

ES.S10: Drugs and the Brain – Syllabus

Spring 2013

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About the Class:

One-Sentence Description:

This class is a multidisciplinary introduction to pharmacology, neurotransmitters, drug mechanisms, and brain diseases from addiction to schizophrenia.

One-Paragraph Description:

From Abilify to Zyrtec, the world is full of fascinating drugs. If you are poisoned by sarin nerve gas, you may be able to save your life by huffing some BZ nerve gas. This class will explain that chemical curiosity, along with a host of other interesting tidbits of pharmacology. The structure of the class interleaves basic concepts with specific examples and entertaining tangents, so it is not loaded with boring abstract theory. In the first class you will learn what a neurotransmitter is, and you will immediately apply that knowledge when we discuss the mechanism of caffeine. The class is highly multidisciplinary, including topics such as patent law, medical ethics, history, and the physics of crack pipes. This seminar is open to all MIT students.

Class Schedule:

This class meets once a week on Monday evenings from 7 to 9 PM. There are 12 weekly sessions in total.

Credits and Grading:

This class gives 6 units of General Elective credit. Note that the average MIT class gives 12 units of credit. This class is graded Pass / Fail.

Schedule of Topics:

Week 1: **Introduction**

How the brain works: neurons, synapses, and neurotransmitters
Introducing some neurotransmitters: glutamate, GABA, serotonin, dopamine, and more
Excitatory vs. inhibitory
Receptor agonist vs. antagonist
A few example drugs

Week 2: **Drug Mechanisms, Explained with Antidepressants**

The steps of neural signaling: action potential, neurotransmitter release, receptor binding
How drugs work, using antidepressants as examples:
Increase neurotransmitter (NT) synthesis
Increase NT release
Inhibit NT reuptake
Inhibit NT breakdown
Mimic the NT (receptor agonist)
Partially mimic the NT (receptor partial agonist)
Interfere with negative feedback (presynaptic antagonist)

Week 3: **Pharmacokinetics**

ADME: Absorption, distribution, metabolism, and excretion
How dopamine signals facilitate reward-based learning and motivate behavior
Dopamine's central role in drug addiction
Drugs that are absorbed faster are more addictive
Routes of administration: IV injection, IM injection, smoking, and pills
Ways to mess with ADME

Week 4: **Drug Addiction, Dopamine, and Liking vs. Wanting**

The definition of addiction
These are **not** defining characteristics of addiction:
Withdrawal
Dependence
Tolerance
Liking vs. wanting:
These are separate neurochemical phenomena
Distinct neurotransmitters in each
Distinct brain structures in each
A cocaine addict *wants* cocaine very badly, but he does not even *like* cocaine anymore, he does not enjoy it.

Week 5: Action Potentials, Alcohol, and Shock Therapies

Action potentials
Local anesthetics
Alcohol, and the many diseases caused by alcohol
Shock therapies: inducing a seizure to (hopefully) promote health

Week 6: Alcohol Antagonists

Drugs that block or partially block the effects of alcohol

Week 7: Dose-Response Curves

Dose-response curves, log(dose)-response curves
Partial agonists
Inverse agonists
Competitive and noncompetitive antagonists
Explained by example with benzodiazepines

Week 8: Anxiety and Sedatives

The history of anxiolytics: bromides, barbiturates, benzodiazepines, SSRIs
Anti-punishment effects
More about GABA and GABA-A receptors

Week 9: Psychosis, Antipsychotics, and Parkinson's Disease

Psychosis symptoms:
Hallucinations
Delusions
Thought disorder
Blunted and/or inappropriate emotions
Cognitive impairment
Lack of motivation
Neurochemical basis of psychosis
Types of antipsychotic:
Dopamine antagonist
Serotonin antagonist
Benzodiazepines, nicotine, adrenergic antagonists
Neurochemical basis for Parkinson's
Antipsychotic side effects are similar to Parkinson's

Week 10: The Two Dichotomies

Dichotomy I: Sympathetic vs. Parasympathetic
Dichotomy II: Vasoconstrictor vs. Vasodilator
Viagra
Cocaine and heart attacks
Headaches and heart attacks in explosives factory workers

Week 11: Recreational Drugs

Stimulants: cocaine, methamphetamine, bath salts

MDMA

The underappreciated dangers of MDMA

Sedatives: barbiturates, benzodiazepines, alcohol, Quaaludes

Marijuana

Opioids: heroin, methadone, OxyContin

Psychedelics: LSD, psilocybin, mescaline

Dissociative anesthetics: PCP, ketamine, dextromethorphan

Deliriant: scopolamine, diphenhydramine

Week 12: Appetite and Nausea, Syringes

Neurotransmitters that cause nausea: serotonin, dopamine, opioids, and more

Drugs that cause nausea

Drugs that relieve nausea, especially ondansetron

Weight-loss drugs (anorectics)

Syringes

Vein damage caused by chronic injecting

Unsafe and disgusting syringe use

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