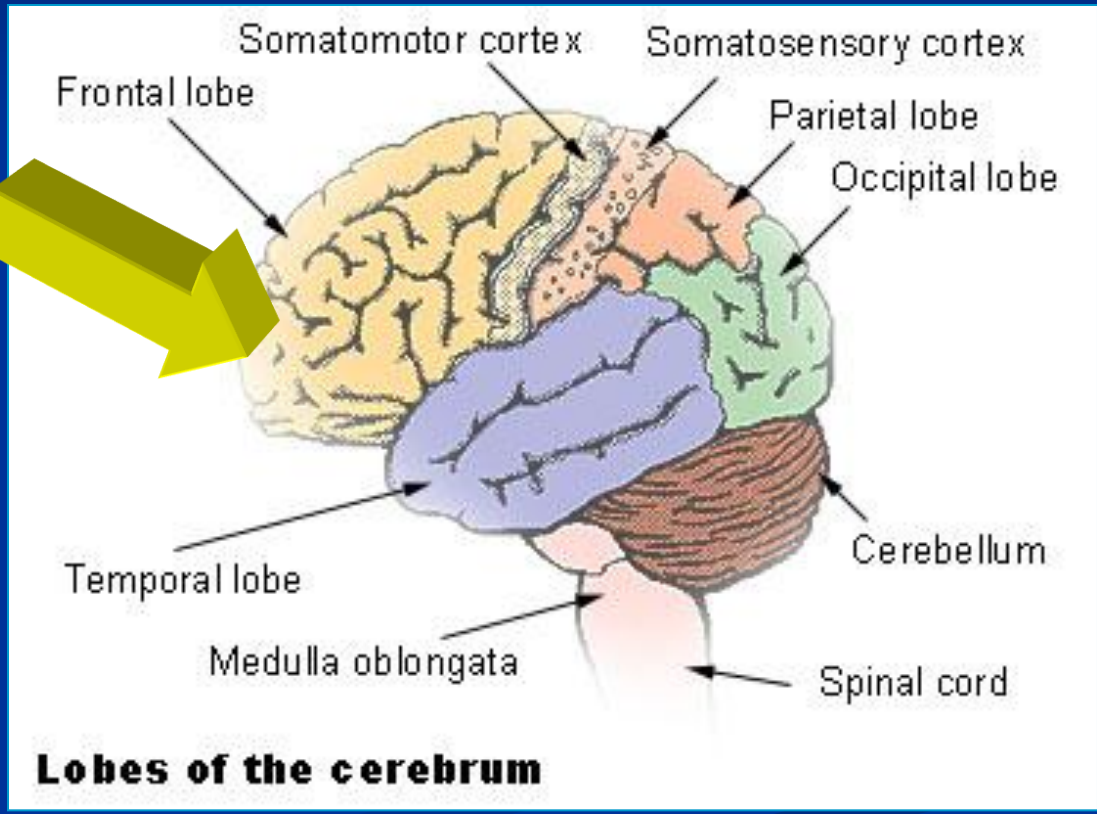
Cognitive Development

Imaginary Audience

- Adolescents believe that **other people are always watching them, concerned** about their thoughts and characteristics
- **Extreme self-consciousness**

Adolescent Cognitive Development

- **Prefrontal cortex regulates:**
  - planning
  - setting priorities
  - organizing thoughts
  - suppressing impulses
  - weighing consequences of one's actions



Adolescent Brain Development

Introduction: The Human Brain

- The most complex three pound mass in the known universe
- At four weeks gestation, neurons are forming at 250,000 per minute
- ≈ 90% of its adult size by age 6
- The average adult brain contains around 100 billion neurons

Prefrontal Cortex

- "CEO" of the brain
- Memory
- Voluntary Motor Control
- Attention
- Reasoning
- Planning
- Decision Making
- Impulse Control
- Abstract Thinking

Gray vs. White Brain Matter

- Gray Matter
  - Neurons' cell bodies and dendrites
  - "Thinking" portion of brain
- White Matter
  - Insulation for neurons = myelination
  - Enhances efficiency

Brain Development

- 3-4 weeks gestation
  - Key events in CNS development
  - Fold of ectodermal tissue into neural tube
- 4-12 weeks gestation
  - Neural tube becomes different parts of nervous system
  - Forebrain and spinal cord develop

Source: Lenroot RK. Giedd JN. Brain development in children and adolescents: insights from anatomical magnetic resonance imaging. [Review] [94 refs] Neuroscience & Biobehavioral Reviews. 30(6):718-29, 2006.

Brain Development

- 12-20 weeks gestation

  Neurons multiply and migrate

- 15 weeks gestation

  Surface of brain begins to fold into sulci and gyri

Source: Lenroot RK. Giedd JN. Brain development in children and adolescents: insights from anatomical magnetic resonance imaging. [Review] [94 refs] Neuroscience & Biobehavioral Reviews. 30(6):718-29, 2006

Brain Development

- 20 weeks gestation

  Proliferation and organization of synapses

- 24 weeks gestation to 4 weeks after birth

  Rapid cell death

Source: Lenroot RK. Giedd JN. Brain development in children and adolescents: insights from anatomical magnetic resonance imaging. [Review] [94 refs] Neuroscience & Biobehavioral Reviews. 30(6):718-29, 2006

Critical Periods

- Window of time in which brain must receive certain type of stimuli to develop optimally
- Examples in humans
  - Vision
  - Hearing

Introduction: Adolescence

- Interplay of changes
  - Emotions
  - Hormones
  - Physical Body
  - Judgment

Adolescence: Definition

Transition from childhood to adulthood

- No fixed age range
- Individual acquires skills necessary to survive on own

Adolescence: Behavior

- Behavior characterizing adolescence
  - Increased risk-taking and novelty seeking

Adolescence: Puberty

- Puberty = sexual maturation process that occurs during adolescent period
- Puberty ≠ Adolescence
- Girls begin puberty 1-2 years before boys

Adolescence: Puberty

- Hormonal Change:
  - Hypothalamic-Pituitary-Gonadal Axis
    - Gonadotropin-releasing hormone from hypothalamus
    - FSH and LH from pituitary gland
    - Estrogen and testosterone from ovary
    - Testosterone from testis

Adolescence: Brain Development

- Unique Process
- Neuronal circuitry changing
- Discoveries made possible by advanced brain imaging technology

Imaging in Children/Adolescents

- Studies previously limited: CT scans and x-rays exposed children to ionizing radiation
- Magnetic Resonance Imaging (MRI)
  - Non-ionizing radiation
  - Provides detailed images of brain

MRI Studies of Brain Development

- 1980s
  - First MRI studies of brain development
- 1990s
  - General findings: white matter increases and gray matter decreases

Source: Lenroot RK. Giedd JN. Brain development in children and adolescents: insights from anatomical magnetic resonance imaging. [Review] [94 refs] Neuroscience & Biobehavioral Reviews. 30(6):718-29, 2006.

Adolescent Brain Development: NIMH Study

- First large scale longitudinal study
  - NIMH Child Psychiatry Branch 1989
  - Scans children/adolescents at 2 y intervals
  - Dec '05: 4000 scans from 2000 subjects

Source: Lenroot RK. Giedd JN. Brain development in children and adolescents: insights from anatomical magnetic resonance imaging. [Review] [94 refs] Neuroscience & Biobehavioral Reviews. 30(6):718-29, 2006.

Adolescent Brain Development: NIMH Study

- Three goals of study
  - Map developmental trajectories of brain development
  - Differentiate genetic vs. environmental influences
  - Use results of study to guide treatment or optimize healthy brain development

Source: Lenroot RK. Giedd JN. Brain development in children and adolescents: insights from anatomical magnetic resonance imaging. [Review] [94 refs] Neuroscience & Biobehavioral Reviews. 30(6):718-29, 2006.

Adolescent Brain Development

Dr. Giedd et al. 1999

- Longitudinal study on 145 children/adolescents
- Two "waves" of gray matter over-production
  - Conception to 18 months
  - Adolescent period

Source: Giedd JN, Blumenthal J, Jeffries NO, et al. Brain development during childhood and adolescence: a longitudinal MRI study. *Nature Neuroscience*, 1999; 2(10): 861-3.

Adolescent Brain Development

- Increased cortical gray matter
  - Extra connections between neurons "arborization"
- Maximum thickness at different times

	Female age	Male age
Frontal Lobe	11 y	12.1 y
Parietal Lobe	10.2 y	11.8 y
Temporal Lobe	16.7 y	16.2 y

Source: Lenroot RK. Giedd JN, Blumenthal J, Jeffries NO, et al. Brain development during childhood and adolescence: a longitudinal MRI study. *Nature Neuroscience*, 1999; 2(10): 861-3.

Adolescent Brain Development

Late development of prefrontal cortex

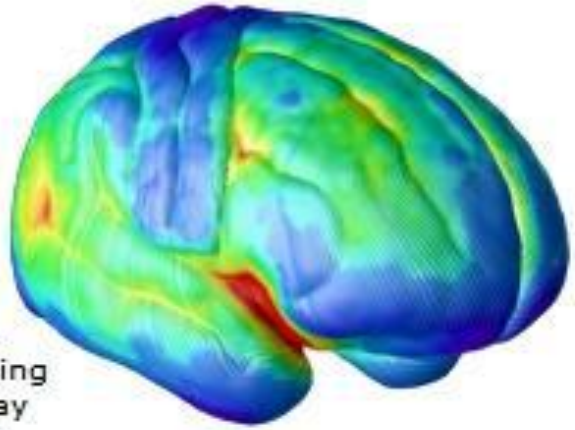
- Gray matter loss occurs latest in the dorsolateral prefrontal cortex (DLPFC)
- Reaches adult levels ~ 20s
- Portion of brain involved in higher order cognitive functions

Source: Giedd JN. Structural Magnetic Resonance Imaging of the Adolescent Brain. Ann. N.Y. Acad. Sci. 2004; 1021: 77-85

Adolescent Brain Development

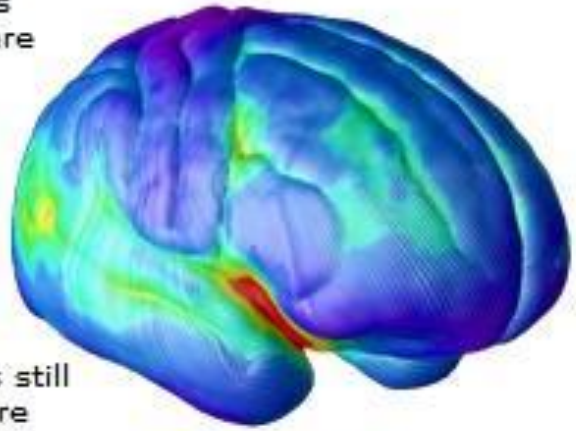
- Sowell et al. 1999
  - Compared brain MRI scans of 23-30 year olds to 12-16 year olds
  - Areas of frontal lobe showed the largest differences among these two groups

Source: Teenage Brain: A work in progress; available at www.nimh.gov



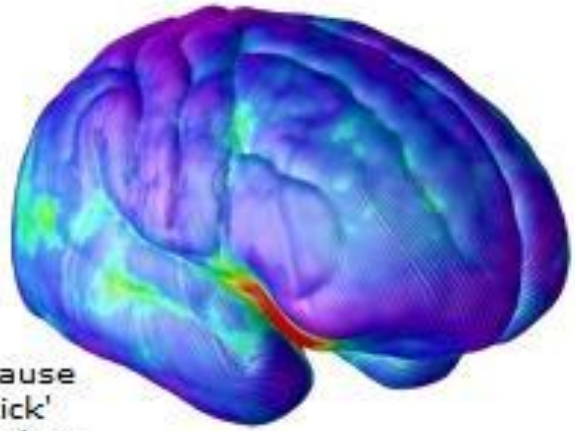
Age 12

During adolescence, the brain is undergoing a lot of changes. Gray matter diminishes as neural connections are pruned.



Age 16

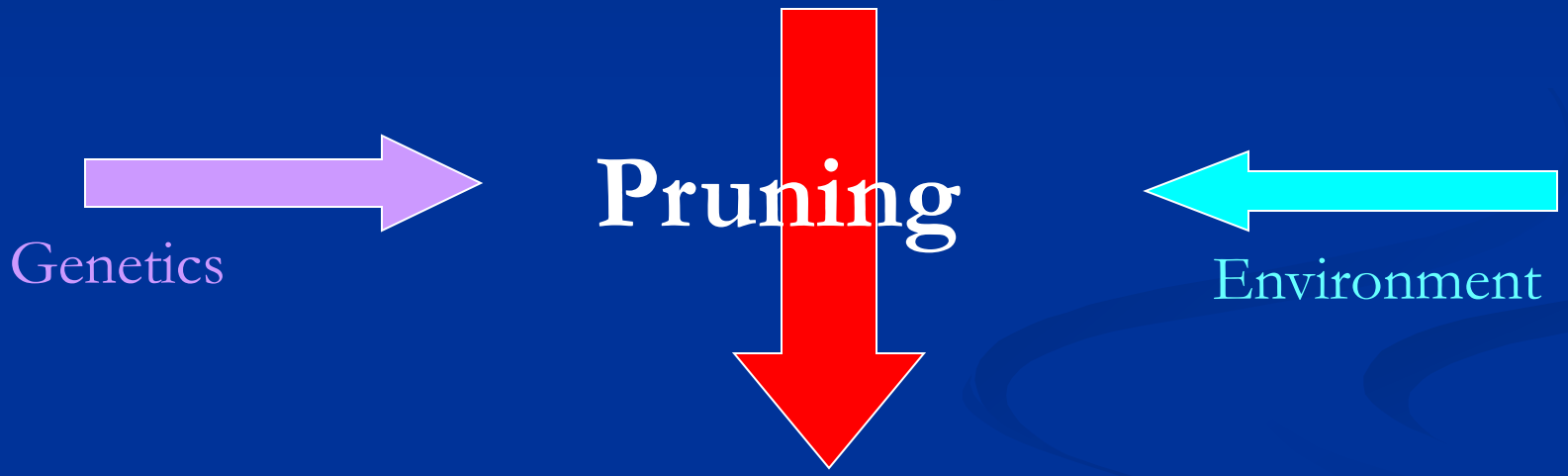
Because the brain is still developing, it is more sensitive to drugs.



Age 20

The changes drugs cause are more likely to 'stick' and become hardwired as addiction by adulthood.

Increased Gray Matter



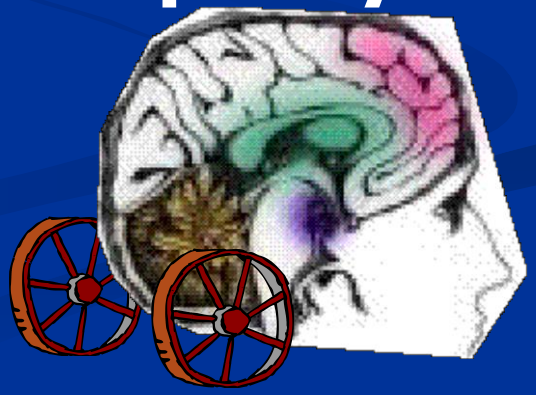
Decreased Gray Matter

More Efficient Connections

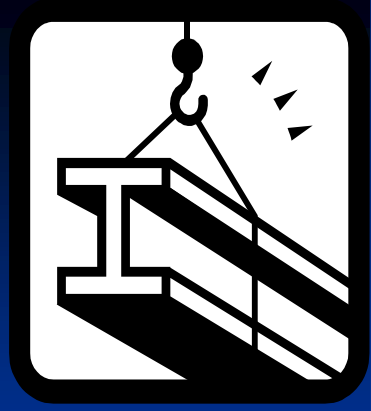
Construction Ahead

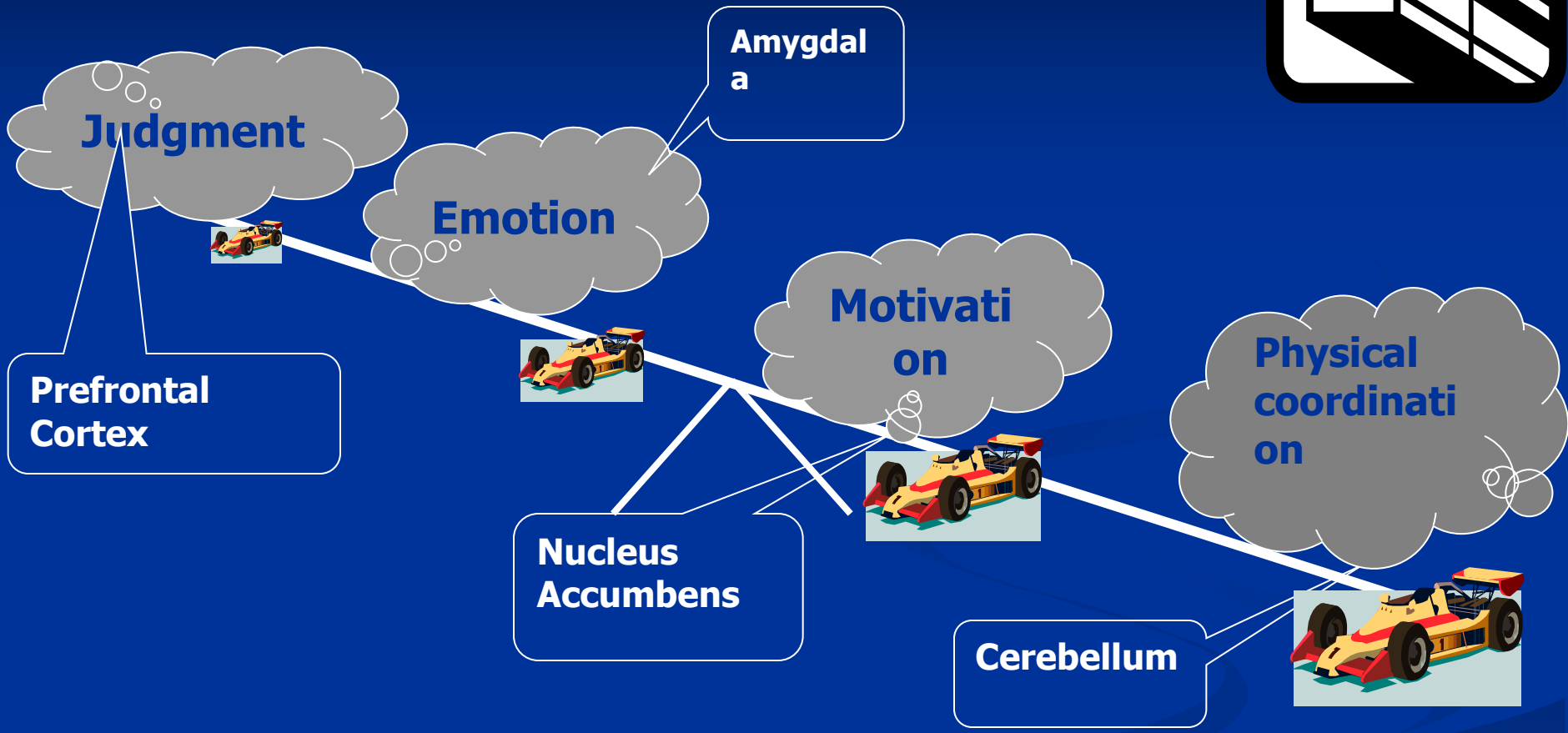
- When the pruning is complete, the brain is faster and more efficient.

- **But…** during the pruning process, the brain is not functioning at full capacity



Neurological maturation starts at the back of the brain, and moves to the front





Notice: Judgment is last to develop!

Example of Genes vs. Environment

Cerebellum and corpus callosum studies in twins

- Corpus callosum very similar (genetics)
- Cerebellum different (environment)

Source: Interview with Jay Giedd, Inside the Teenage Brain, Frontline PBS, available at www.pbs.org

Cautionary Statements

- Direct correlations between adolescent brain and behavior changes has not yet been established

Summary

- Brain development begins in early gestation and continues into twenties
- Major brain restructuring during adolescence includes prefrontal cortex, which is important in executive functioning
- Alcohol use during adolescence concerning given ongoing brain development

The Health Paradox of Adolescence

- Adolescence is (physically) the healthiest period of the lifespan: prior to adult declines; beyond the frailties of infancy and childhood:
  - Improvements in strength, speed, reaction time, reasoning abilities, immune function …
  - Increased resistance to cold, heat, hunger, dehydration, and most types of injury …

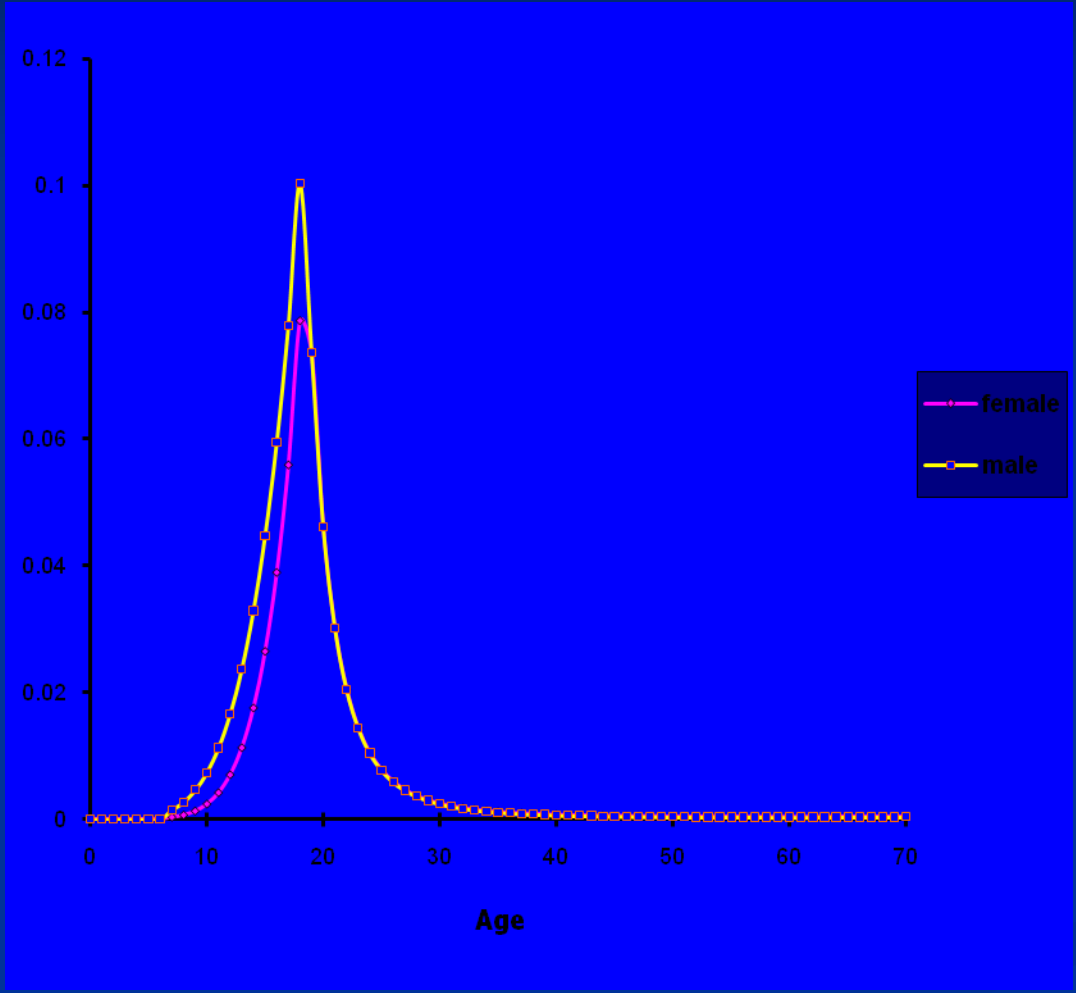
- ***Yet: overall morbidity and mortality rates increase 200% from childhood to late adolescence***

Morbidity & Mortality in Adolescence

Primary sources of death/disability are related to problems with ***control of behavior and emotion***

- accidents, suicide, homicide, depression, alcohol & substance use, violence, reckless behaviors, eating disorders, risky sexual behaviors…
- risk-taking, sensation-seeking, and erratic (emotionally-influenced) behavior
- onset of problems with later health consequences

Adolescence: an inflection-point in life course trajectory



Probability of Smoking *Initiation*

- Alcohol use/abuse
- 95% of MJ use begins before 25
- Onset of initial depression episode
- Greatest risk of HIV exposure
- Rates of accidents related to violence and reckless behavior

EXECUTIVE FUNCTIONS
Building blocks form in childhood

- Forethought
- Attention/Concentration
- Verbal Ability
- Abstract Reasoning
- Problem Solving
- Programming and Planning Goal Oriented Behavior
- Behavioral Inhibition
- Learning from Experience
- Interpreting Social Cues
- Using Socially Adaptive Behavioral Responses
- Avoiding Negative Consequences or Situations
- Regulating Emotional Responses
- Sensitivity to Penalties

Focal Point: Prefrontal Deficits

- Inability to accurately interpret social cues
- Permits negative emotions to dominate
- Heightened sensitivity to rewards
- Impulsivity and Inattention
- Insensitivity to Consequence

* Doesn't connect until after adolescence!!!

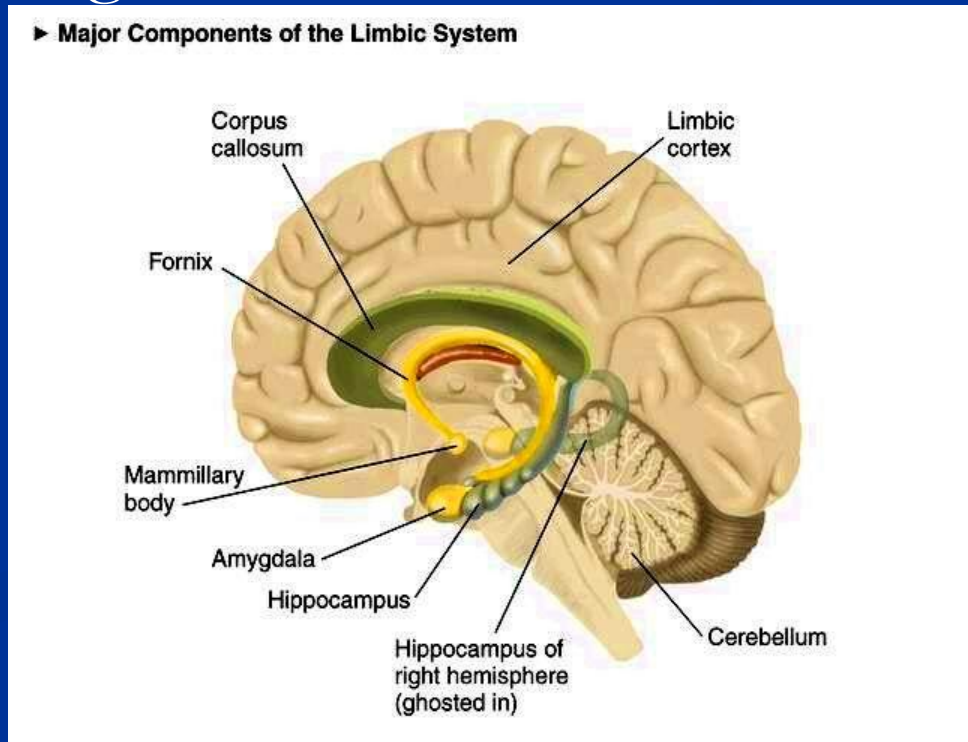
Frontal lobes

- Memory, planning, problem solving
- Gray matter volume peaks ~ age 12
- Change with experience = *plasticity*

Emotional Regulation

Prefrontal cortex controls lower functions of limbic system

- Motivation and emotion
- Assigns feeling to incoming stimuli
- Emotional drives
- Stress responses
- Provides for rewarding and addictive properties of drugs and seeking



Breakdown in Brain's Regulatory System may Heighten Risk

Regulatory neural circuitry b/t prefrontal cortex and limbic system vulnerable to:

- genetic defects
- developmental delays
- injury
- metabolic errors
- stress and adversity
- drug and alcohol use

The Adolescent Brain

Particularly vulnerable to external inputs:

- Environmental exposures
- Psychosocial stressors
- Drug and alcohol use
- Protective factors

Prefrontal cortex not fully developed until early adulthood

- Unique stage of change in metabolism, pruning, and increased efficiency in prefrontal function

Emotional centers (limbic) without checks and balances

- Greater sensitivity to rewards, less inhibition
- Seek altered states of consciousness

Effects are longstanding

Fundamental Imbalance in Puberty

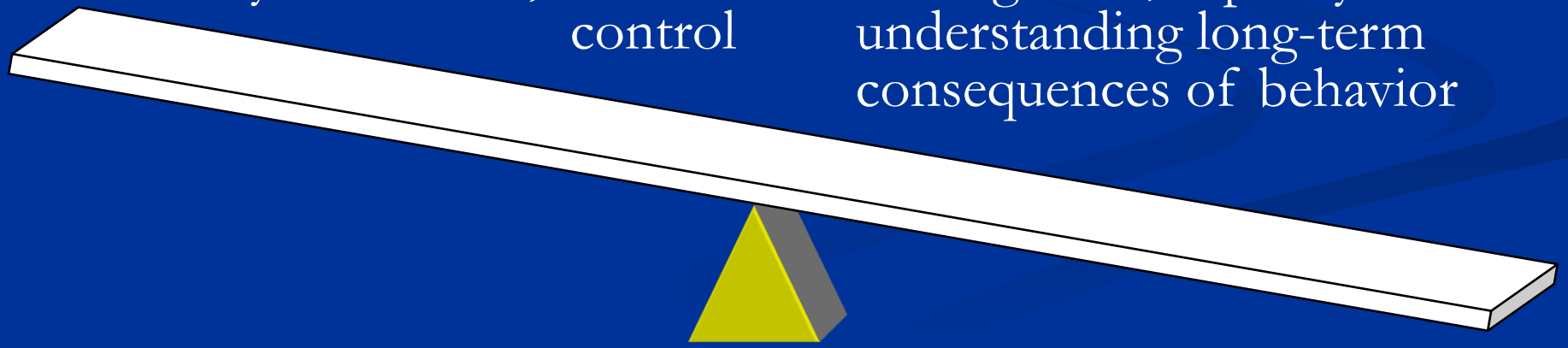
- Rapid physical, endocrine, and social changes that create *early* affective motivations and challenges
- Gradual, *later* development of affect regulation and maturation of cognitive/self-control skills

Emotional Capacity

Pubertal drives and emotions; sensation seeking; risk taking; sensitivity to rewards, low self control

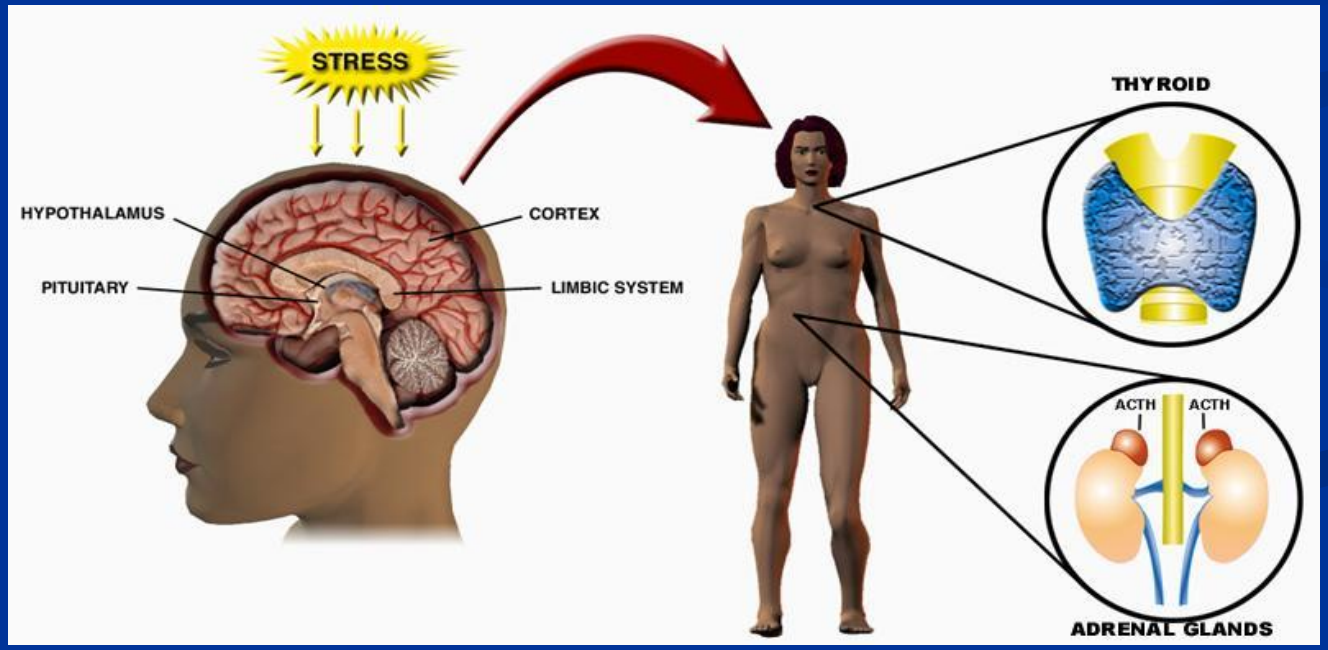
Cognitive Capacity

Planning; logic; reasoning, inhibitory control; problem-solving skills; capacity for understanding long-term consequences of behavior



Chronic stress primes the brain for novelty seeking and drug use

- Alters brain function, disengages coping mechanisms, and compromises ability to execute rational choices
- Increases the likelihood of psychopathology
- Genetic vulnerabilities affect behavioral outcomes
- Positive attributes of person or environment = protection



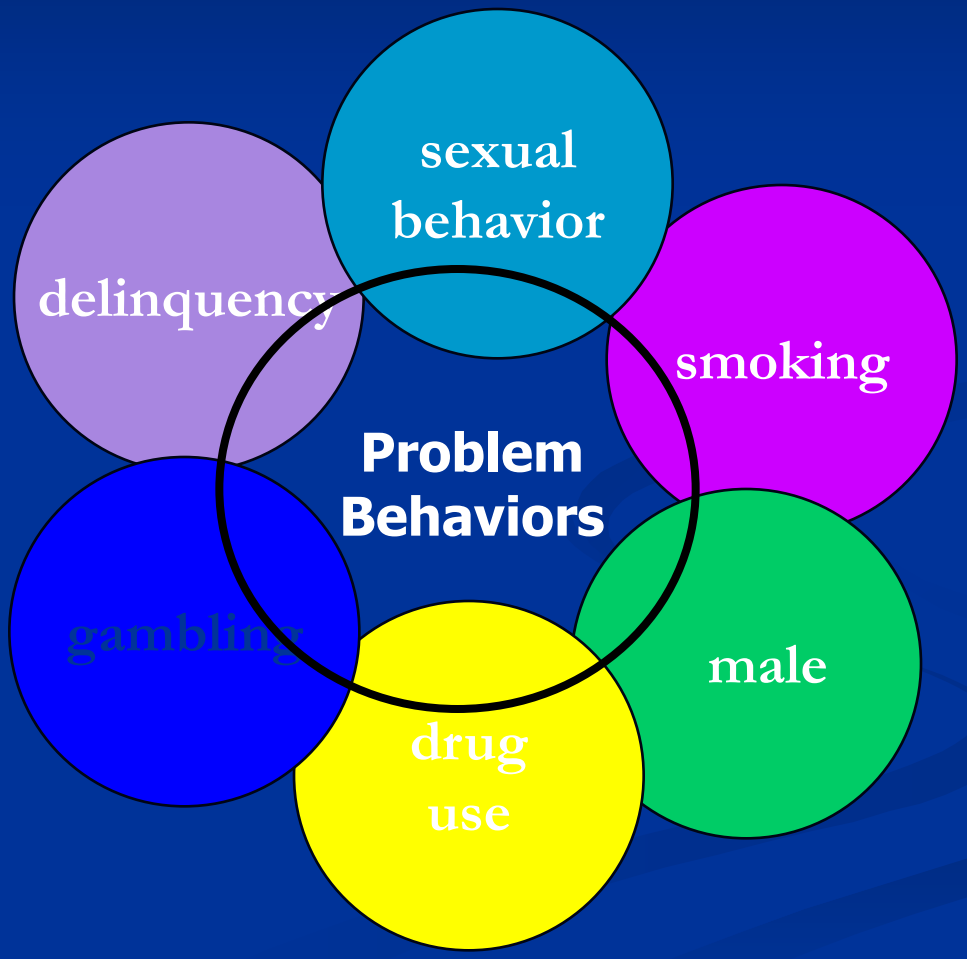
Gender: Girls' Disadvantages

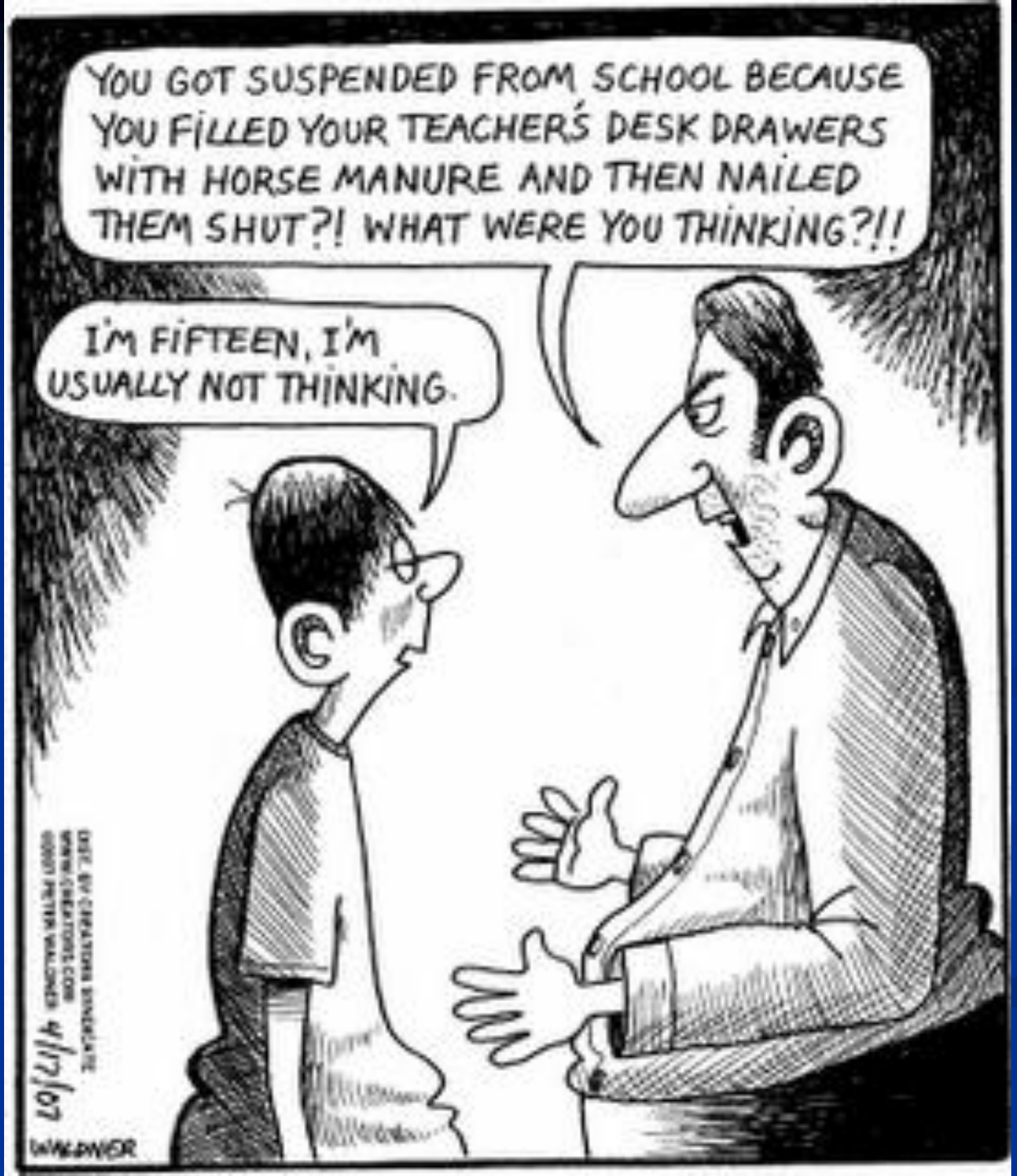
- Greater ***sensitivity*** to stressors, particularly familial
  - Strongly related to early pubertal maturation
- Greater ***incidence*** of stressors in antisocial girls
  - Greater early pubertal maturation in antisocial girls
- Proneness to psychological and psychiatric illnesses: e.g., depression and anxiety (over ¾ in JJ system)
- Differences in development of amygdala and hippocampus heighten stress sensitivity
- Adrenal gland sensitivity negatively alters mood
- Estrogen amplifies stress responses, increasing mood disturbances
- Perception of greater stress than males

Gender: Girls' Advantages

- Larger Prefrontal Cortex → less acting out behaviors
- Advanced language and verbal skills
- More effective processing of social and emotional cues
- Female hormones protect against cognitive damage from stress
- "Tend and Befriend", rather than "Fight and Flight" due to hormonal differences

Youth Problem Gambling as a Component of Problem Behaviors




YOU GOT SUSPENDED FROM SCHOOL BECAUSE YOU FILLED YOUR TEACHER'S DESK DRAWERS WITH HORSE MANURE AND THEN NAILED THEM SHUT?! WHAT WERE YOU THINKING?!!
I'M FIFTEEN, I'M USUALLY NOT THINKING.
WAGNER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"But Mom, all the girls are doing it."

THE TEENAGER MANTRA