

Addiction as a Brain Disease: What does Science Tell Us?

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Science Policy Branch – NIDA - NIH

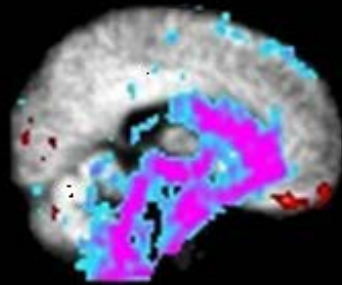


- BRAIN
- DRUGS
- RISK
- RESILIENCE

A brain story



System 1



Fast

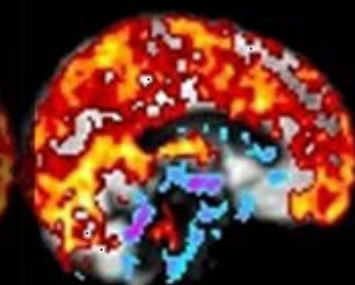
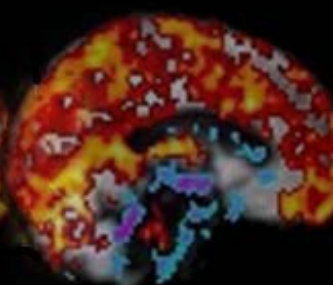
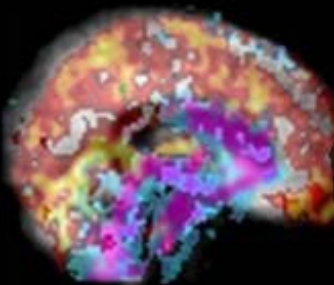
Automatic

Implicit

Effortless

Abstract

System 2



Slow

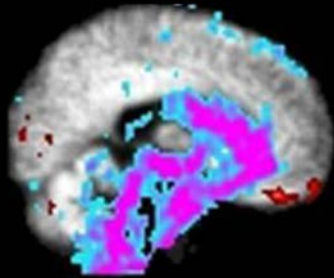
Conscious

Explicit

Effortful

Rule-based

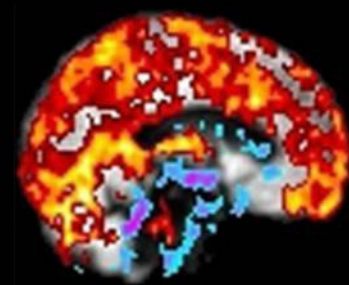
System 1



Fast



System 2



Slow

RED BLUE GREEN RED

GREEN RED BLUE GREEN

BLUE GREEN RED BLUE

RED BLUE GREEN RED

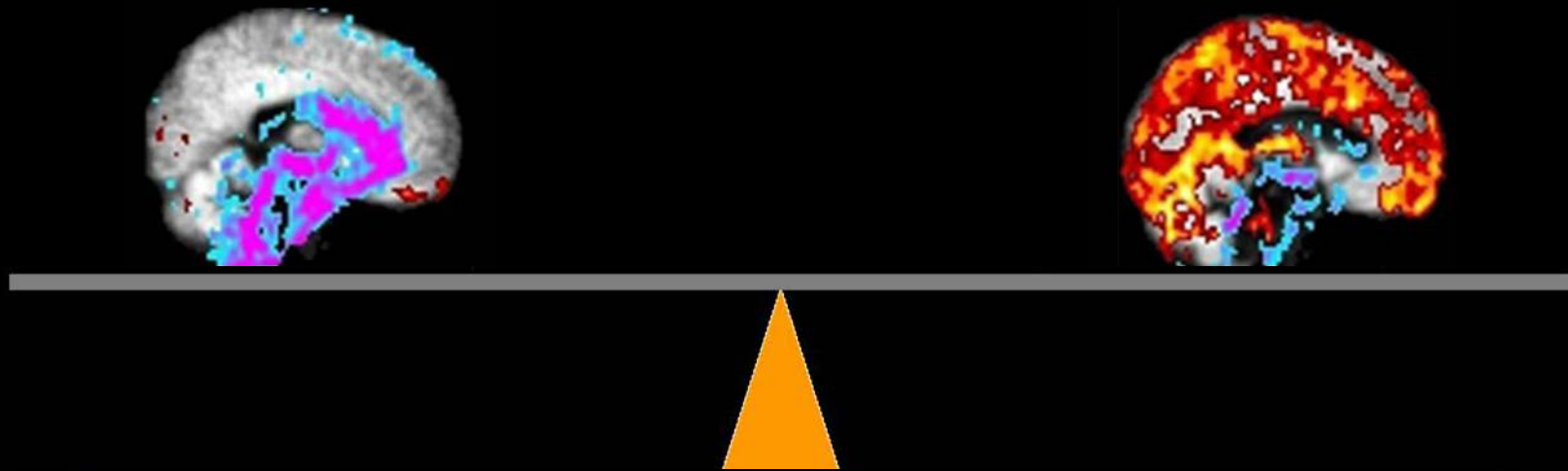
GREEN RED BLUE GREEN

BLUE RED GREEN BLUE





What is it supposed to accomplish ?



intuition

reasoning



look around

eat

reproduce



look around

eat

reproduce



texting
while
driving

junk
food

virtual sex,
bizarre porn

look around

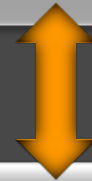
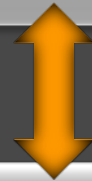
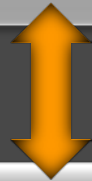
eat

reproduce

texting
while
driving

Junk
food

virtual sex,
bizarre porn



look around

eat

reproduce



OBVIOUS

NOT SO OBVIOUS ...



chronic stress



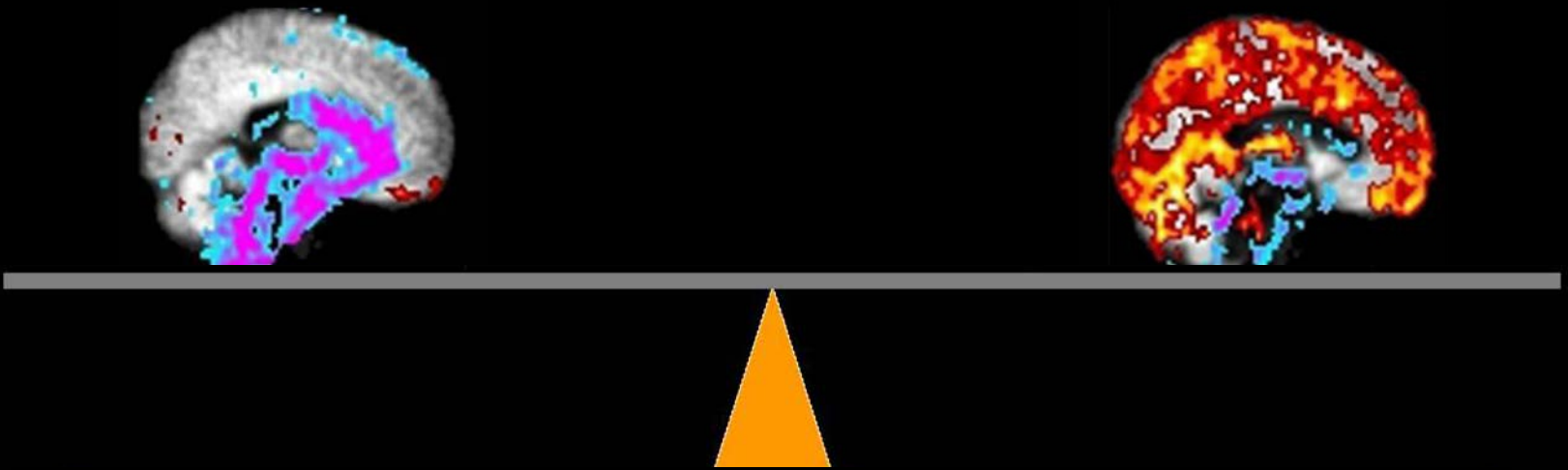
heart disease



mental illness

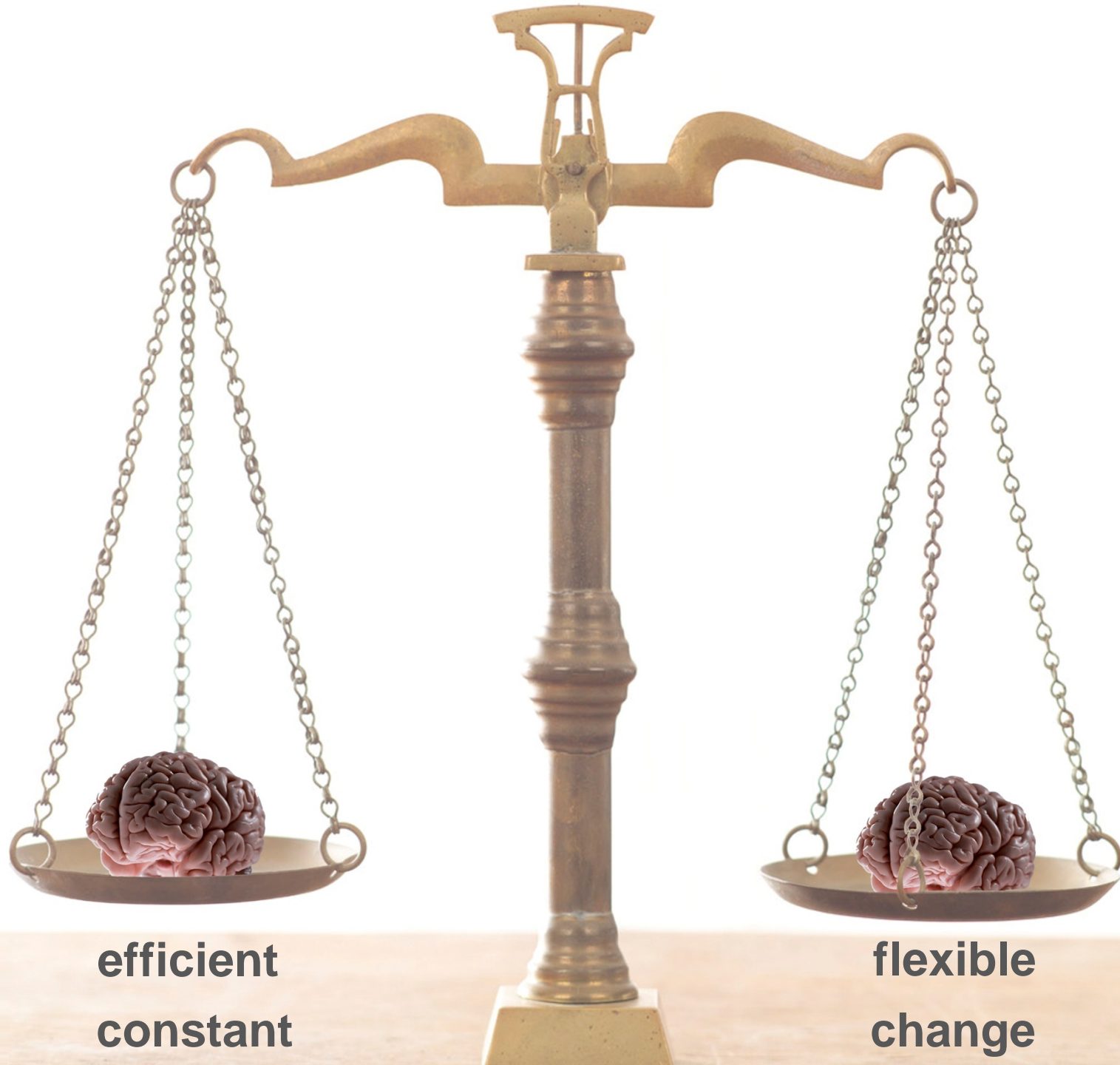


addictions



Automatic
responses

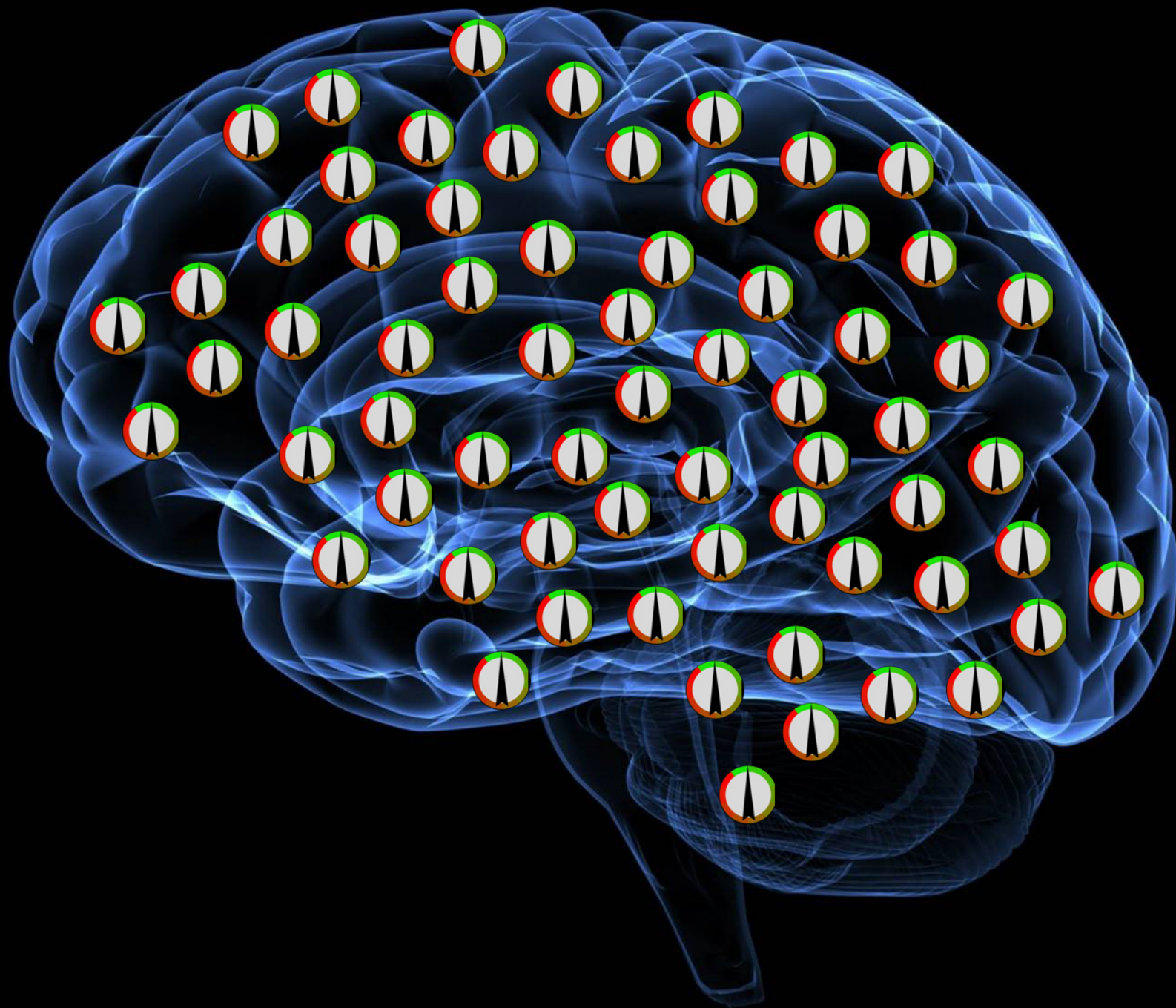
Complex
reasoning



efficient
constant

flexible
change

How does the brain achieve flexibility?





And just like thermostats, our brains are
ROBUST YET FRAGILE

- robust to disturbances that the system is designed to handle.
- fragile to rare events and flaws in the design.

Seek the fattiest meat, the sweetest fruits, the most high-energy foods





ORIGINAL GLAZED



STRAWBERRIES & KREME



LEMON MERINGUE PIE



FOOTBALL DOUGHNUT



CARAMEL DREAMCAKE



CHOCOLATE ICED GLAZED



COOKIES & KREME £1.55

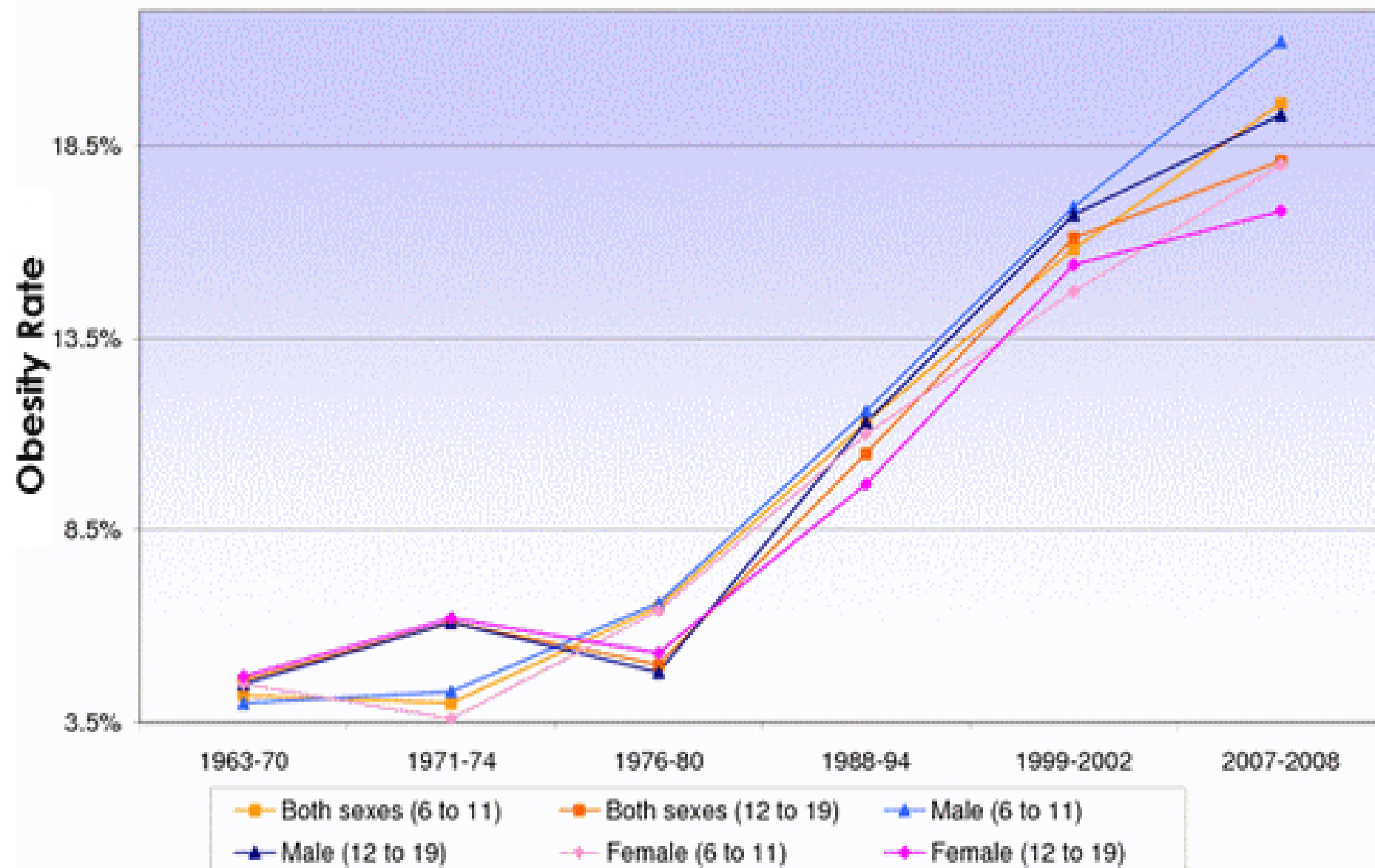


GLAZED CINN

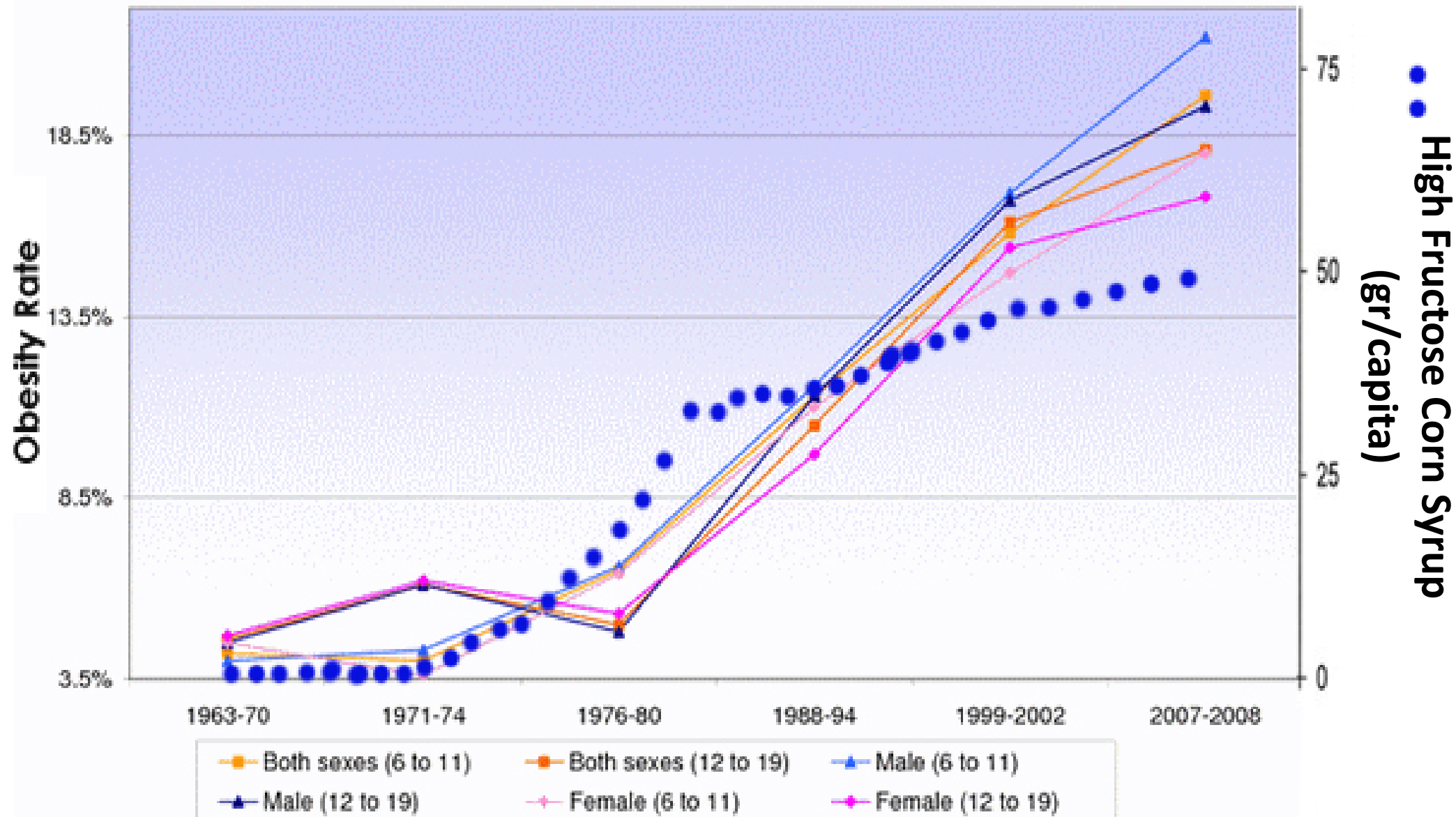




Child Obesity Statistics & Teenage Obesity Statistics by Age and Gender



the rise of processed foods









texting
while
driving

junk
food

virtual sex,
porn



look around

eat

reproduce

EVOLVED SYSTEMS

ACQUIRE ROBUSTNESS
TO WHATEVER DROVE SELECTION

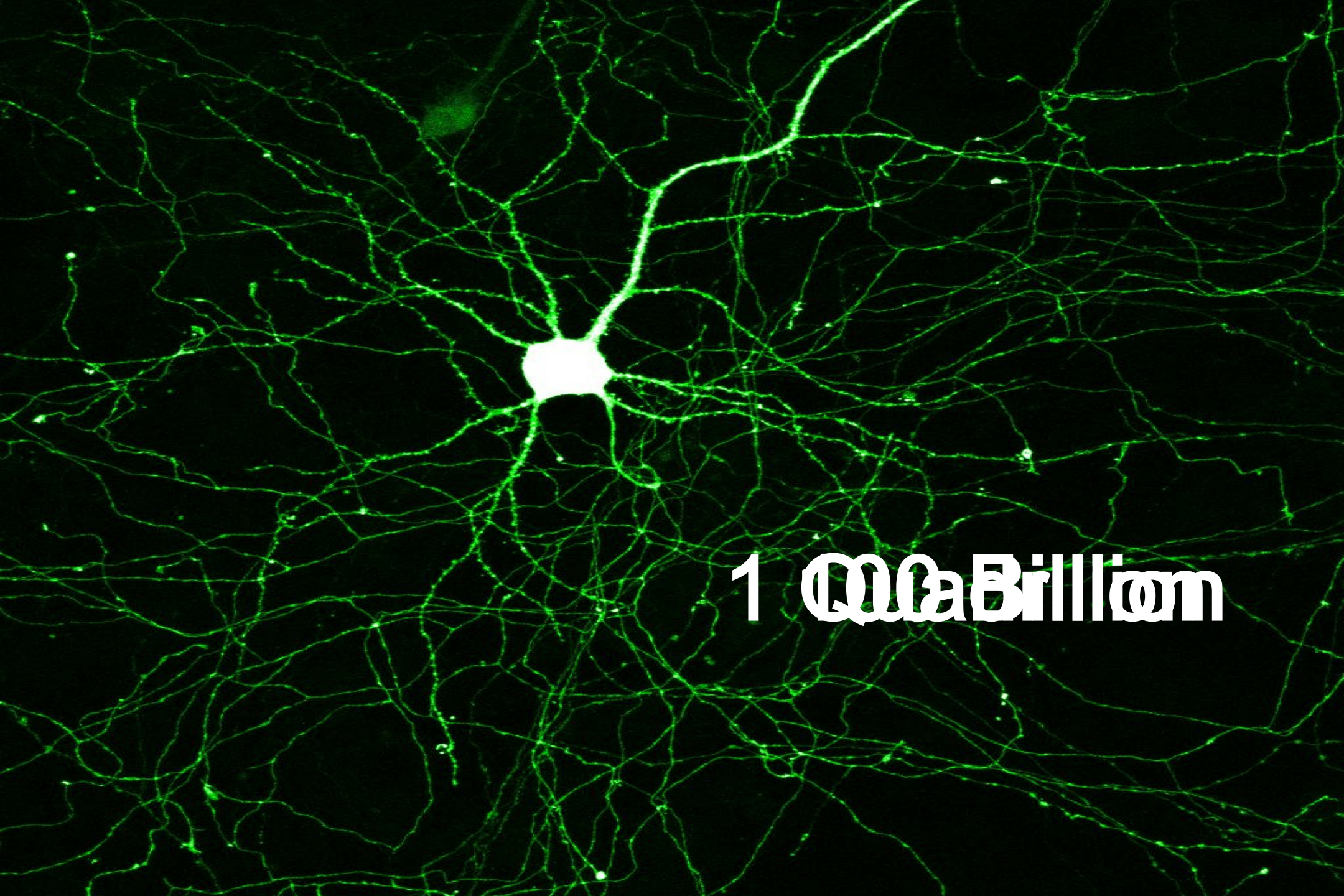
ROBUST YET FRAGILE



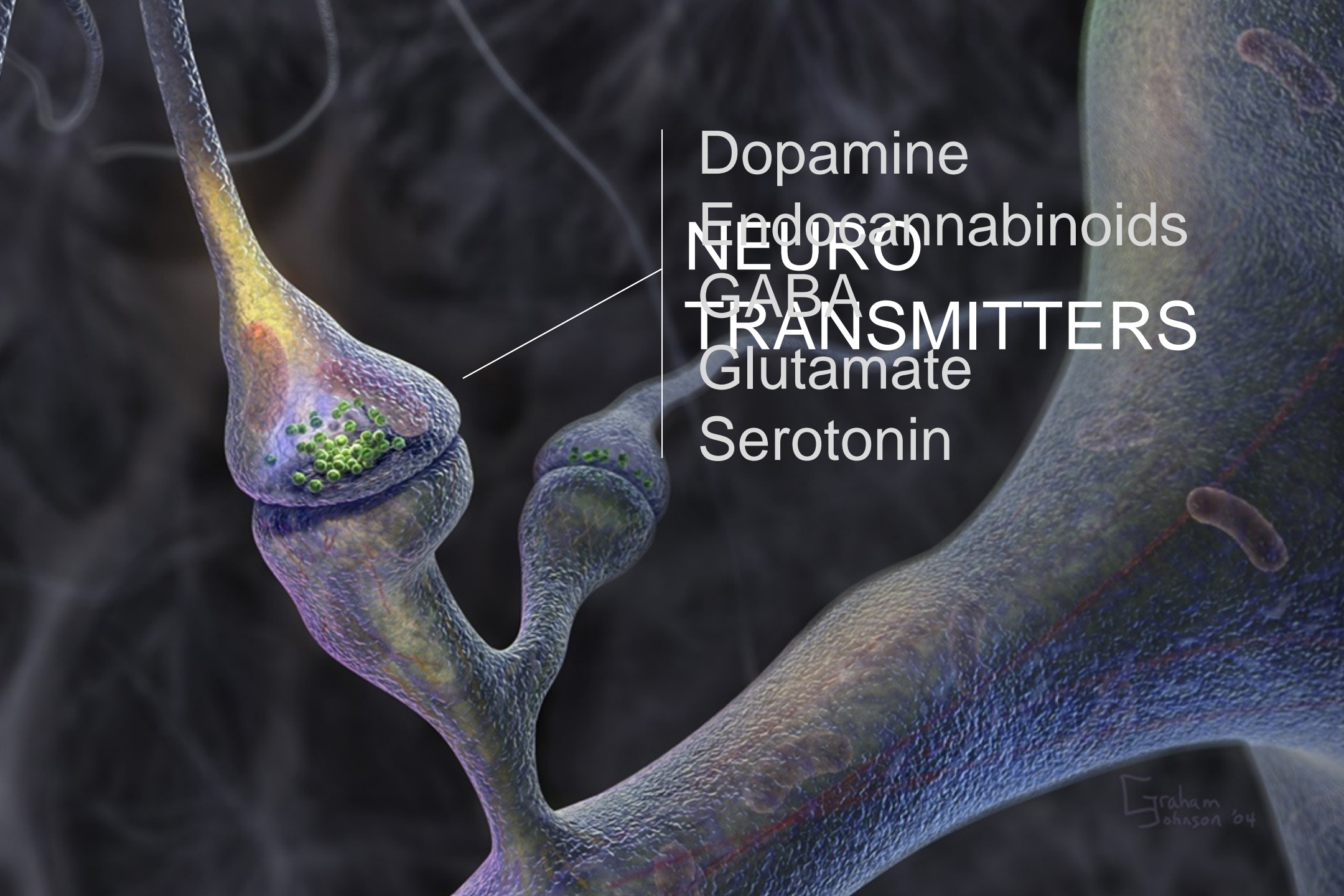
robust, yet
fragile
systems

they are
complex





100 Billion



Dopamine
Endocannabinoids
NEUROTRANSMITTERS
GABA
Glutamate
Serotonin

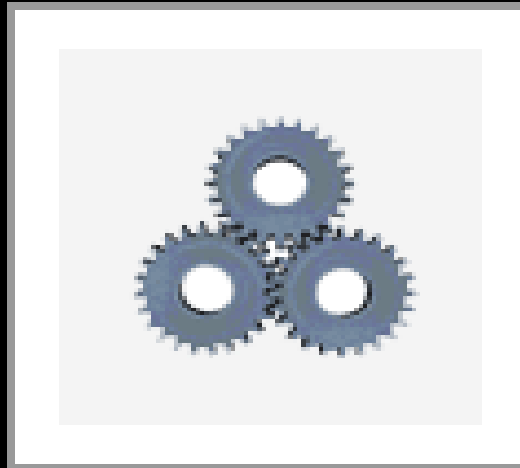
Graham
Johnson '04

- BRAIN
- DRUGS
- RISK
- RESILIENCE

Despite their many differences

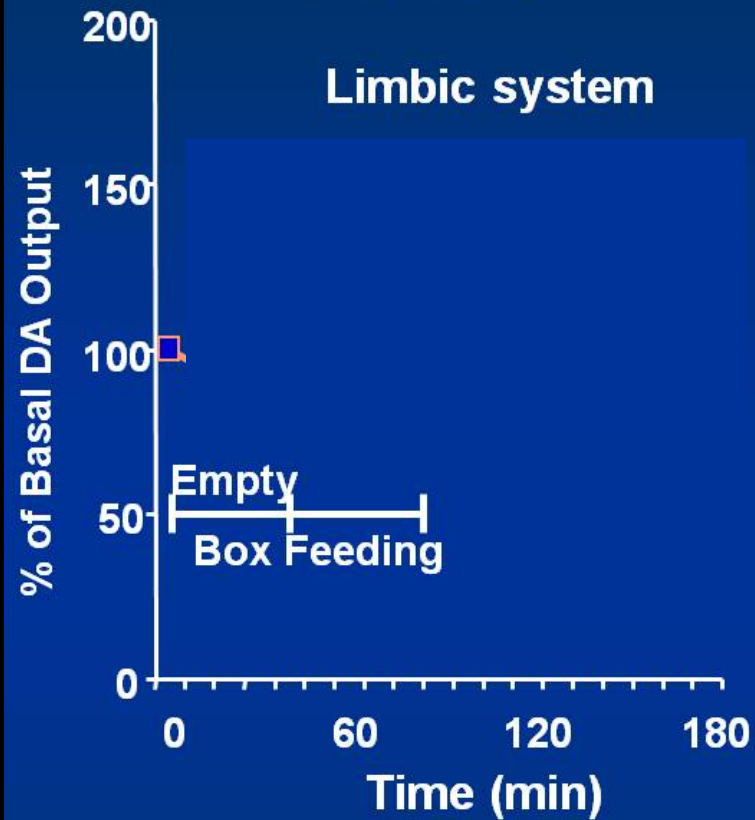
most abused substances have an
amazing ability to boost the levels of
a key chemical in the brain called...

Dopamine





FOOD



Di Chiara et al.
(1999)

robust,
yet
fragile

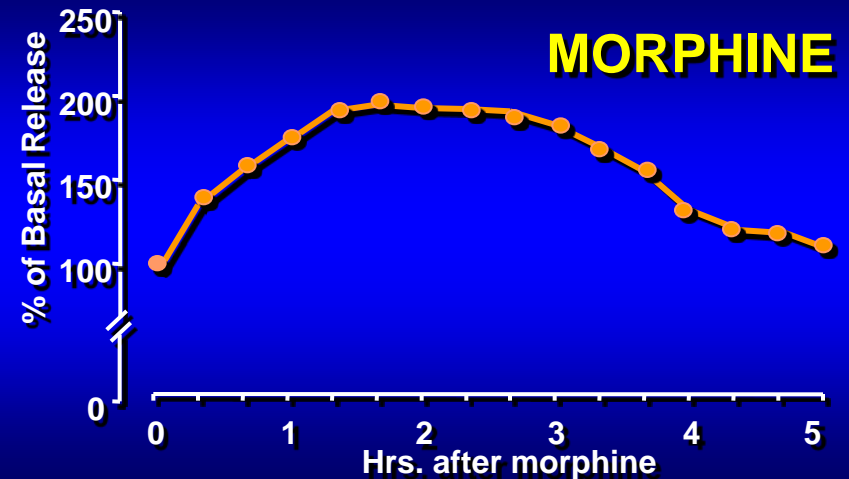
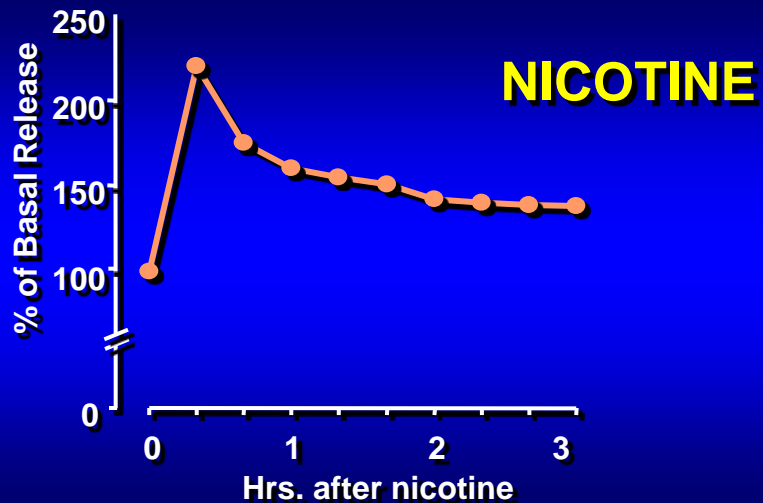
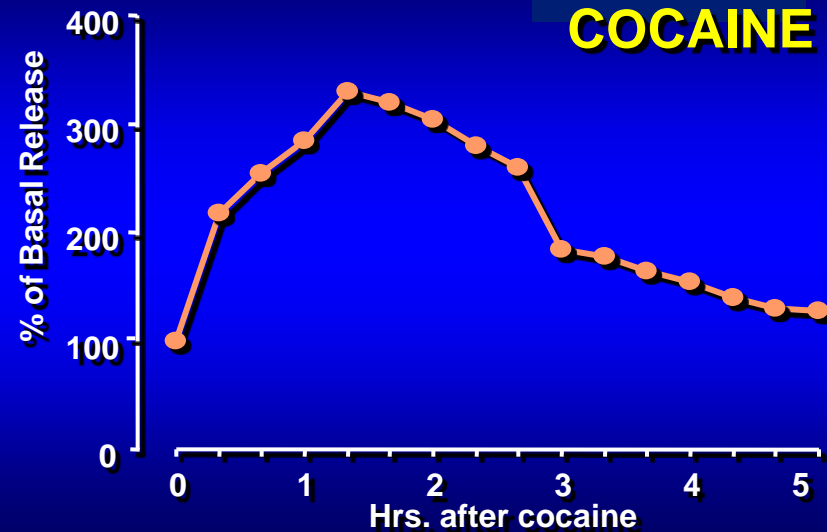
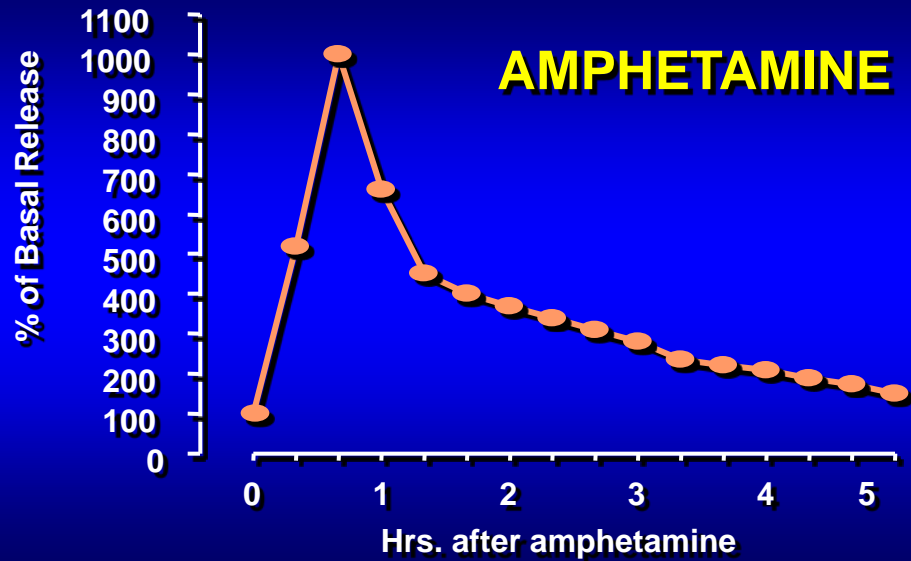


Natural Rewards Elevate Dopamine Levels But Drugs are amazingly more effective

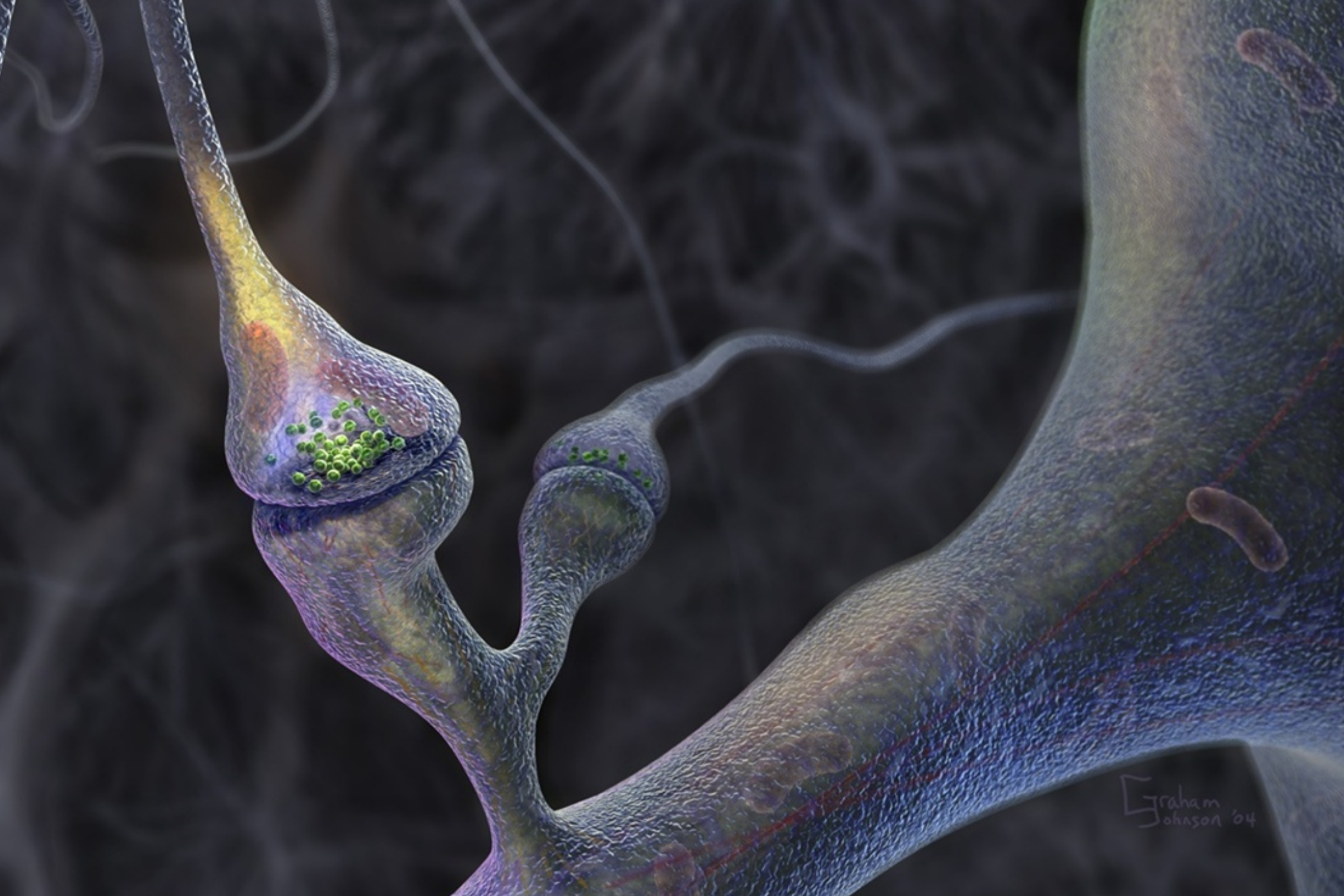


Fiorino and Phillips, J. Neuroscience, 1997.

Effects of Drugs on Dopamine Release (DA in Accumbens)

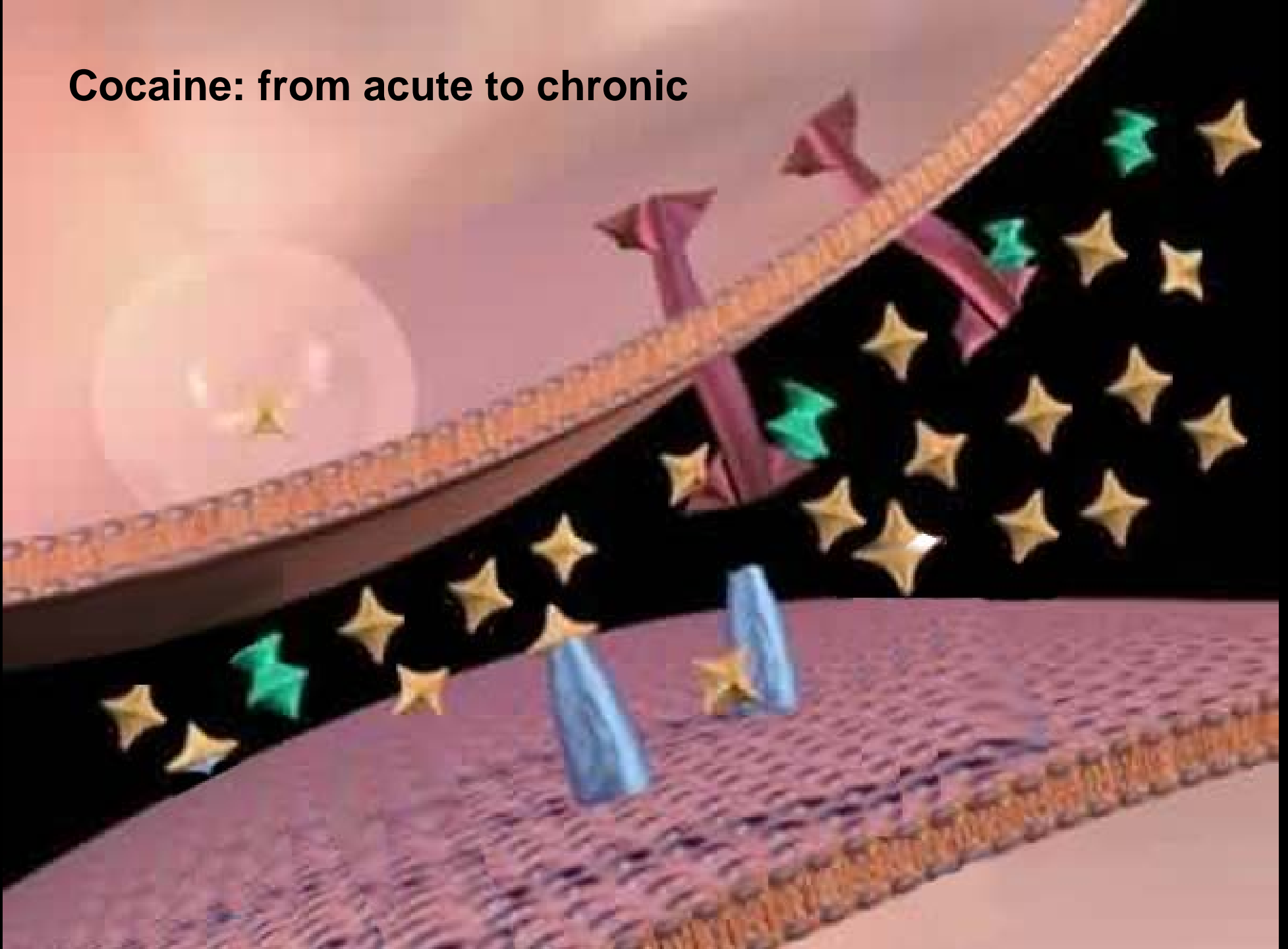


Source: Di Chiara and Imperato



Graham
Johnson '04

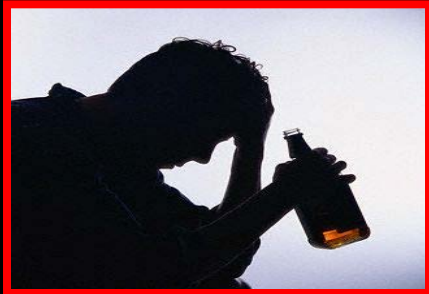
Cocaine: from acute to chronic



Dopamine Receptor level is Lower in Addiction



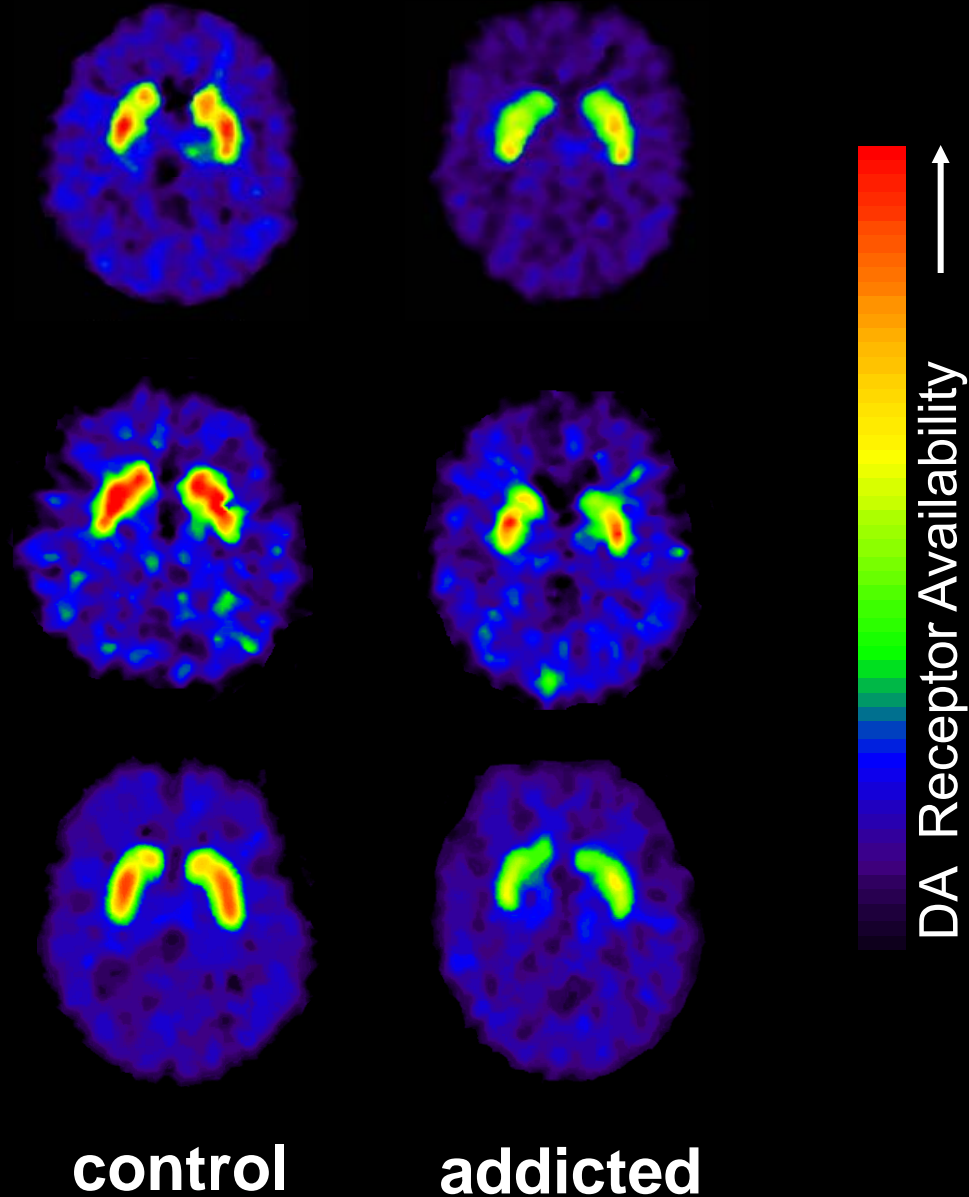
Cocaine

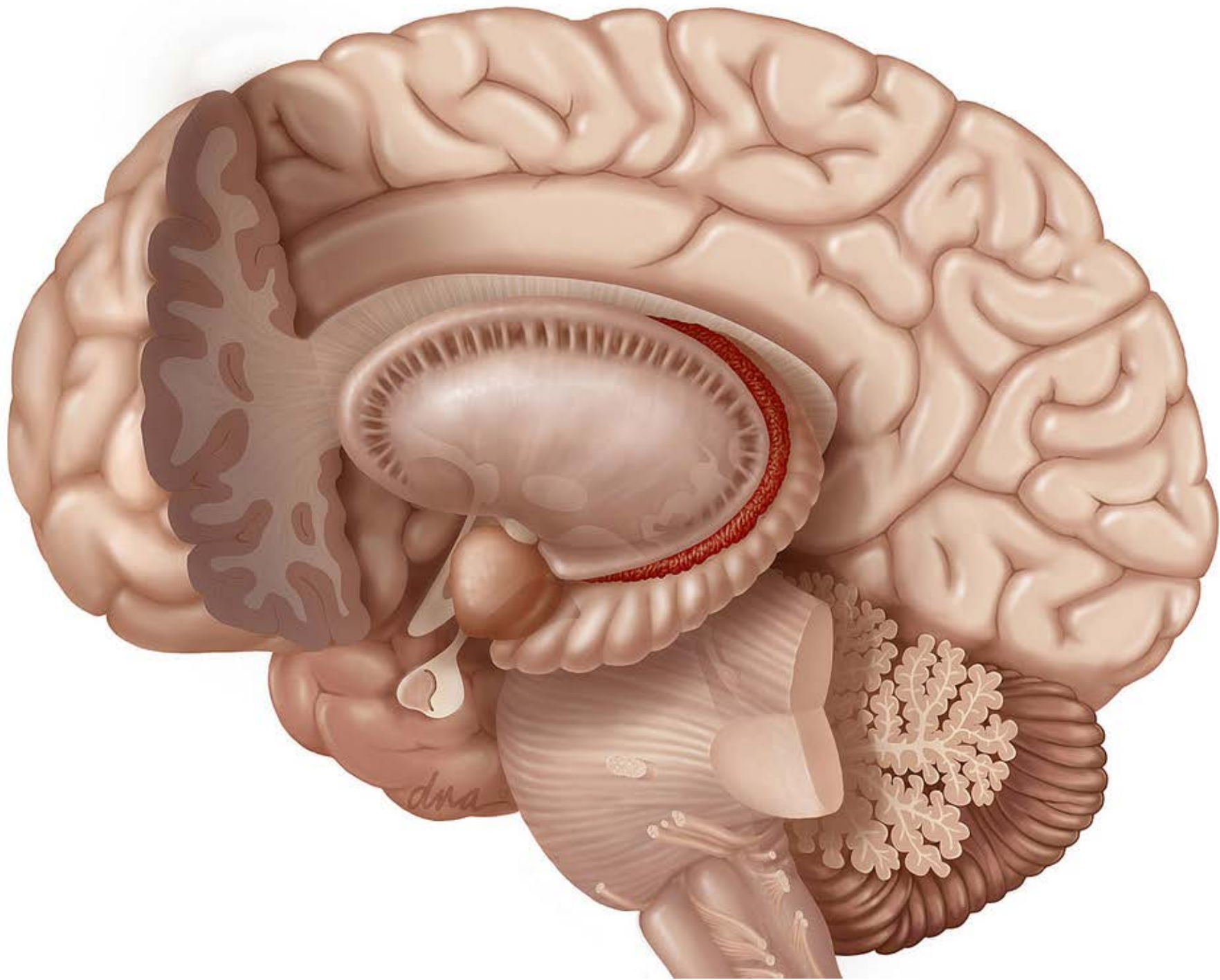


Alcohol



Heroin

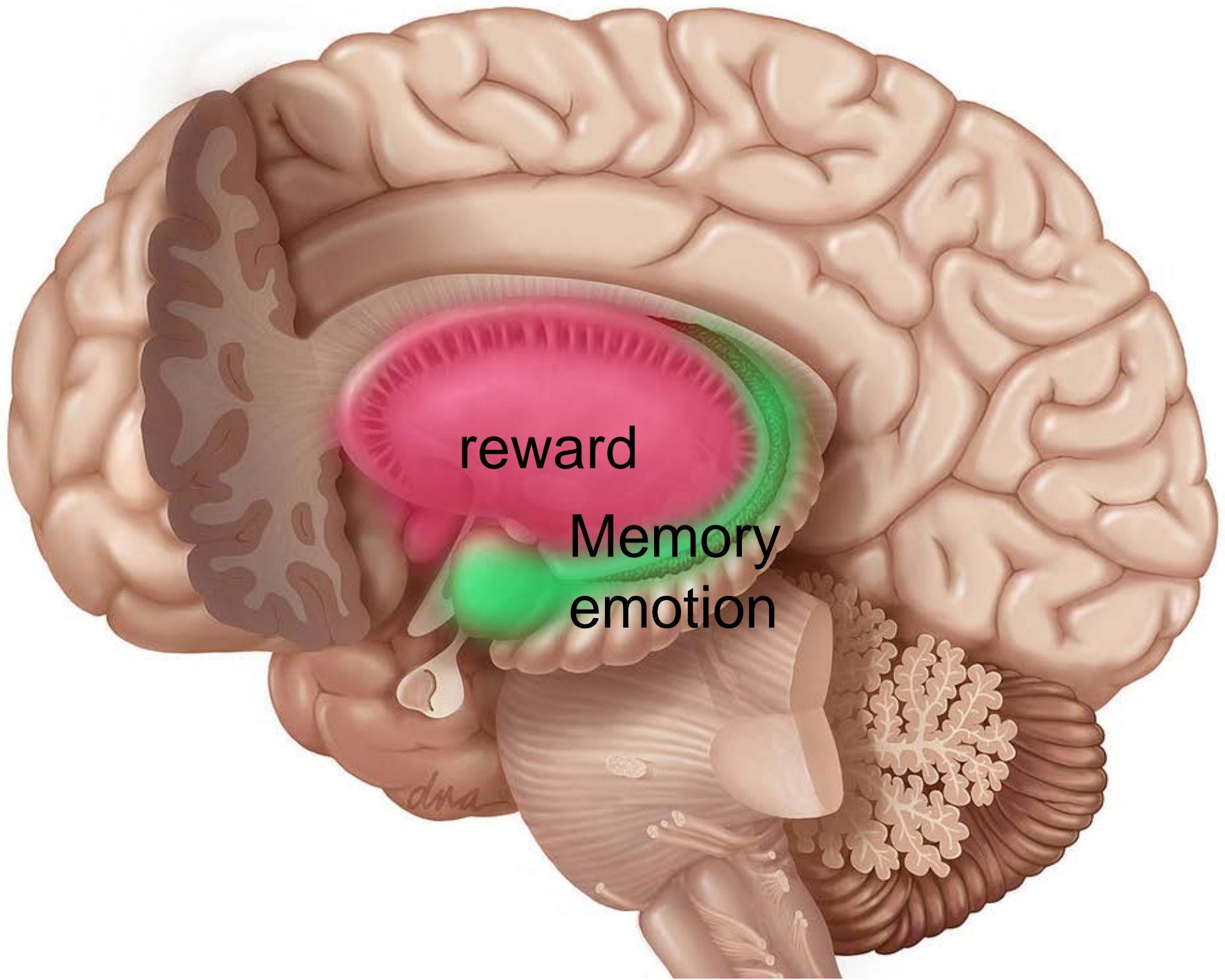






reward

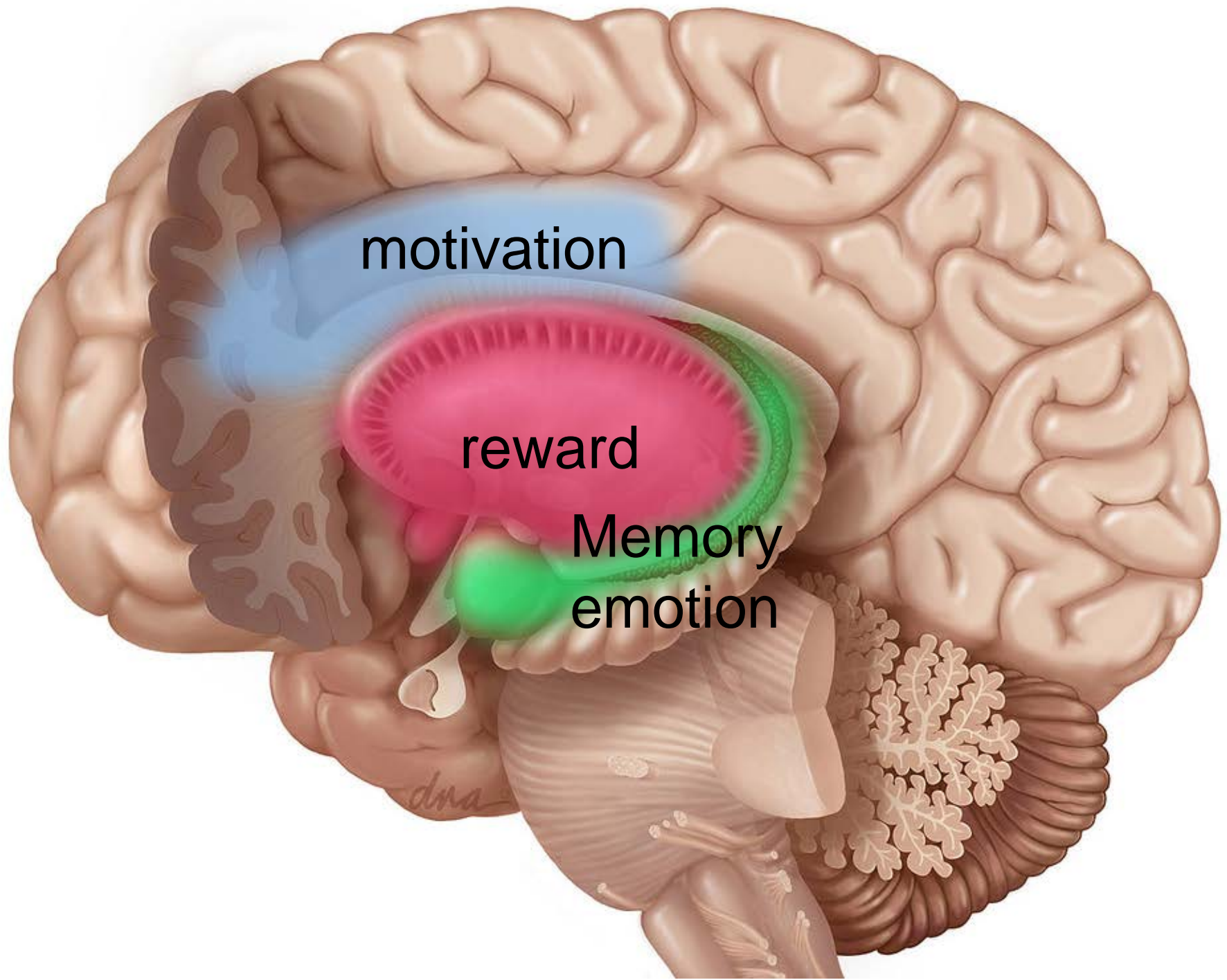
dna



reward

Memory
emotion

dna

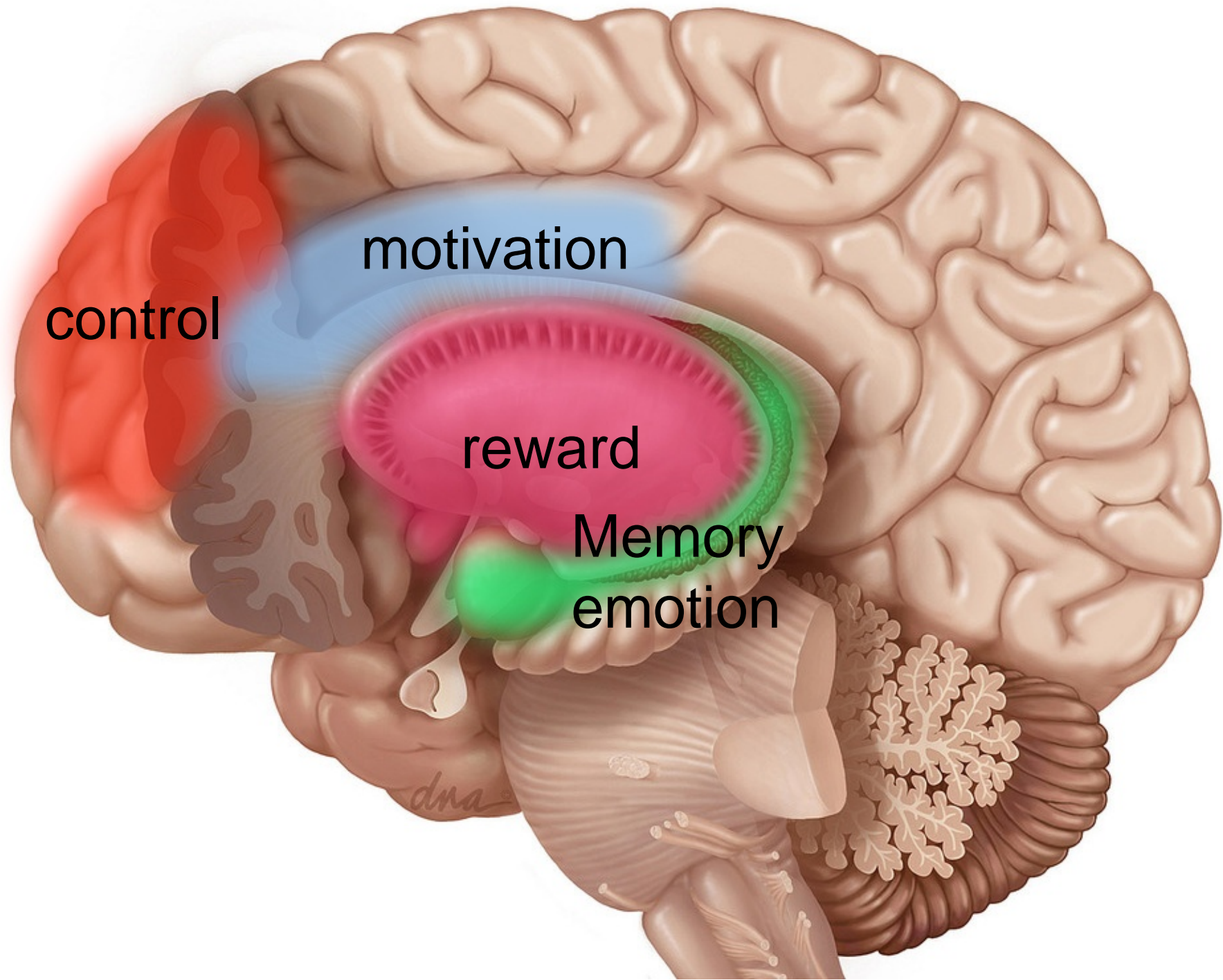


motivation

reward

Memory
emotion

dna



control

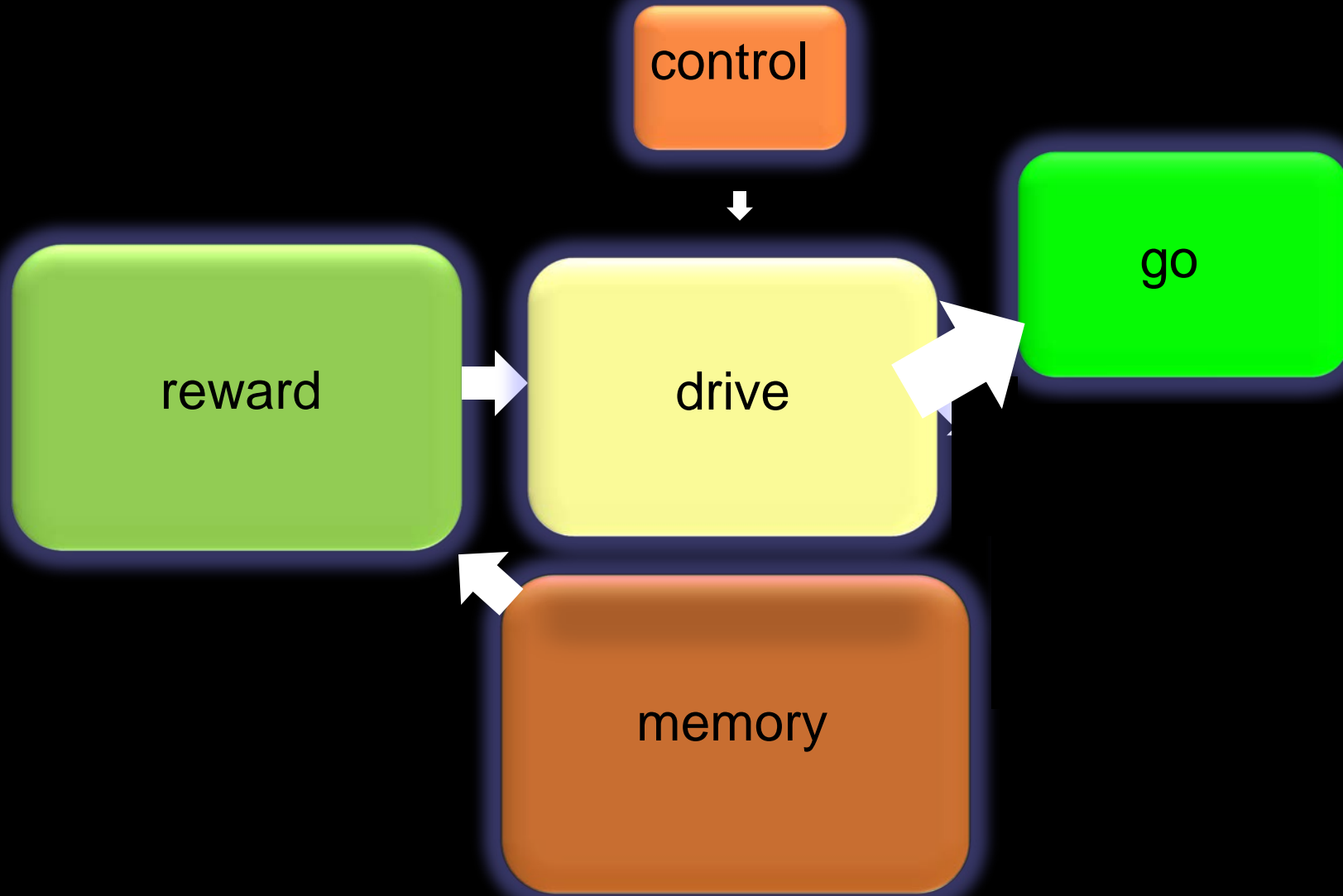
motivation

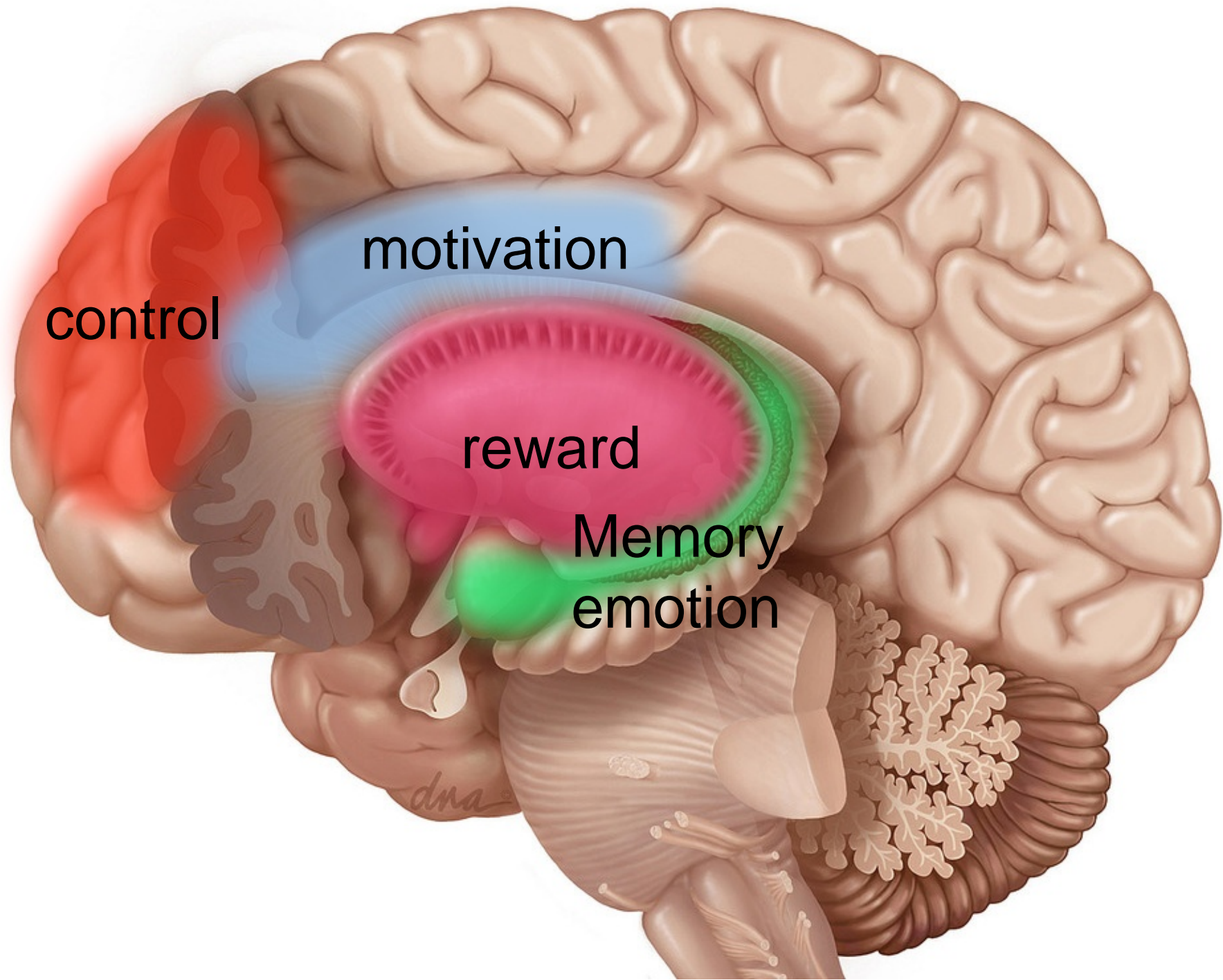
reward

Memory
emotion

dna

Addicted brain





control

motivation

reward

Memory
emotion

dna

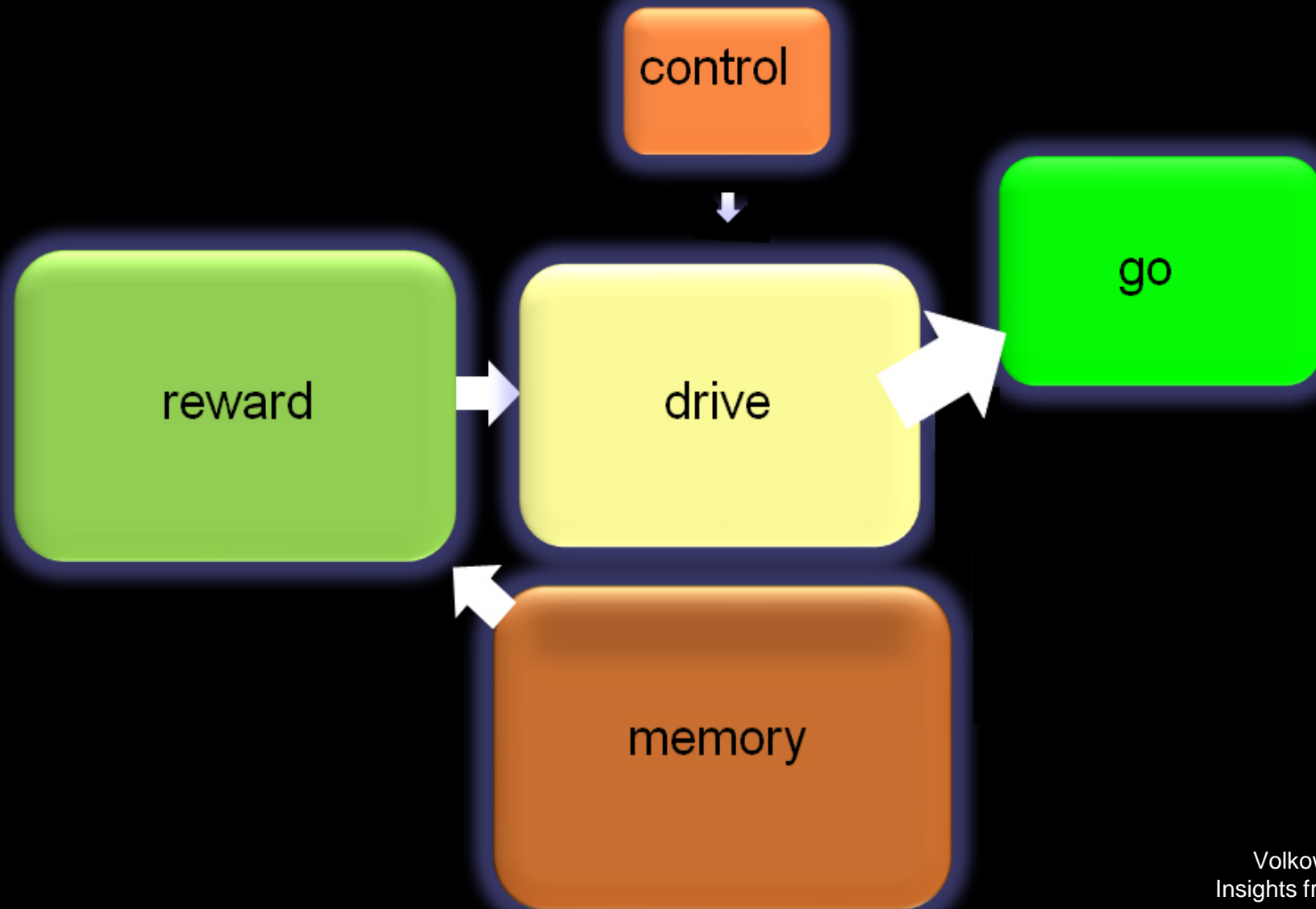
“As I sit to compose this plea I can’t say with any amount of certainty that my son is alive. My son discovered narcotics at the age of 13, [after] he experienced a severe orthopedic sports injury.

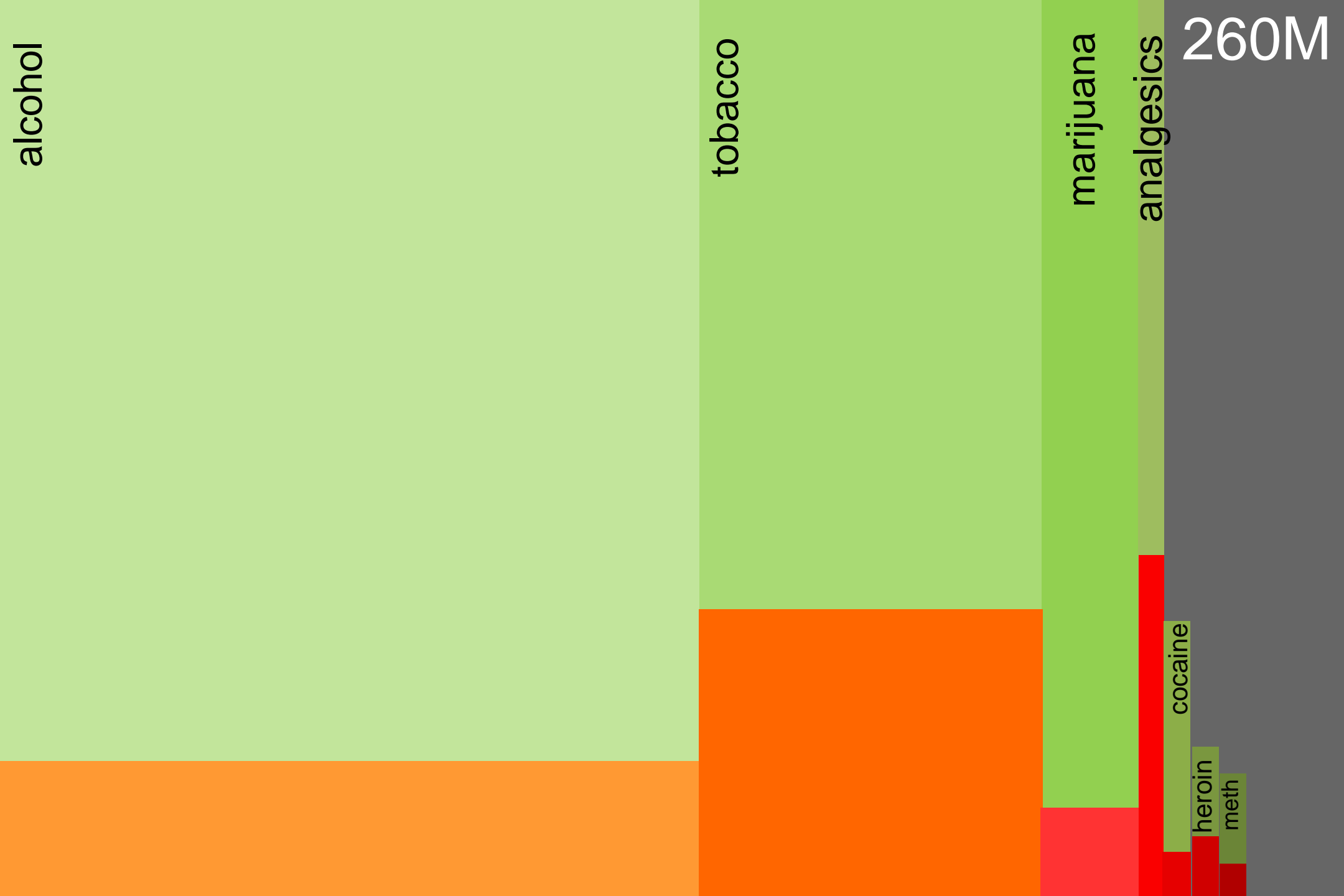
There seems to be nothing that can induce him to stop for any appreciable length of time. I had him arrested May of 2006 for heroin possession and identity fraud, he stole 900 dollars from our checking account while I was in Connecticut burying my dad and his sister .

He tells me he cannot stop. Our family is being destroyed . We have exhausted our savings and retirement. Everything seems so hopeless.”

is a moral failure.

It's not, it's an operational failure

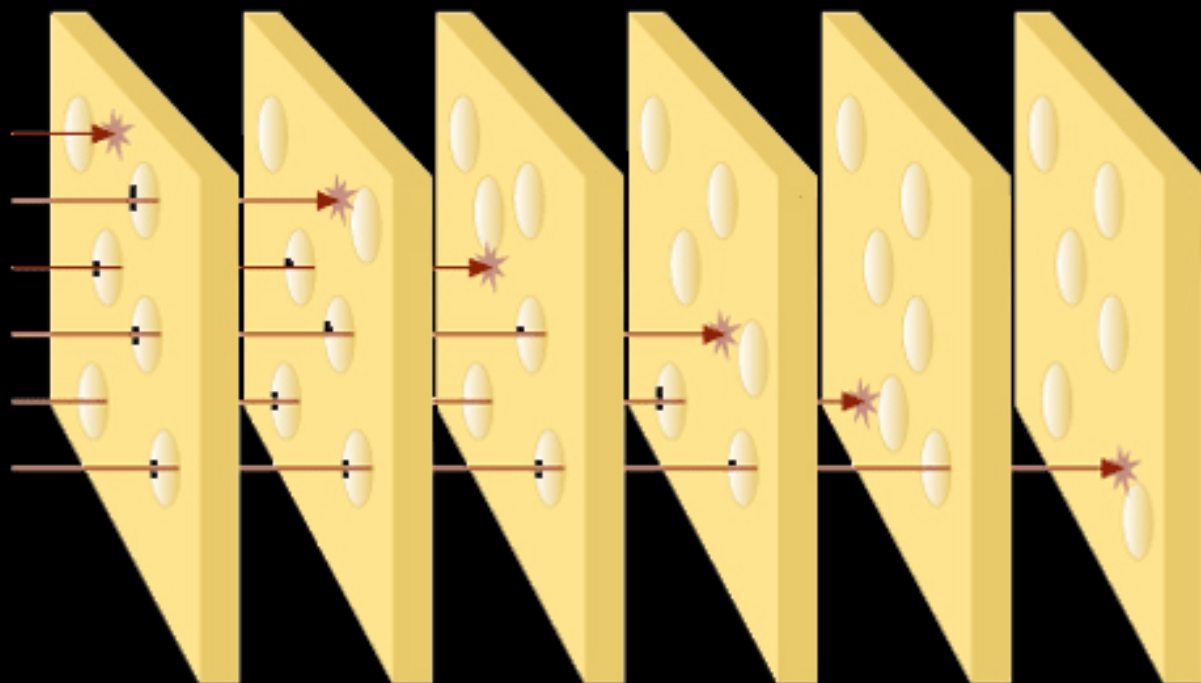




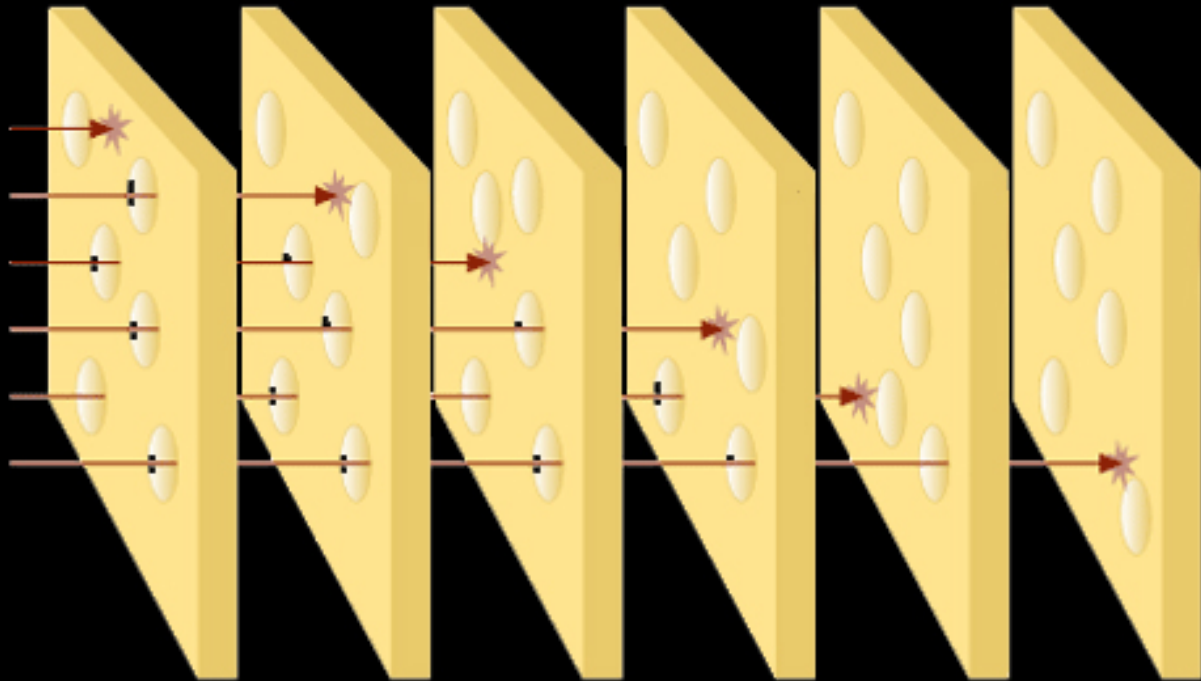
- BRAIN
- DRUGS
- **RISK**
- RESILIENCE

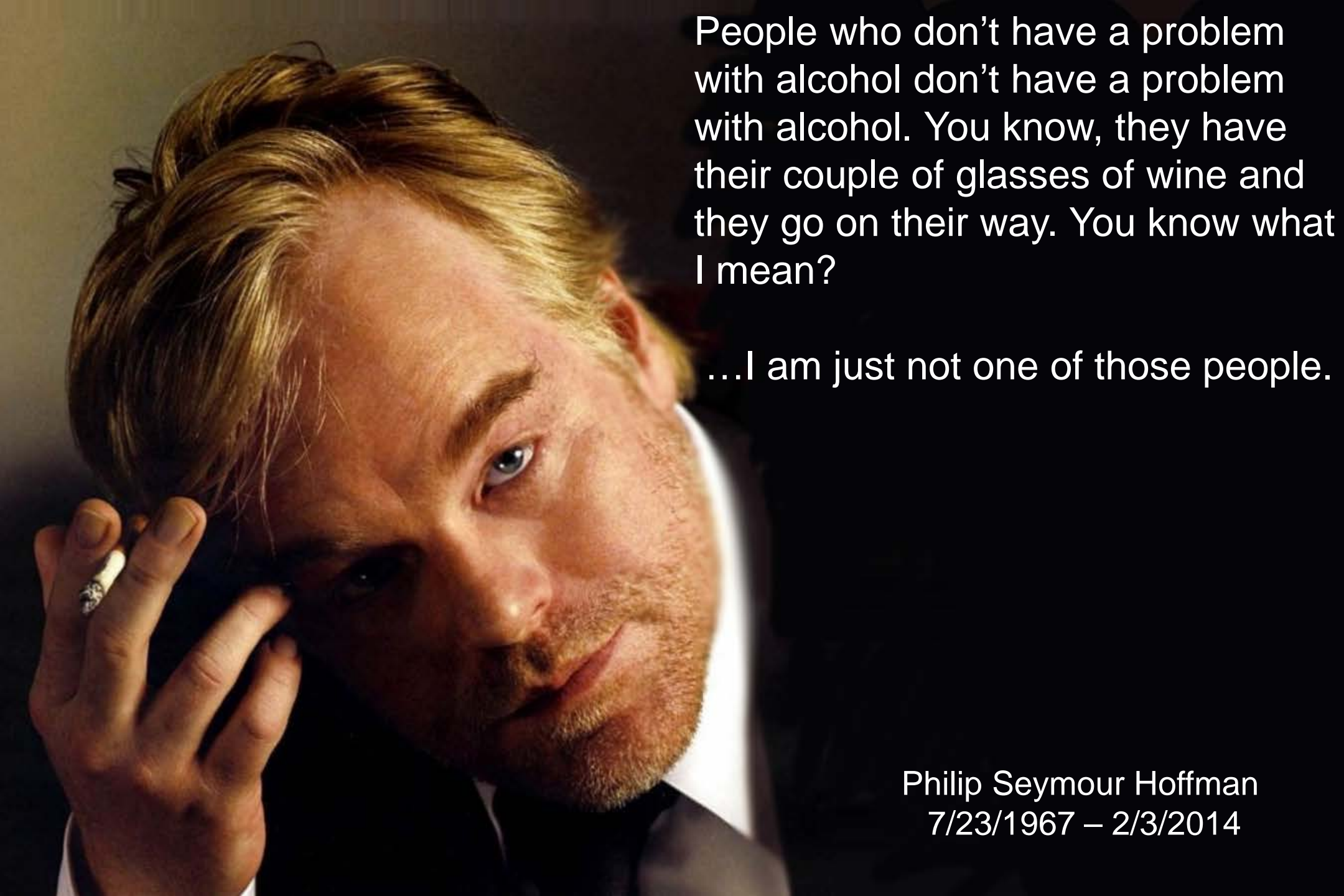


genetics
epigenetics
development
parental style
education
environment



genetics



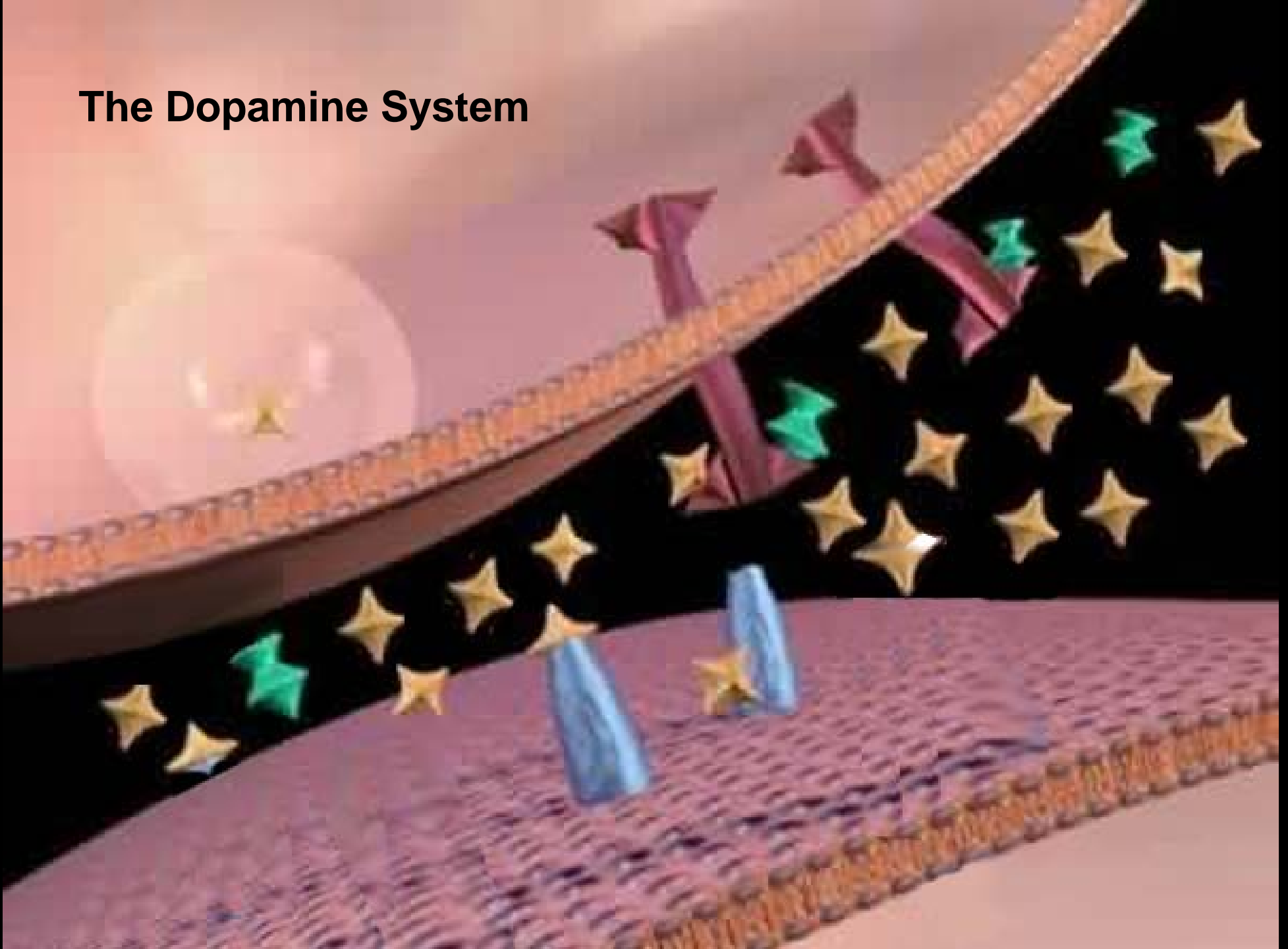
A close-up portrait of actor Philip Seymour Hoffman. He has light brown hair and a light beard, looking directly at the camera with a slight smile. He is holding a lit cigarette in his right hand, which is raised near his face. He is wearing a dark suit jacket over a white shirt and a dark tie. The background is dark and out of focus.

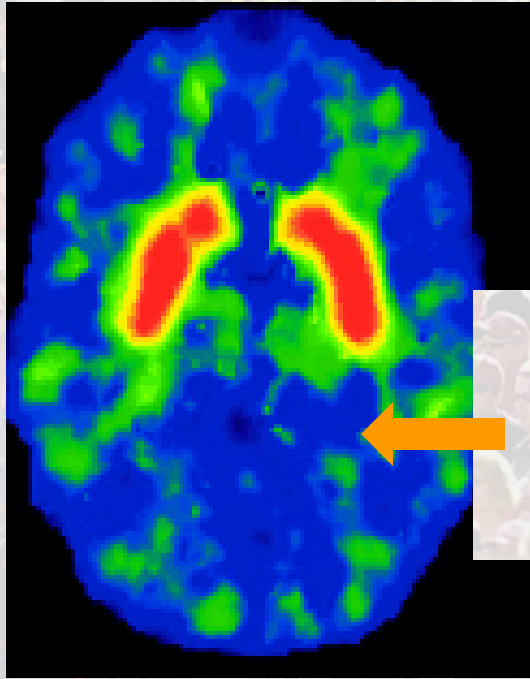
People who don't have a problem
with alcohol don't have a problem
with alcohol. You know, they have
their couple of glasses of wine and
they go on their way. You know what
I mean?

...I am just not one of those people.

Philip Seymour Hoffman
7/23/1967 – 2/3/2014

The Dopamine System

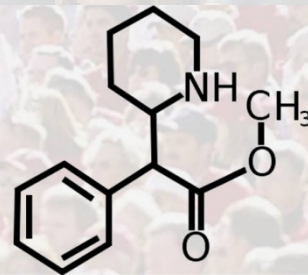




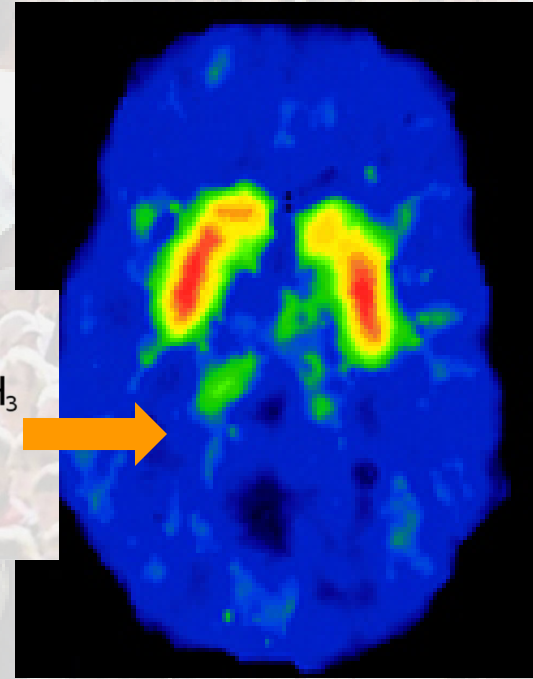
High Dopamine Receptor



Aversive



Ritalin

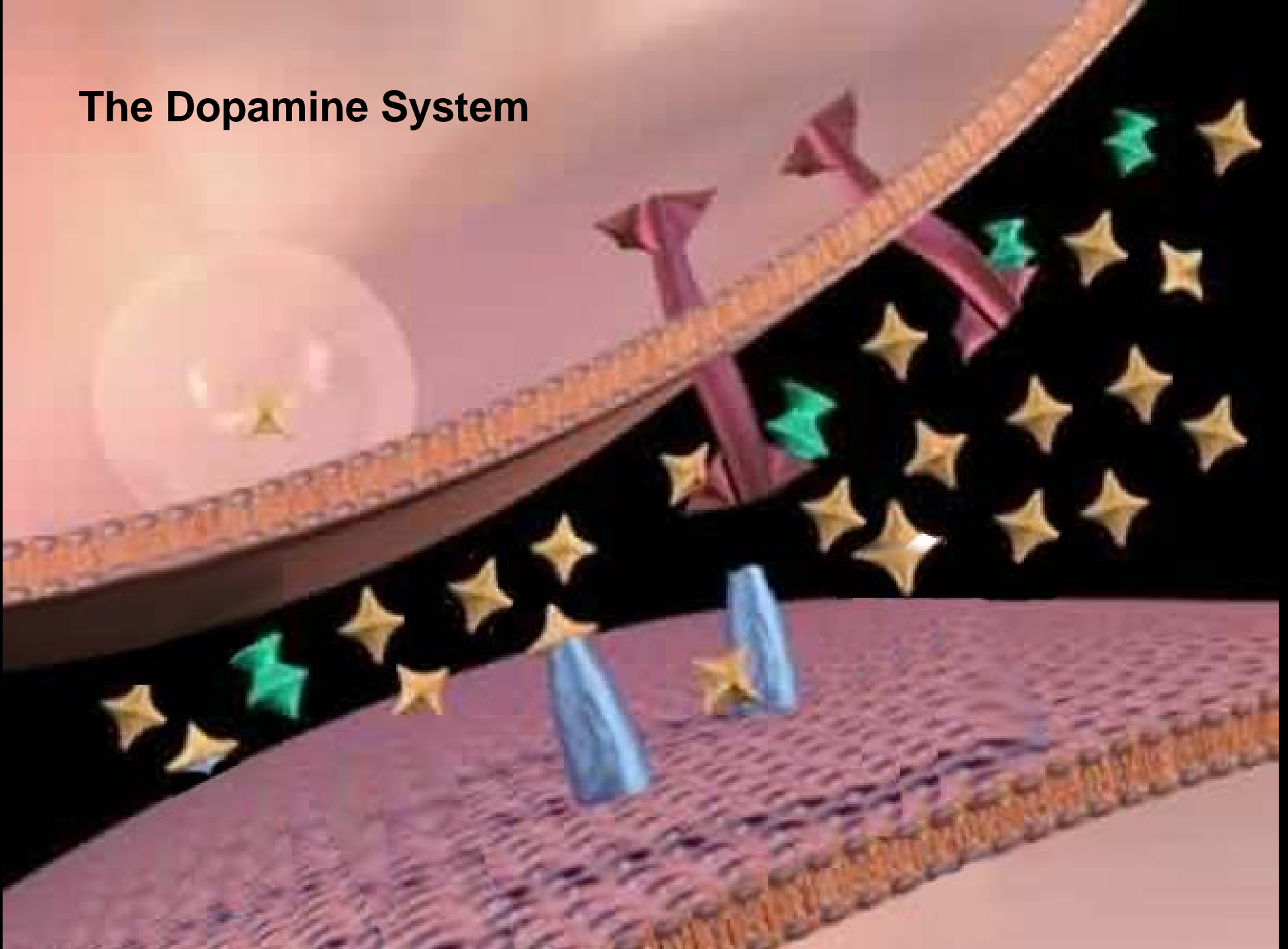


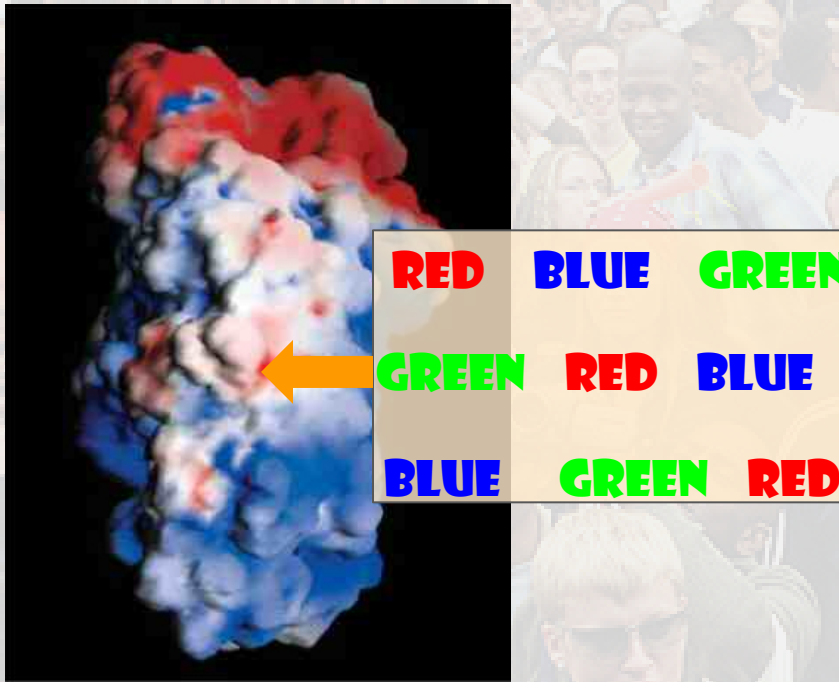
Low Dopamine Receptor



Pleasurable

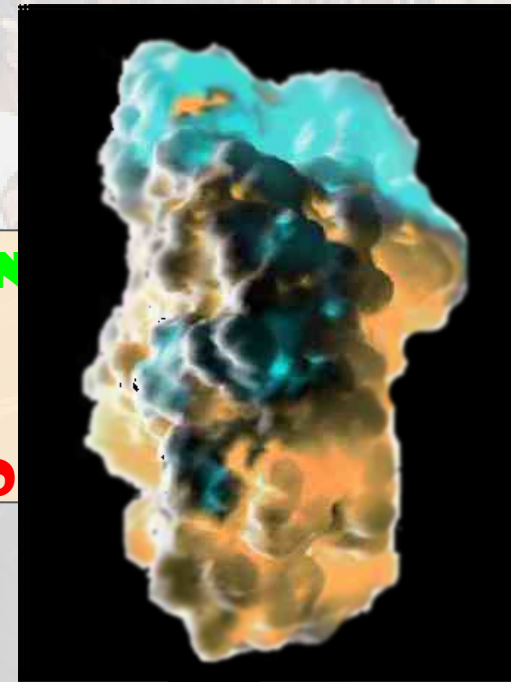
The Dopamine System





**Dopamine Transporter
GG**

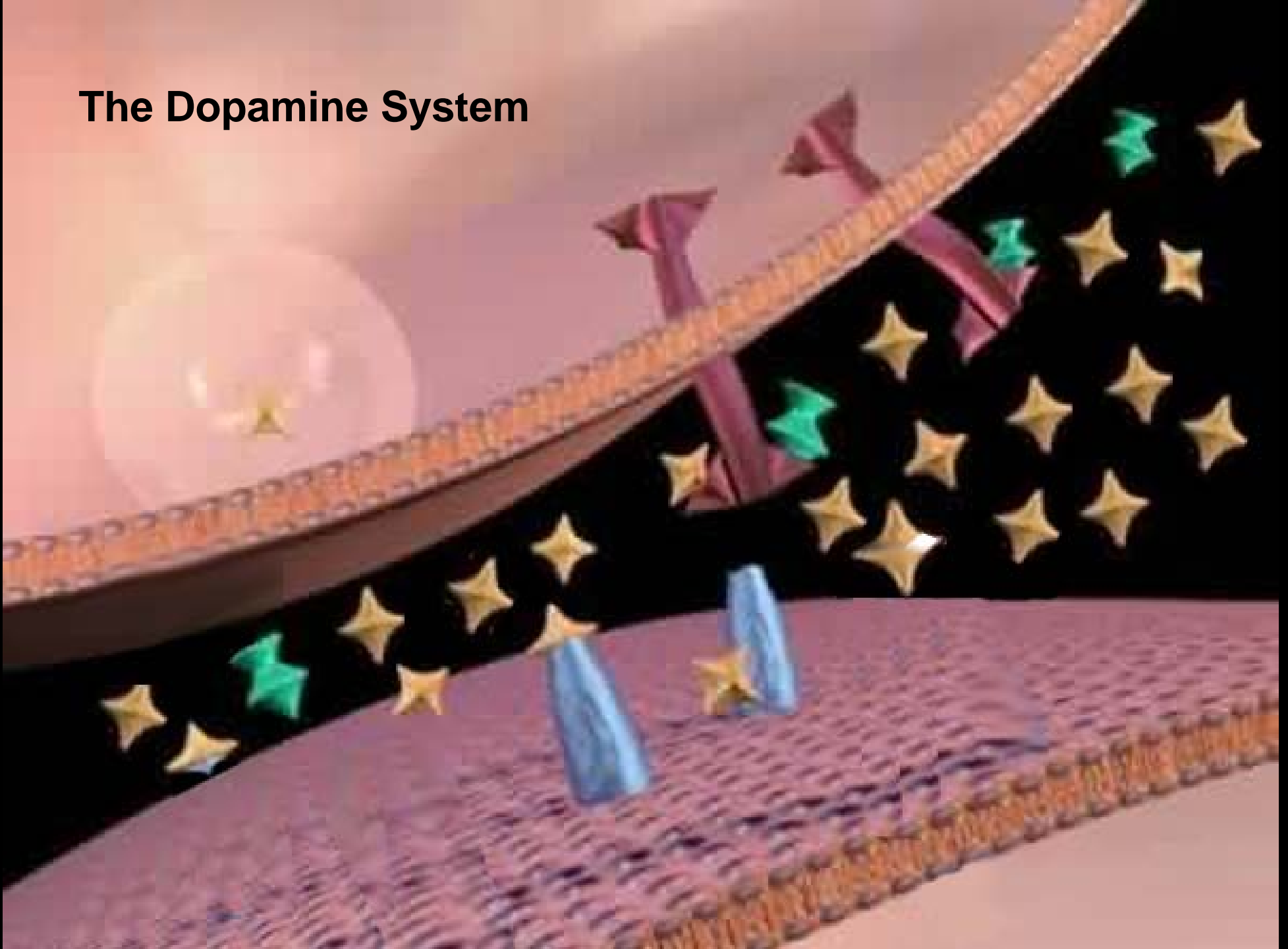
↓
**Good
Impulse Control**



**Dopamine Transporter
TT**

↓
**Poor
Impulse Control**

The Dopamine System

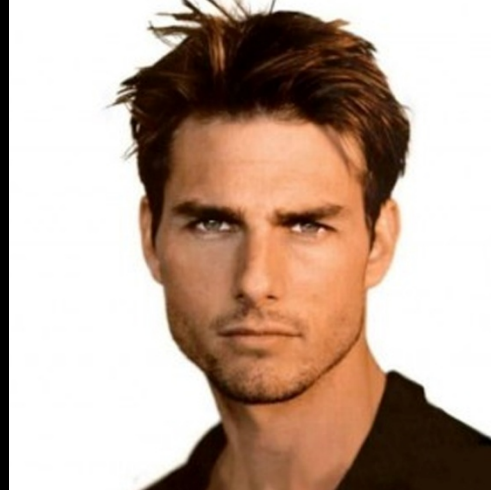


(drug liking)

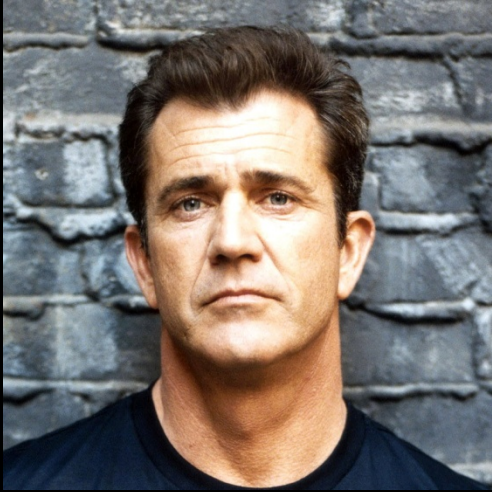
Dopamine Receptor

HIGH

LOW



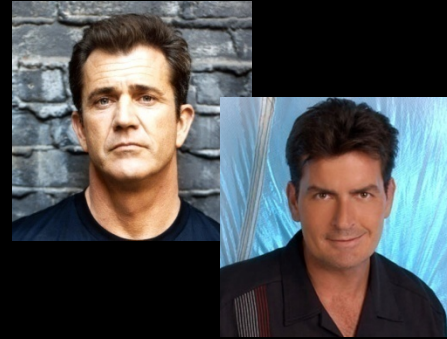
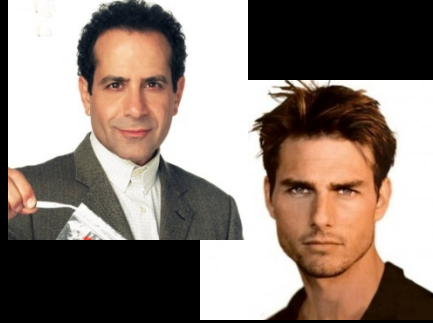
(impulsivity)
Dopamine Transporter
TT GG

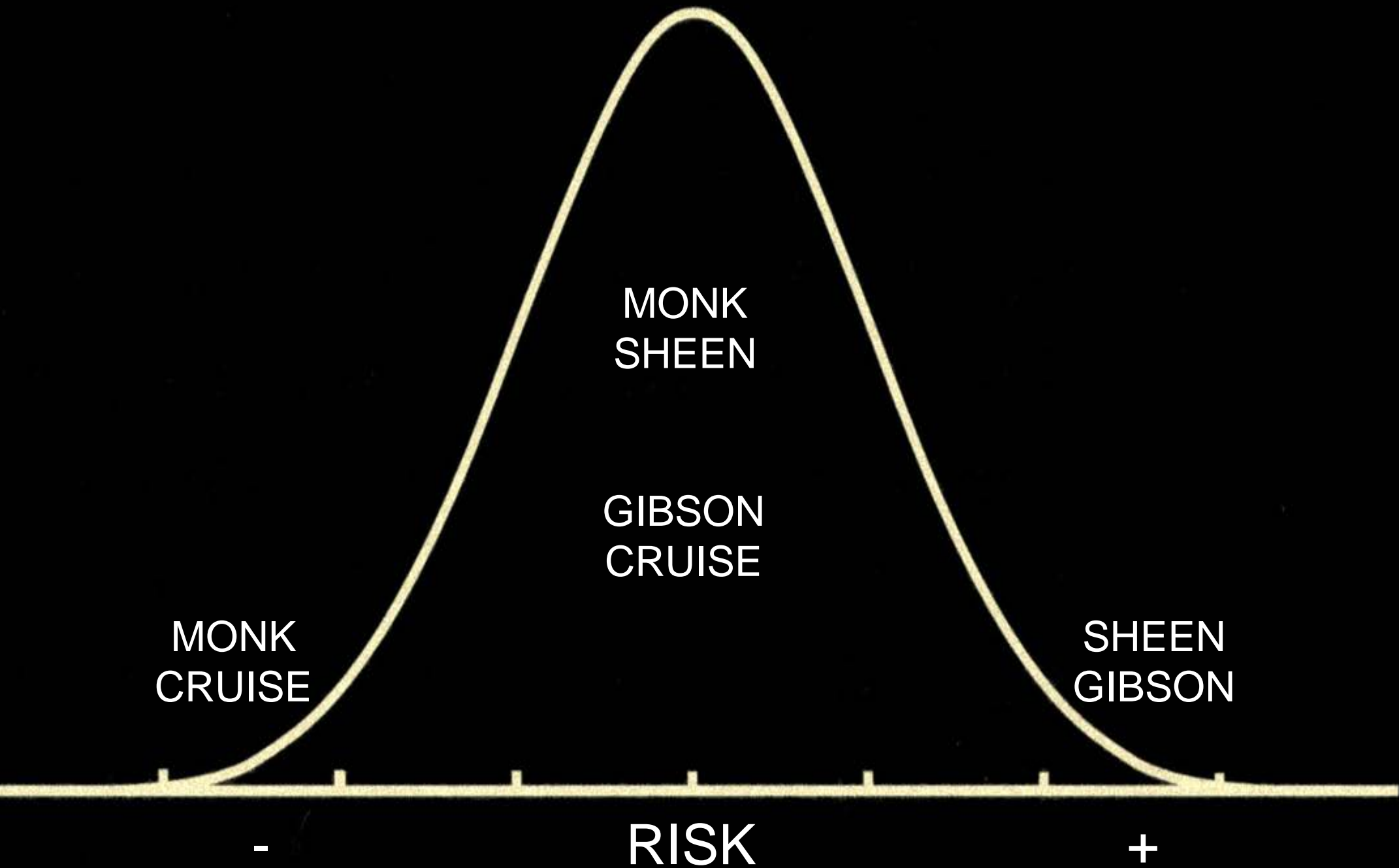


(impulsivity)
Dopamine Transporter
TT GG

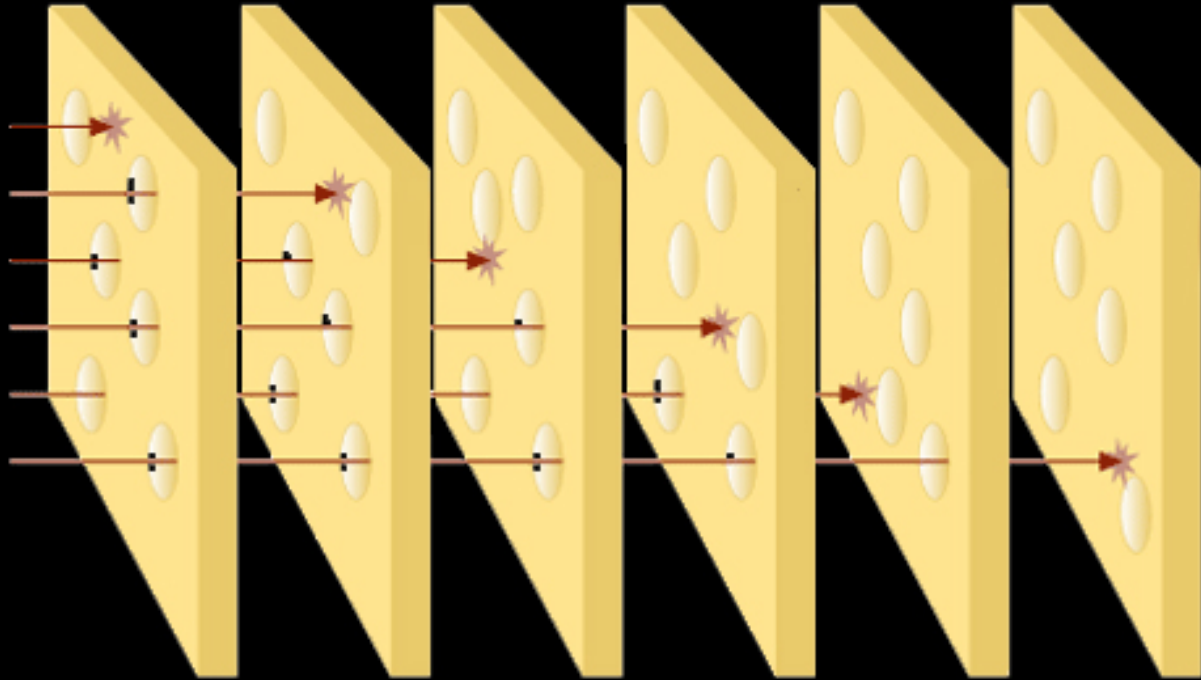
(drug liking)

Dopamine Receptor
HIGH LOW



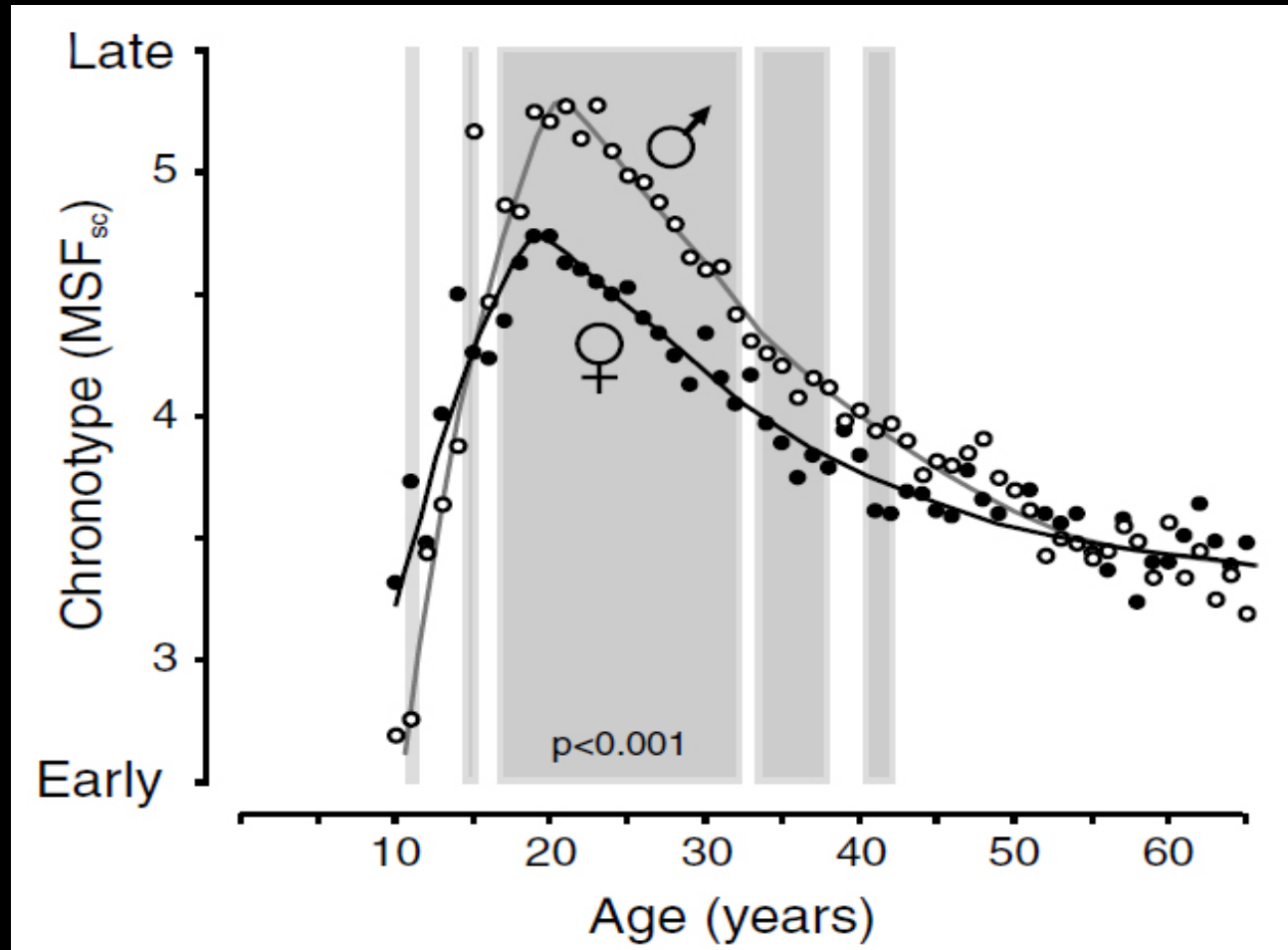


environment





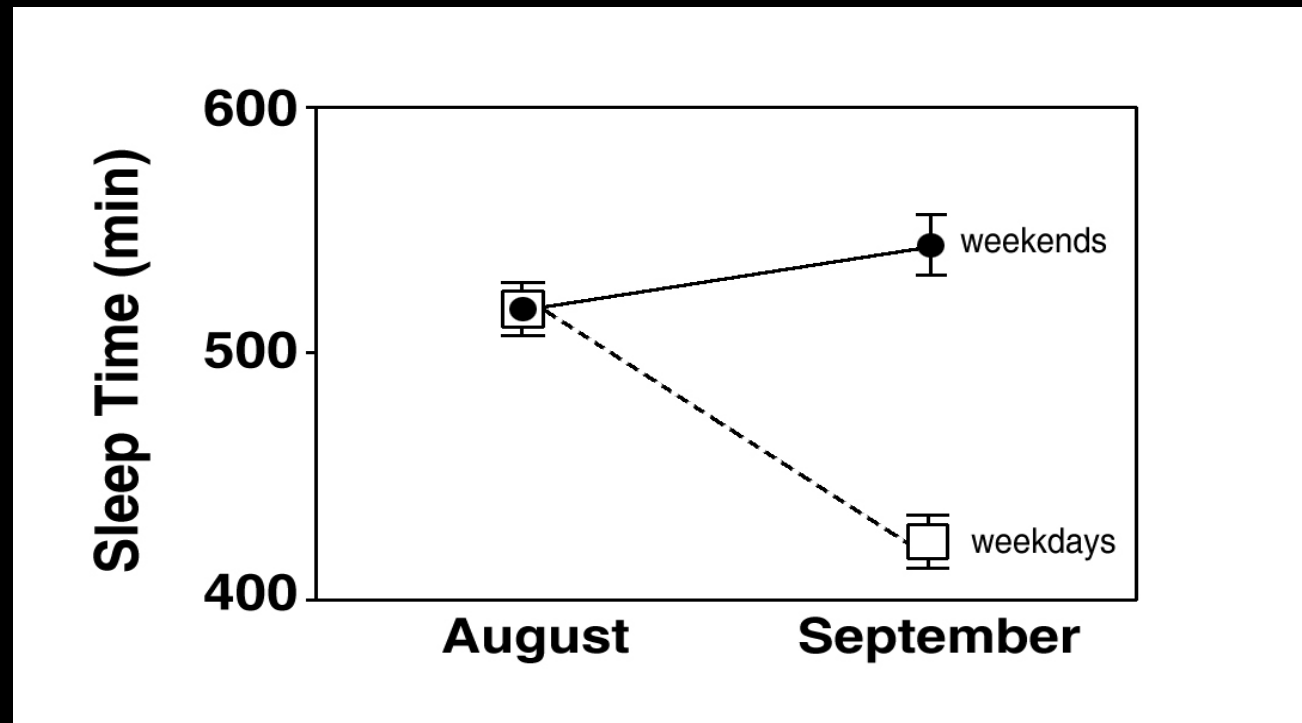
Chronotype Changes with Age



(MSF: midpoint of sleep on free days)

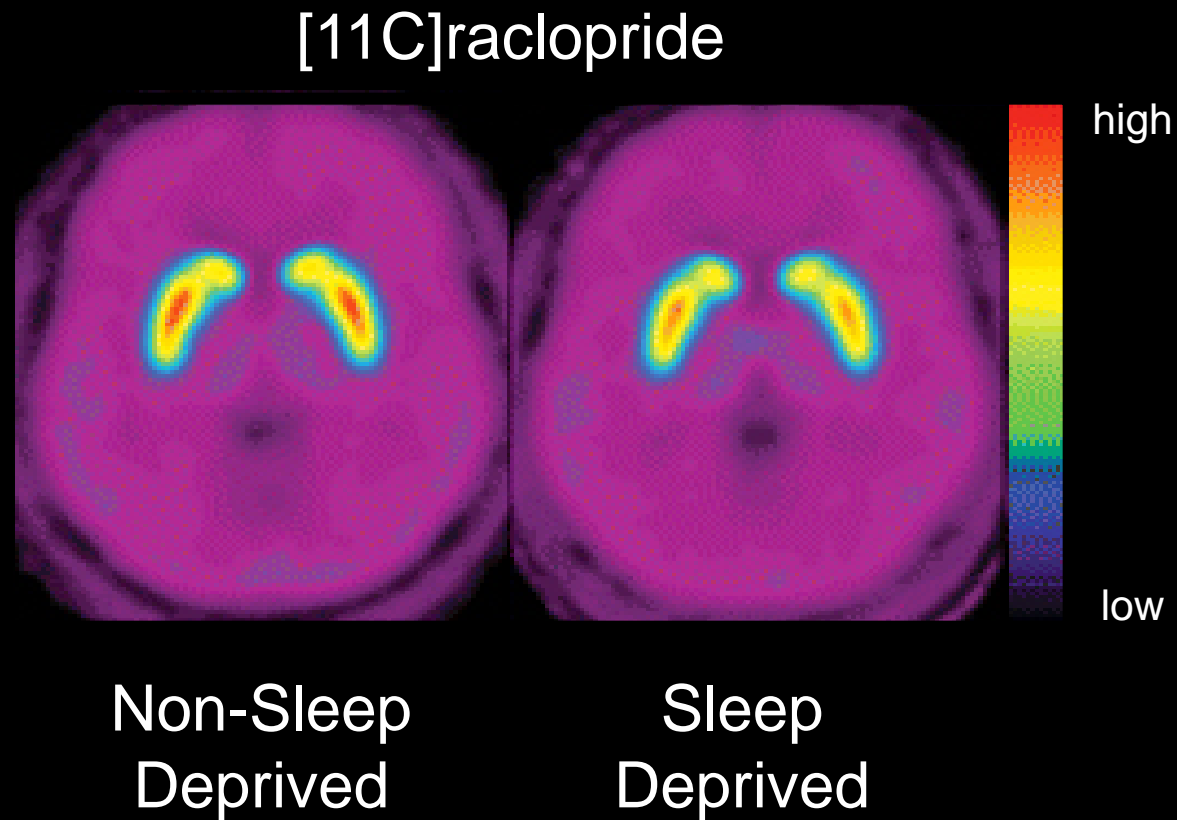
Till Roenneberg (2004). *Current Biology* 14(24) :R1038

Current High School Start Times Contribute to Sleep Deprivation Among Adolescents.

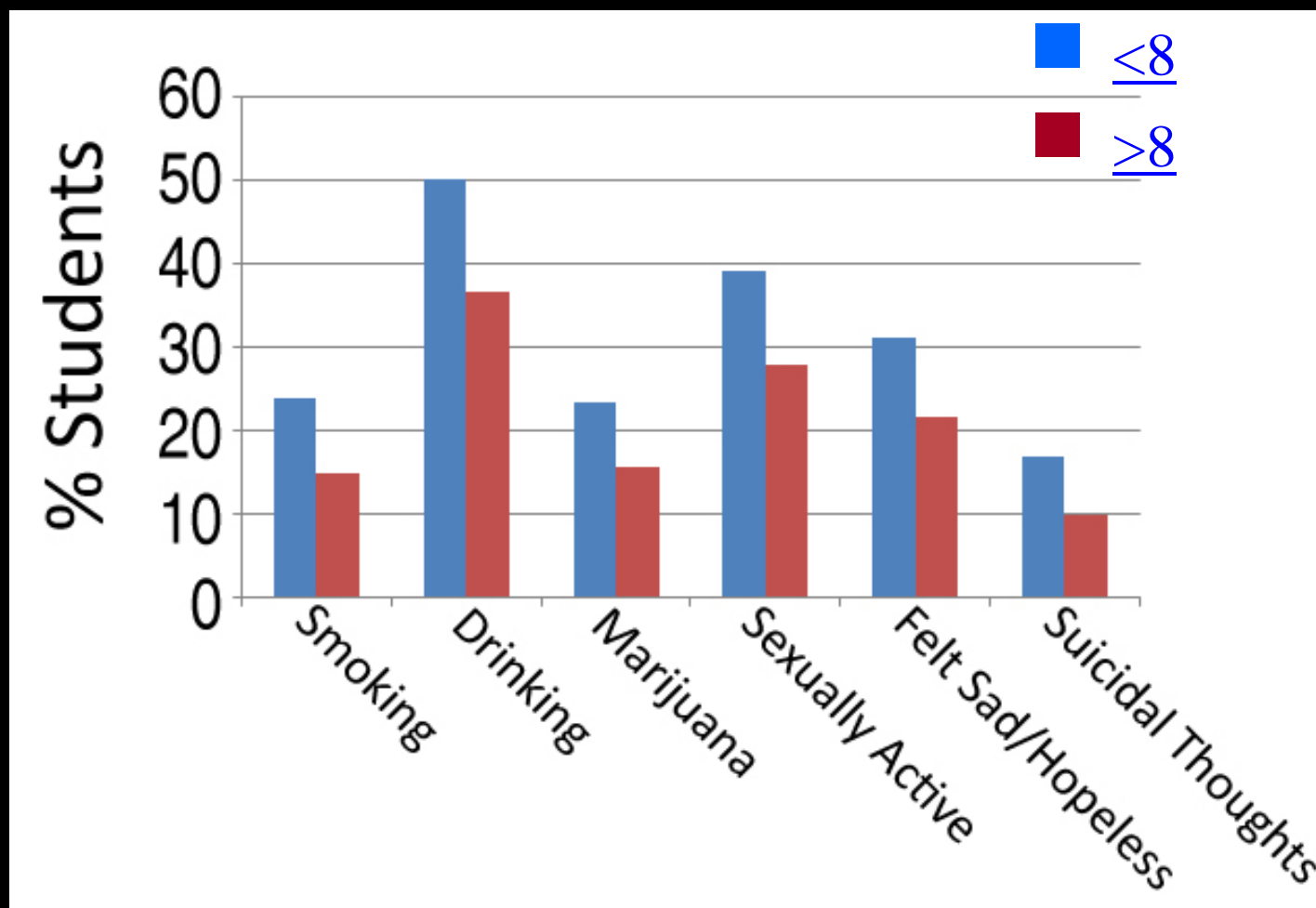


120 min

Effect of Sleep Deprivation on Dopamine Receptor Availability



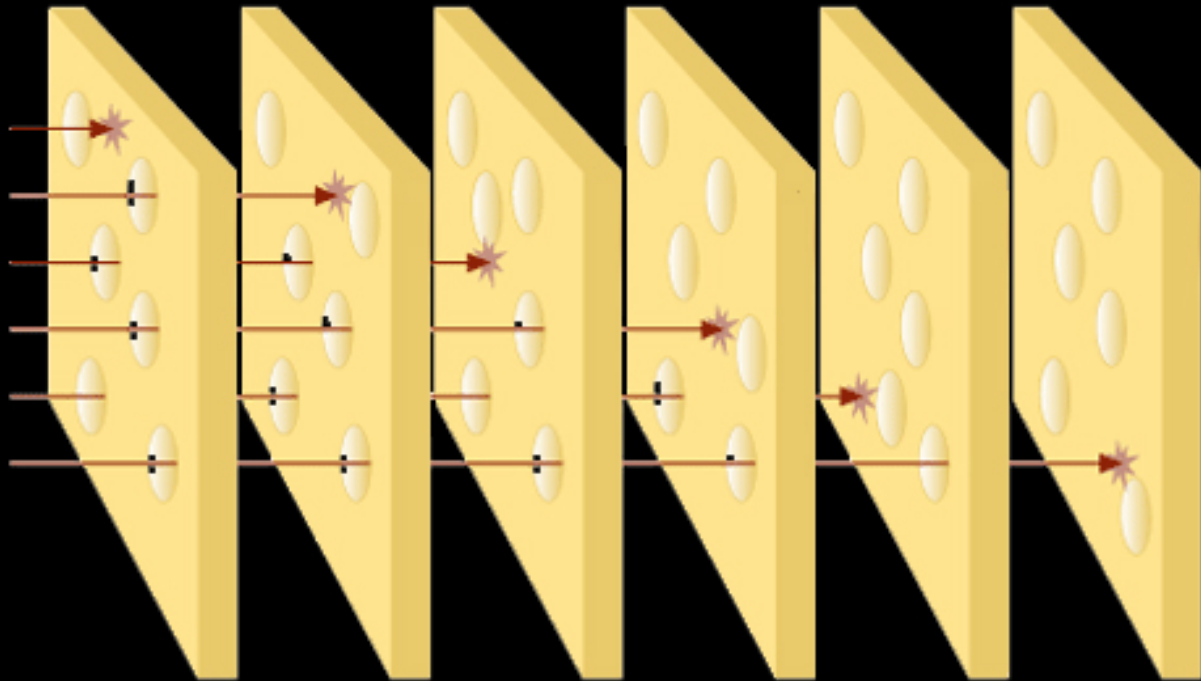
Self-Reported Hours of Sleep and Selected Health-Risk Behaviors



CDC, 2008. Youth risk behavior surveillance, 2007

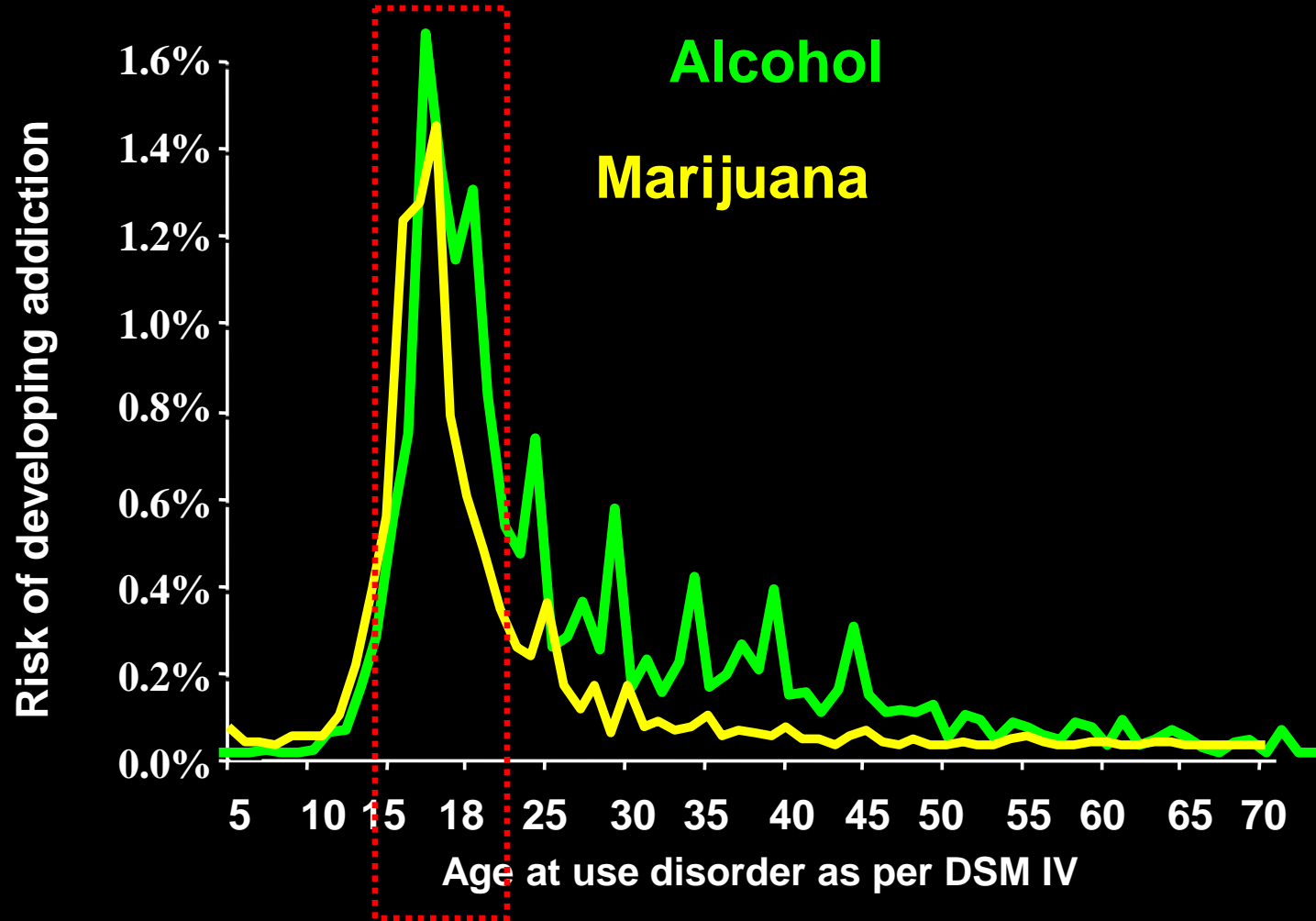
McKnight-Eily, Preventive Medicine, 2011

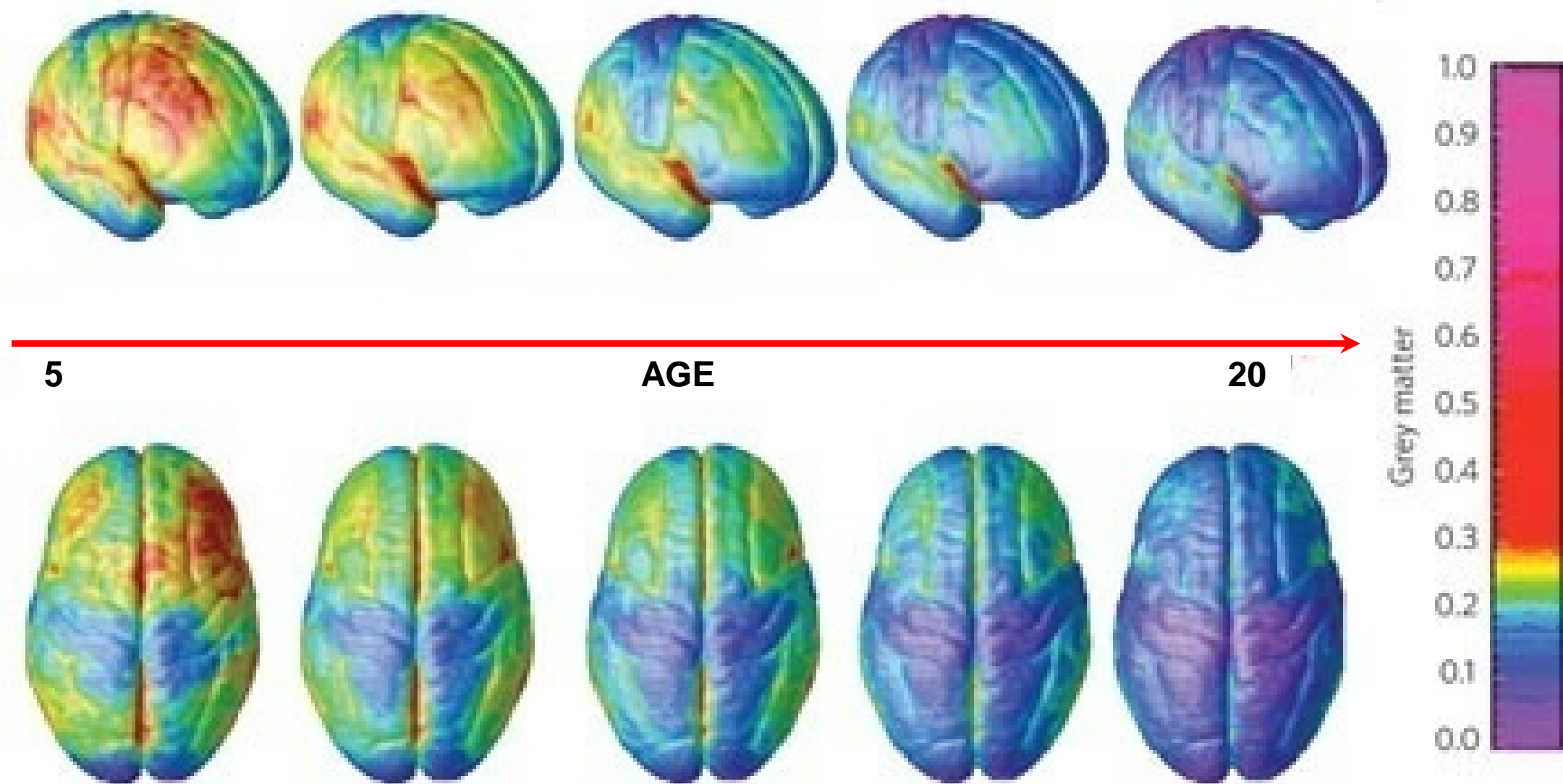
development



ADDICTION IS A DEVELOPMENTAL DISEASE

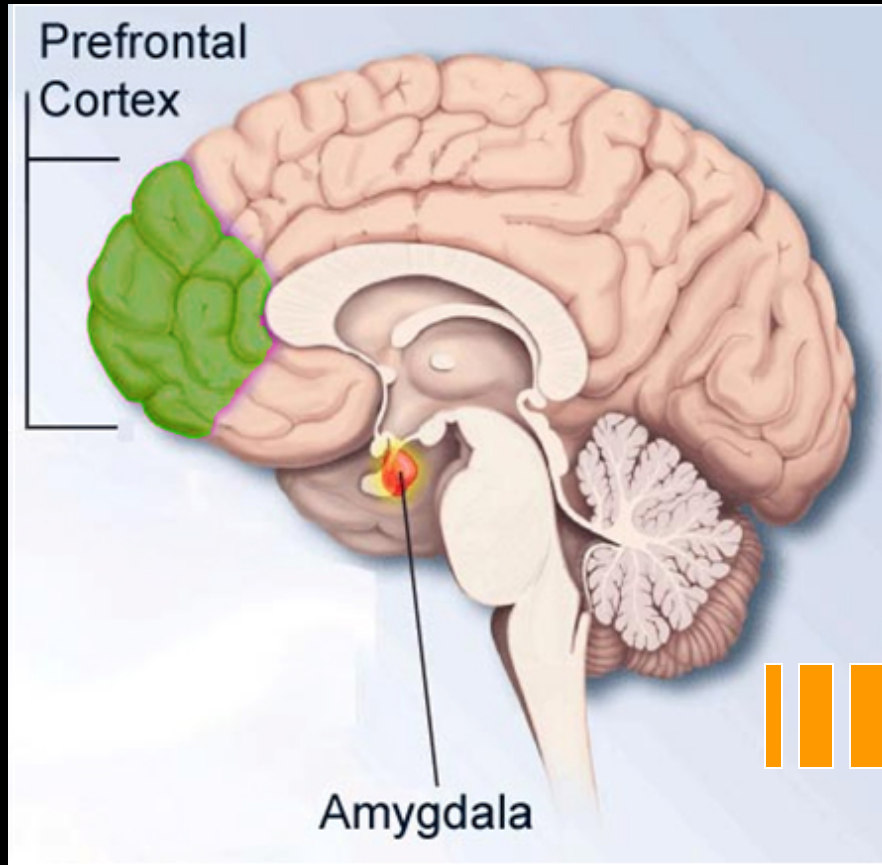
It starts in adolescence and even childhood



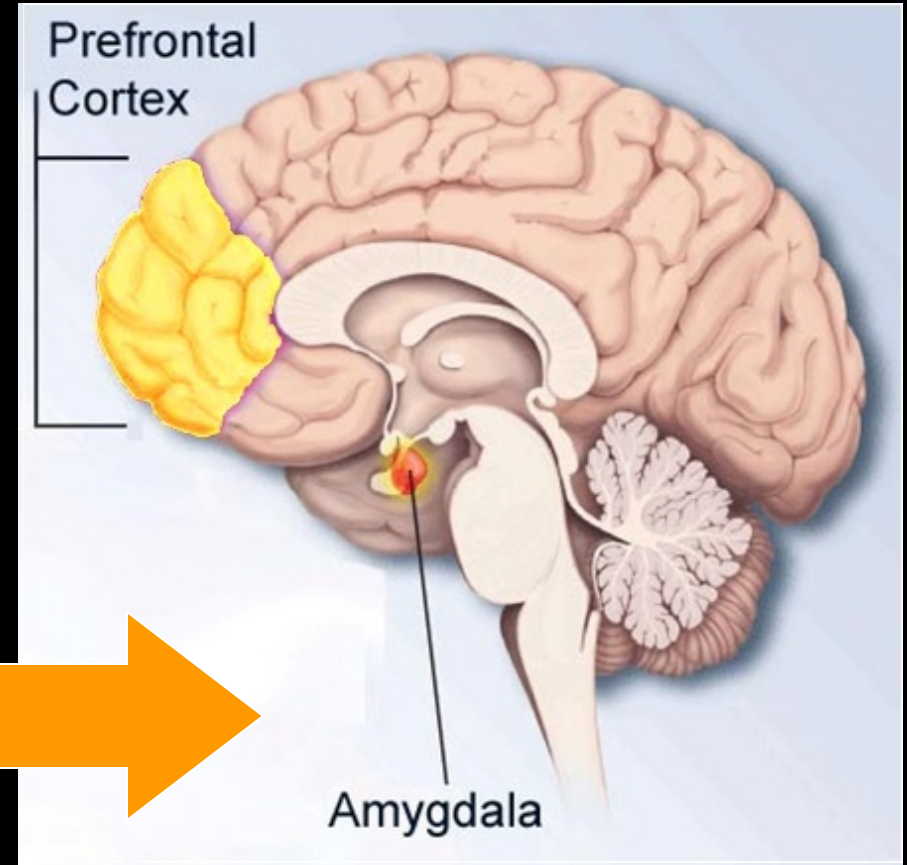


Brain development

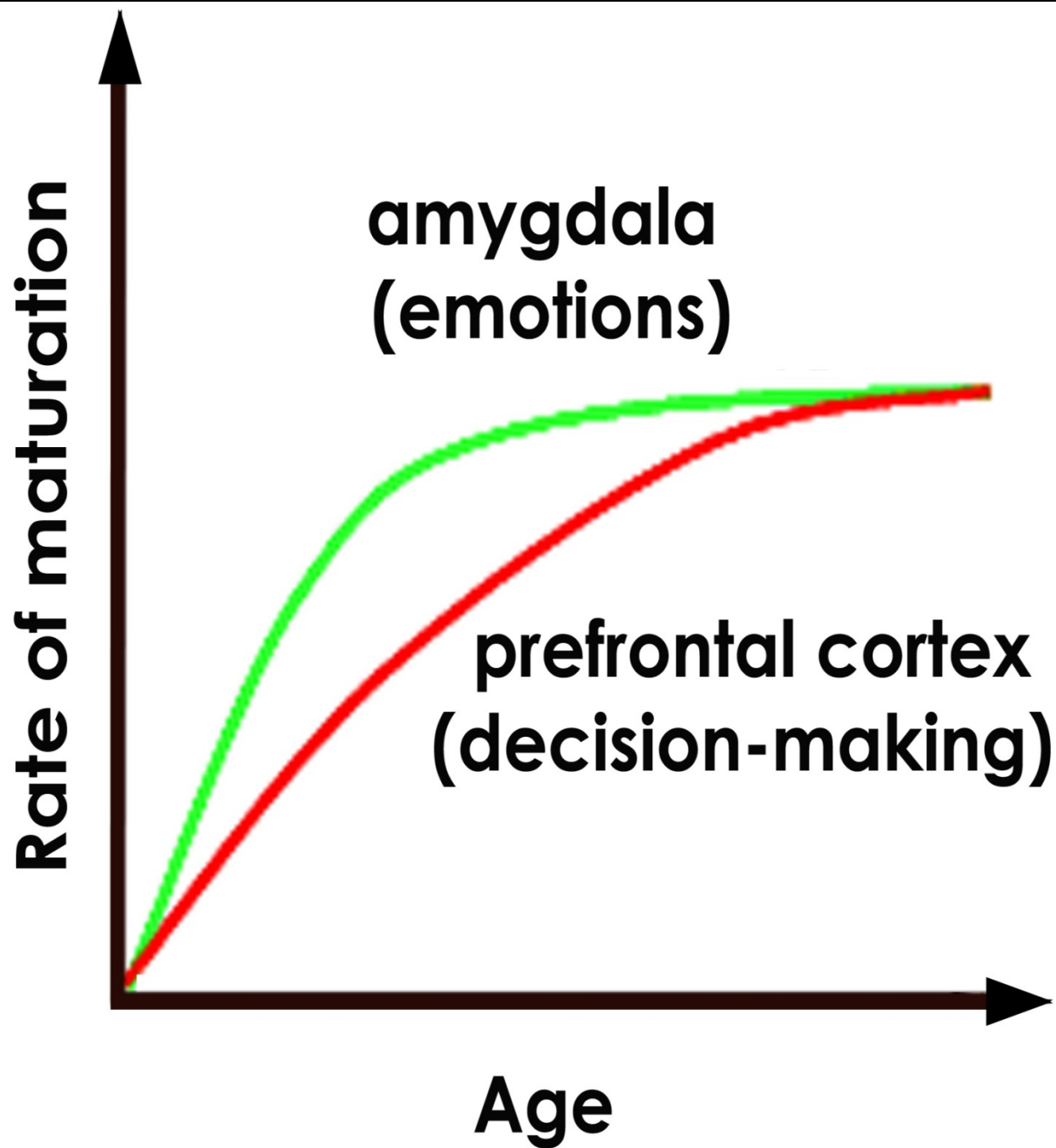
Shifting balance during maturation between the PFC and the limbic system_



Adolescence

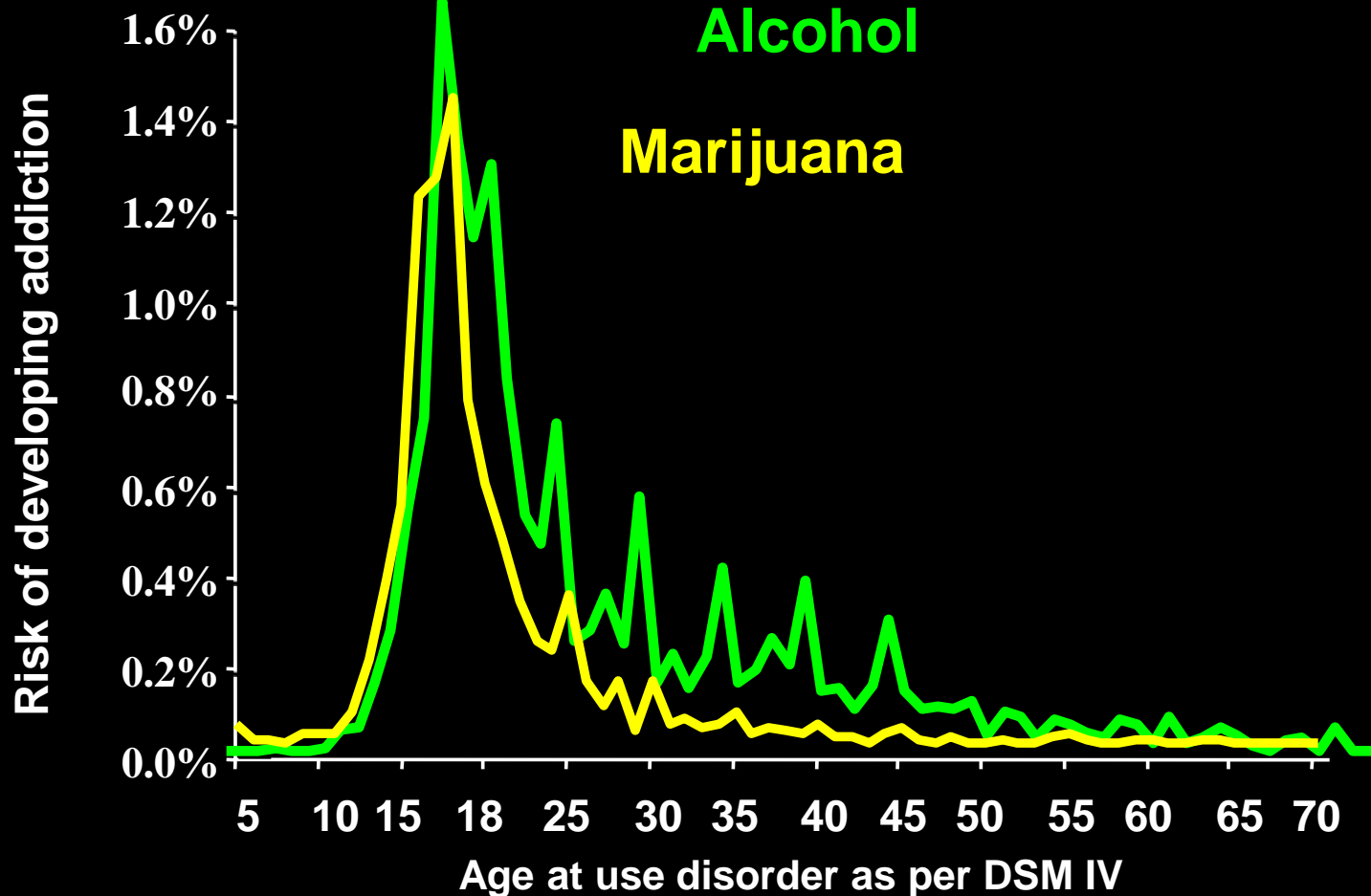


Adulthood



ADDICTION IS A DEVELOPMENTAL DISEASE

It starts in adolescence and even childhood



NIAAA National Epidemiologic Survey on Alcohol and Related Conditions, 2003





The Effects of Keyboard Scrambling are Time-Dependent



After the Programming



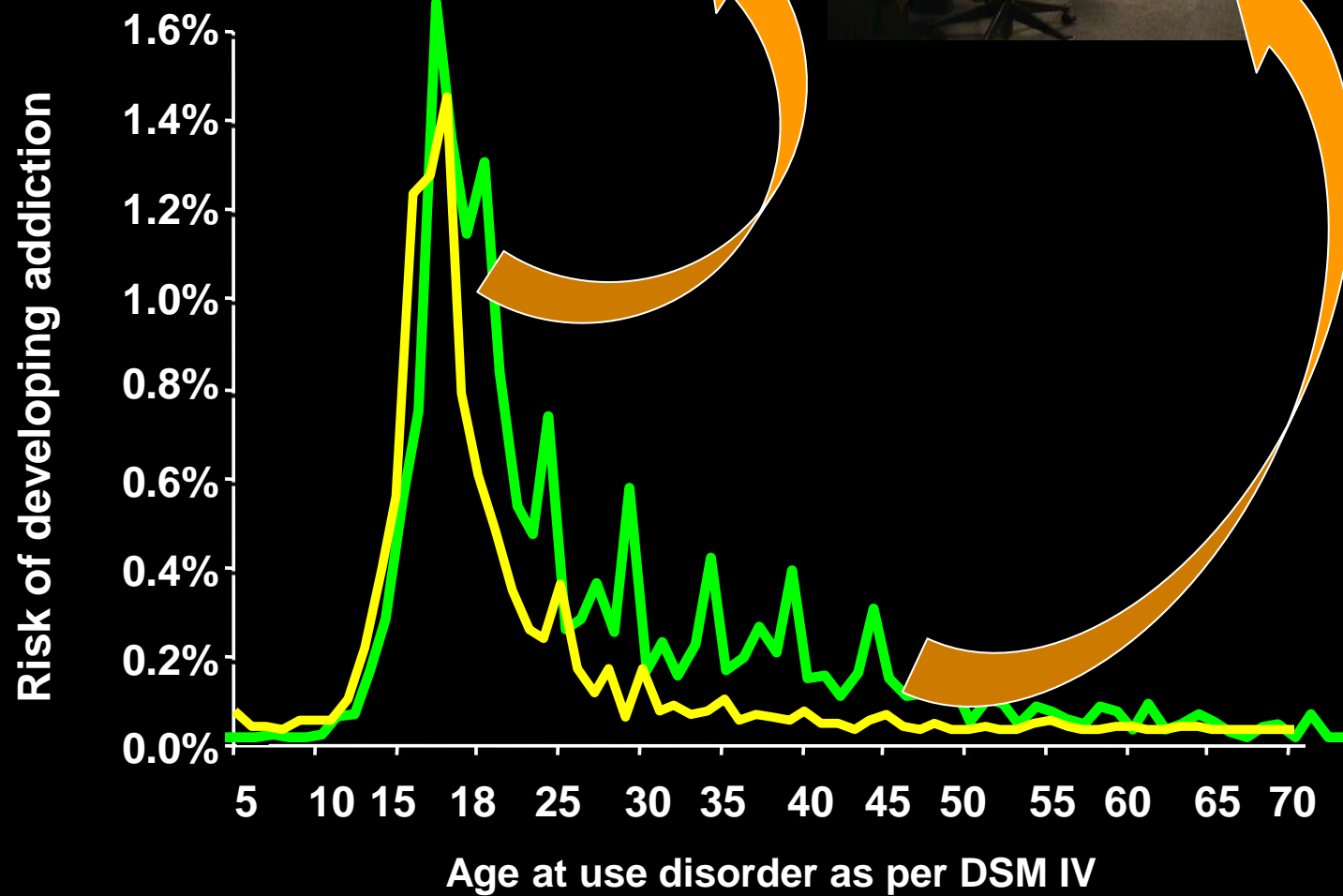
Temporary Difficulties
Running a Program



During the Programming



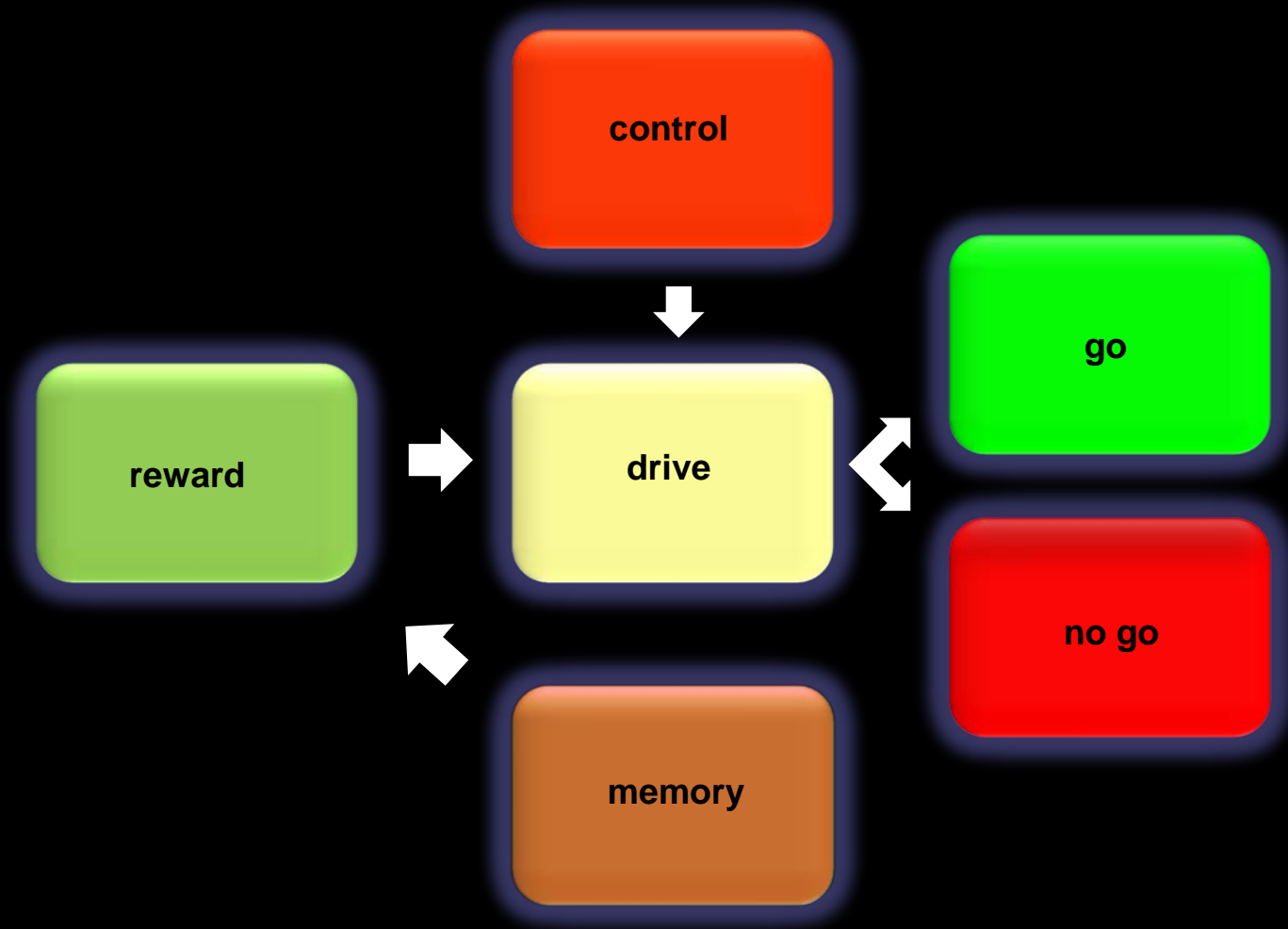
Persistent Glitches
in the Program



Scientific Message

Increased risk-taking is wired into the adolescent brain.

...learning to pause



The Marshmallow Experiment





Score higher in tests of assertiveness, self-reliance, dependability, trustworthiness, have higher coping skills, academic competence, and ability to refrain from using alcohol and drugs.



More likely to be indecisive, stubborn, and impulsive, easily frustrated, more jealous and envious of others, poorer students, with a lower self-image, and had more experience with drugs and alcohol.

- BRAIN
- DRUGS
- RISK
- RESILIENCE





poverty



poor
parenting

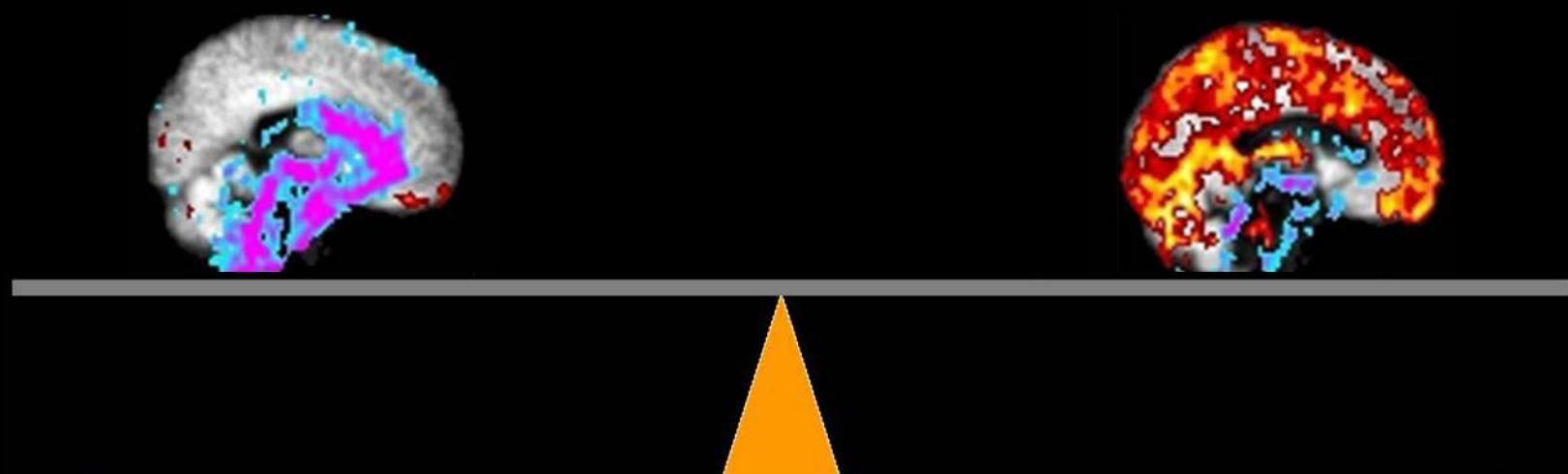


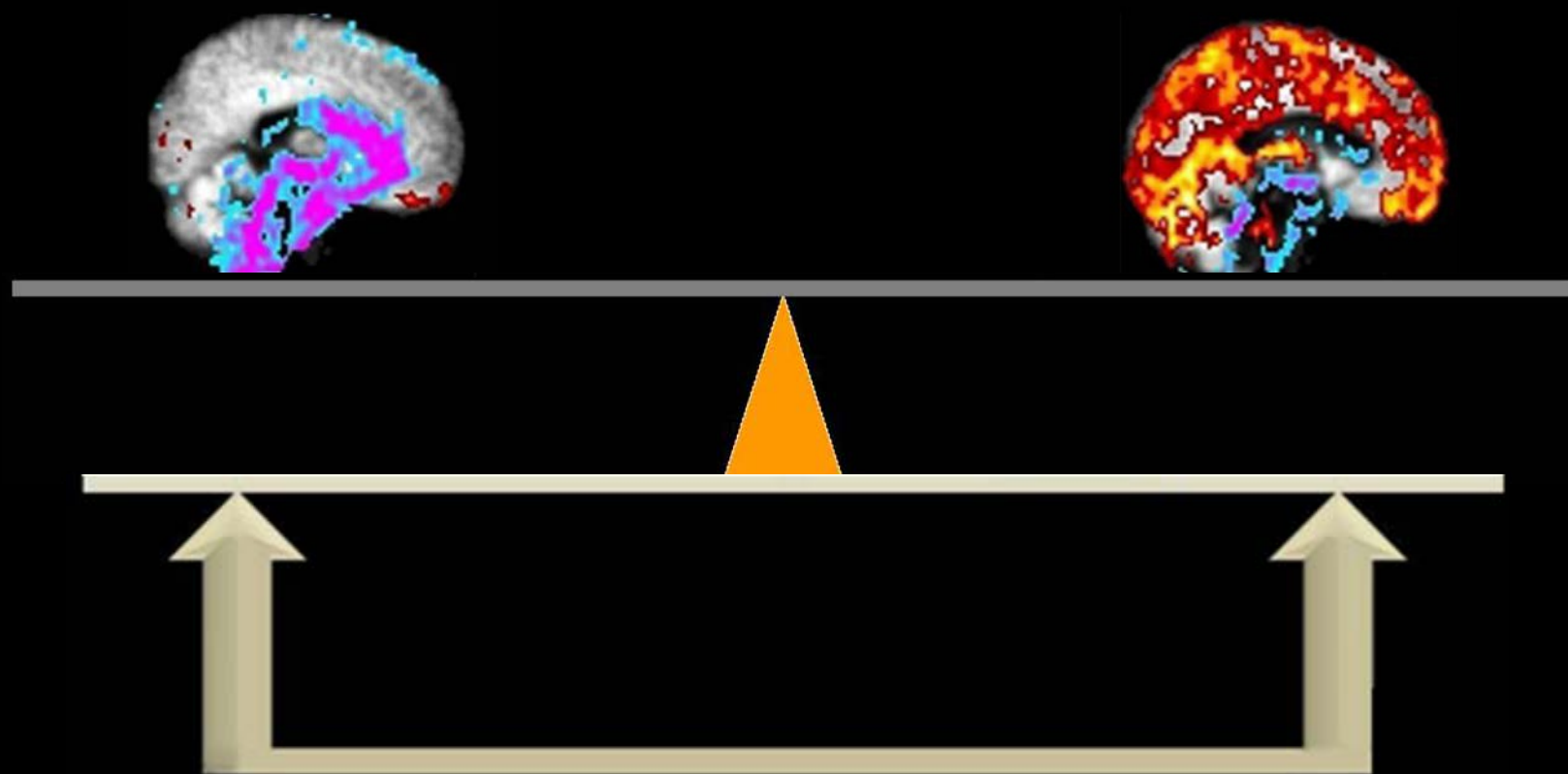
deviant
peers



drug
availability

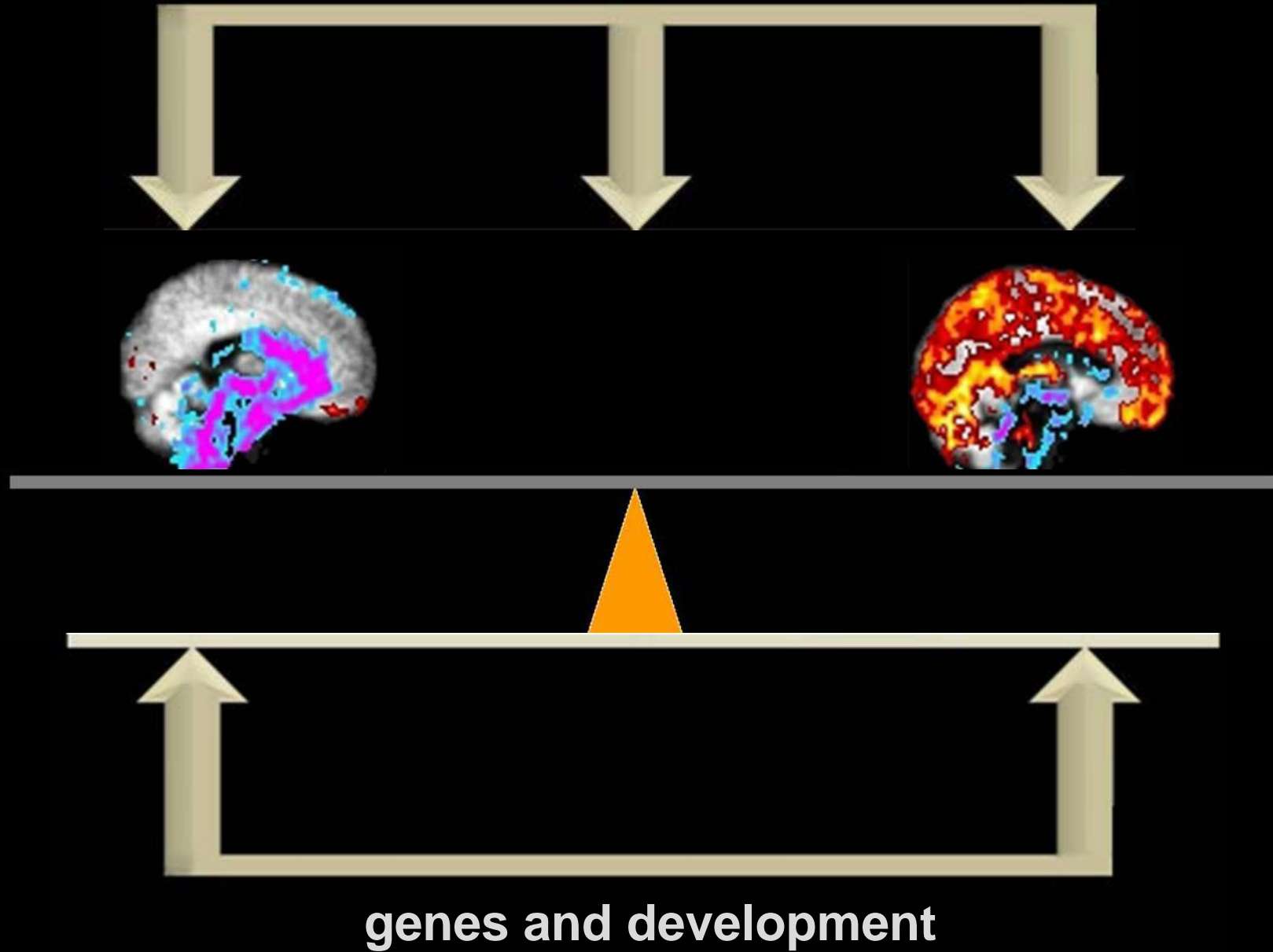




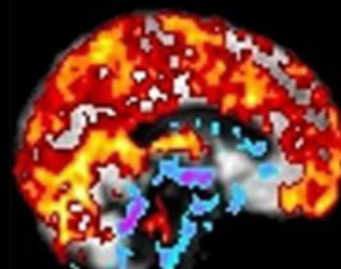
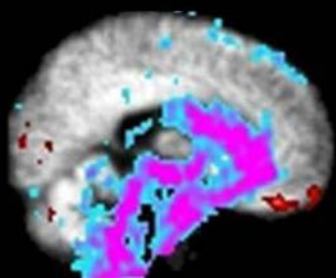


genes and development

environment

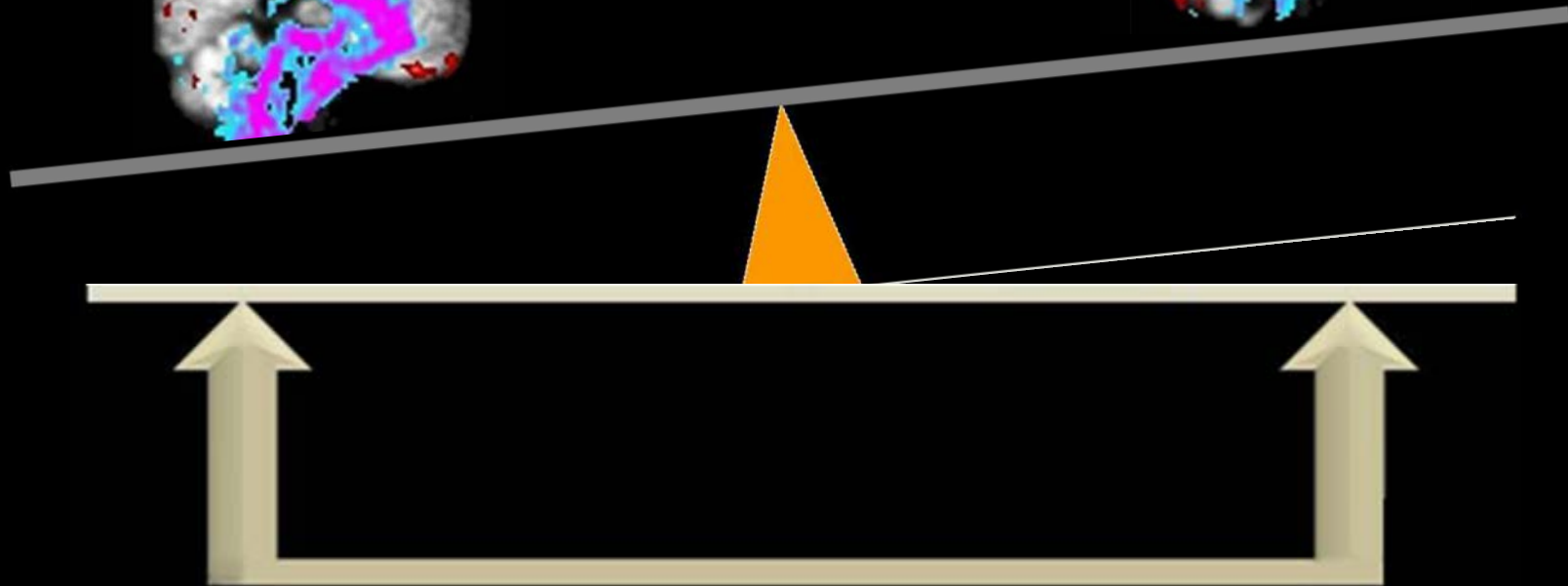
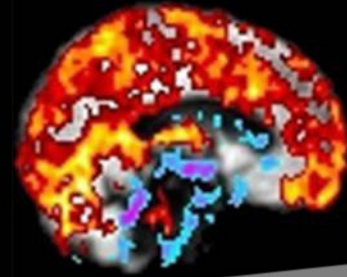
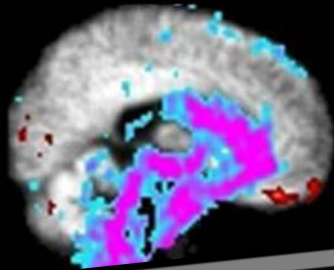


increase risk



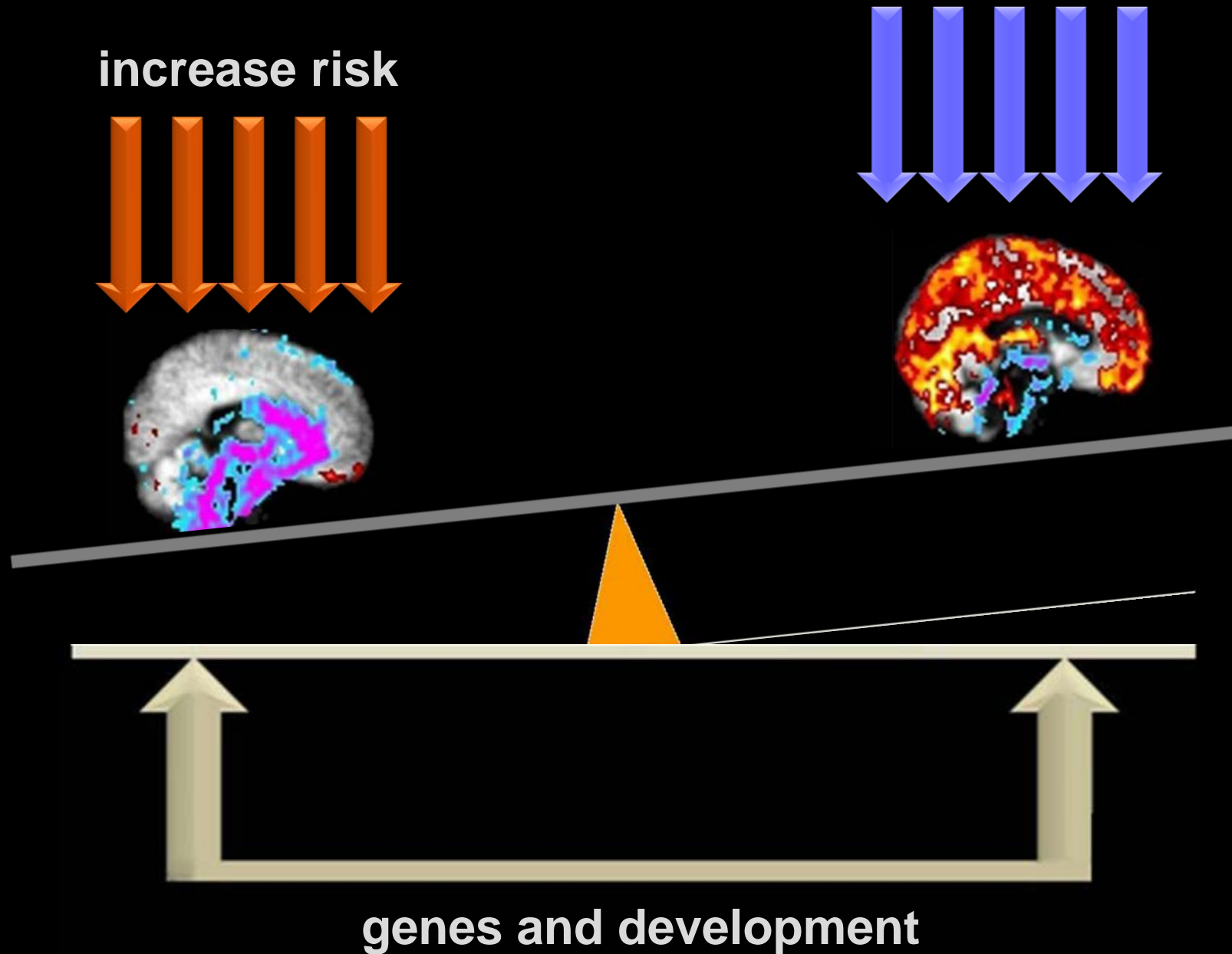
genes and development

increase risk

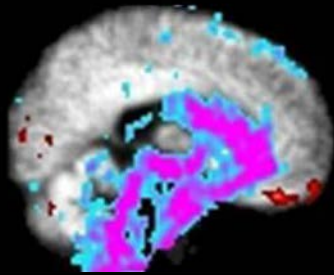


genes and development

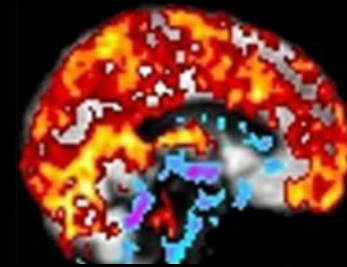
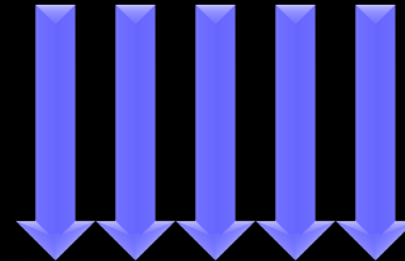
Strategies to Empower System II



increase risk



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- Embrace different brain architectures (Ken Robinson)

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