



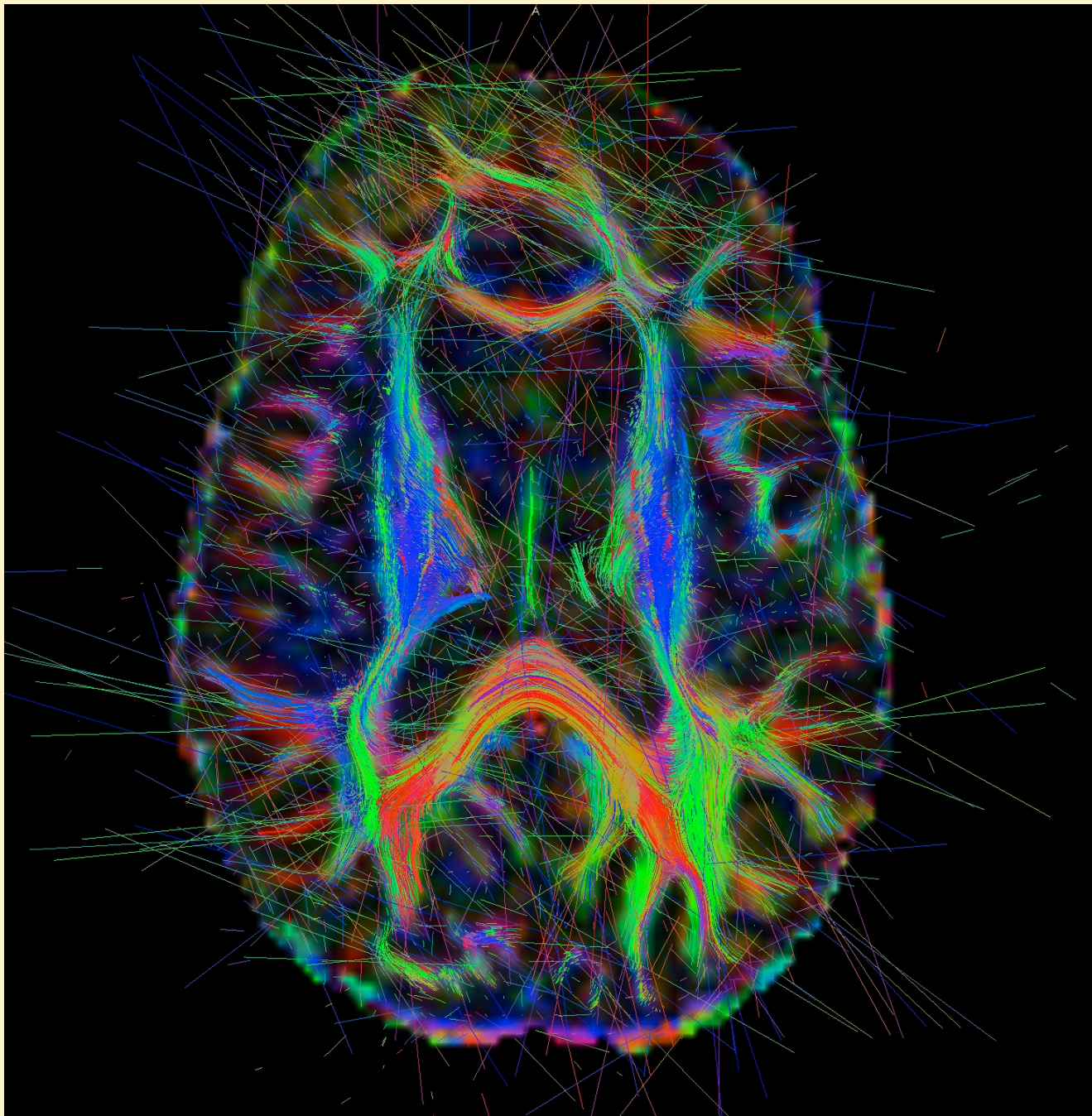
THE PHYSIOLOGY OF ADDICTION

Effects of Drug-Taking Behavior on the Brain

Ruth A. Potee, MD

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Medical Director, Franklin County House of Corrections
Medical Director, Franklin Recovery Center
Medical Director, Pioneer Valley Regional School District
Chair, Department of Medicine, Baystate – Franklin Medical Center
Co-Chair – Healthcare Solutions of the Opioid Taskforce

*Thanks to Tess Jurgensen and the OTF of Franklin County
and North Quabbin for organizing these forums*



HIJACKING THE BRAIN

New research suggests that the brain's reward system has different mechanisms for craving and pleasure. Craving is driven by the neurotransmitter dopamine. Pleasure is stimulated by other neurotransmitters in "hedonic hot spots." When the craving circuitry overwhelms the pleasure hot spots, addiction occurs, leading people to pursue a behavior or drug despite the consequences.

PATHWAYS TO CRAVING

Desire is triggered when dopamine, which originates near the top of the brain stem, travels through neural pathways to act on the brain. Drugs increase the flow of dopamine.

Ventral tegmental area (VTA)

Dopamine is produced here and flows outward along neurons distributed throughout the brain's reward system.

Dorsal striatum

Neurons here help form habits by identifying enjoyable patterns, such as the anticipation of buying drugs.

Prefrontal cortex

The amino acid glutamate, produced here, interacts with dopamine to spark visualizations that cue cravings.

Amygdala

Neurons here are stimulated by learned emotional responses, such as memories of cravings and pleasure.

Orbitofrontal cortex

This hot spot gives a sense of gratification but is also the first to shut down if a person has indulged too much.

Ventral pallidum

Animal experiments show that damaging this hot spot can turn something that once gave pleasure into a source of disgust.

Nucleus accumbens

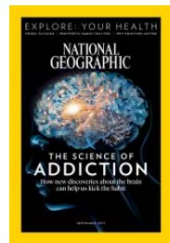
A hot spot within this key part of the craving circuitry amplifies the response to pleasure.

PLEASURE HOT SPOTS

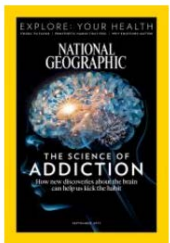
A system of small hedonic hot spots, unrelated to dopamine, provides temporary sensations of pleasure and forms a feedback loop with the reward system that controls desire.

Brain stem

Basic visceral sensations and reactions to pleasure, such as smiling, originate from this hot spot.

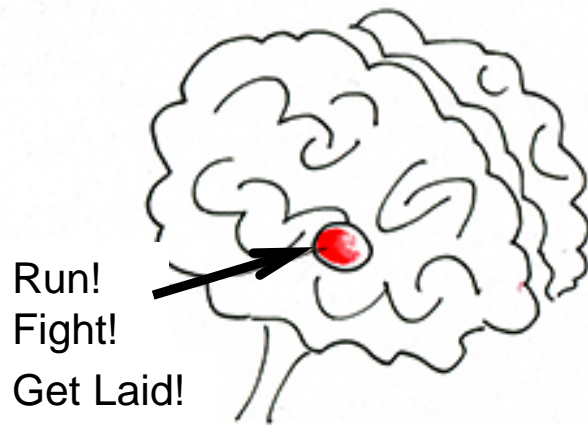


September 2017

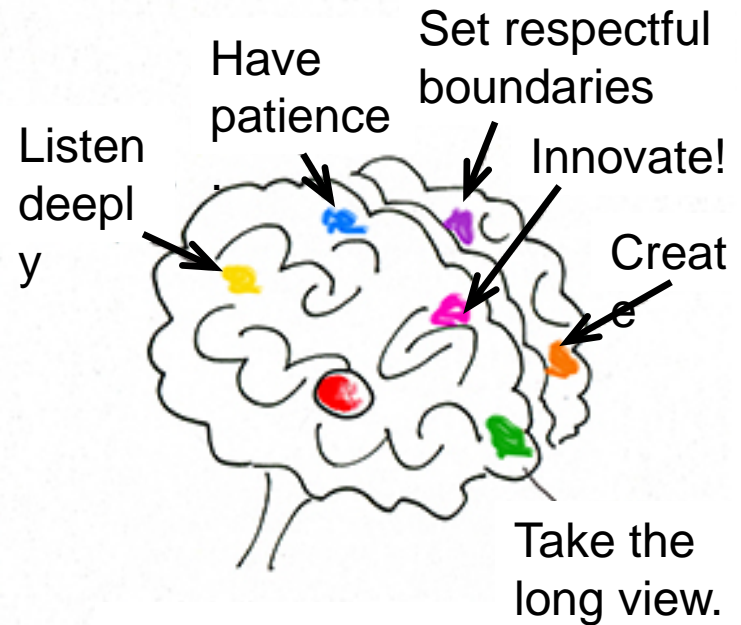


September 2017

EAT, DRINK, HAVE SEX (AND USE DRUGS)



Lizard brain advice

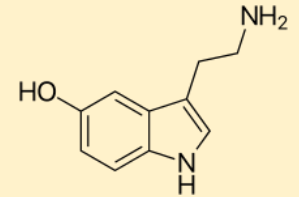
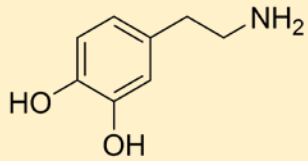


Cortex advice



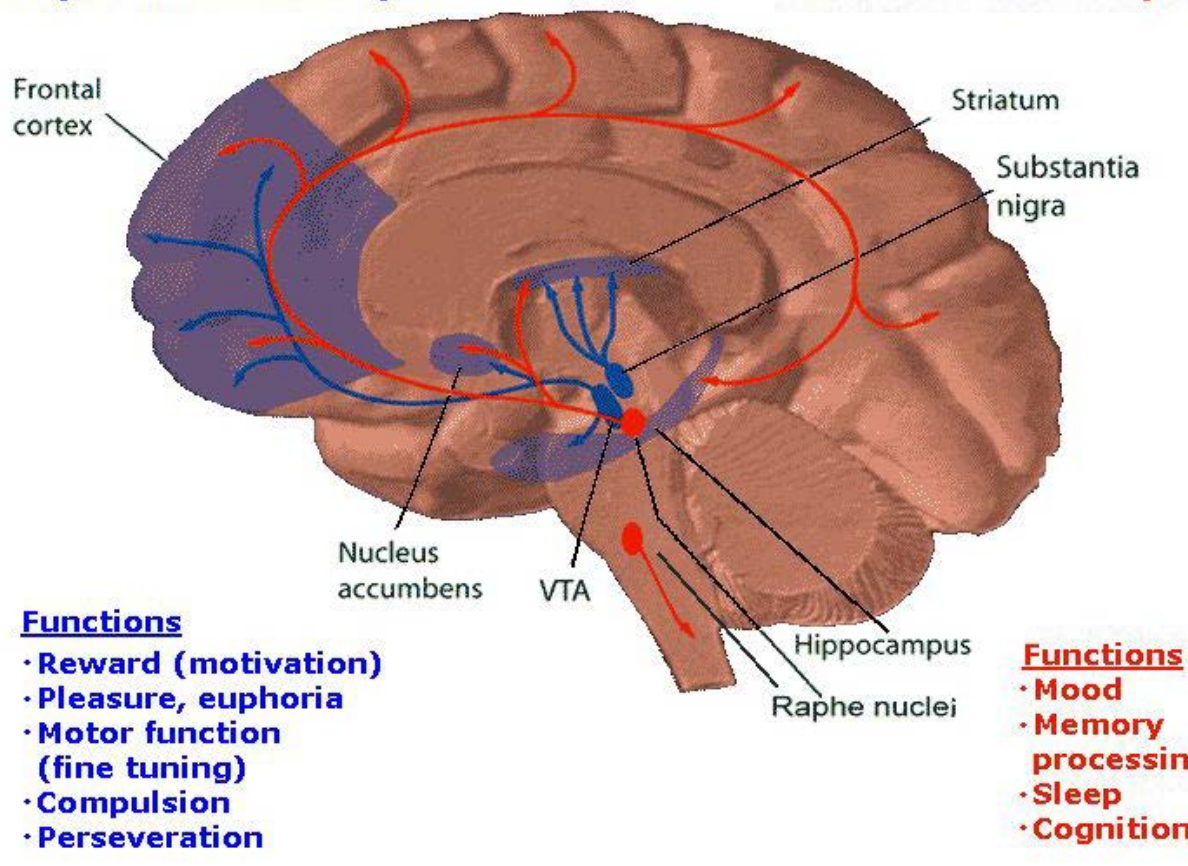
DOPAMINE & SEROTONIN

Location and Function



Dopamine Pathways

Serotonin Pathways

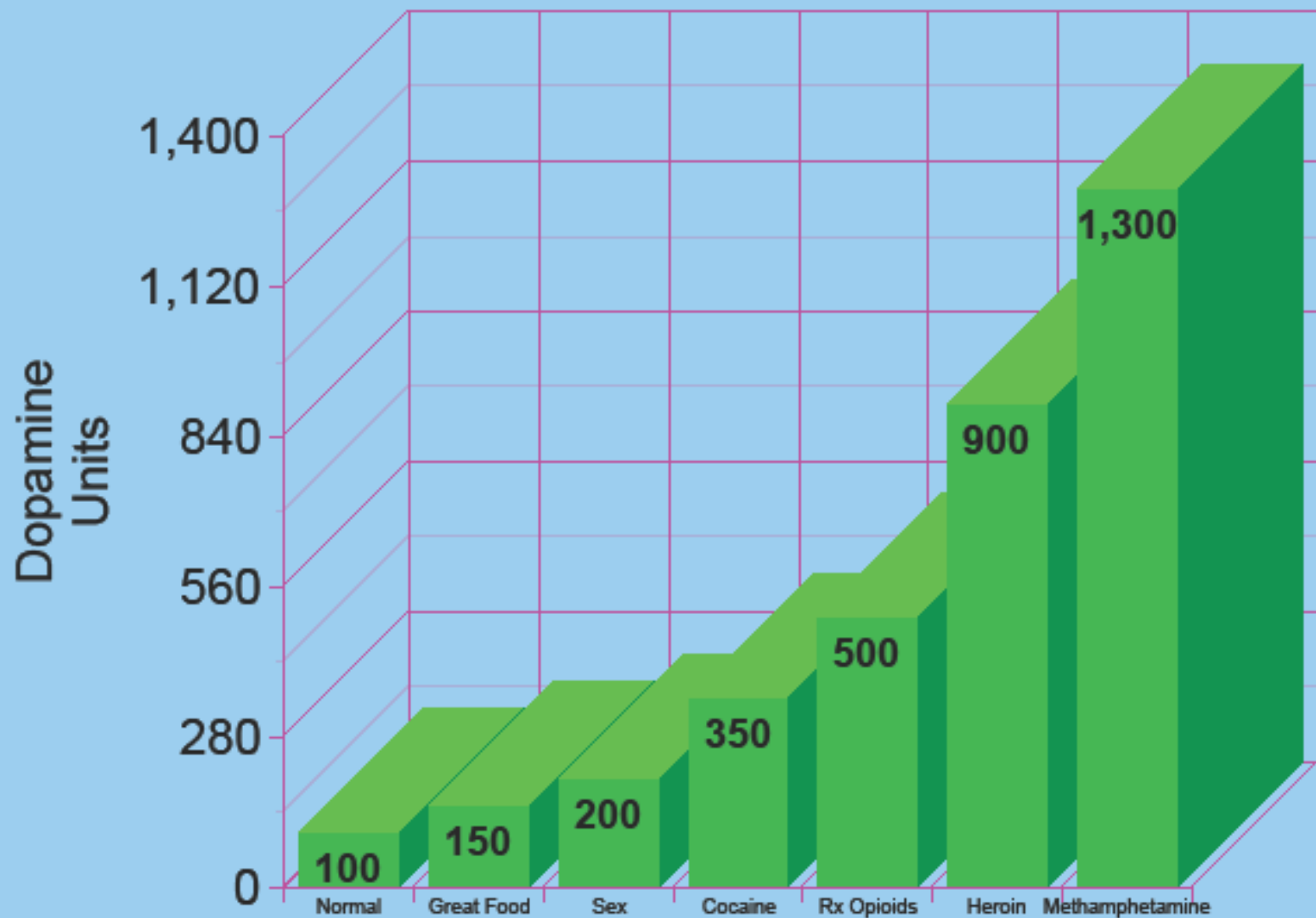




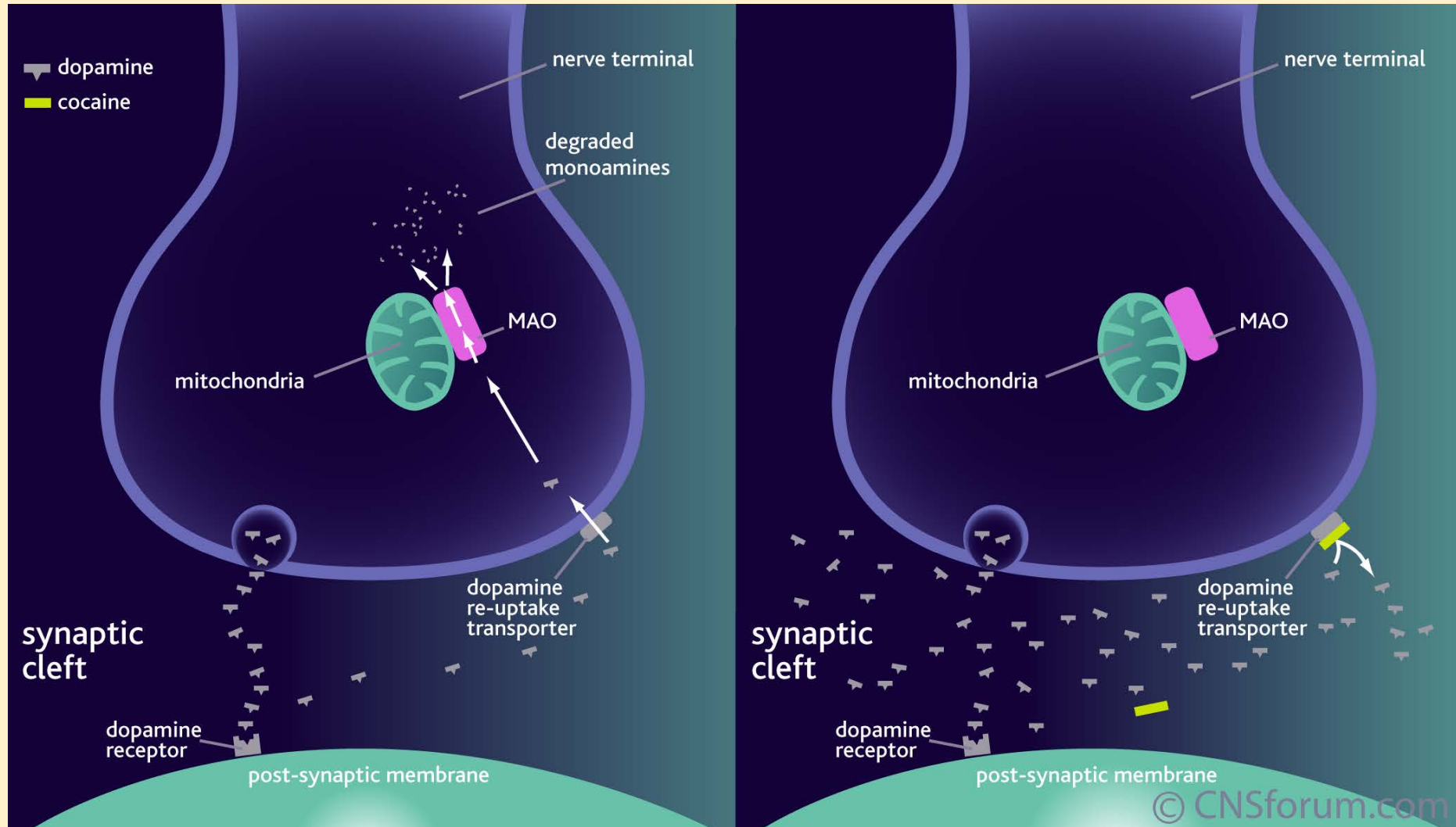
IT IS SAD
TODAY.



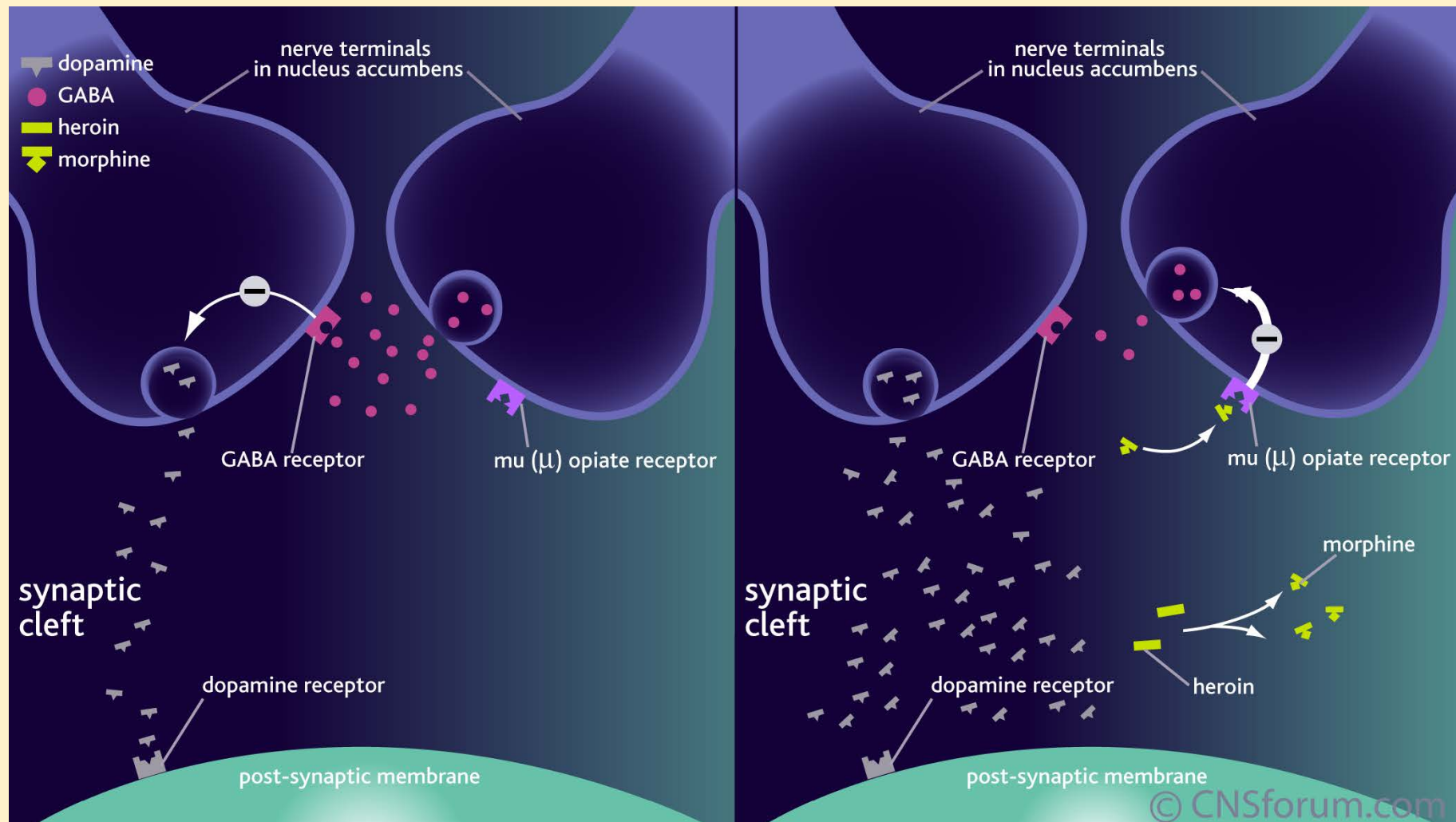
Dopamine Levels



How Cocaine Works



How Heroin Works





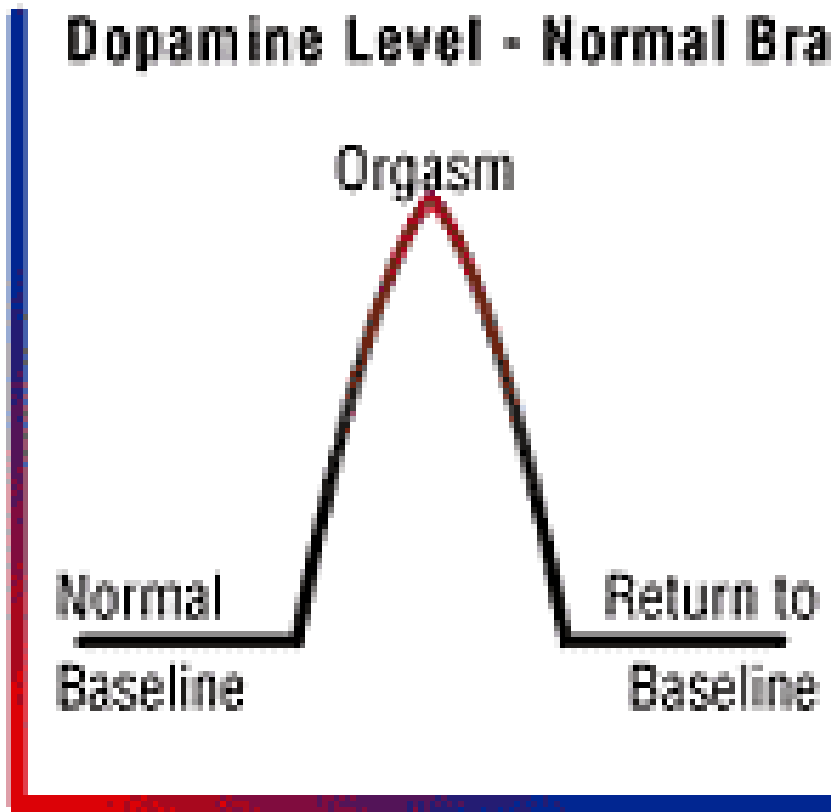
Dopamine Level - Normal Brain

Orgasm

Normal
Baseline

Return to
Baseline

0



Dopamine Level - Addicted Brain

1st Drug High

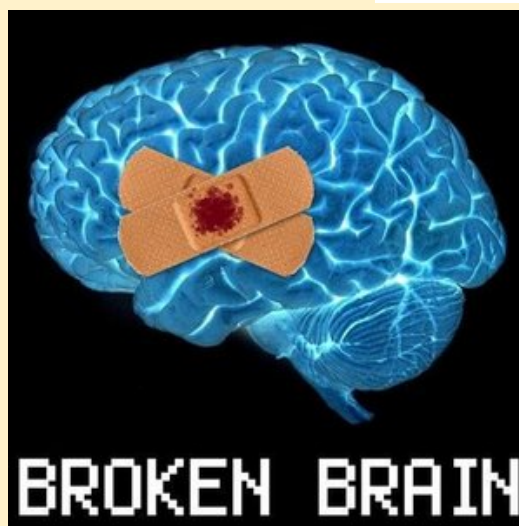
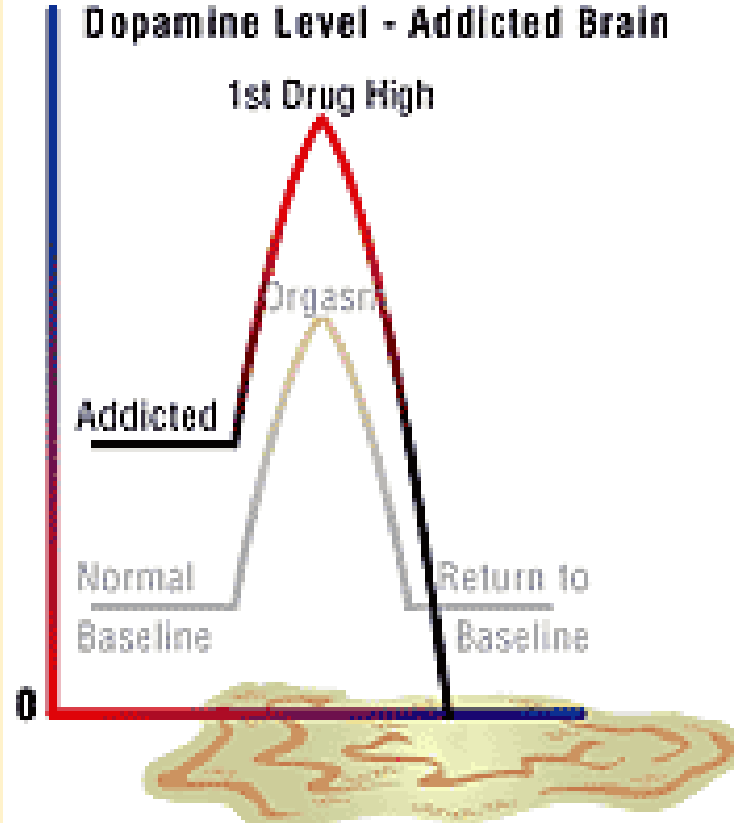
Orgasm

Addicted

Normal
Baseline

Return to
Baseline

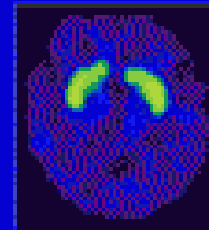
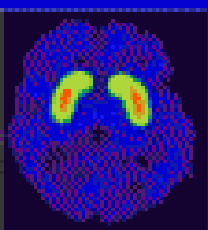
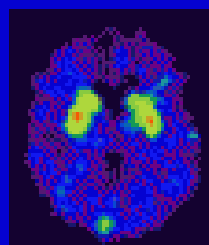
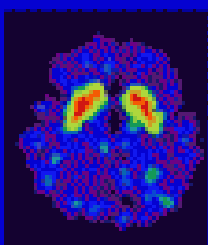
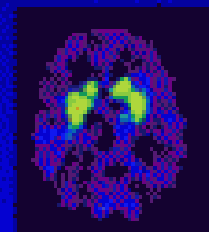
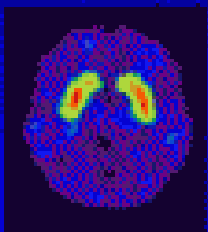
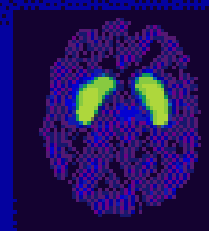
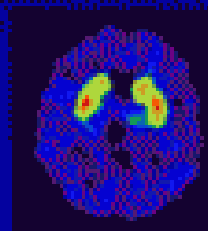
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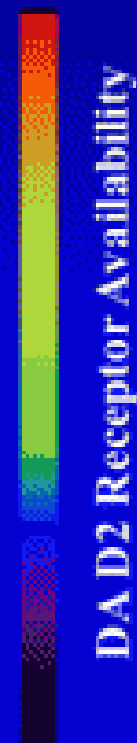
Functionally...

Dopamine D2 Receptors are Decreased by Addiction



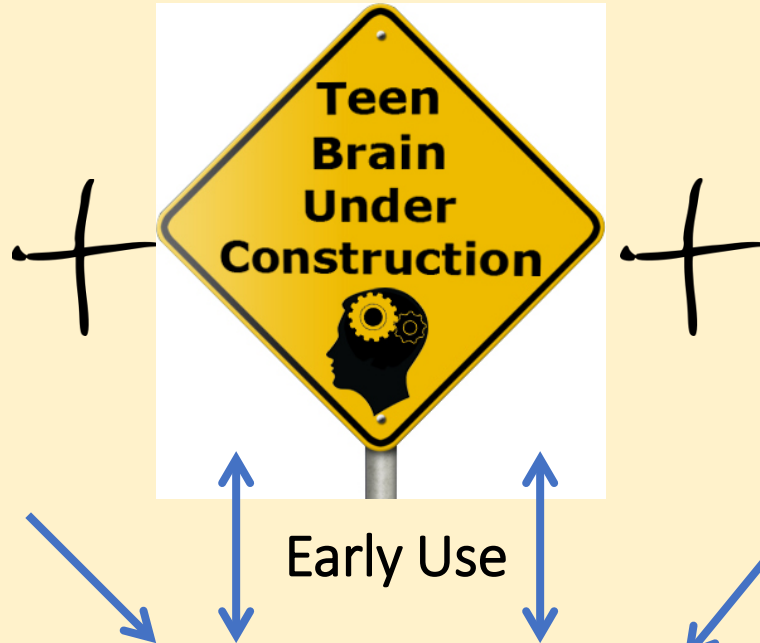
Control

Addicted





Genetics



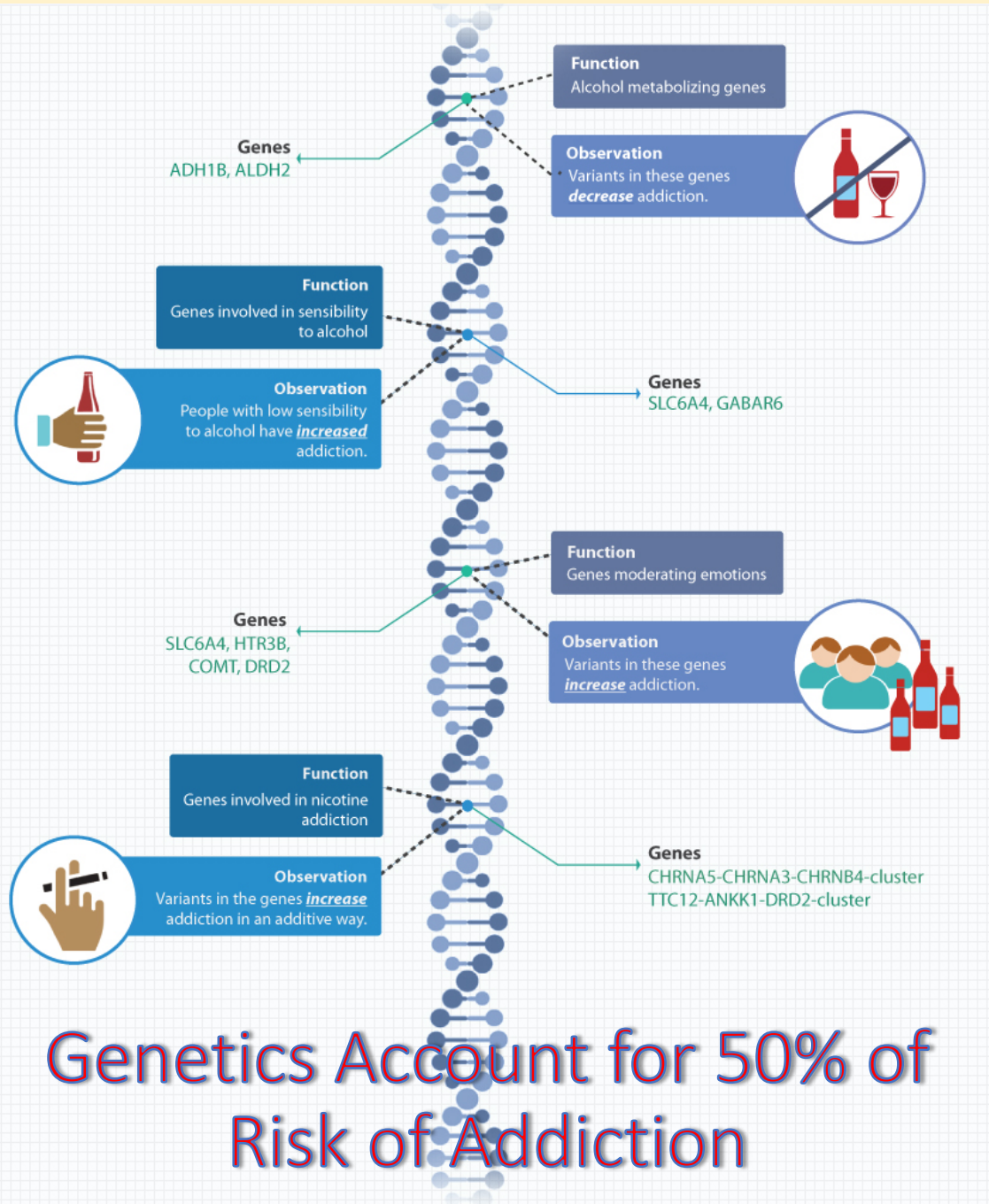
Early Use



Trauma

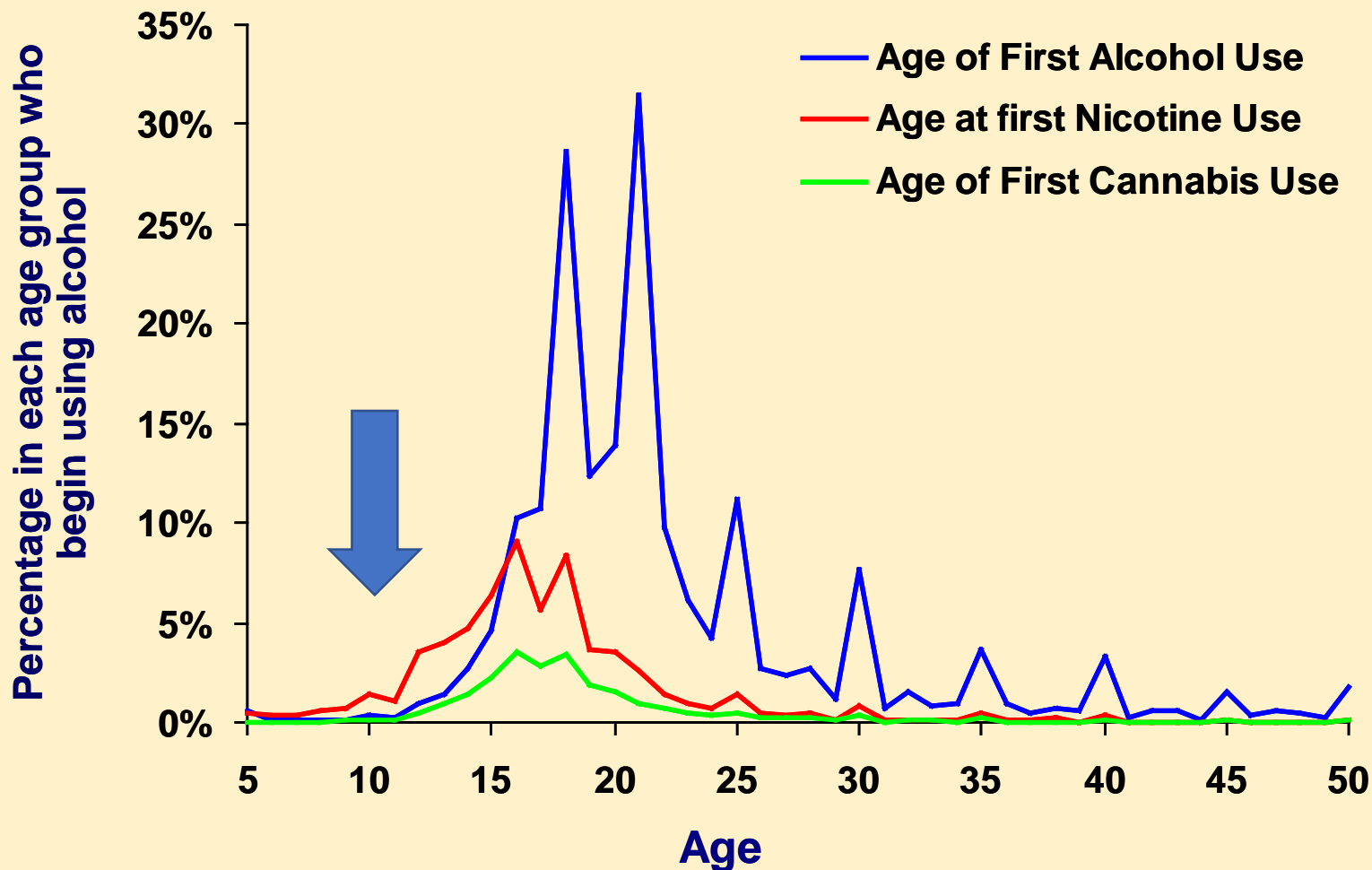


Poor Mental Health



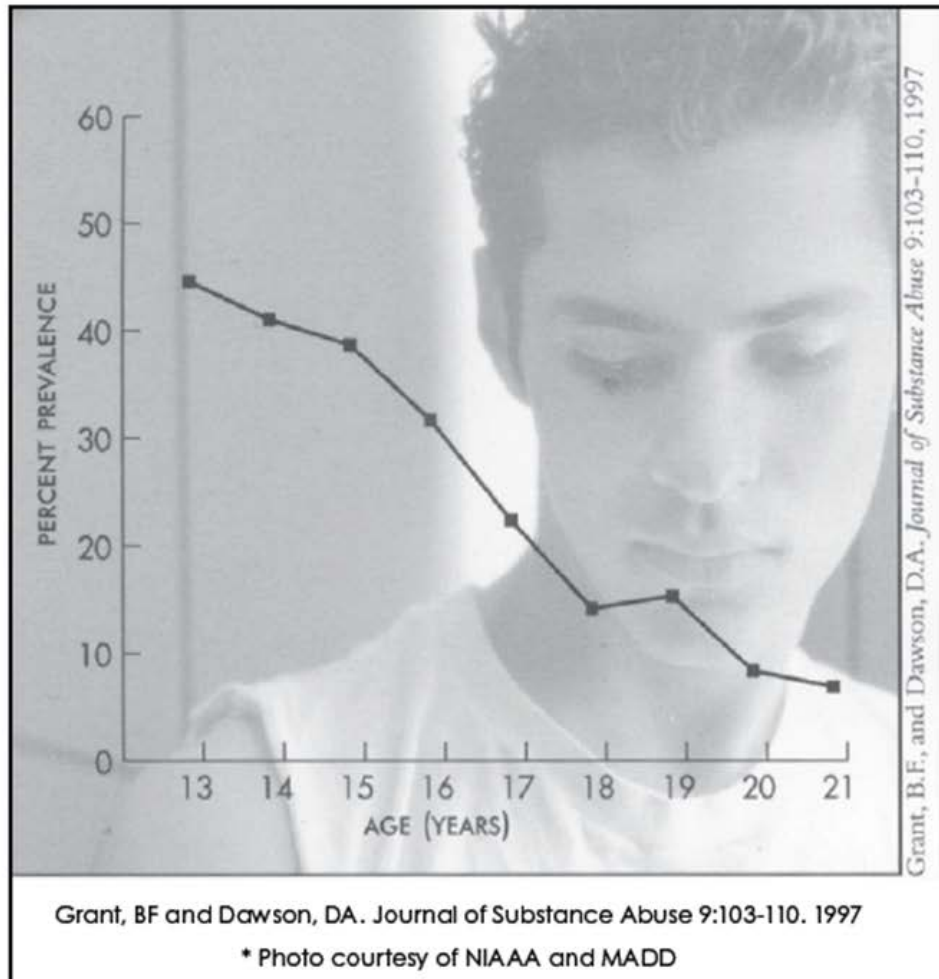


Addiction is a Developmental Pediatric Disease



Source: NIAAA National Epidemiologic Survey on Alcohol and Related Conditions, 2003

Teen Alcohol Use Wires The Brain For Addiction



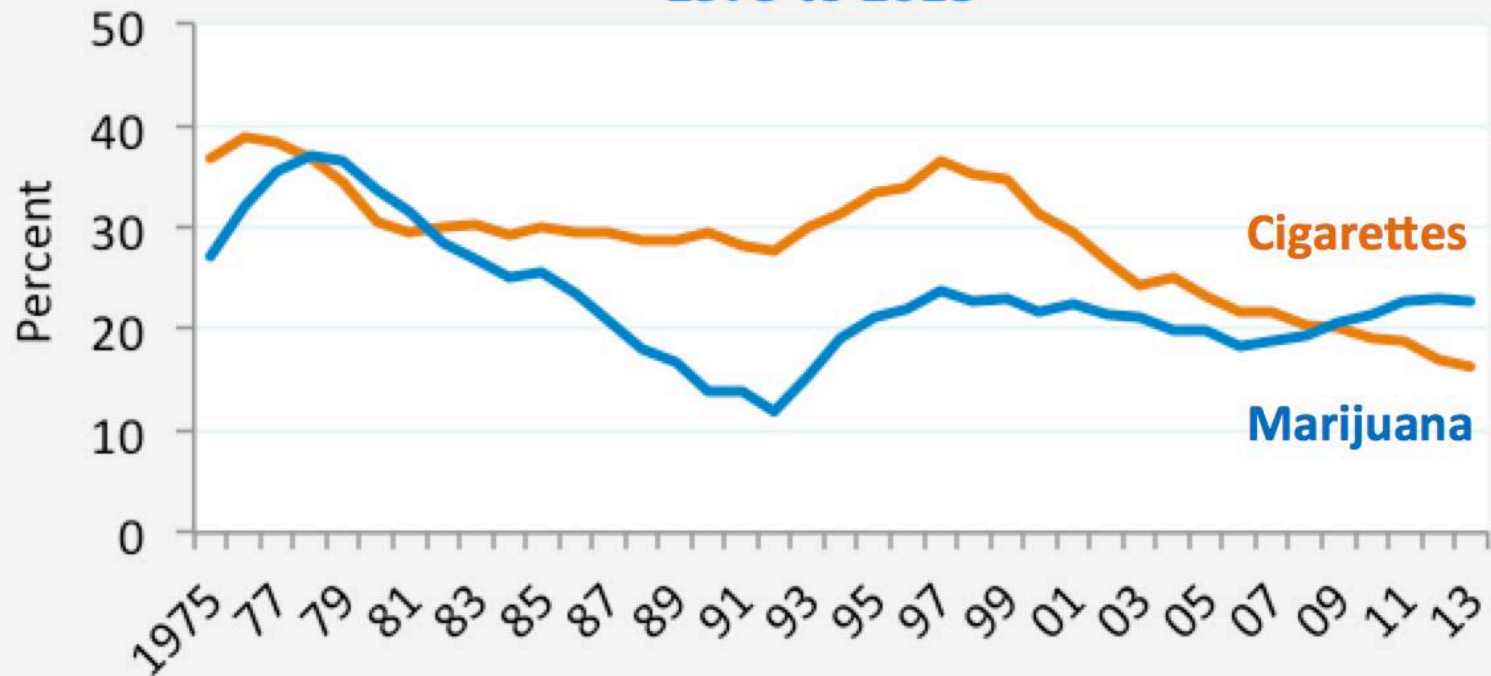
40% of kids who begin drinking at age 15 will become alcoholics.

Only 7% of those who begin drinking at age 21 become alcoholics.

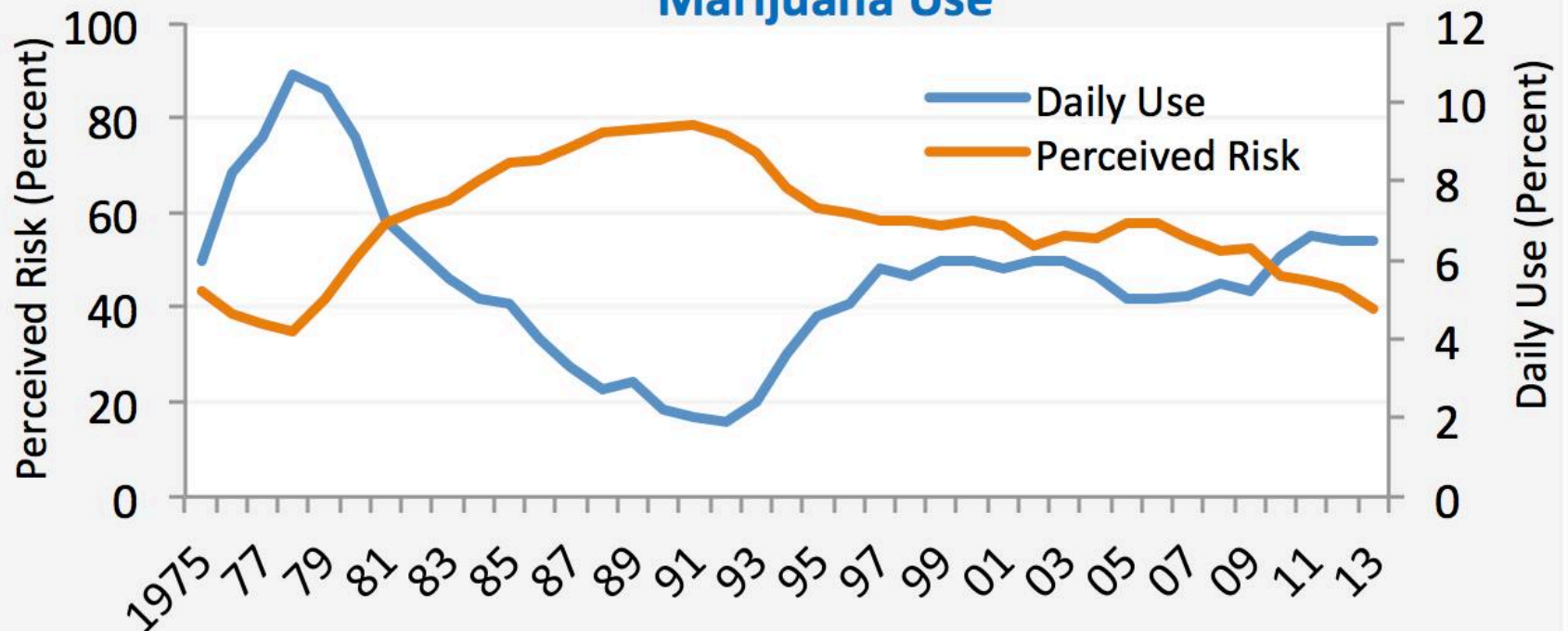




Percentage of U.S. 12th Grade Students Reporting Past Month Use of Cigarettes and Marijuana, 1975 to 2013



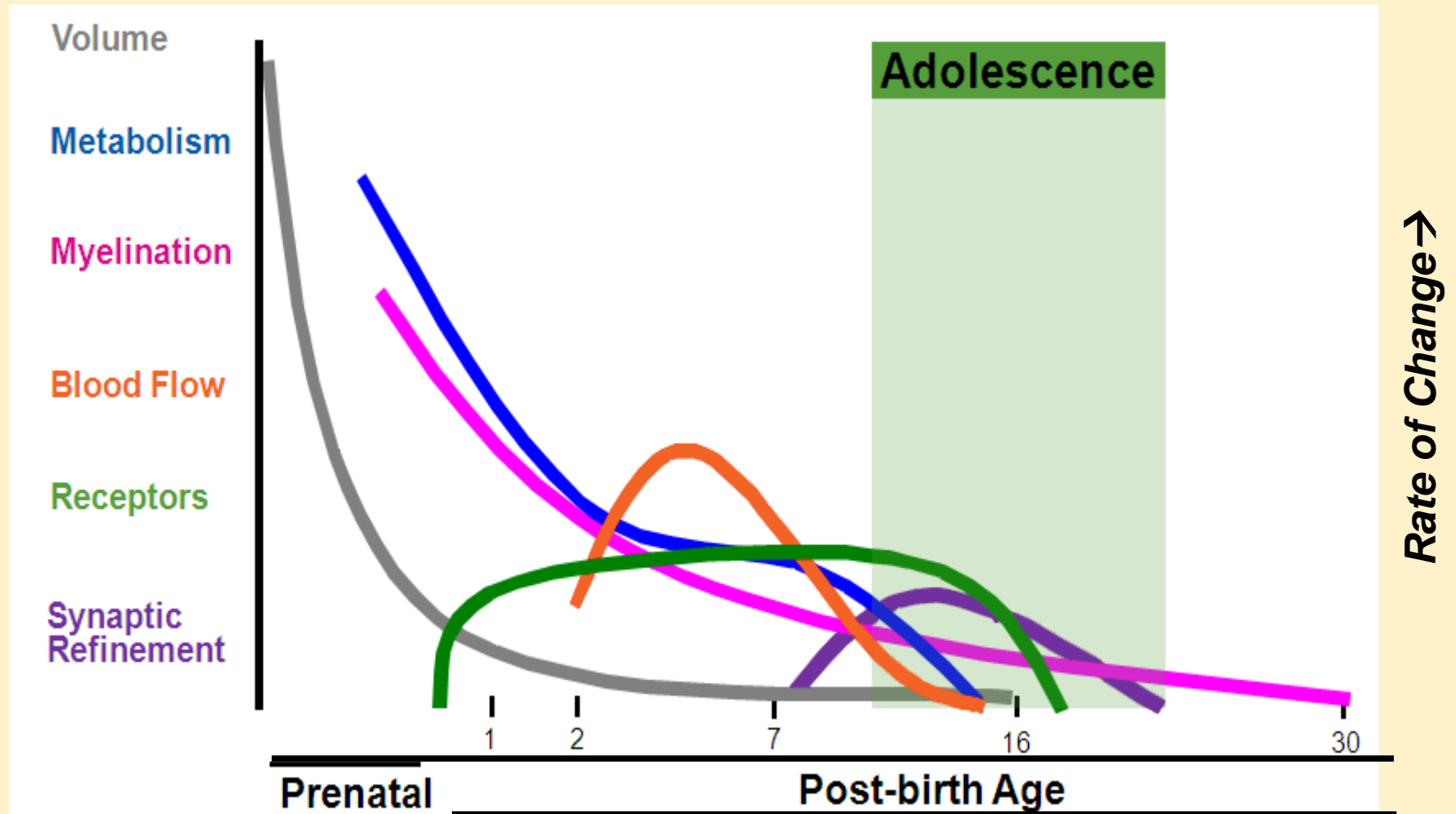
Percentage of U.S. 12 Grade Students Reporting Daily Marijuana Use vs. Perceived Risk of Regular Marijuana Use



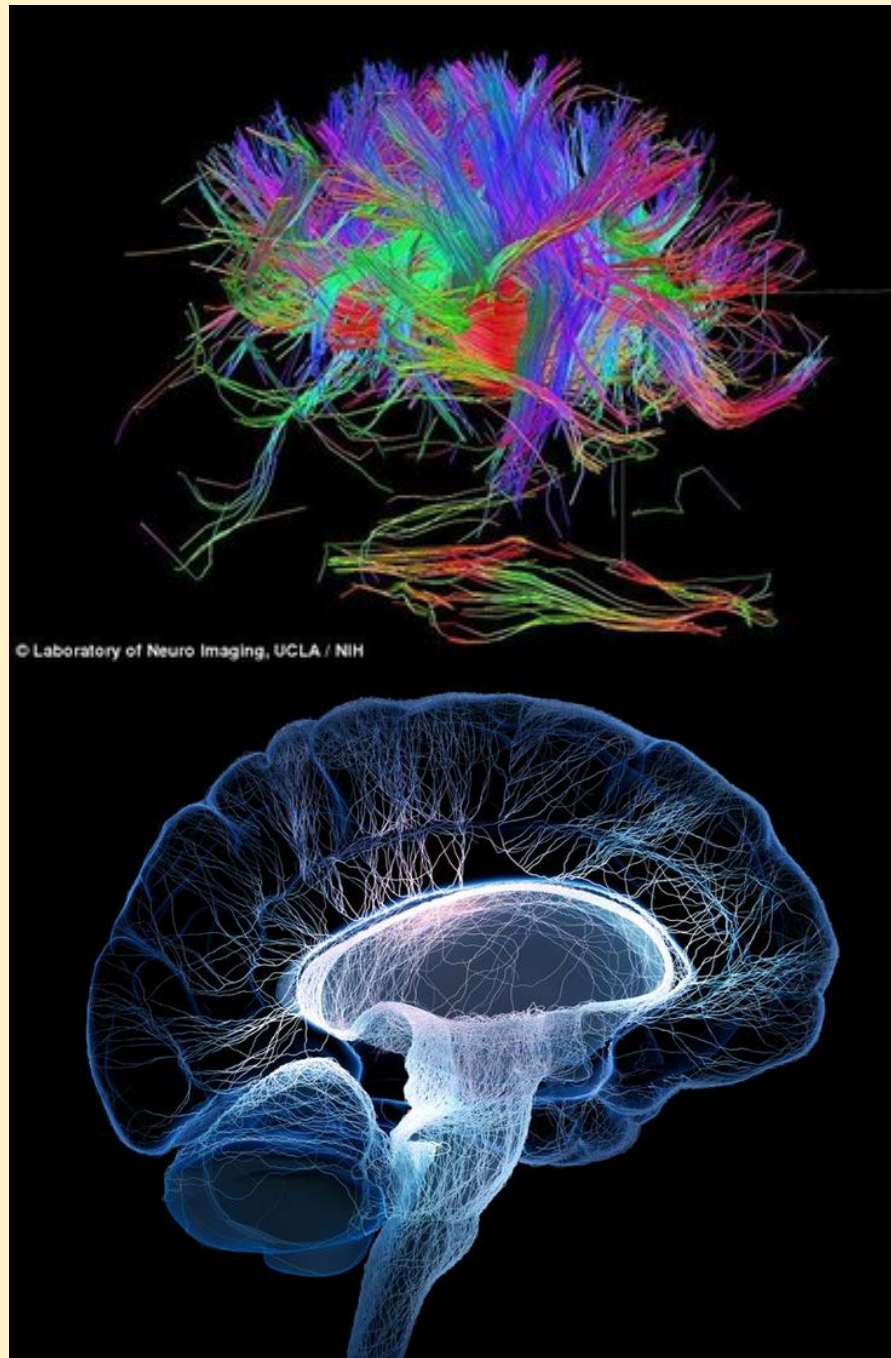
Source: The Monitoring the Future study, the University of Michigan



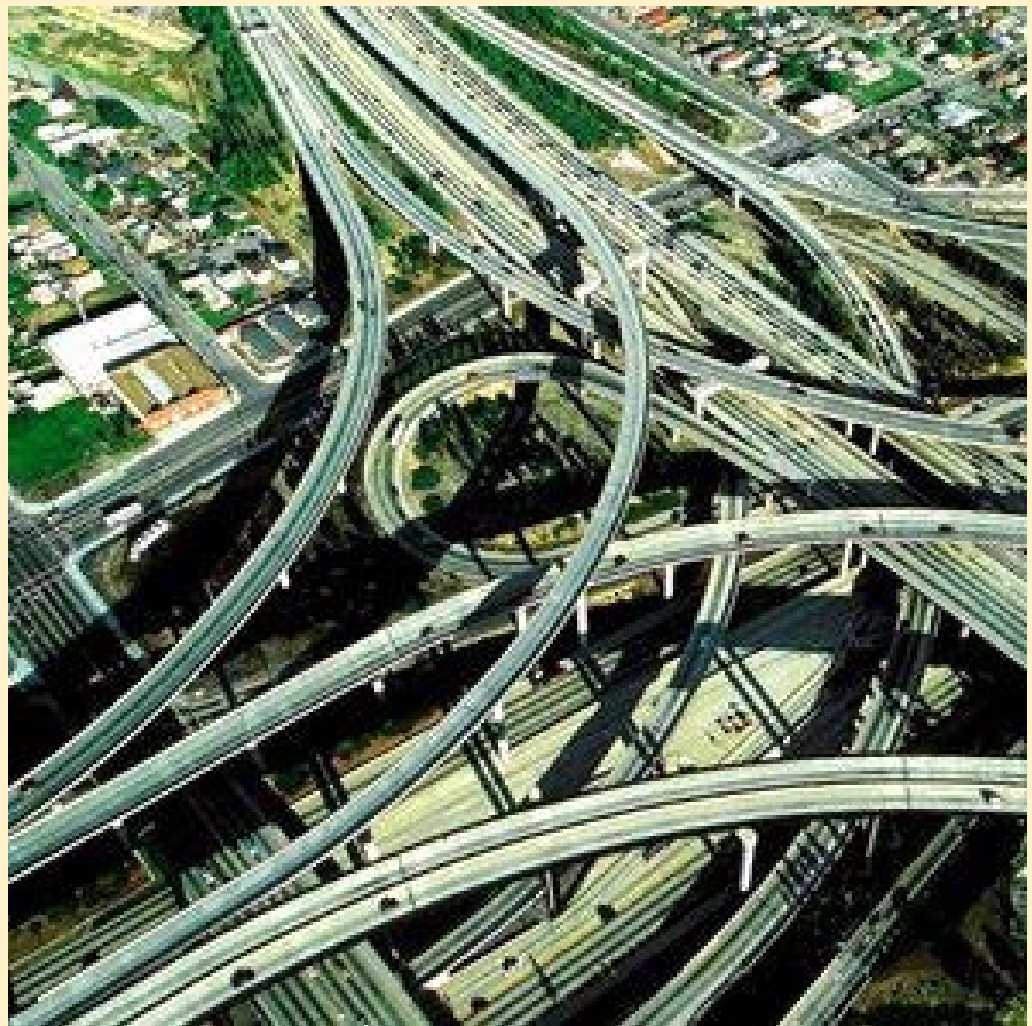
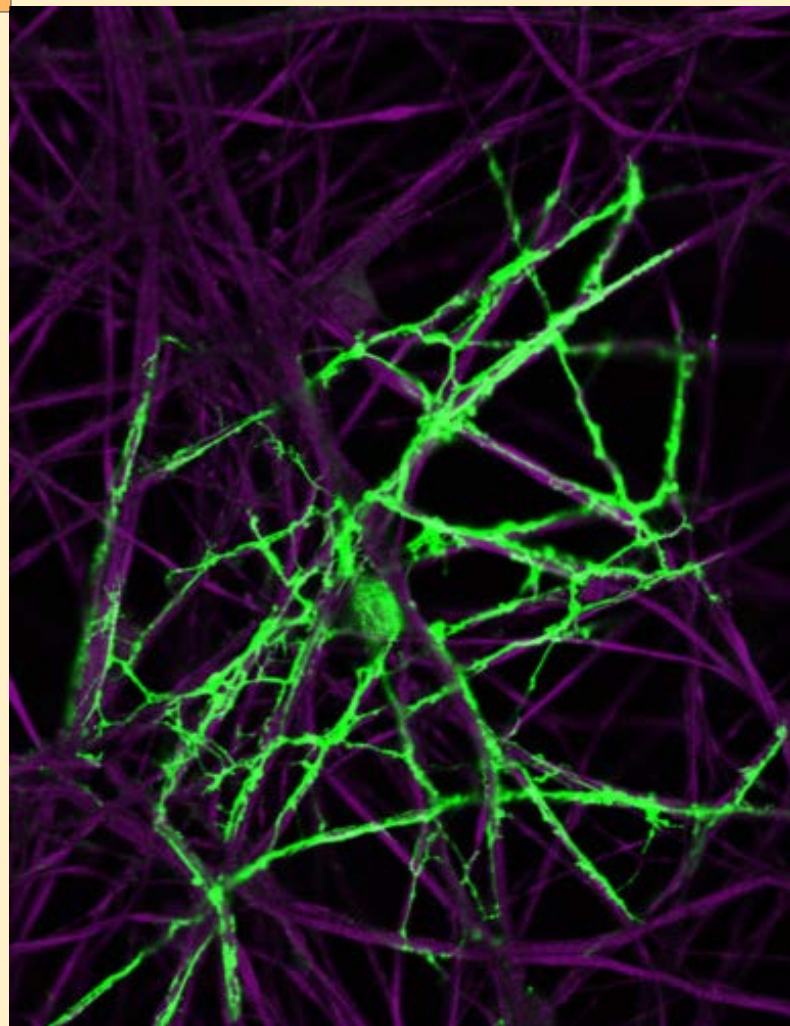
Brain Development



Source: Tapert & Schweinsburg, 2005



Synaptic Refinement



Myelination

This is Normal Development

Act First,
Think Later

Preference
for Physical
Activity and
Sensation
Seeking

More Risky
Impulsive
Behavior

Emotions Felt
Very
Intensely



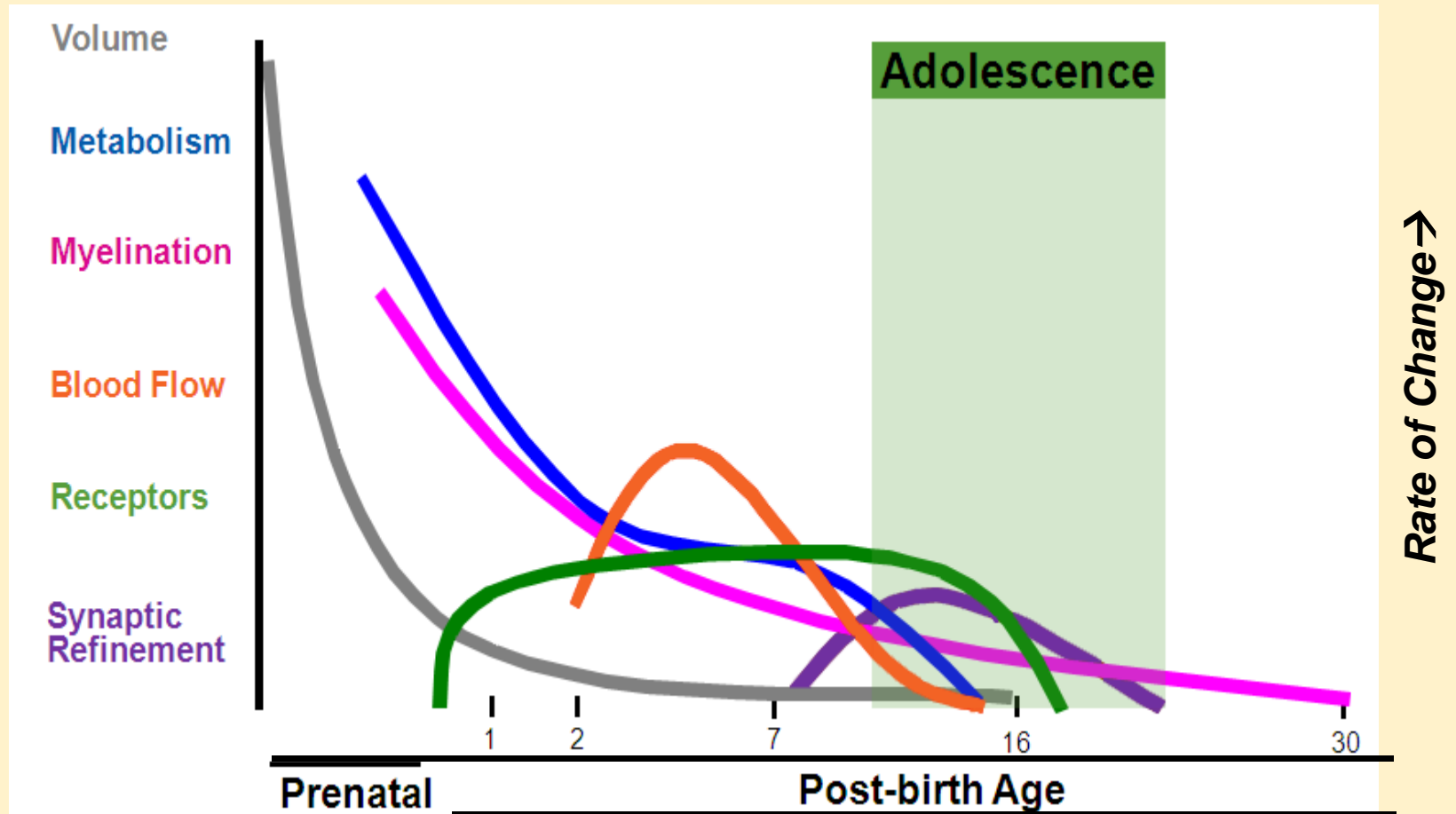
Less than
Optimal
Planning

Less
Consideration
of Negative
Consequences

Strongly
Influenced by
Friends and
Peers



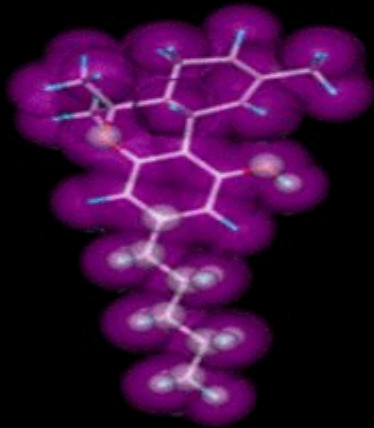
Brain Development



Source: Tapert & Schweinsburg, 2005

Marijuana
(Tetrahydrocannabinol)

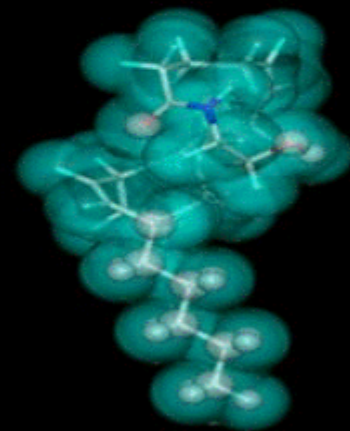
Drug



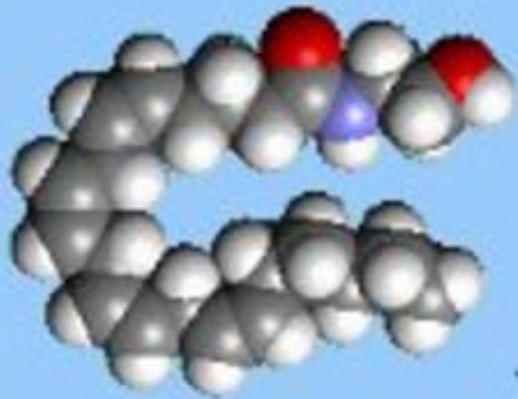
THC

Endo-cannabinoid
(Anandamide)

Brain's Chemical



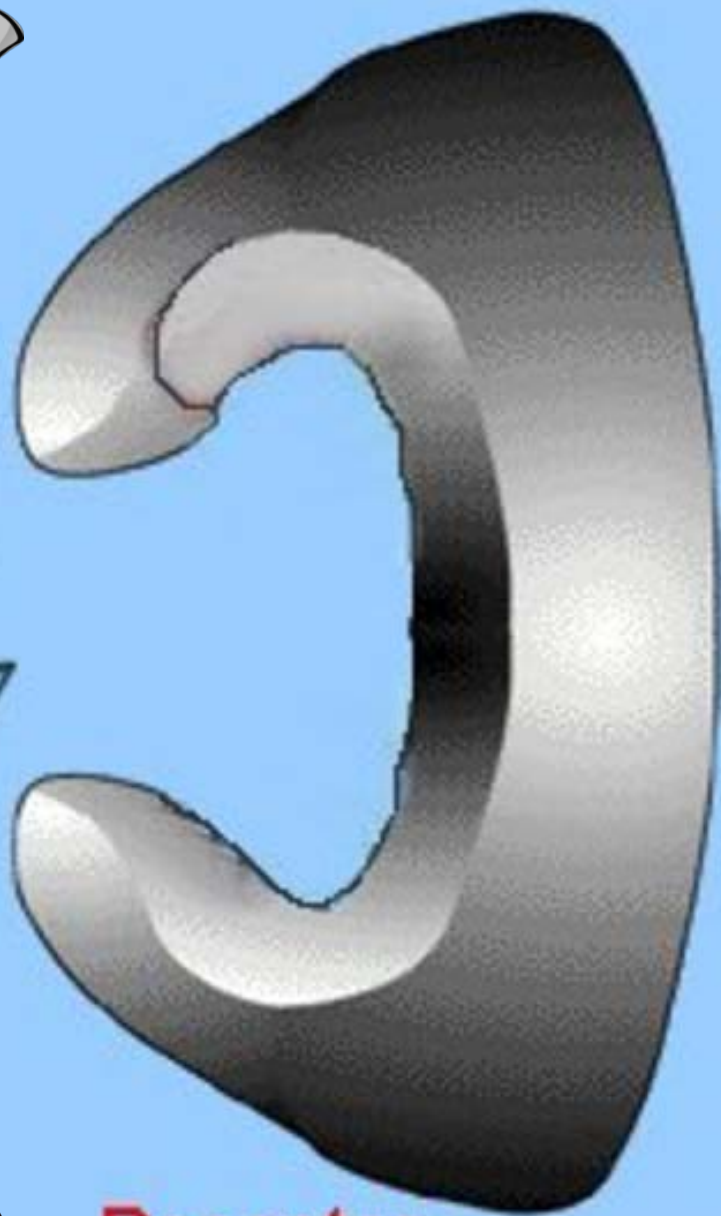
Anandamide



anandamide



THC



Receptor

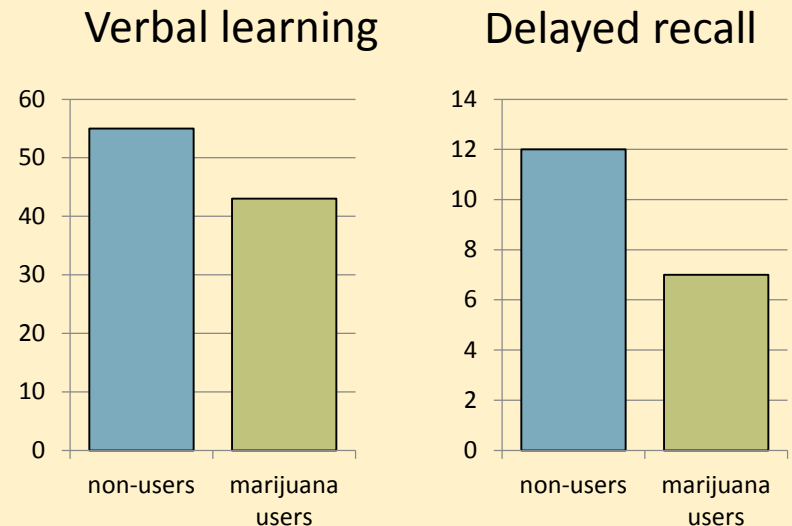


Deficits in Cognitive Functioning Among Active Marijuana Users

Many studies show that adolescents who use marijuana heavily tend to score worse than non-users on tests of:

- attention
- verbal learning
- memory
- processing speed

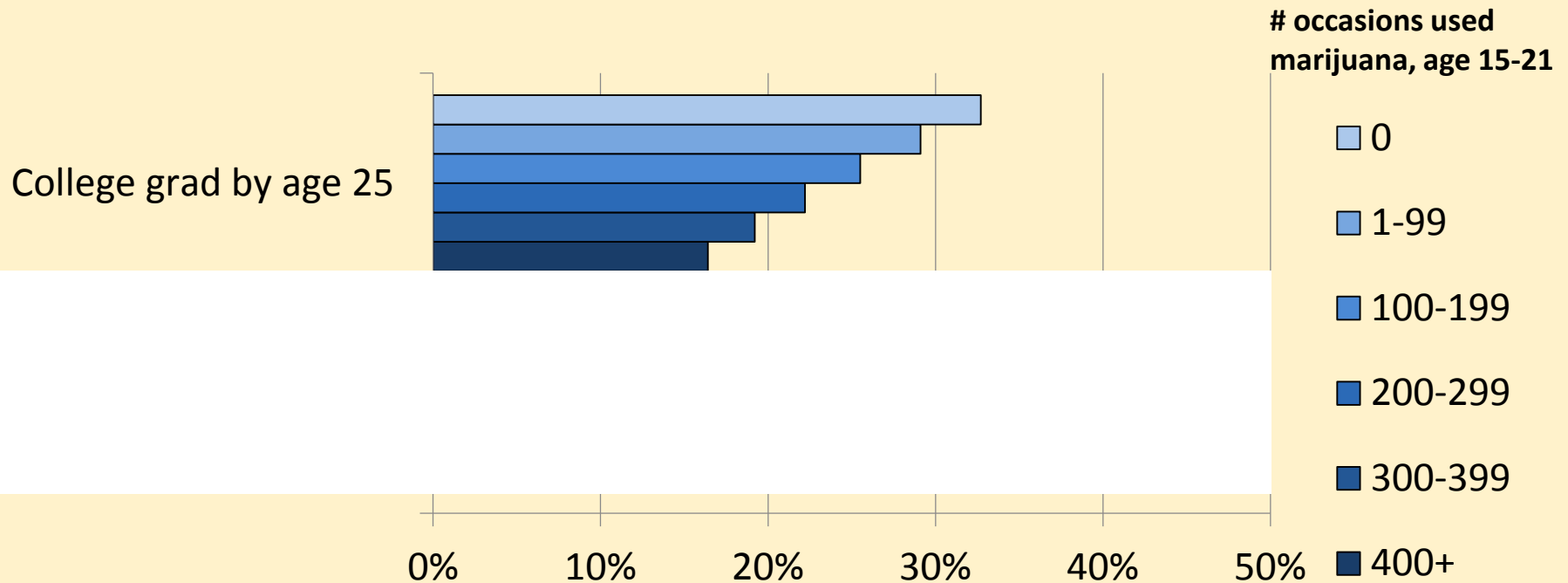
... even when
they are not high.



Messinis, et al 2006



Adult life outcomes affected by marijuana use in adolescence





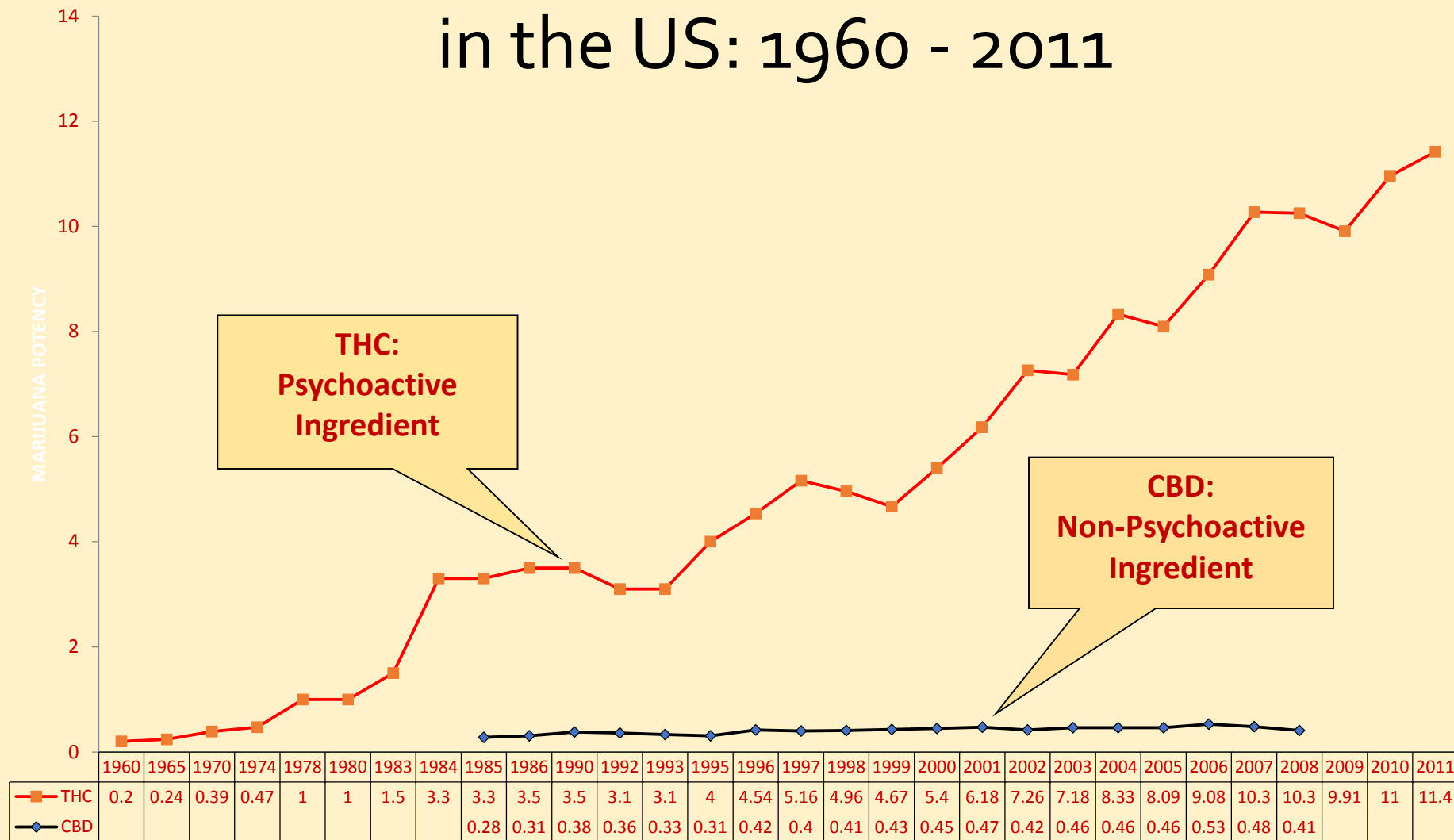
Loss of Adult IQ with Marijuana Dependence in Adolescence

Findings:

- **Those who developed marijuana dependence before age 18 showed IQ decline in adulthood.**
- The longer their dependence persisted, the greater the decline, with a decline of 8 IQ points for the most persistent users.
- **Those who began using in adulthood did not show IQ decline.**
- Quitting in adulthood did not restore functioning in those who began in adolescence.



Average THC & CBD levels in the US: 1960 - 2011



Data from the NIDA-sponsored Potency Monitoring program at the University of Mississippi, showing average THC and CBD levels in samples of marijuana seized by federal, state and local governments in each year shown.



THC Concentrates



"Green Crack" wax



"Ear Wax"



Butane Hash Oil (BHO)



Hash Oil Capsules



"Budder"

"Shatter"





SMOKING



PIPE



BONG



BUBBLER



DAB



JOINT



BLUNT

BEVERAGES



TEA



SODA



ALCOHOL



MILK

Ways to
consume
marijuana

EDIBLES



CANDY



ICE CREAM



BAKED GOODS

VAPORIZING



DESKTOP VAPORIZER



PORTABLE VAPORIZER

OTHER



CAPSULES



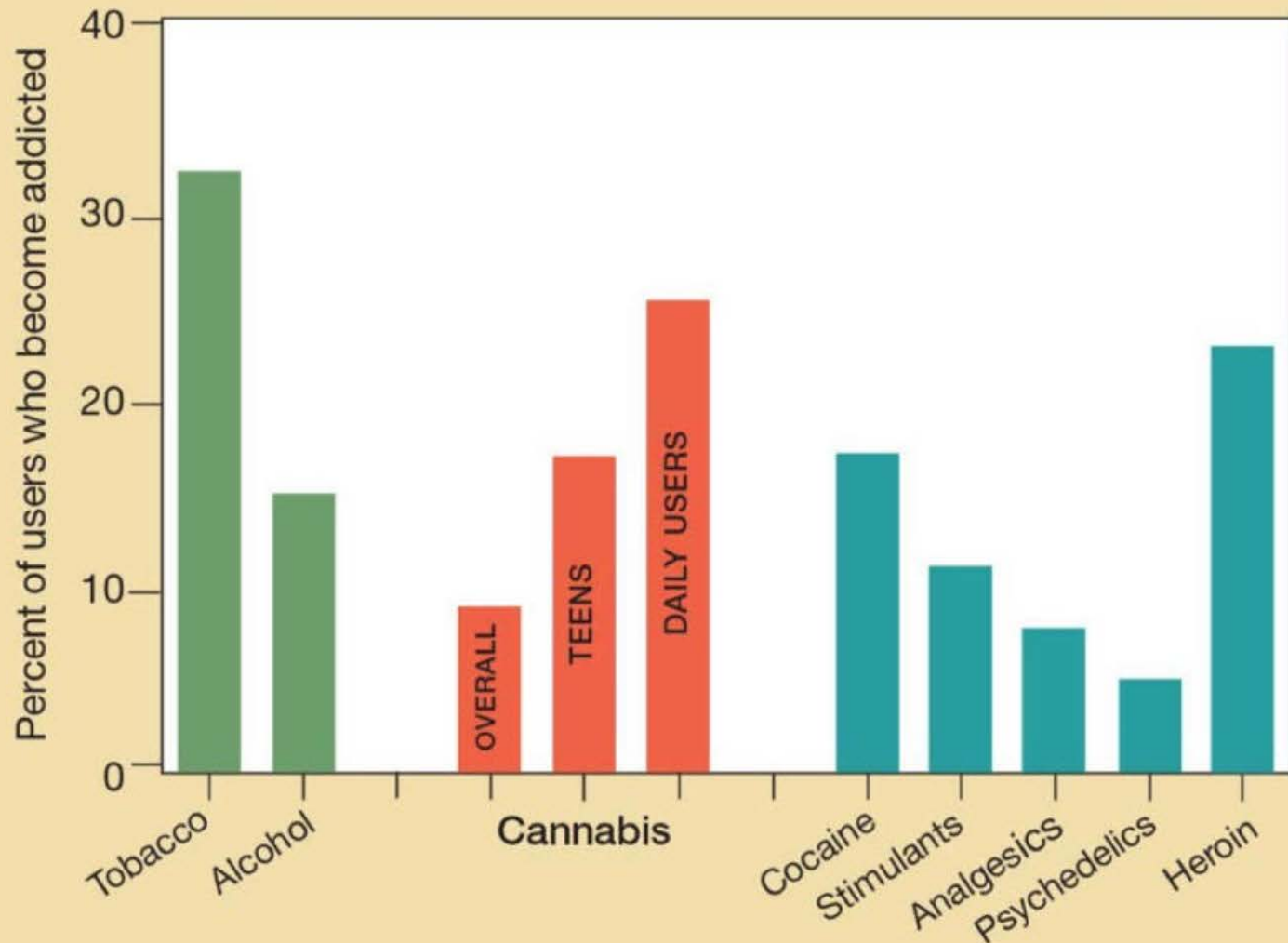
SPRAY



TINCTURE



Comparison of addictive potential by drug type¹⁹



Gilman, 2015--<http://www.psychiatrictimes.com/special-reports/cannabis-use-young-adults-challenges-during-transition-adulthood>

Big Marijuana — Lessons from Big Tobacco

Kimber P. Richter, Ph.D., M.P.H., and Sharon Levy, M.D., M.P.H.

The United States is divided over the legalization of marijuana. Arguments in favor include protection of individual rights, elimination of criminal sentencing for minor offenses, collection of tax revenue, and elimination of the black market. Counterarguments include the

N ENGL J MED 371:5 NEJM.ORG JULY 31, 2014

399

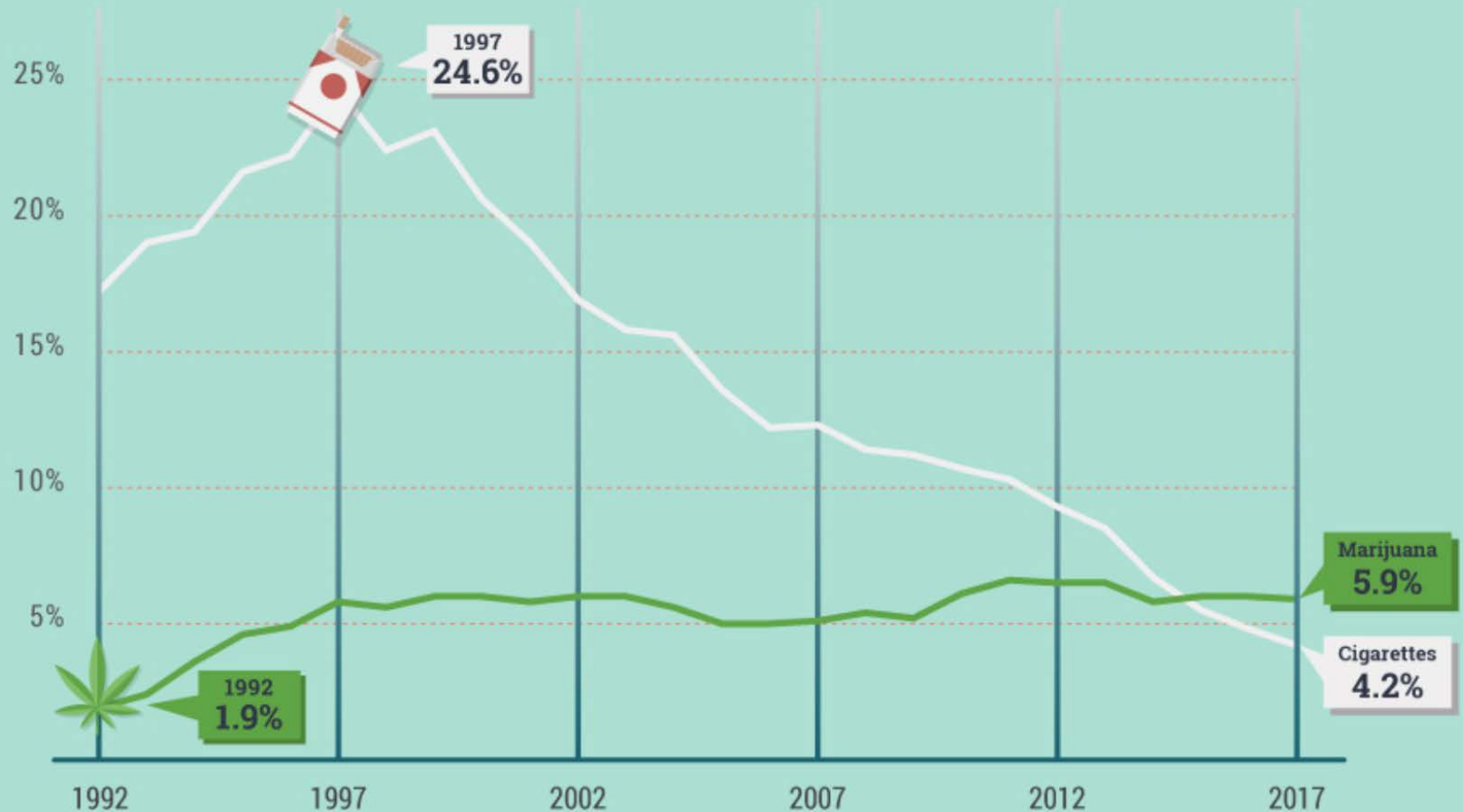
The New England Journal of Medicine

It took the medical and public health communities 50 years, millions of lives, and billions of dollars to identify the wake of illness and death left by legal, industrialized cigarettes. The free-market approach to tobacco clearly failed to protect the public's welfare and the common good: in spite of recent federal regulation, tobacco use remains the leading cause of death in the United States.

History and current evidence suggest that simply legalizing marijuana, and giving free rein to the resulting industry, is not the answer. To do so would be to once again entrust private industry with safeguarding the health of the public — a role that it is not designed to handle.

TEENS MORE LIKELY TO USE MARIJUANA THAN CIGARETTES

Daily use among 12th graders



National Institute
on Drug Abuse

DRUGABUSE.GOV

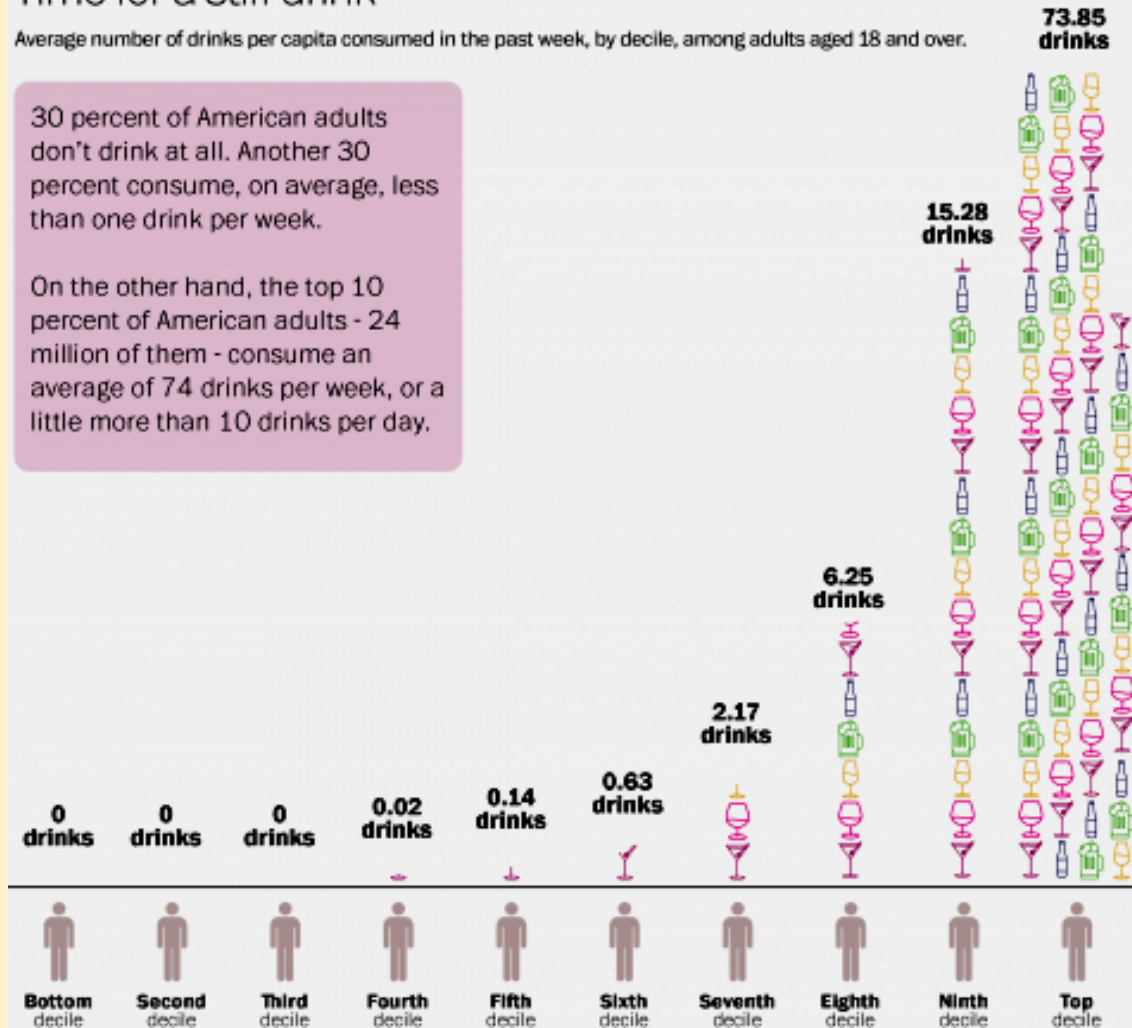
Think you drink a lot?

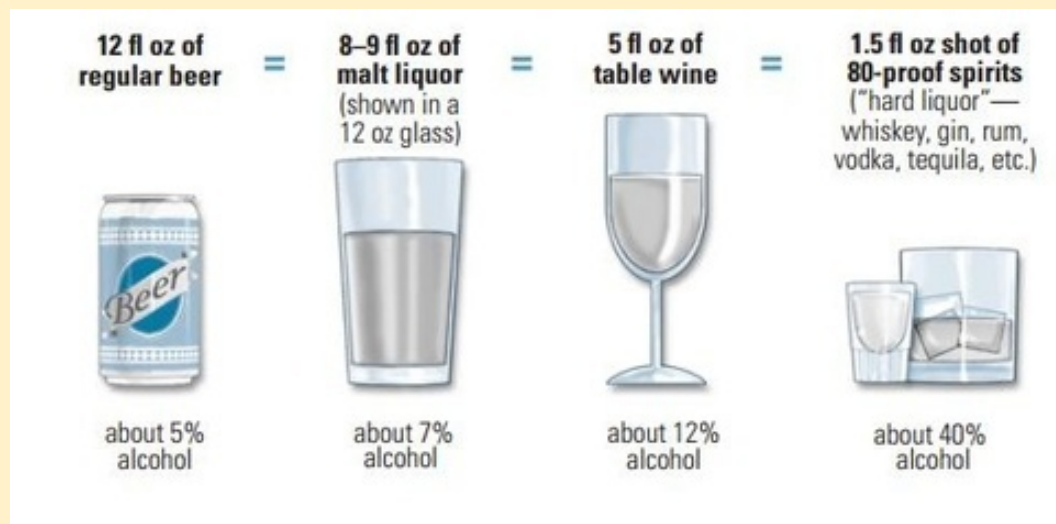
Time for a stiff drink

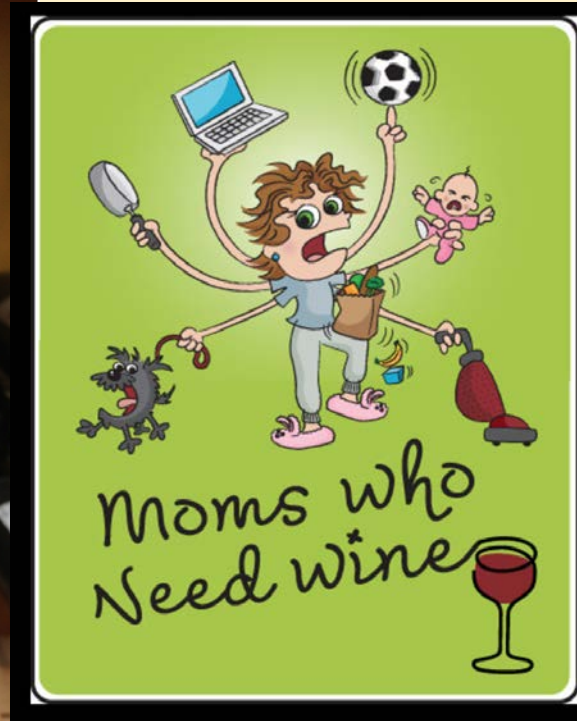
Average number of drinks per capita consumed in the past week, by decile, among adults aged 18 and over.

30 percent of American adults don't drink at all. Another 30 percent consume, on average, less than one drink per week.

On the other hand, the top 10 percent of American adults - 24 million of them - consume an average of 74 drinks per week, or a little more than 10 drinks per day.









Adverse Childhood Experiences – ACEs

Emotional Neglect

Abuse

Household Dysfunction

Relationship of Childhood Abuse and Household Dysfunction to Many of the Leading Causes of Death in Adults

The Adverse Childhood Experiences (ACE) Study

Vincent J. Felitti, MD, FACP, Robert F. Anda, MD, MS, Dale Nordenberg, MD, David F. Williamson, MS, PhD, Alison M. Spitz, MS, MPH, Valerie Edwards, BA, Mary P. Koss, PhD, James S. Marks, MD, MPH

Background: The relationship of health risk behavior and disease in adulthood to the breadth of exposure to childhood emotional, physical, or sexual abuse, and household dysfunction during childhood has not previously been described.

Methods: A questionnaire about adverse childhood experiences was mailed to 13,494 adults who had completed a standardized medical evaluation at a large HMO; 9,508 (70.5%) responded. Seven categories of adverse childhood experiences were studied: psychological, physical, or sexual abuse; violence against mother; or living with household members who were substance abusers, mentally ill or suicidal, or ever imprisoned. The number of categories of these adverse childhood experiences was then compared to measures of adult risk behavior, health status, and disease. Logistic regression was used to adjust for effects of demographic factors on the association between the cumulative number of categories of childhood exposures (range: 0–7) and risk factors for the leading causes of death in adult life.

Results: More than half of respondents reported at least one, and one-fourth reported ≥ 2 categories of childhood exposures. We found a graded relationship between the number of categories of childhood exposure and each of the adult health risk behaviors and diseases that were studied ($P < .001$). Persons who had experienced four or more categories of childhood exposure, compared to those who had experienced none, had 4- to 12-fold increased health risks for alcoholism, drug abuse, depression, and suicide attempt; a 2- to 4-fold increase in smoking, poor self-rated health, ≥ 50 sexual intercourse partners, and sexually transmitted disease; and a 1.4- to 1.6-fold increase in physical inactivity and severe obesity. The number of categories of adverse childhood exposures showed a graded relationship to the presence of adult diseases including ischemic heart disease, cancer, chronic lung disease, skeletal fractures, and liver disease. The seven categories of adverse childhood experiences were strongly interrelated and persons with multiple categories of childhood exposure were likely to have multiple health risk factors later in life.

Conclusions: We found a strong graded relationship between the breadth of exposure to abuse or household dysfunction during childhood and multiple risk factors for several of the leading causes of death in adults.

Medical Subject Headings (MeSH): child abuse, sexual, domestic violence, spouse abuse, children of impaired parents, substance abuse, alcoholism, smoking, obesity, physical activity, depression, suicide, sexual behavior, sexually transmitted diseases, chronic obstructive pulmonary disease, ischemic heart disease. (Am J Prev Med 1998;14:245–258) © 1998 American Journal of Preventive Medicine

Finding Your ACE Score

While you were growing up, during your first 18 years of life:

1. Did a parent or other adult in the household **often or very often**...
Swear at you, insult you, put you down, or humiliate you?
or
Act in a way that made you afraid that you might be physically hurt?
Yes No If yes enter 1 _____
2. Did a parent or other adult in the household **often or very often**...
Push, grab, slap, or throw something at you?
or
Ever hit you so hard that you had marks or were injured?
Yes No If yes enter 1 _____
3. Did an adult or person at least 5 years older than you **ever**...
Touch or fondle you or have you touch their body in a sexual way?
or
Attempt or actually have oral, anal, or vaginal intercourse with you?
Yes No If yes enter 1 _____
4. Did you **often or very often** feel that ...
No one in your family loved you or thought you were important or special?
or
Your family didn't look out for each other, feel close to each other, or support each other?
Yes No If yes enter 1 _____
5. Did you **often or very often** feel that ...
You didn't have enough to eat, had to wear dirty clothes, and had no one to protect you?
or
Your parents were too drunk or high to take care of you or take you to the doctor if you needed it?
Yes No If yes enter 1 _____
6. Were your parents **ever** separated or divorced?
Yes No If yes enter 1 _____
7. Was your mother or stepmother:
Often or very often pushed, grabbed, slapped, or had something thrown at her?
or
Sometimes, often, or very often kicked, bitten, hit with a fist, or hit with something hard?
or
Ever repeatedly hit at least a few minutes or threatened with a gun or knife?
Yes No If yes enter 1 _____
8. Did you live with anyone who was a problem drinker or alcoholic or who used street drugs?
Yes No If yes enter 1 _____
9. Was a household member depressed or mentally ill, or did a household member attempt suicide?
Yes No If yes enter 1 _____
10. Did a household member go to prison?
Yes No If yes enter 1 _____

Now add up your "Yes" answers: _____ This is your ACE Score.



WHAT ARE THEY?

ACEs are
ADVERSE
CHILDHOOD
EXPERIENCES

HOW PREVALENT ARE ACEs?

The ACE study* revealed the following estimates:

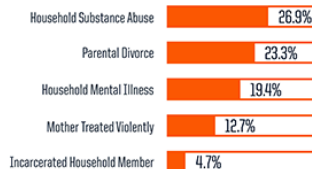
ABUSE



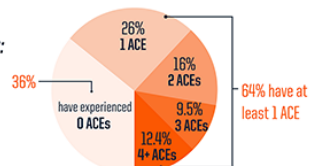
NEGLECT



HOUSEHOLD DYSFUNCTION



Of 17,000 ACE study participants:



ABUSE



Physical



Emotional



Sexual

NEGLECT



Physical



Emotional

HOUSEHOLD DYSFUNCTION



Mental Illness



Incarcerated Relative



Mother treated violently



Substance Abuse



Divorce

WHAT IMPACT DO ACEs HAVE?

As the number of ACEs increases, so does the risk for negative health outcomes



Possible Risk Outcomes:

BEHAVIOR



Lack of physical activity



Smoking



Alcoholism



Drug use



Missed work

PHYSICAL & MENTAL HEALTH



Severe obesity



Diabetes



Depression



Suicide attempts



STDs



Heart disease



Cancer



Stroke



COPD



Broken bones

Talk Early, Talk Often

“Delay, Delay, Delay or Avoid Altogether”



Genetics

+



Trauma

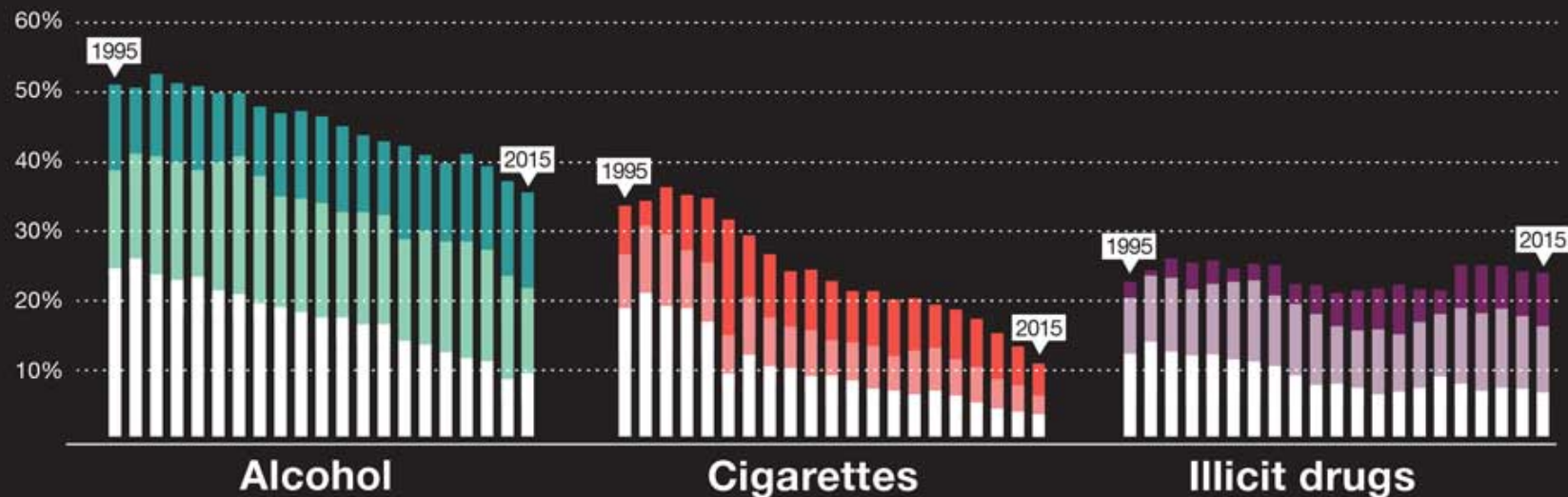
+






Early Use




LAST TWO DECADES OF ALCOHOL, CIGARETTE, AND ILLICIT DRUG USE*




*Past-month use



2015

 35.3% OF 12TH GRADERS
 21.5% OF 10TH GRADERS
 9.7% OF 8TH GRADERS

 11.4% OF 12TH GRADERS
 6.3% OF 10TH GRADERS
 3.6% OF 8TH GRADERS

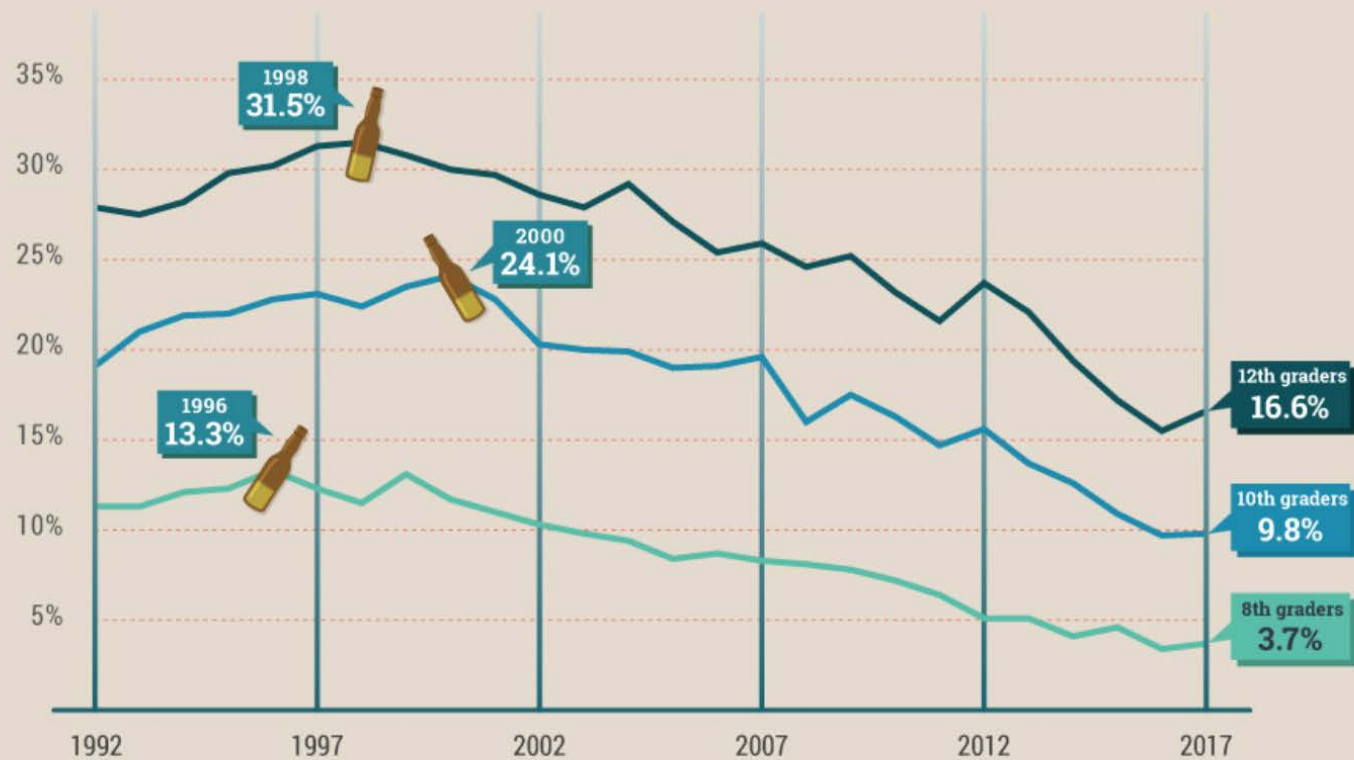
 23.6% OF 12TH GRADERS
 16.5% OF 10TH GRADERS
 8.1% OF 8TH GRADERS



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BINGE DRINKING RATES STEADY AFTER DECADES OF DECLINE



**Binge drinking is defined as having 5 or more drinks in a row in the last 2 weeks.*

BINGE DRINKING APPEARS TO HAVE LEVELED OFF THIS YEAR, BUT IS SIGNIFICANTLY LOWER THAN PEAK YEARS.



National Institute
on Drug Abuse

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TOBACCO PRODUCT USE BY HIGH SCHOOL STUDENTS (2011-2016)

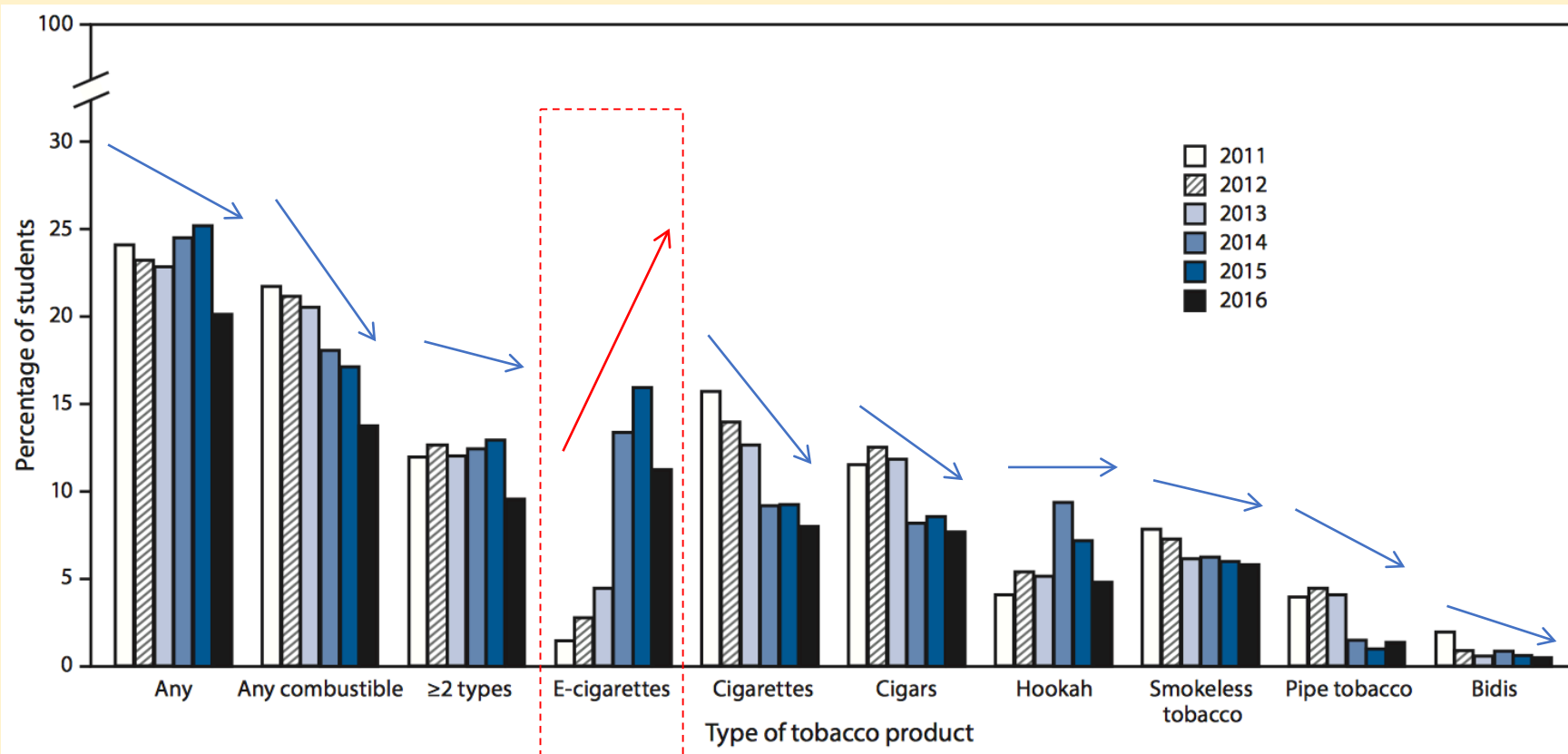
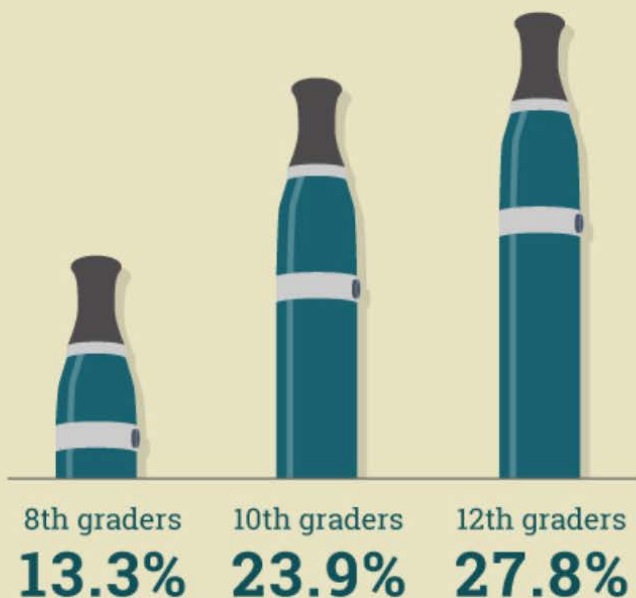
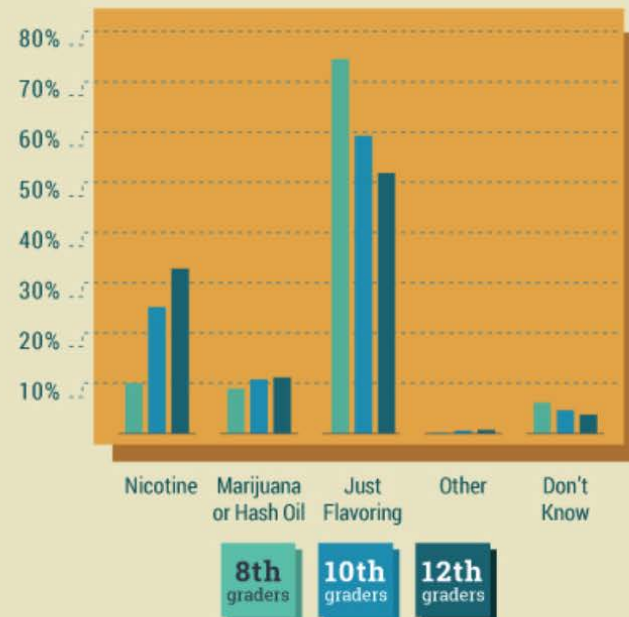


Figure 1. Estimated percentage of **high school students** who currently use any tobacco products, any combustible tobacco products, ≥ 2 tobacco products, and selected tobacco products – National Youth Tobacco Survey, United States. 2011-2016.

PAST-YEAR E-VAPORIZER USE AND WHAT TEENS ARE INHALING



When asked what they thought was in the e-vaporizer mist students inhaled the last time they smoked, these were their responses:



NEARLY 1 IN 3 STUDENTS IN 12TH GRADE REPORT PAST-YEAR USE OF E-VAPORIZERS, RAISING CONCERNS ABOUT THE IMPACT ON THEIR LONG-TERM HEALTH.



National Institute
on Drug Abuse

DRUGABUSE.GOV

JUUL e-cigarettes

Some e-cigarette critics are calling the JUUL e-cigarette the “Apple of vaping” or the “iPhone of vaping.” With its relatively low entry price, sleek portable design, ease of use, and nicotine head rush it generates for users, JUULS are catching on with younger people.

JUUL flavor pods



*Contains one JUULpod each of Virginia Tobacco, Cool Mint, Fruit Medley and Creme Brulee. Each JUULpod contains 0.7mL with 5% nicotine by weight, approximately equivalent to 1 pack of cigarettes or 200 puffs.

The design of the e-cigarette is about the same size as a cigarette and weighs a couple of grams.

Charging dock
It looks like a USB thumb drive

cigarette's body is designed to contain a built-in battery.

Body



USB charging dock

The battery is charged by dropping the body on a magnetic USB adapter. It takes an hour to fully charge and will last up to 200 puffs, a full day of regular use.



An illustration of a person in a blue dress with a long, flowing skirt, reaching upwards with their right arm towards a smartphone floating in the air. The person's head is tilted back, and their left arm is extended outwards. The background is a solid teal color. The smartphone is a simple black rectangle with a white screen.

Have Smartphones Destroyed a Generation?

More comfortable online than out partying, post-Millennials are safer, physically, than adolescents have ever been. But they're on the brink of a mental-health crisis.

The
Atlantic

JEAN M. TWENGE

SEPTEMBER 2017 ISSUE

JUNE 15, 2015

TIME

They're the most
**powerful
painkillers**
ever invented.

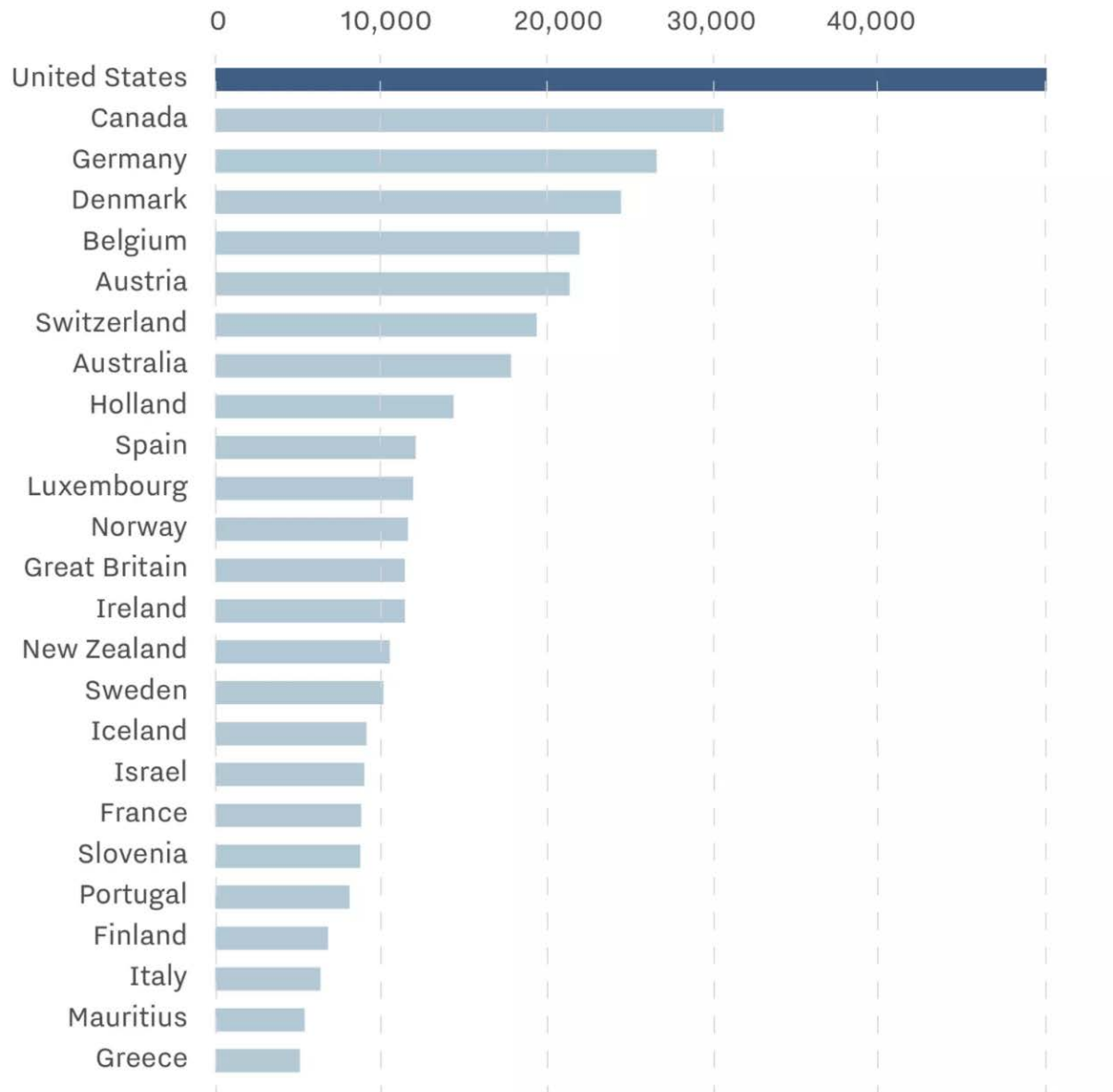
And they're creating
the worst addiction
crisis America
has ever seen.

By Massimo Calabresi



time.com

Standard daily opioid dose for every 1 million people



Source: United Nations International Narcotics Control Board

Credit: Sarah Frostenson

Vox

Drug Deaths in America Are Rising Faster Than Ever

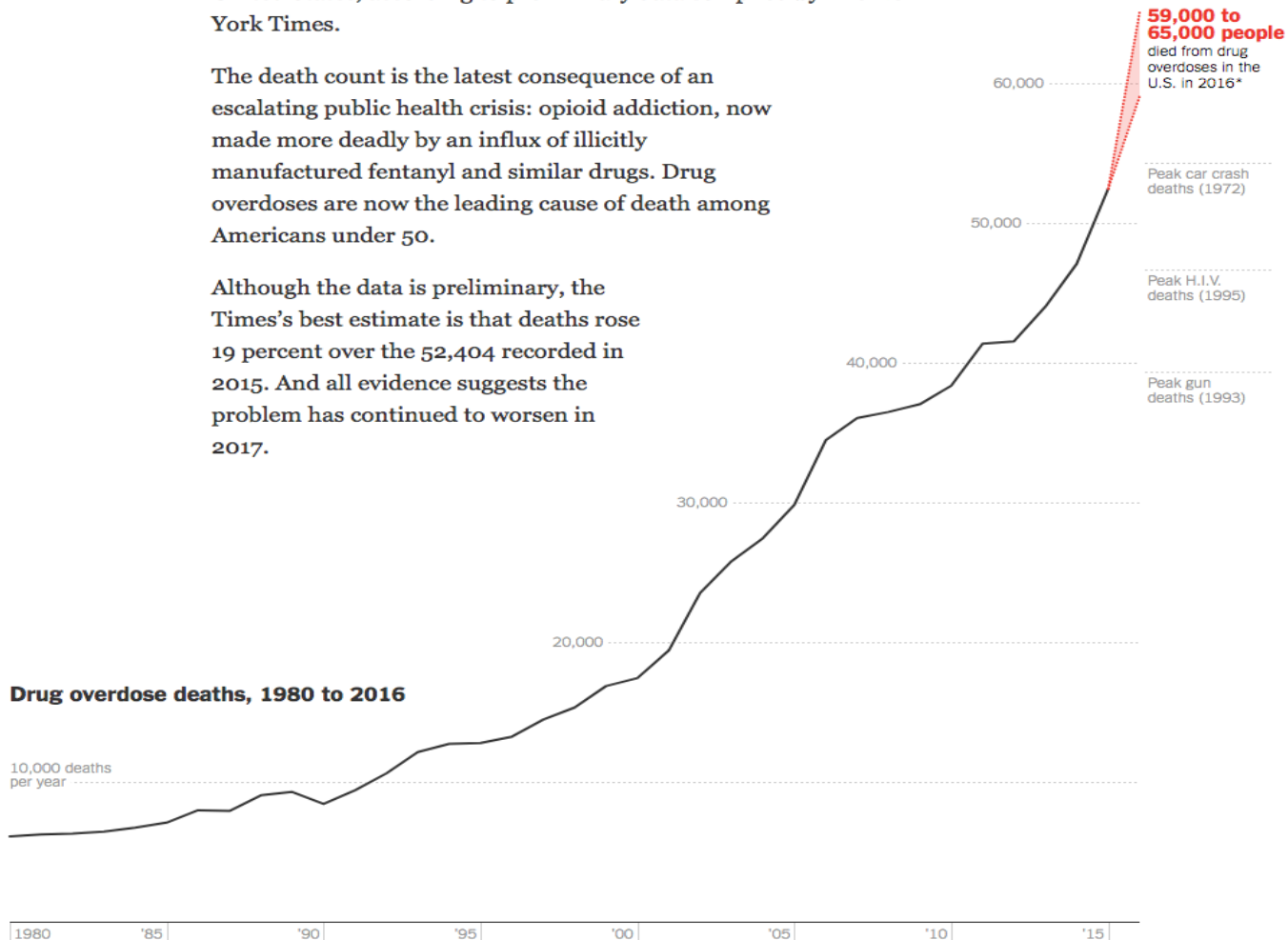
By **JOSH KATZ** JUNE 5, 2017

New data compiled from hundreds of health agencies reveals the extent of the drug overdose epidemic last year.

AKRON, Ohio — Drug overdose deaths in 2016 most likely exceeded 59,000, the largest annual jump ever recorded in the United States, according to preliminary data compiled by The New York Times.

The death count is the latest consequence of an escalating public health crisis: opioid addiction, now made more deadly by an influx of illicitly manufactured fentanyl and similar drugs. Drug overdoses are now the leading cause of death among Americans under 50.

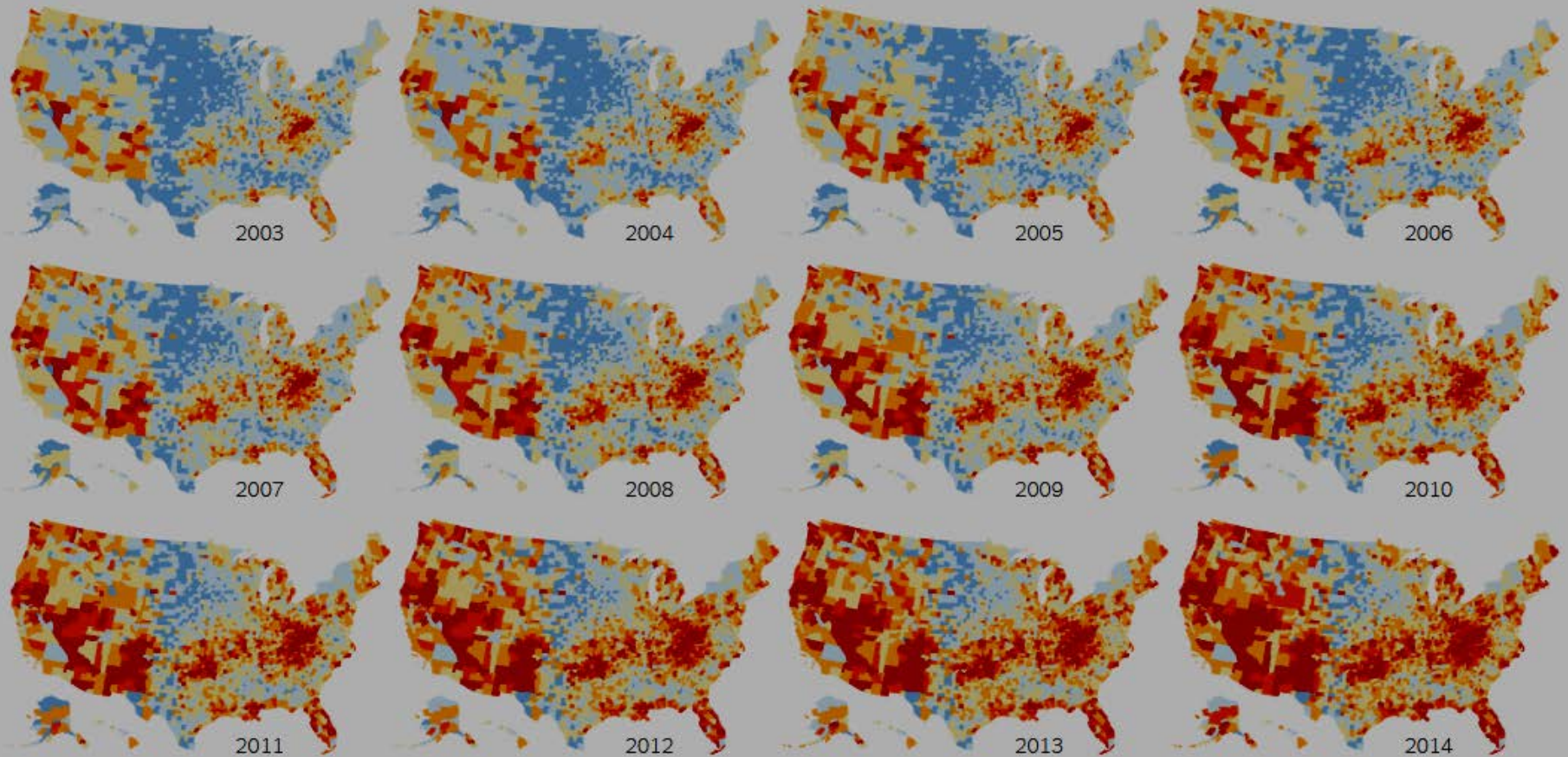
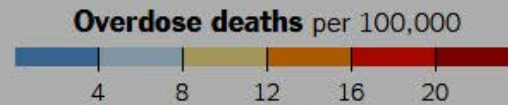
Although the data is preliminary, the Times's best estimate is that deaths rose 19 percent over the 52,404 recorded in 2015. And all evidence suggests the problem has continued to worsen in 2017.



*Estimate based on preliminary data

Deaths Ripples Across America

By HAEYOUN PARK and MATTHEW BLOCH JAN. 19, 2016



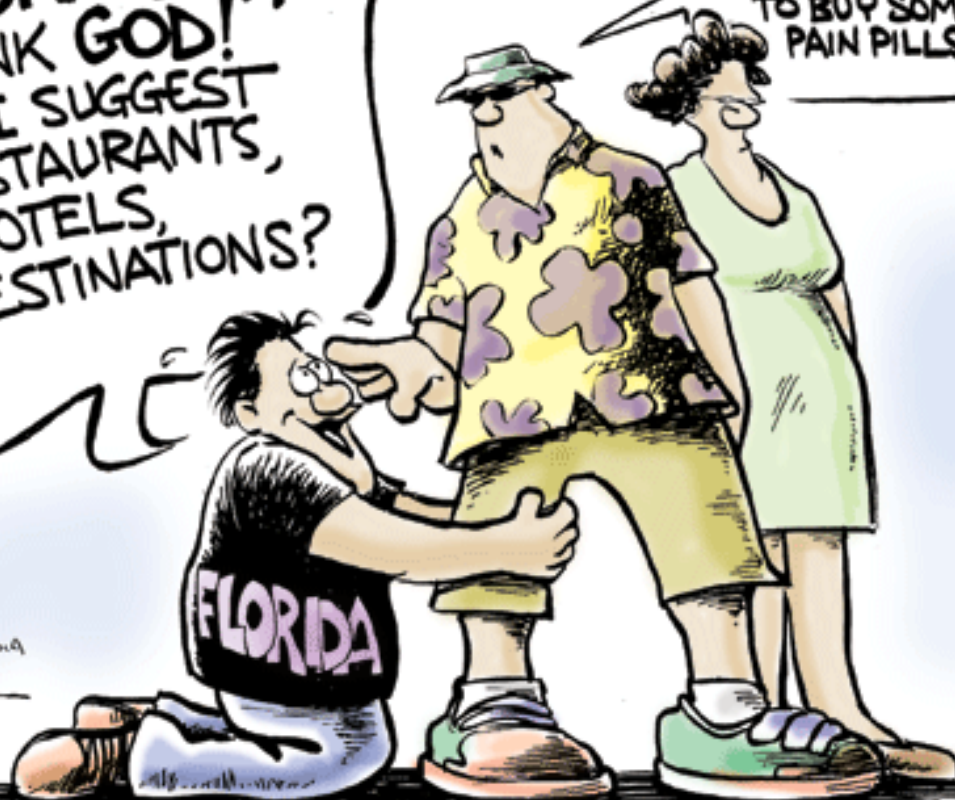
NYT January 19, 2016



TOURISTS!!
THANK GOD!!
MAY I SUGGEST
RESTAURANTS,
HOTELS,
DESTINATIONS?

WE'RE
JUST HERE
TO BUY SOME
PAIN PILLS.

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Florida Shutting 'Pill Mill' Clinics



Tim Chapman/Miami Herald, via Associated Press

At an Aug. 15 news conference, Florida officials displayed prescription drugs that were surrendered to the state by pain clinics.

By LIZETTE ALVAREZ

Published: August 31, 2011

WEST PALM BEACH, Fla. — Florida has long been the nation's center of the illegal sale of prescription drugs: Doctors here bought 89 percent of all the Oxycodone sold in the country last year. At its peak, so many out-of-staters flocked to Florida to buy drugs at more than 1,000 pain clinics that the state earned the nickname "Oxy Express."

Related

Times Topics: [OxyContin \(Drug\)](#)
[Prescription Drug Abuse](#)

[Enlarge This Image](#)



Joe Raedle/Getty Images

Florida Gov. Rick Scott attends a

But with the help of tougher laws, officials have moved aggressively this year to shut down so-called pill mills and disrupt the pipeline that moves the drugs north. In the past year, more than 400 clinics were either shut down or closed their doors.

Prosecutors have indicted dozens of pill mill operators, and nearly 80 doctors have seen their licenses suspended for prescribing mass quantities of pills without clear medical need.

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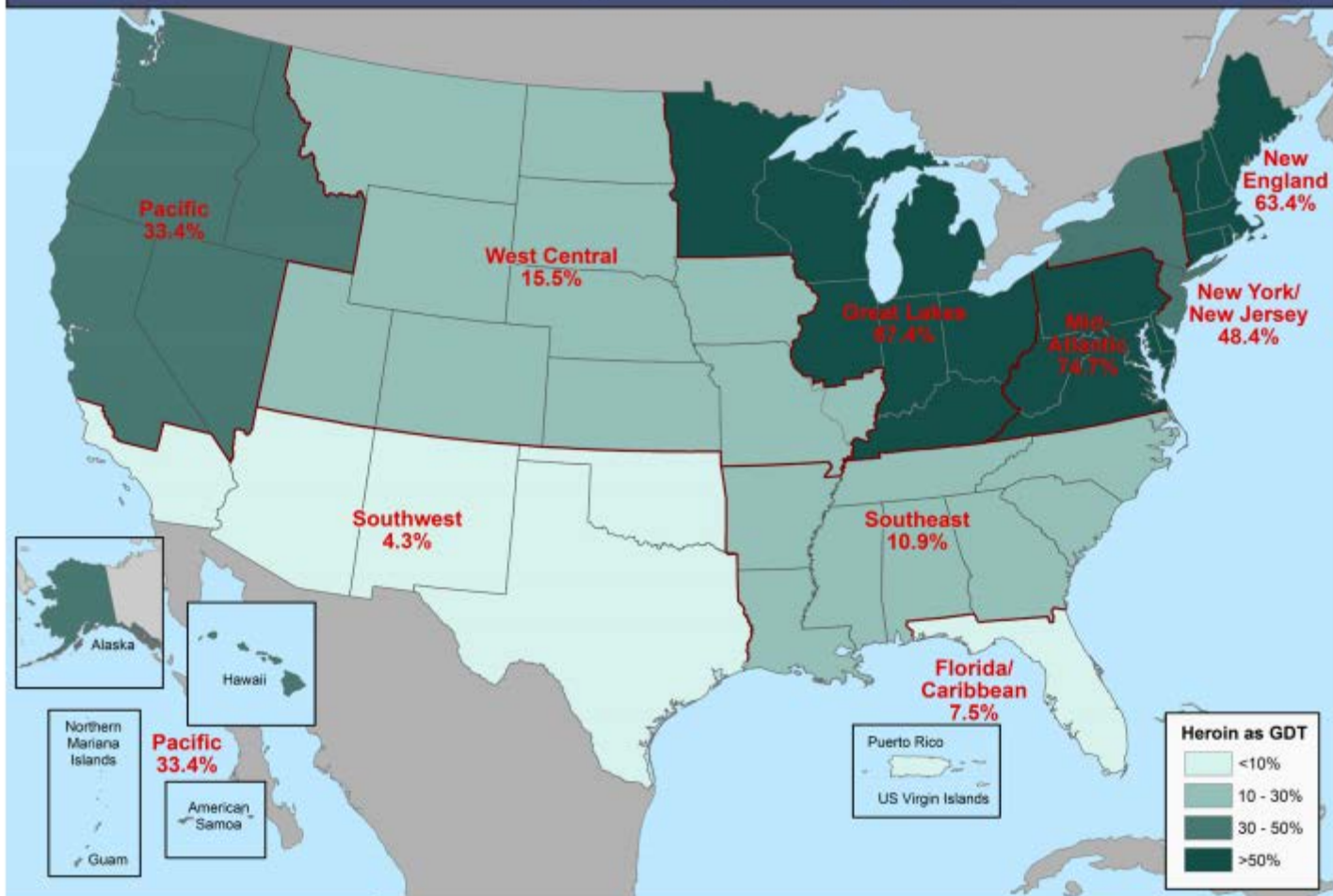




A cap, containing what looks like a dusting of heroin, sells for \$10.

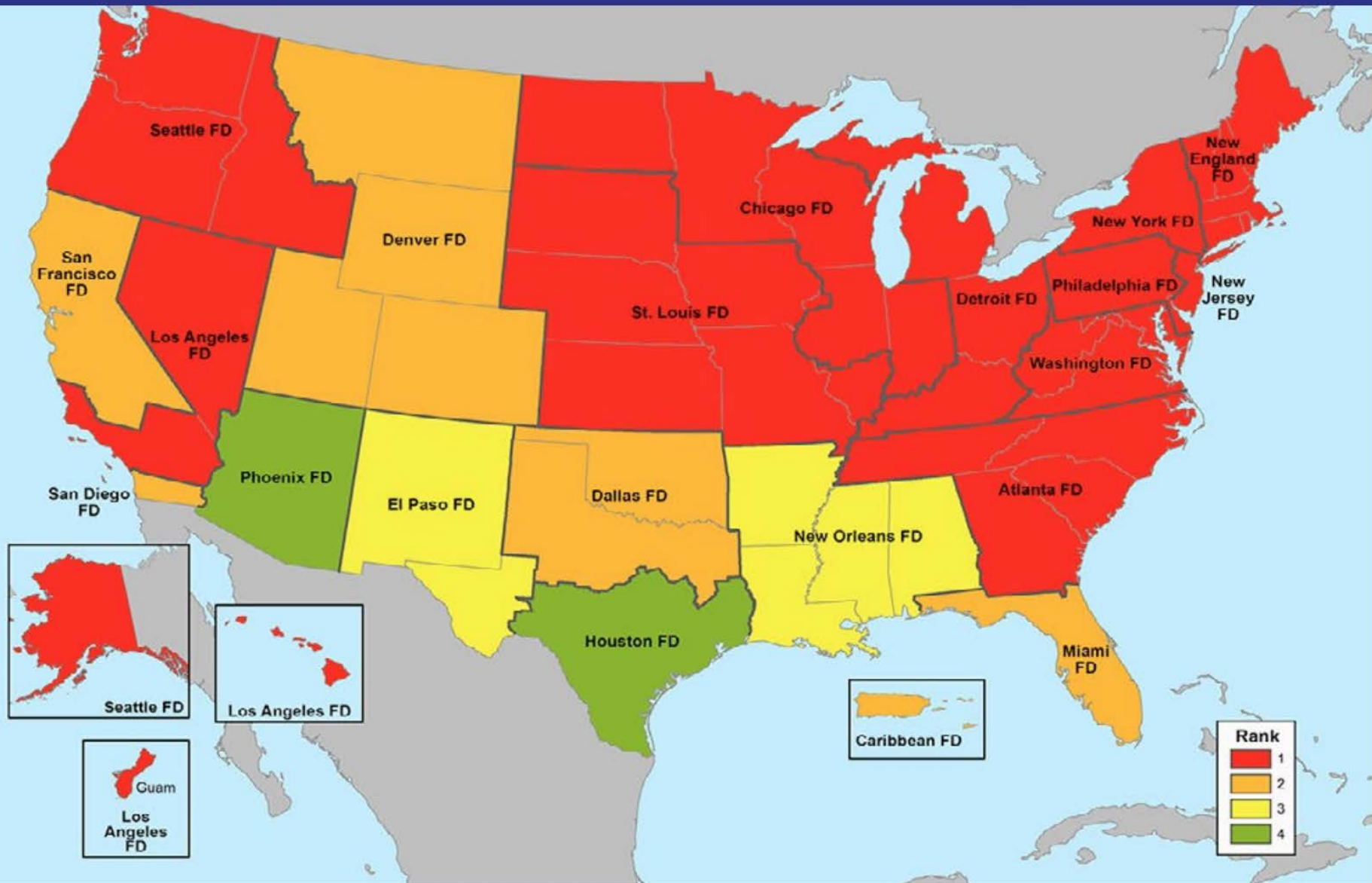


(U) Map 2. Percentage of 2015 NDTs Respondents Reporting Heroin as Greatest Drug Threat, by OCDETF Region



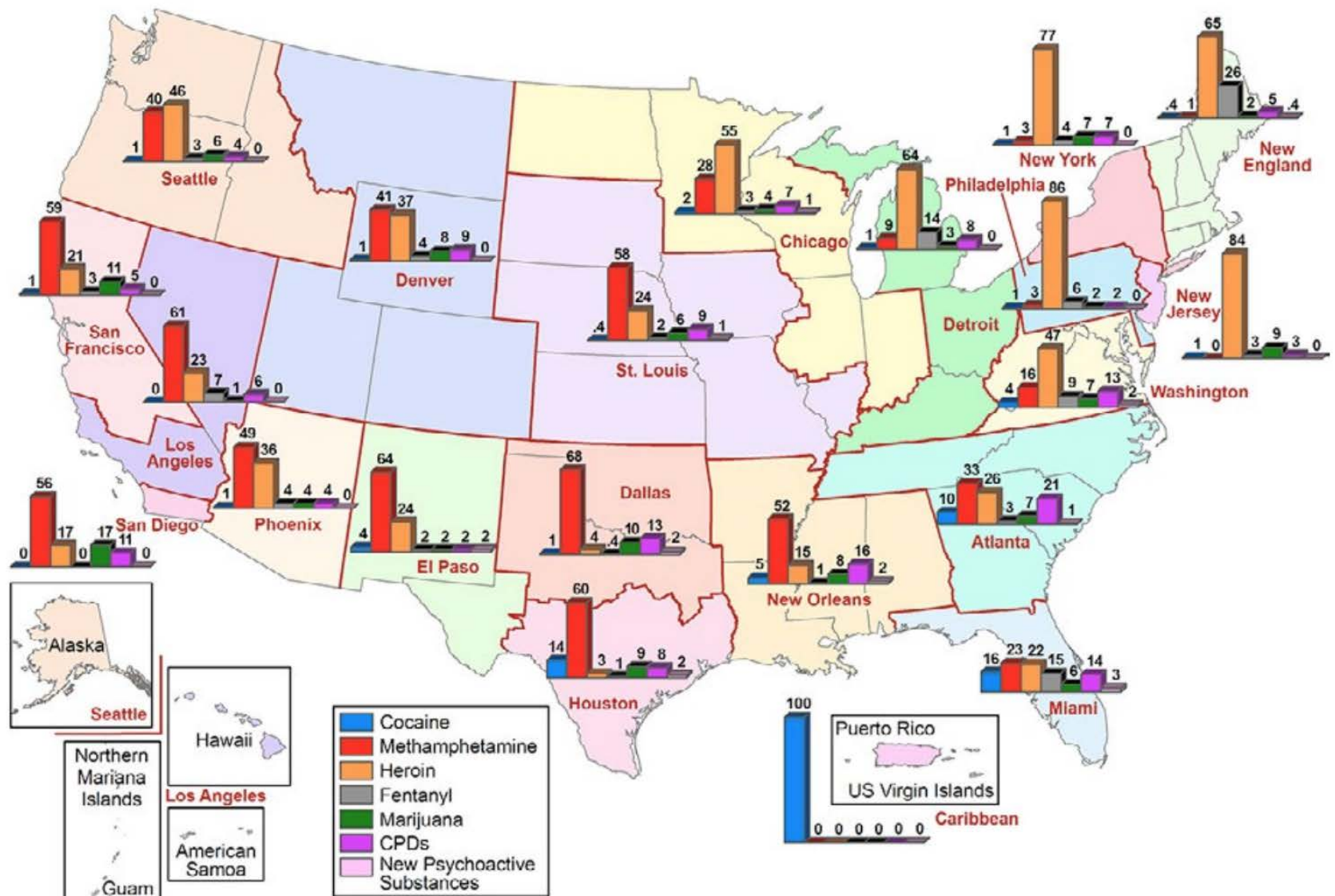
Source: 2015 National Drug Threat Survey

Figure 34. Heroin Threat in the DEA Field Divisions.



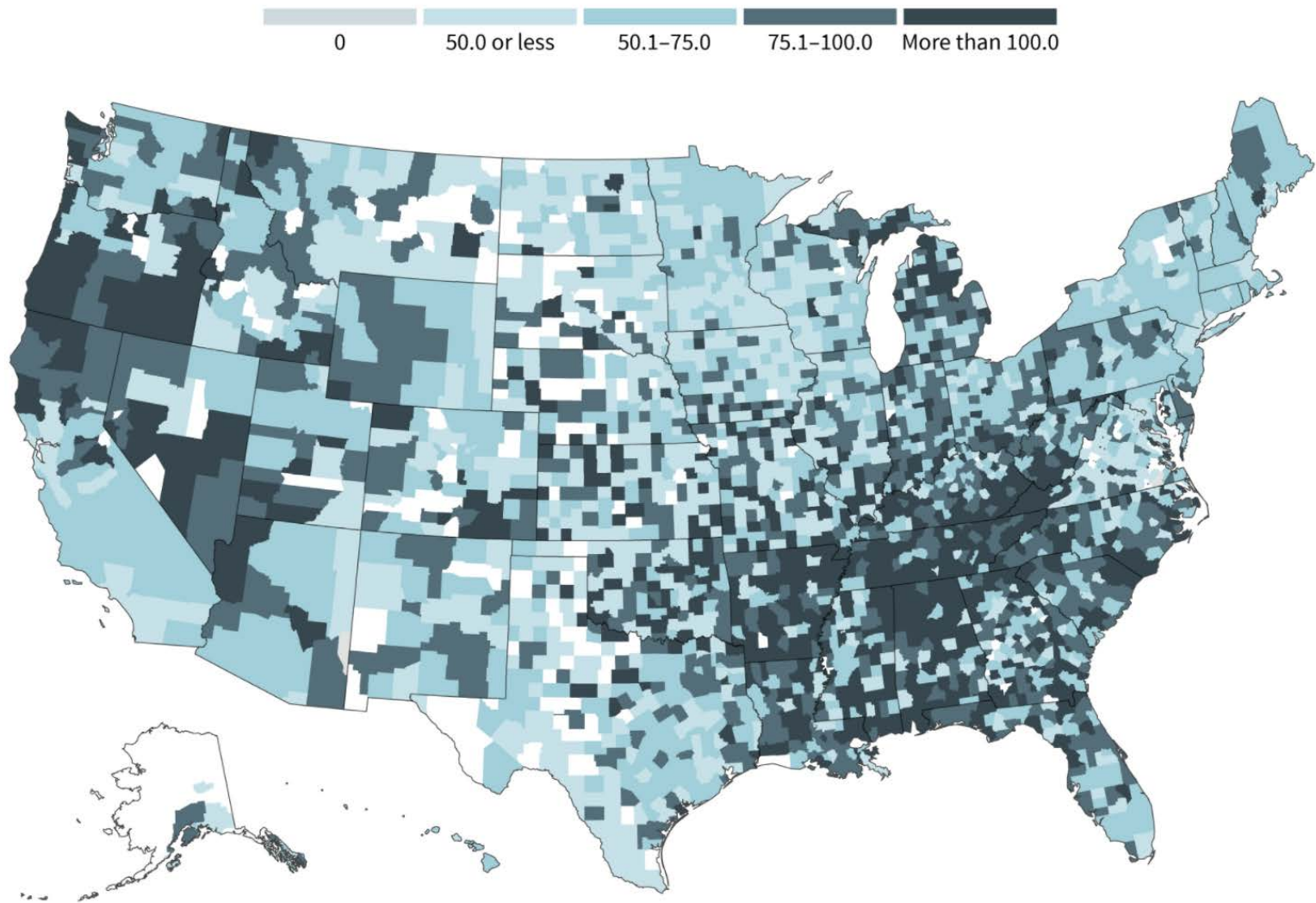
Source: DEA Field Division Reporting

Figure A3. Greatest Drug Threat by Field Division – Reported by Percentage of State and Local Agencies, 2017.



Source: National Drug Threat Survey

The map below shows the amount of retail opioid prescriptions dispensed per 100 people in 2016.

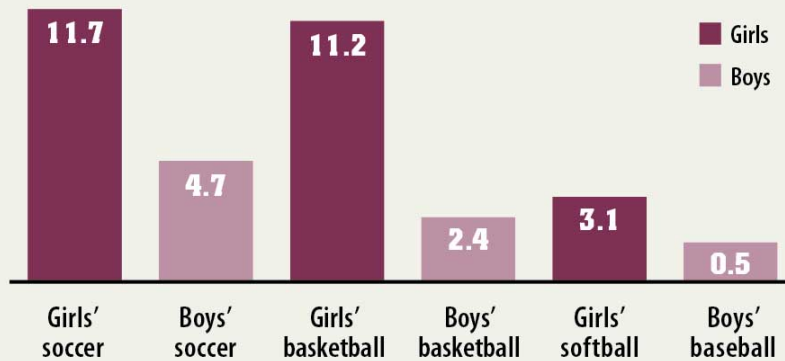


Note: Counties with insufficient data are left blank.



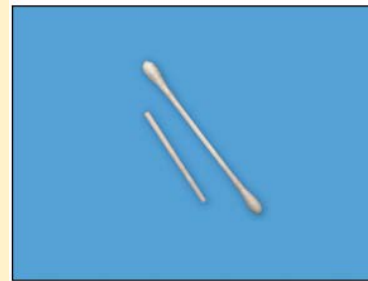
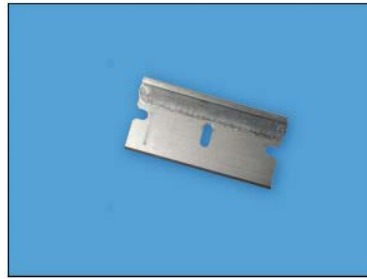
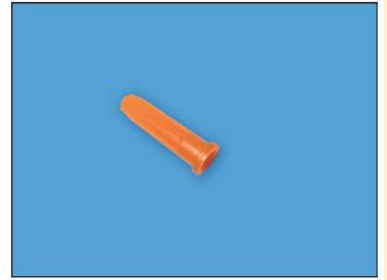
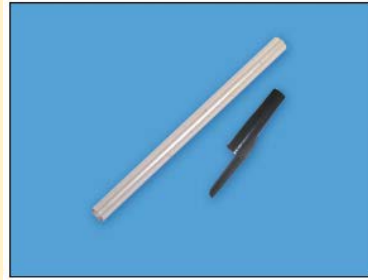
FIGURE 2 High school ACL injury rates

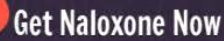
High school anterior cruciate ligament (ACL) injury rates per 100,000 athlete exposures (AEs) by sport and sex. (An athlete exposure is 1 athlete participating in 1 practice or competition.)



Adapted from Comstock RD, et al.³







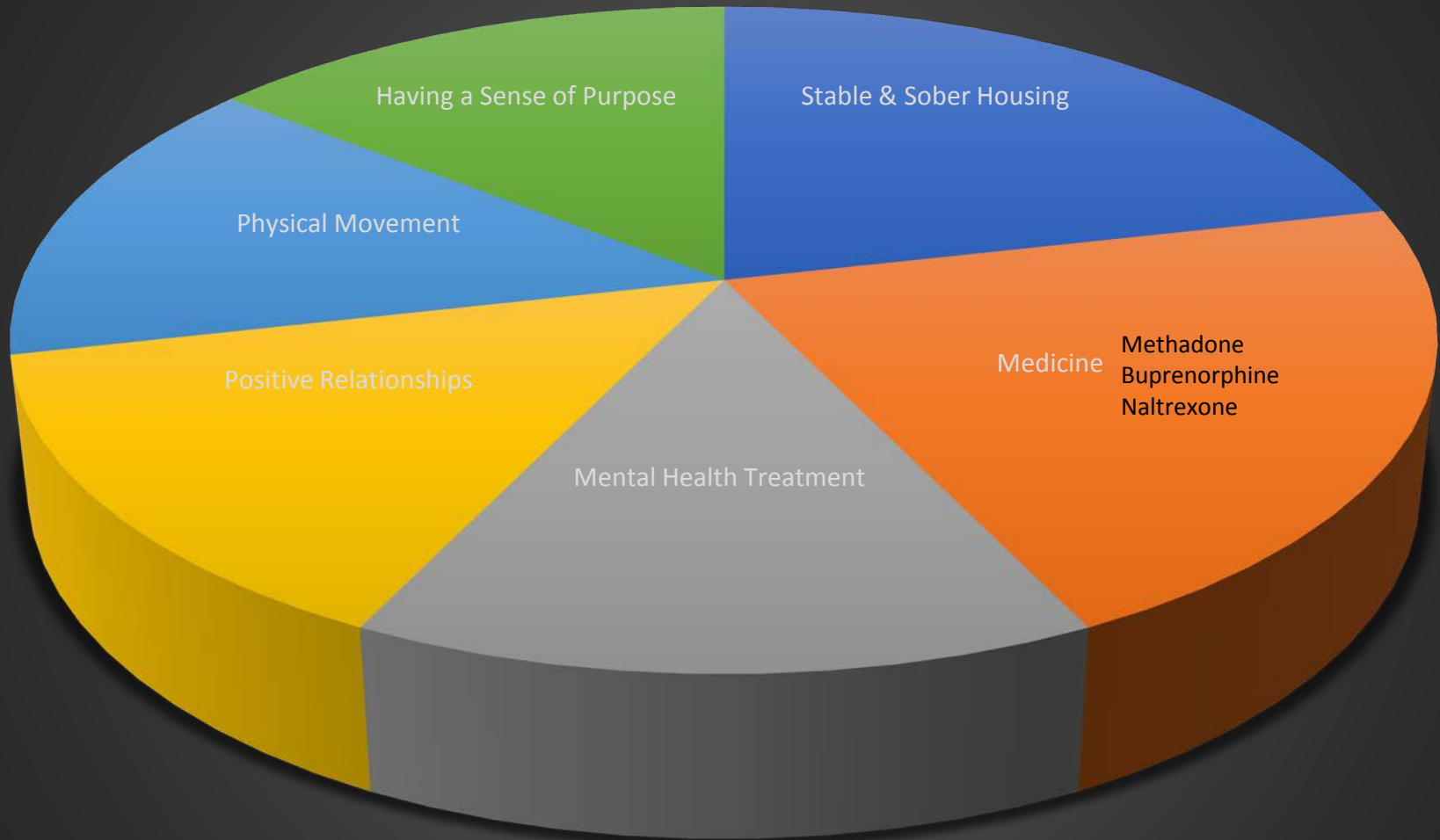
Contact Us



Get Naloxone Now is an online resource to train people to respond effectively to an opioid-associated overdose emergency. Get Naloxone Now advocates for widespread access to overdose education and training in how to administer naloxone, the life-saving antidote for opioid-associated overdose. Get Naloxone Now seeks to increase the number of lives saved by bystanders and professional first responders (police officers, firefighters and EMTs). Find out how you can contribute to reducing overdose deaths by accessing our online training modules.

Our computer-based training modules can help you give someone a second chance, and spare those who love them the pain of a preventable loss of life or brain injury. The online training is provided free of charge. If you wish to obtain CE or CASAC credits (pending accreditation) after completing the module, a nominal

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■ Stable & Sober Housing

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■ Physical Movement

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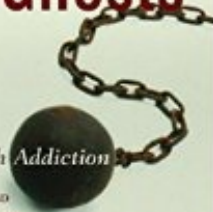
—NORM STAMPEL, former Seattle Chief of Police and author of *Breaking Banks: A Top Cop's Exposure of the Dark Side of American Policing*

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In the Realm of Hungry Ghosts

Close Encounters with Addiction

Foreword by PETER A. LEVINE, PhD
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BRAIN, MIND, AND BODY
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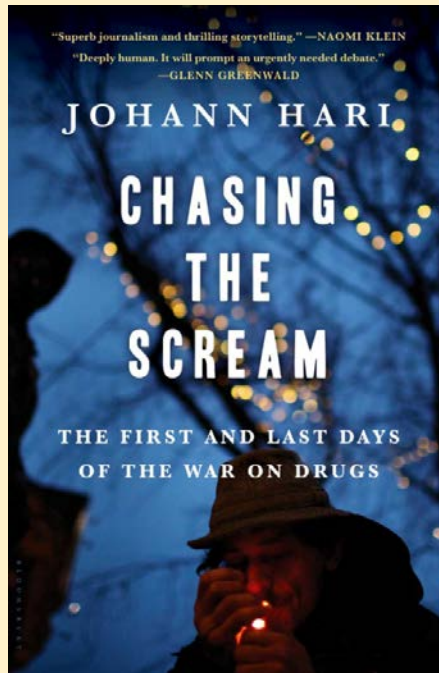


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CHASING THE SCREAM

THE FIRST AND LAST DAYS
OF THE WAR ON DRUGS



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The True Tale of America's Opiate Epidemic

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Dr. Potee joins the Home Podcast to talk about addiction and stigma

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Dr. Potee on the impact of the opioid crisis upon children

BOSTON GLOBE; MICHAEL LEVENSON



CNN's Anthony Bourdain discusses addiction with Dr. Potee

CNN; ANTHONY BOURDAIN



Dr. Potee speaks with The Boston Globe about the lack of medication assisted treatment

BOSTON GLOBE; KAREN D. BROWN



Dr. Potee on opioid addiction among high school

