Adolescent Brain Development, Substance Use and Gambling Involvement

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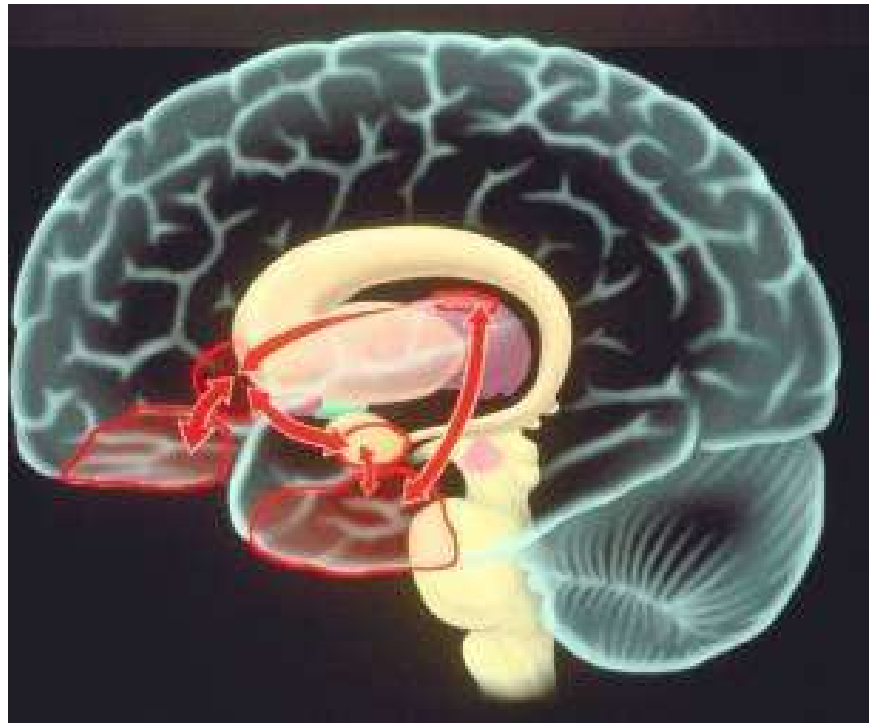
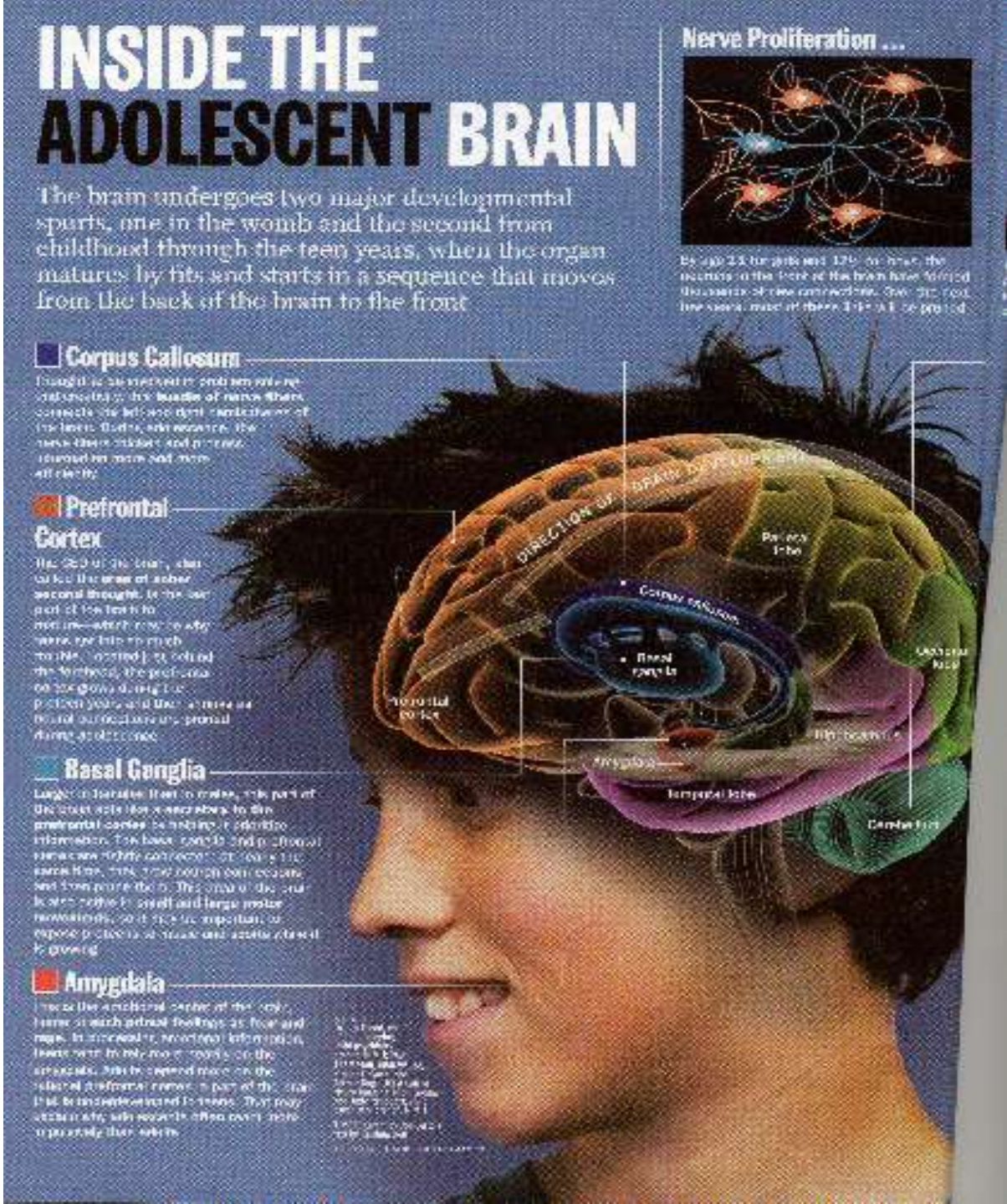
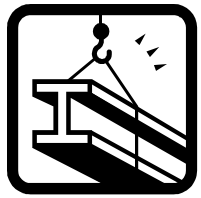


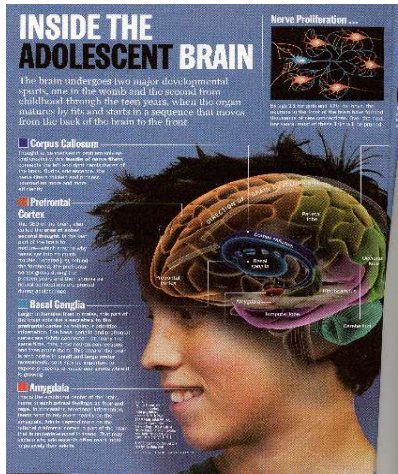
- **Adolescence is a period of profound brain maturation.**
  - **It was believed that brain development was complete during childhood**
  - **The maturation process is not complete until about age 25!!!**



Construction Ahead



- During late childhood, neurons get bushier and increase in the number of connections.
- At about age 11 in girls and age 12½ in boys, this thickening undergoes pruning.
- At the same time, the myelin sheaths that encase nerve cells thicken.
  - Myelin sheaths are like insulation on a wire; they make nerve cell transmissions faster and more efficient
- Net effect when complete is faster, yet fewer, connections in the brain.



Pruning occurs in stages, from back of the brain to the front

PFC

amygdala

emotional processing center; evaluates relative pleasure vs aversiveness

nucleus accumbens

cerebellum

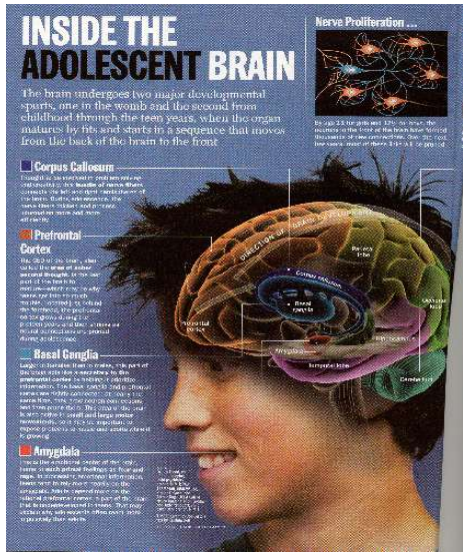
planning; setting priorities; organizing thoughts; suppressing impulses; weighing consequences of one's actions

regulates motivation to seek rewards

physical coordination; sensory processing; learning linked to math and music

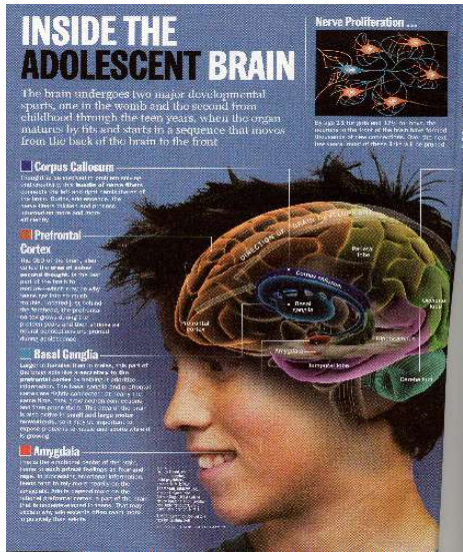
Arrested Development

- **Back of brain matures before to the front of the brain…**
  - **sensory and physical activities favored over complex, cognitive-demanding activities**
  - **propensity toward risky, impulsive behaviors**
    - **group setting may promote risk taking**
  - **poor planning and judgment**



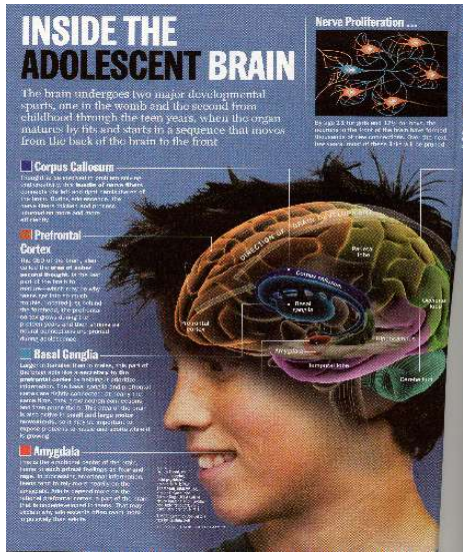
Arrested Development

- Immature nucleus accumbens
  - activities with high excitement and low effort are preferred
- Under-developed amygdala
  - poor modulation of emotions (hot emotions more common than cold emotions)
  - misinterpret the emotions and intentions of others
    - over-interpret non-angry facial expressions as a sign of anger

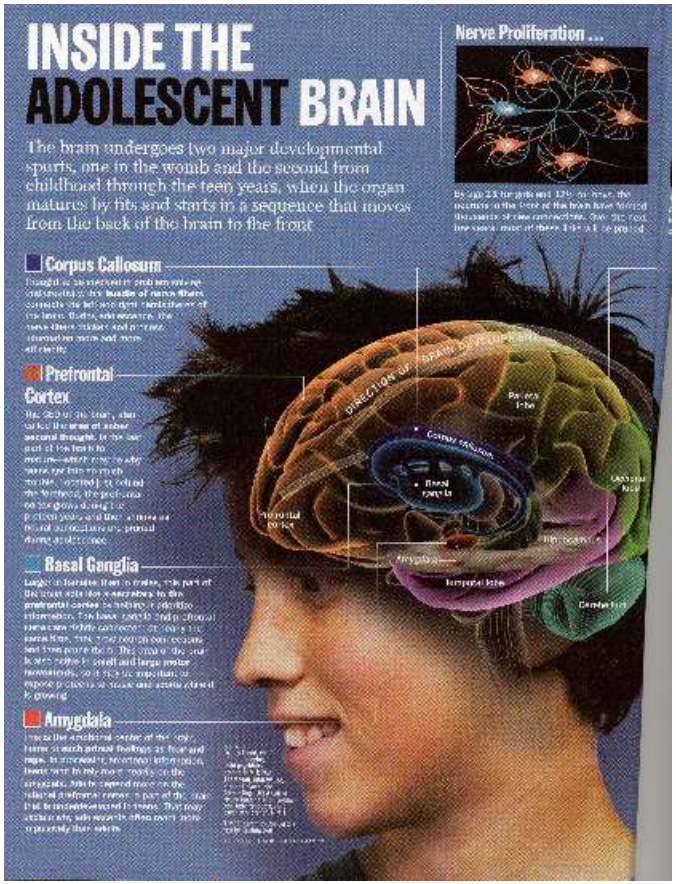


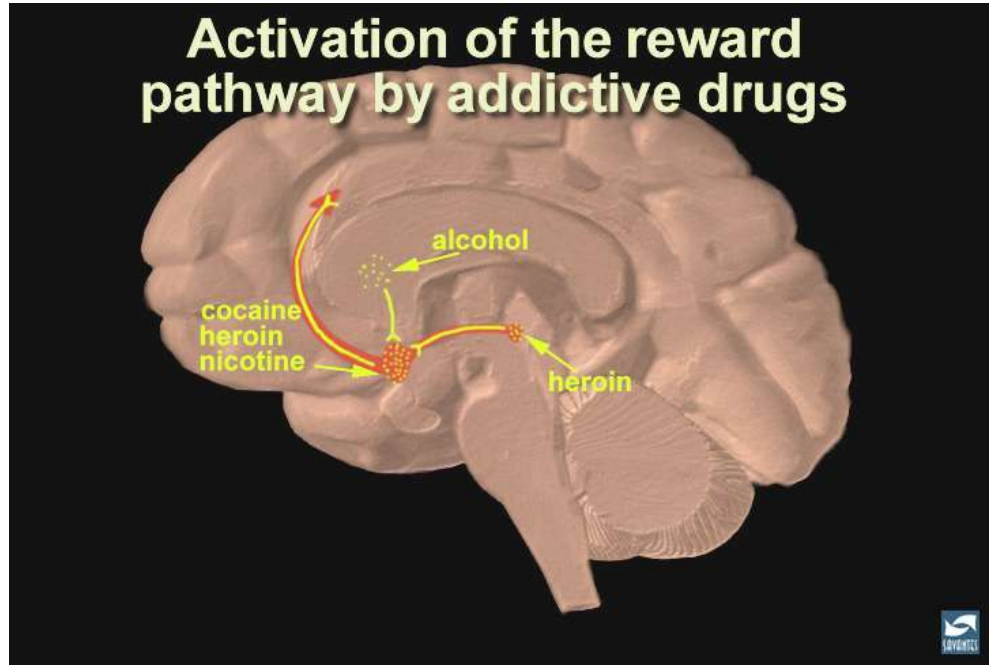
Construction Plans Can Change

- Experiences may alter the brain maturation process
  - piano practicing quickly thickens neurons in the brain region that control the fingers
  - engaging in high-level memory tasks has been shown to increase the size of the hippocampus
  - Stress may slow down the maturation of the prefrontal cortex

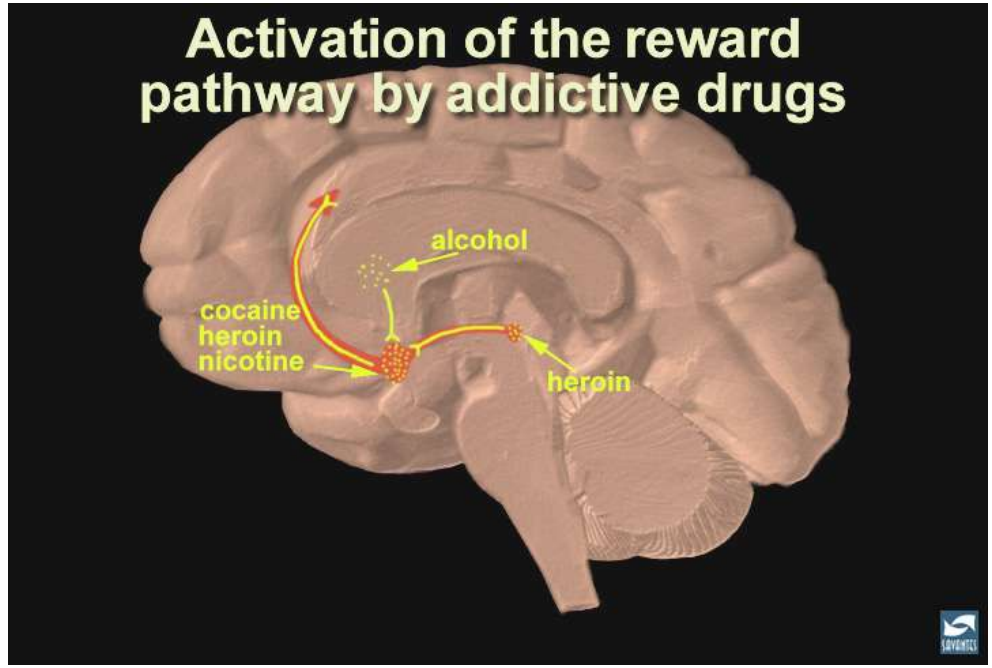


The Developing Adolescent Brain is Susceptible to Drugs

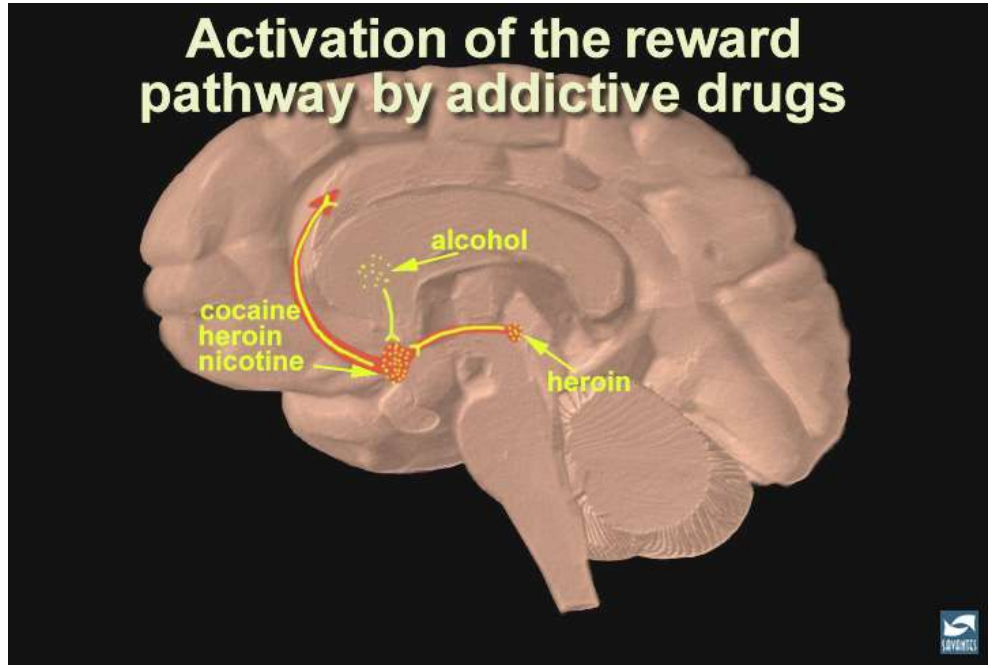




- **Drugs activate or "light-up" the brain's reward pathway**
- **The reward pathway directs behaviors essential for survival value**
  - **seeking food, water, sex, and nurturance**



How does this activation of a "survival" system lead to addiction for some individuals?

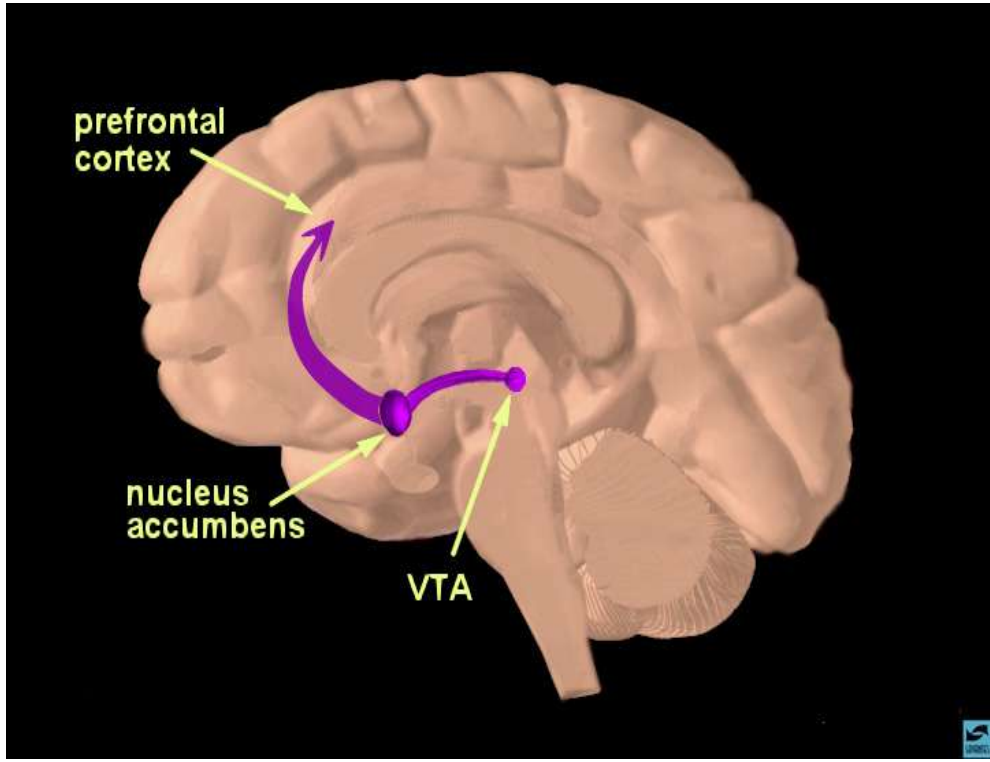


Veni, Vidi, Vici

Veni, Vidi, Vici

Veni: The drug came (to the user's brain)

drug ingested → **VTA** signals nucleus accumbens (**na**) → levels increase of a euphoria-inducing neurotransmitter, dopamine ("wow")



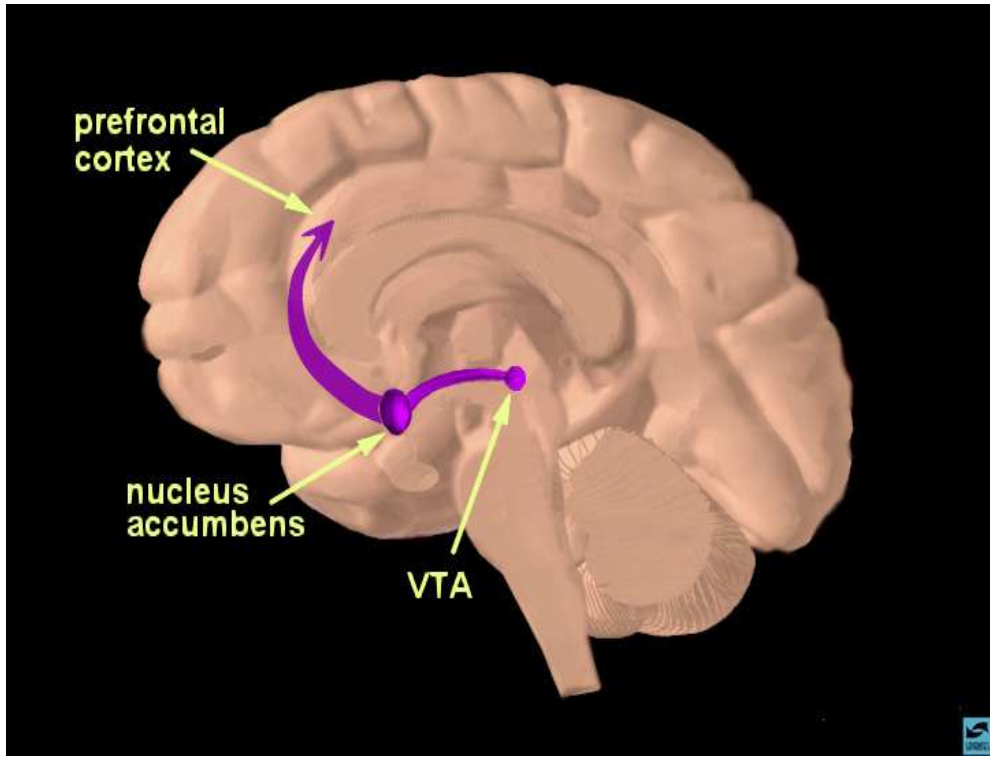
Veni, **Vidi,** Vici

Vidi: The drug saw (its impact on the brain)

na signals the amygdala → weighs the relative pleasure and aversiveness of the experience ("This is worth repeating.")

amygdala signals the hippocampus → records memory of the experience, including where and when ("I am going to remember this drug experience.")

PFC → receives, coordinates and processes this molecular experience, and shapes future behavior and attitudes of the drug experience ("Go for it again?" vs. "Too risky?")



Veni, Vidi, **Vici**

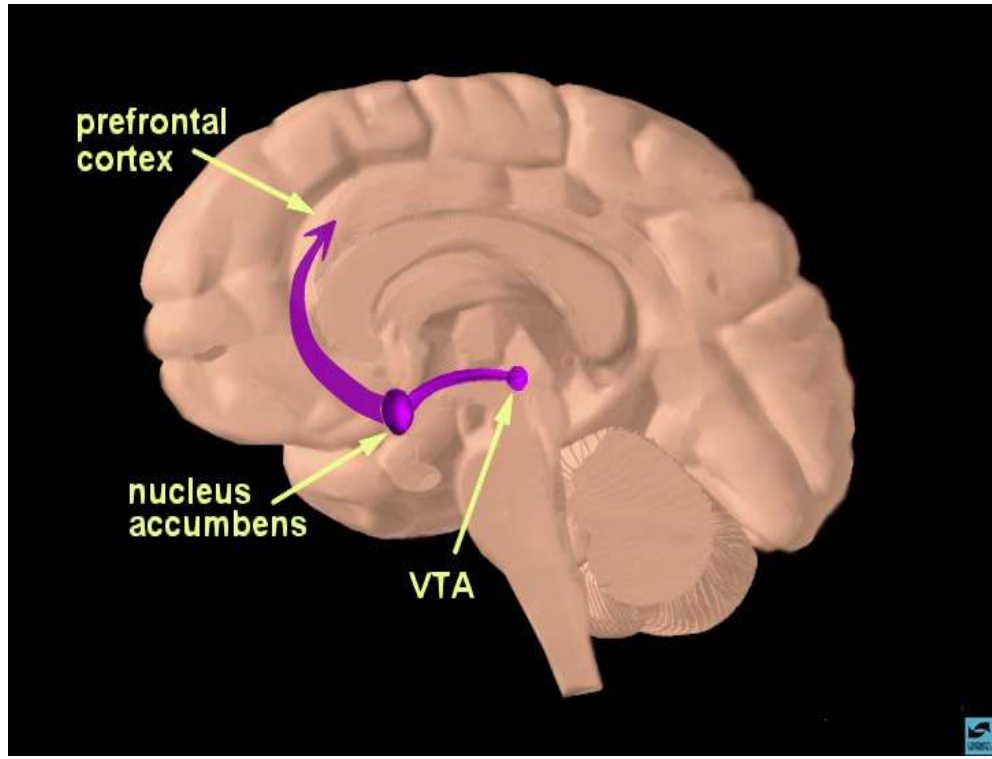
Vici: The drug conquered (by commandeering the brain)

continued use of the drug……..

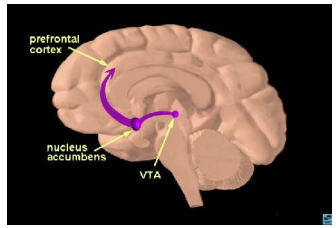
CREB, a protein is activated → reduction in dopamine levels and dampening to the overall reward system ("I crave the drug. I need to take more of the drug.")

delta FosB, another protein is activated → creates sensitization to drugs and the cues associated with prior use ("I am prone to relapsing.")

- **May promote growth of dendrite buds in the na, which are "tagged" with memories of the drug**



Review:
Veni, Vidi, Vici

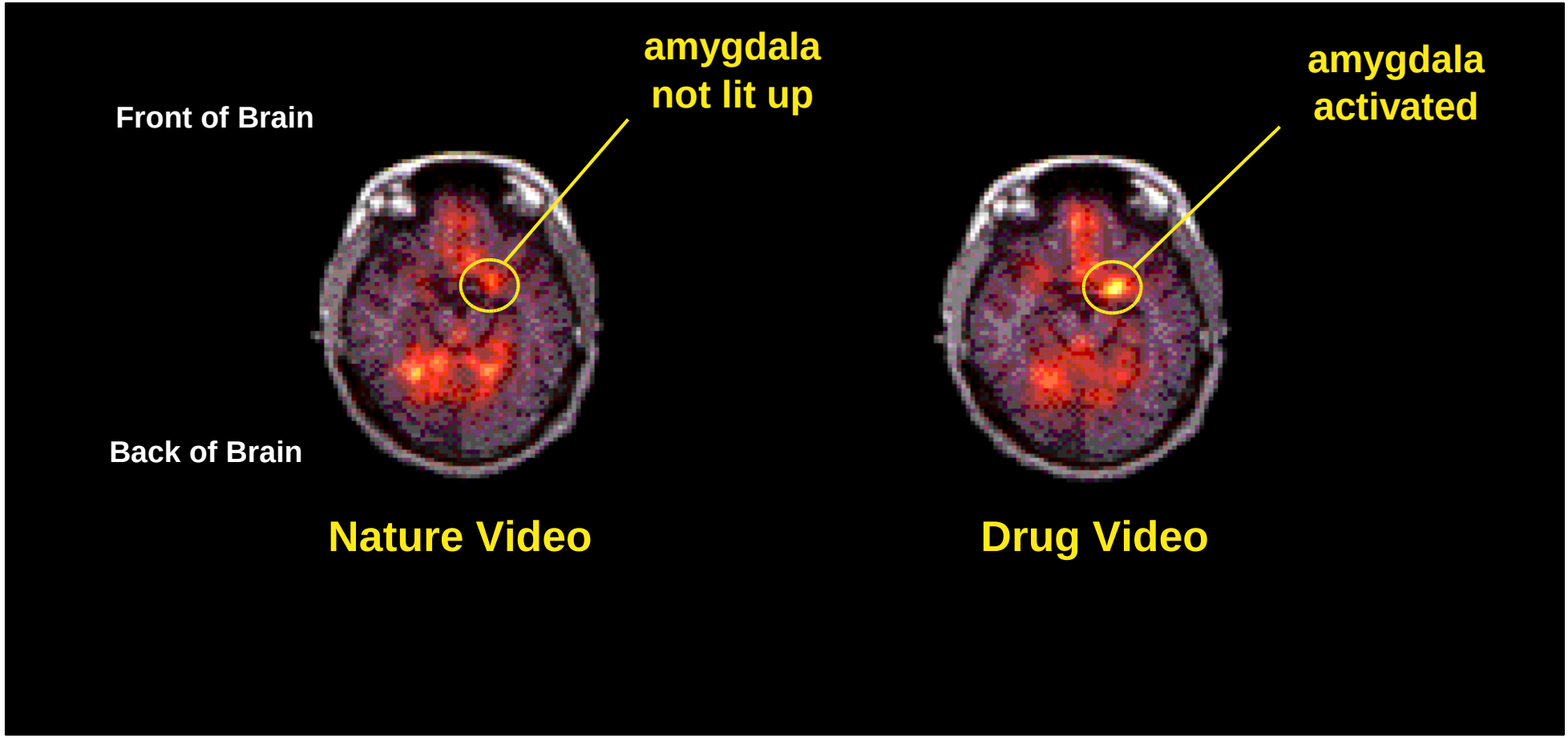


- Drugs of abuse immediately activate the brain's reward pathway, particularly by increasing levels of a euphoria-inducing neurotransmitter, dopamine.
- Continued, chronic heavy drug use leads to several adaptations in the brain that promote the ingredients of addiction: tolerance, craving and relapse.
- Future research:
  - How much and how quickly can reversal or correction of the brain adaptations occur when drug use is reduced or stopped?
  - What new-age pharmacotherapies can promote this restoration?
  - Can high-risk individuals be identified for genetic profiles that increase one's susceptibility to the "commandeering of the brain" by drugs?

Evidence

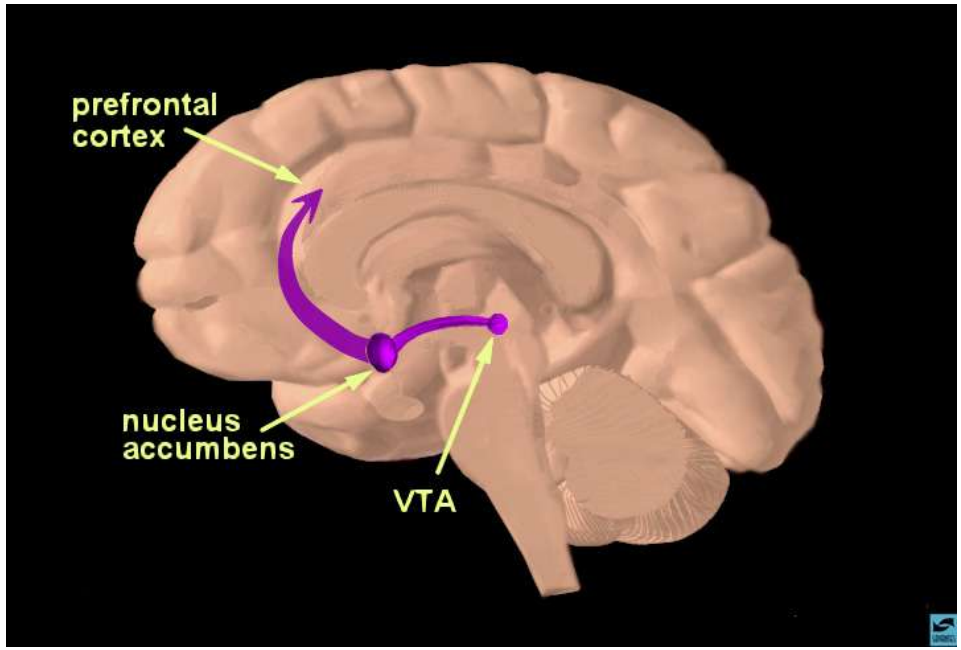
- **Animal Studies:**
  - **animal investigations support the "hijacking" of the brain's reward system by alcohol and other drug use**
    - **when electrodes attached to the reward circuitry, drug use continues until collapse from exhaustion**
    - **when rats are bred for excessive delta FosB, heightened sensitization is observed**
- **Behavioral Genetics Studies:**
  - **heredity plays a role**
    - **identical twins: > chance of becoming alcoholics than fraternal twins**
    - **adoptive children of alcoholics: > chance of becoming alcoholic, even true when raised by non-alcoholic parents**
    - **further research needed regarding other drugs and by gender**

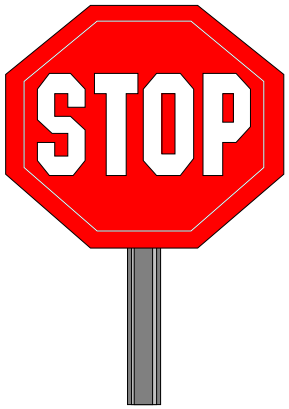
<u>Human Studies:</u> Amygdala (with help from the hippocampus and PFC) has memory of the drug after discontinuation. This "memory" can occur months after discontinuation.



Are adolescents more susceptible to alcohol than adults?

- Adult studies suggest that the areas of the adolescent brain that are remodeled are sensitive to the effects of alcohol





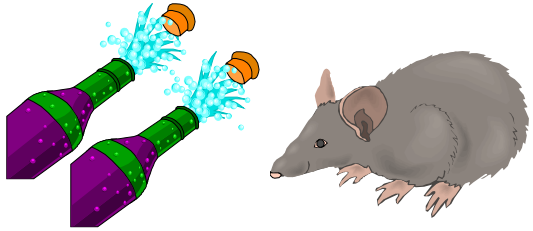
Difficult scientifically and ethically to study adolescent sensitivity to alcohol

Are adolescents more susceptible to alcohol than adults?

- Animal models can be easily used to explore this issue
  - Role of psychosocial factors can not be studied

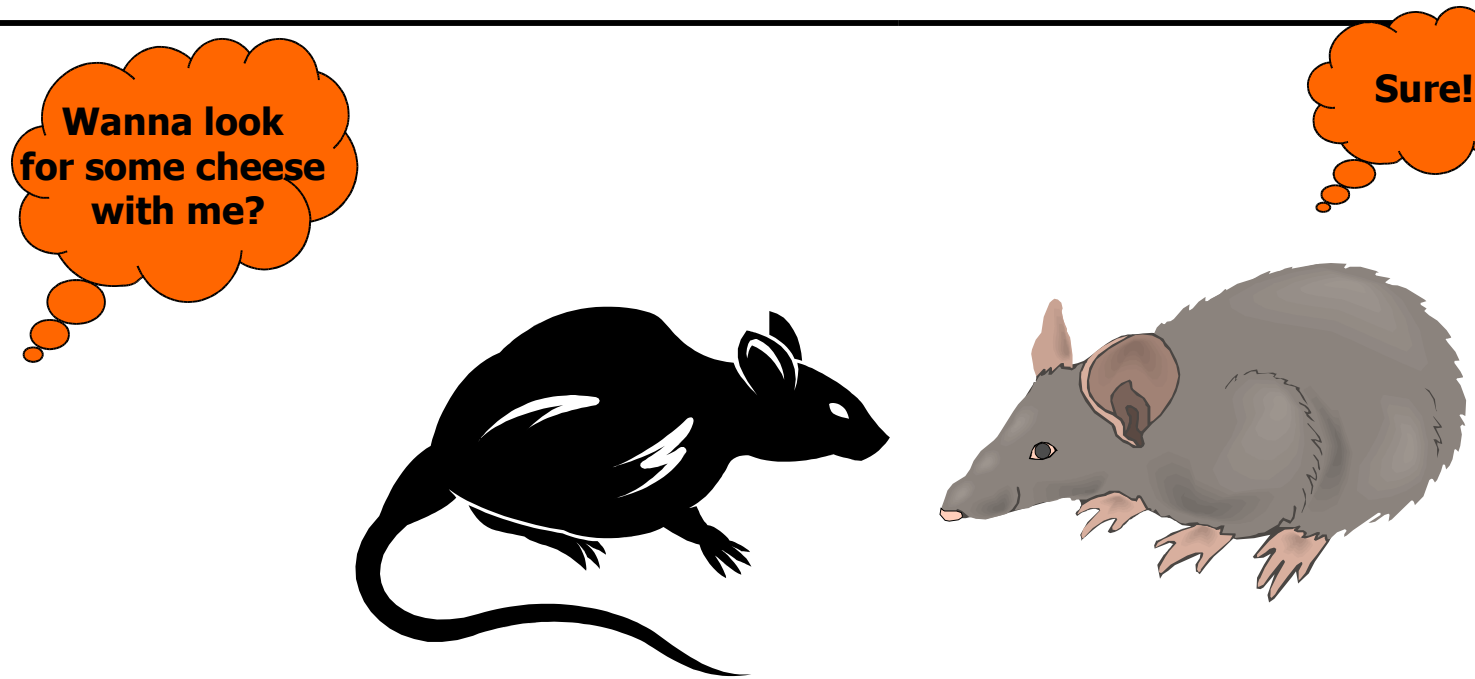
Are adolescents more susceptible to alcohol than adults?

1 **Adolescent rats are <u>less</u> sensitive to effects of intoxication and <u>less</u> sensitive to the "hangover" that follows use**



Are adolescents more susceptible to alcohol than adults?

2 **Adolescent rats are <u>more</u> sensitive to the social disinhibition induced by alcohol use**



Are adolescents more susceptible to alcohol than adults?

3 **Adolescent drunk rats perform worse on memory tasks than adult drunk rats**

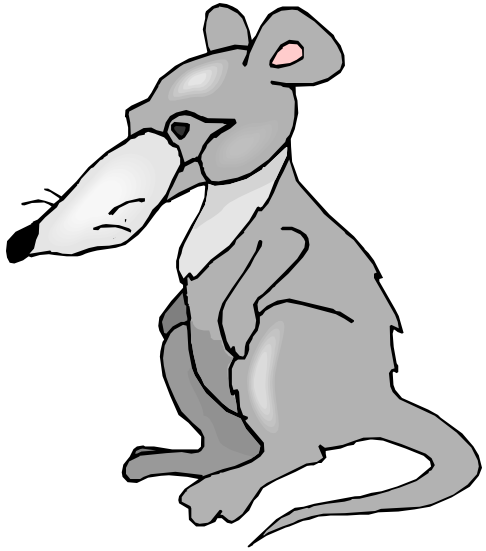
converts information to memory

Ugh??

disrupts the hippocampus

brain damage in the PFC

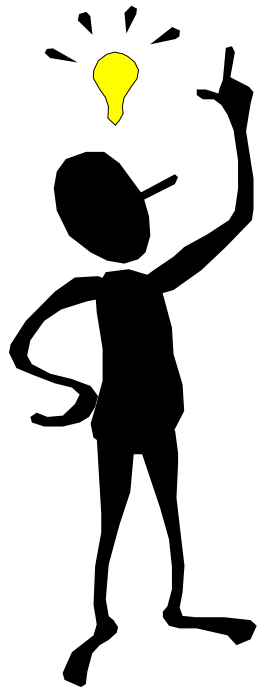
planned thinking



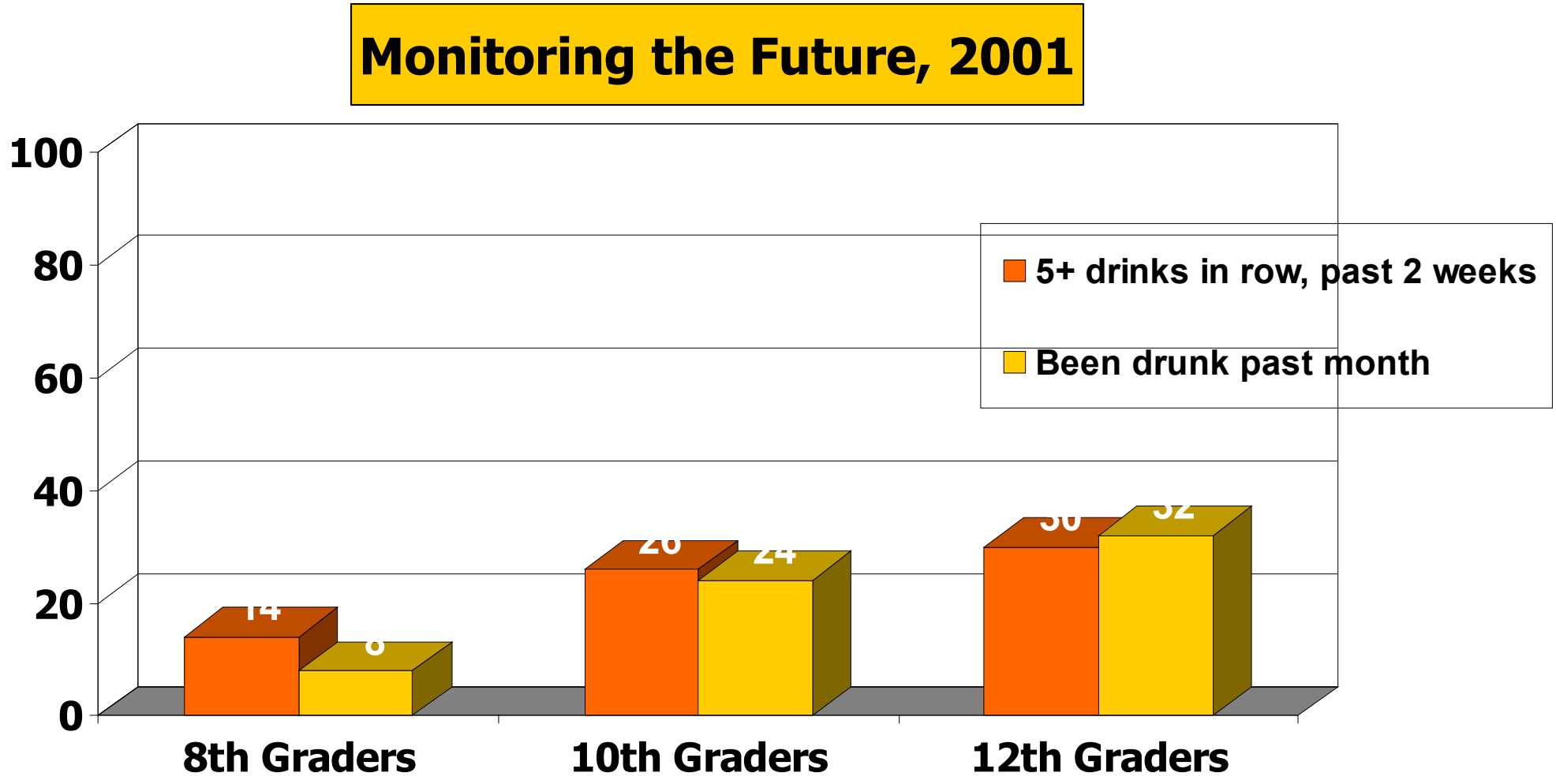
Supporting Human Studies

1. **Reduced sensitivity to intoxication**

3. **Greater adverse effects to cognitive functioning**



Survey Data Suggest that Adolescents Are Less Sensitive to Alcohol's Effects



Alcohol's Effects (Brown, 2002; Wuethrich, 2001)

- **Adolescents with a history of extensive use….**

converts information to memory

↓ **Hippocampus (50%)**

↓ **brain activity during memory tasks**

trigger for relapse

↑ **brain activation when shown alcohol images**

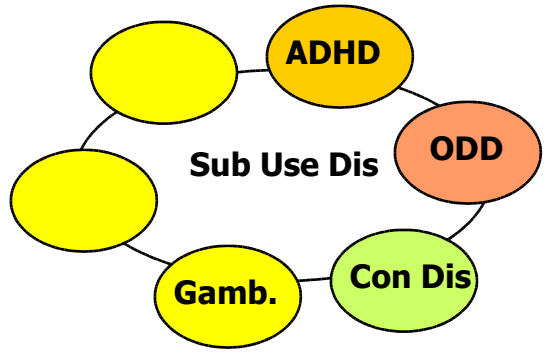
Are adolescents more susceptible to alcohol than adults?

4 **Hyperexcitability issue**

Are adolescents more susceptible to alcohol than adults?

4. Hyperexcitability issue

- Alcohol relieves hyperexcitability state
- Relief is temporary; continued seeking of alcohol is reinforced
- Hyperexcitability is a key characteristic of conduct disorders, ADHD & other impulsive behaviors
- Hyperexcitability found in non-alcoholic relatives - suggests inheritance of this trait



Are adolescents more susceptible to alcohol than adults?

Most certainly YES

1. Reduced sensitivity to intoxication
2. Increased sensitivity to social disinhibitions
3. Greater adverse effects to cognitive functioning
4. Medicates "excitability"

Are adolescents more susceptible to alcohol than adults?

Increases reinforcing properties

1. **Reduced sensitivity to intoxication**
2. **Increased sensitivity to social disinhibitions**

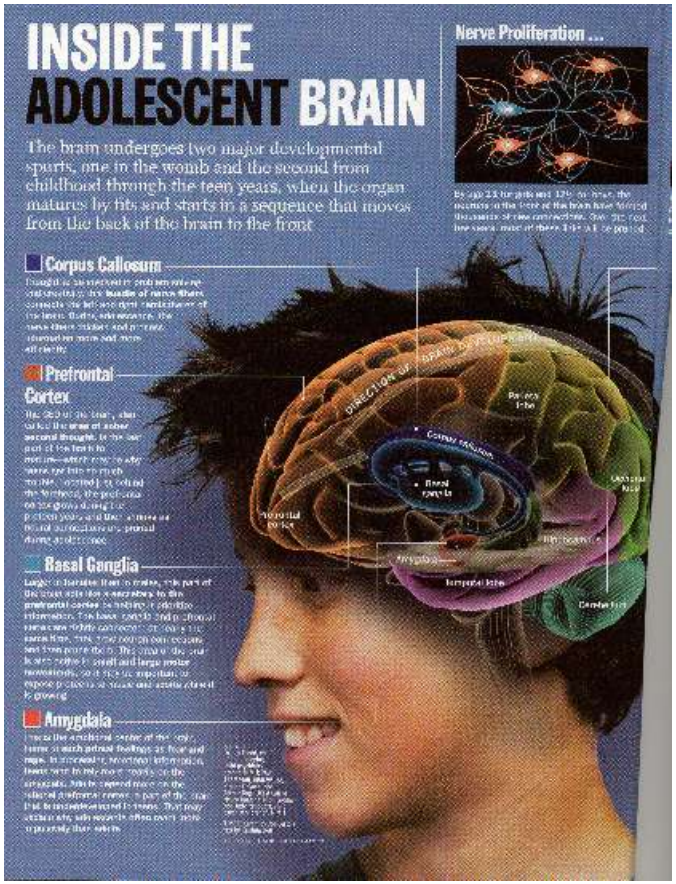
4. **Medicates "excitability"**

Are adolescents more susceptible to alcohol than adults?

Greater deficits

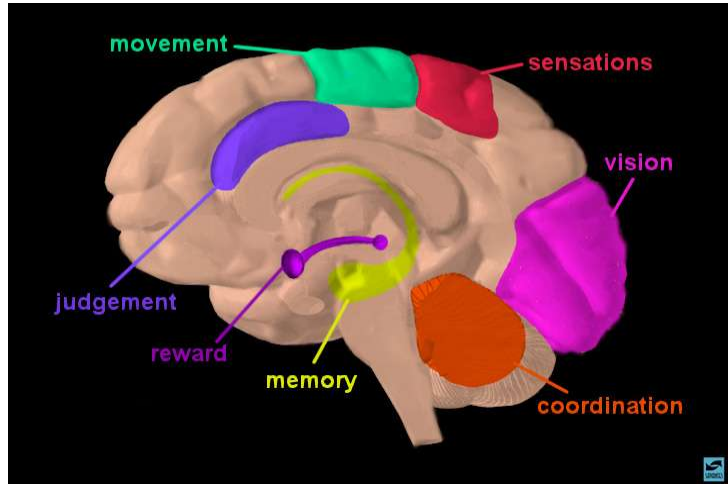
3 **Greater adverse effects to cognitive functioning**

The Developing Adolescent Brain May be Susceptible to Gambling



Implications for Prevention and Treatment

- **Prevention**
  - **The earlier the better**
  - **Educate them about the susceptibility of the adolescent brain and risk taking behaviors**
  - **Developmentally adjust given the maturation of brain development**



Glossary

- **mesolimbic dopamine system:**
  VTA (ventral tegmental area) and nucleus accumbens
- **amygdala:**
  brain region that helps assess whether an experience is pleasurable or aversive, and whether it should be repeated or not
- **hippocampus:**
  records memories of an experience, including where and when
- **frontal cortex:**
  coordinates and processes brain information
- **glutamate:**
  neurotransmitter that communicates with various brain regions and systems
- **CREB:**
  protein key to tolerance; regulates expression of genes that result in a dampening of the reward circuitry
- **delta FosB:**
  protein key to drug sensitization (relapse); increases due to prolonged drug use; regulates genes that increase sensitivity to drugs, perhaps by two mechanisms: promoting growth of new dendrite buds or sprouts in the nucleus accumbens that may be wired to "ID" stimuli associated with the prior drug use; and triggering an increase in dopamine activity in the presence of drug-specific stimuli (craving).