Student Booklet

The Ohio State University College of Pharmacy
Columbus, Ohio

Monday:
Drug Action and Drug Targets

Activities:

- Insidious Insides (group project)
- How do drugs work? (interactive lecture)
- Drug targets come alive! (group project)

Insidious Insides

Organ:

Your Challenge:

- Create a LARGE 3D model that features the physical characteristics of your organ in a healthy state.
- Present your model to the class and include answers to the questions below.

Questions:

1. What are 1-3 primary functions of your organ?

2. Identify a prevalent disease that modifies the function of your organ. Think about:
    a. What causes the disease?
    b. What does the disease look like grossly? (find pictures to share with class)
    c. Could the disease cause death? How?

3. Could chronic use of a drug (prescription, over-the-counter, or illicit) also impair the function of your organ? Think about:
    a. How does this drug affect the function of the organ?
    b. Could this drug cause death by altering organ function? How?

Notes:

Drug Action and Drug Targets

1

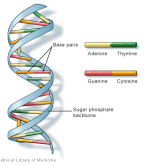
What is a drug?

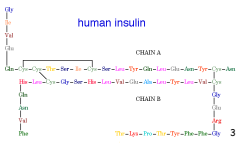
Any chemical agent (other than food) that affects living organisms

2

Types of Drugs

papaver somniferum





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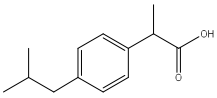
What do we call a drug?

- Chemical name
  - Denotes chemical structure of drug
- Generic name
  - Shortened name used during development
- Trade name
  - "Commercial name" used during marketing

4

What do we call a drug?

- Chemical name
  - 2-(4-isobutylphenyl)-propionic acid
- Generic name
  - Ibuprofen
- Trade name
  - Advil



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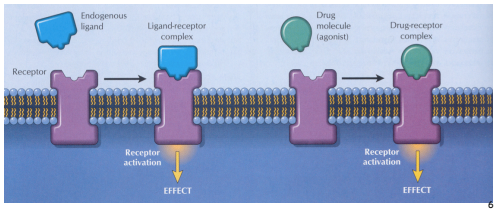
How does a drug work?

- Drugs do not create *new* functions…they *modify* existing functions



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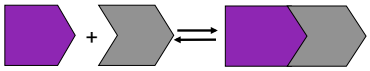
How does a drug work?

1. The drug molecule and its target must interact.



Drug Target Bound Drug-Target

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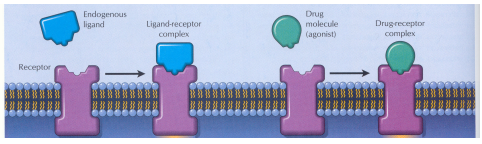
Types of drug targets

- Receptors
  - Protein targets
  - Bind substances in the body or drugs with selectivity



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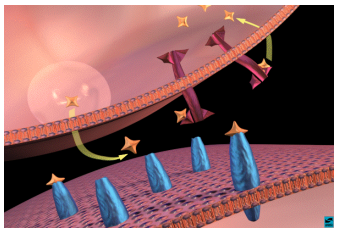
Types of drug targets

- Transporters
  - Proteins that transport molecules across cell membranes



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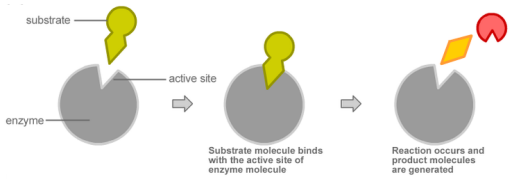
Types of drug targets

- Enzymes
  - Proteins that catalyze biological reactions



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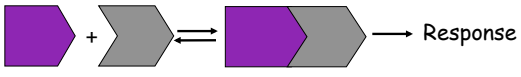
Types of drug targets

- Nucleic acids

11

How does a drug work?

1. The drug molecule and its target must interact.
2. The selective interaction must result in a response.



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Types of drugs based on response

- Agonists
  - Binding of drug activates the target
    - Production of a response
- Antagonists
  - Binding of drug inactivates the target
    - Reduction or loss of response

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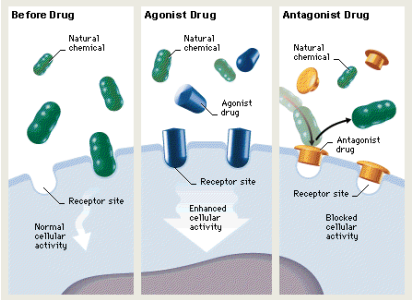
Drug agonists and antagonists



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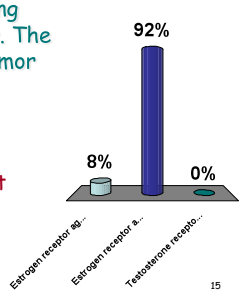
You be the judge: Agonist or antagonist?

A female patient is undergoing treatment for breast cancer. The uninhibited growth of her tumor results from the overactive signaling of estrogen and its receptor. Treatment?

1. Estrogen receptor agonist
2. Estrogen receptor antagonist
3. Testosterone receptor antagonist



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Further classification of antagonists

- Competitive
  - Drug competes for the same binding site on the target as the normal ligand
- Non-competitive
  - Drug binds to a target in a site unique from the normal ligand

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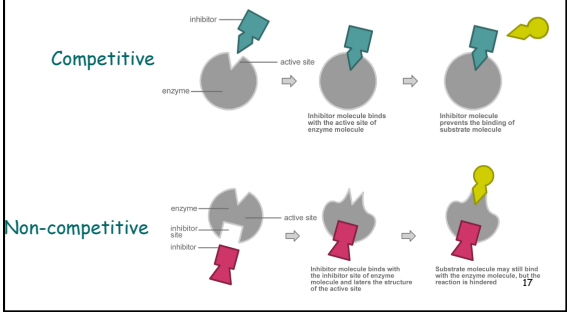
Types of antagonists



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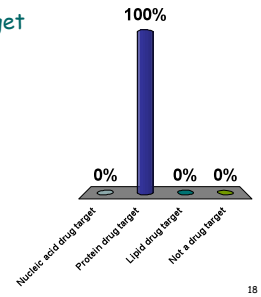
An enzyme is a…

1. Nucleic acid drug target
2. Protein drug target
3. Lipid drug target
4. Not a drug target



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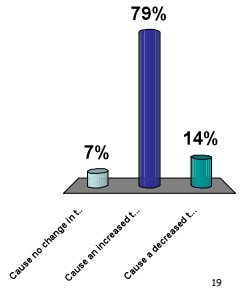
An agonist drug would…

1. Cause no change in the target's response
2. Cause an increased target response
3. Cause a decreased target response



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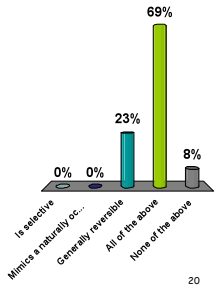
The interaction between a drug and its target…

1. Is selective
2. Mimics a naturally occurring ligand interaction
3. Generally reversible
4. All of the above
5. None of the above



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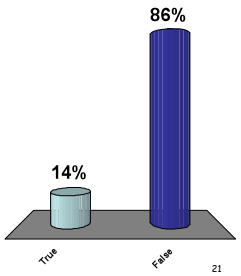
Drugs can only be synthetic chemicals.

1. True
2. False



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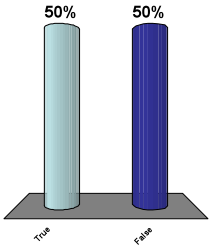
True or False:
Illicit drugs and prescription drugs can bind the same drug target.

1. True
2. False



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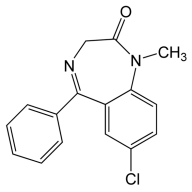
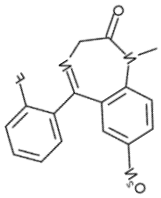
The same target…

Diazepam (Valium)



"Roofies"



GABA receptor

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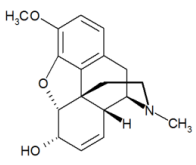
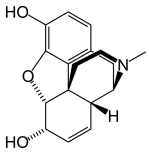
The same target…

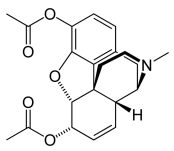
Codeine



Morphine



Heroin



Opiate receptor

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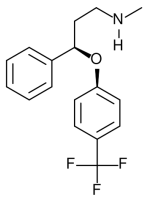
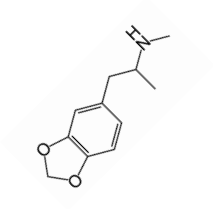
The same target…

Fluoxetine (Prozac)



"Ecstasy"



Serotonin transporter

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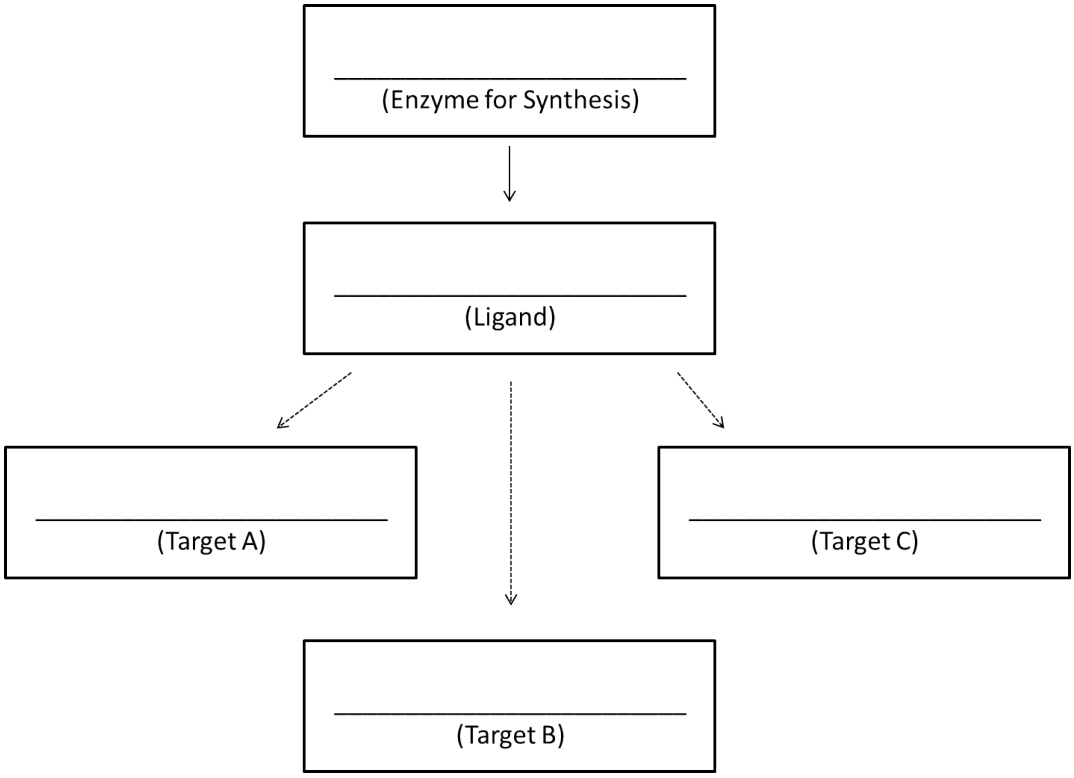
Drug Targets Come Alive!



Part 1: Ligand-Target interactions

1. Each student should review the information on their card. As a group, use this information and your computers to complete the diagram above for your specific system.

2. Use your class notes and computers to research the following:
    a. If you have a ligand…how are you synthesized? How do you interact with Targets A-C?
    b. If you have an enzyme or target…what is your functional role? How do you interact with the identified ligand?

Notes:

Part 2: Drug-Target interactions

1. As a group, use your Play-Doh to build a 3D model of each target in your system (Targets A-C), as well as the ligand. Using your notes from Part 1 and your Play-Doh models, create an animation that demonstrates how the ligand interacts with each target.

2. As a group, research a drug that modifies the function of one of your targets. Classify the drug—is it an agonist, antagonist, inhibitor, or reuptake blocker? Using Play-Doh, create an animation that demonstrates how this drug works.

3. Be prepared to share both animated demonstrations with the class.

Notes:

Tuesday:
Getting Drugs In, Around, and Out of the Body

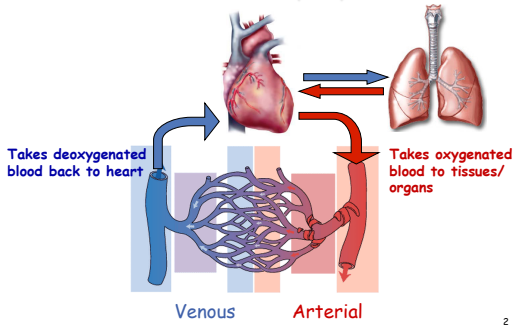
Activities:

- Getting drugs in, around, and out (interactive lecture)
- Red Rover, Red Rover, can this drug cross over? (game)
- Acids, Bases, and Cocaine Addicts (game)
- "I'm on Steroids" (movie and discussion)

Getting drugs in, around, & out of the body

1

The Circulatory System



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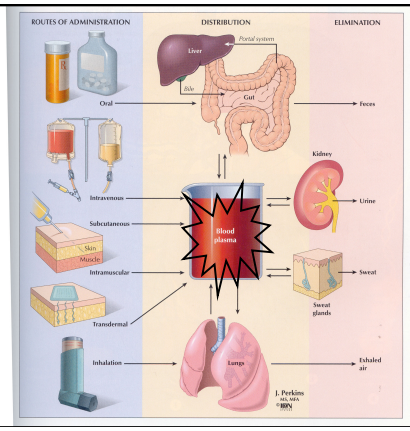

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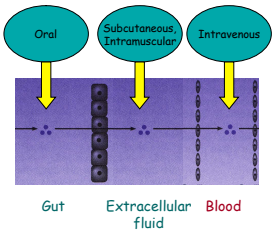
Drugs pass through barriers to get in and out of the bloodstream



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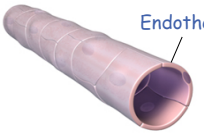
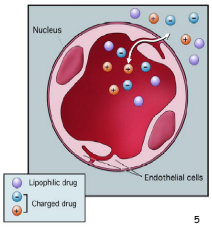
Drugs generally must get past the endothelial cells of capillaries to get in and out of the bloodstream





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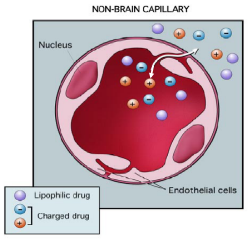
Getting a drug past a membrane barrier

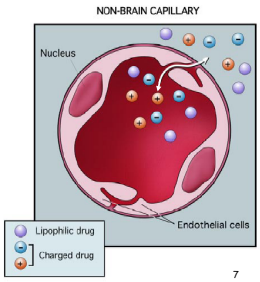


Go around it

6

Filtration

- Movement of drug through spaces between cells



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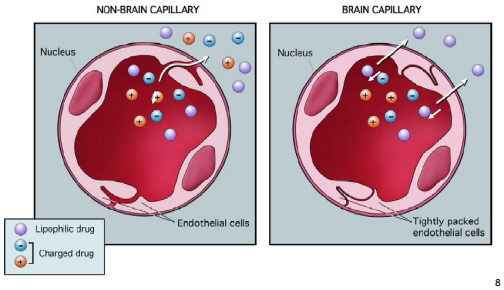
But…
the special case of the brain



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The special case of the brain

Blood Brain Barrier

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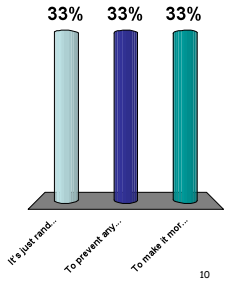
Why might the brain have a special barrier?

1. It's just random evolution.
2. To prevent any toxins from entering the body's most precious organ
3. To make it more difficult for drug companies



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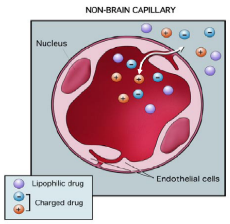
Getting a drug past a membrane barrier



Go around it

Go through it

11

Passive diffusion

- Drug moves through cell membrane
  - No energy required

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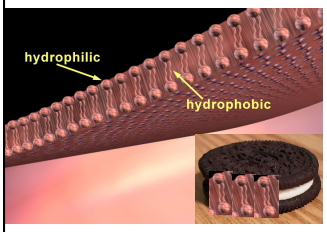
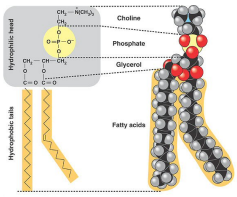
The cell membrane: A lipid bilayer





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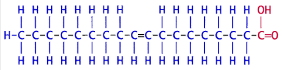
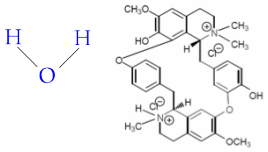
Nonpolar, polar Hydrophobic, hydrophilic…what?!?



Nonpolar = Hydrophobic
Charge: neutral
Atoms: Carbons, Hydrogens



Polar = Hydrophilic
Charge: positive or negative
Atoms: Oxygens, Nitrogens

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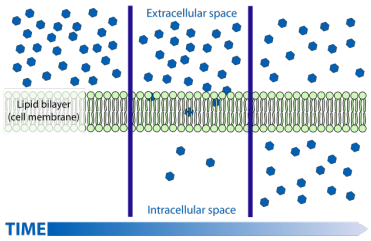
Nonpolar, uncharged drugs easily diffuse across cell membranes



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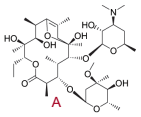
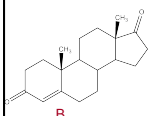
Which of the following would most likely passively diffuse across membranes?

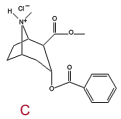
1. A
2. B
3. C



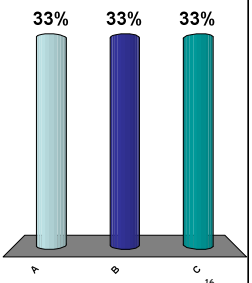
A



B



C



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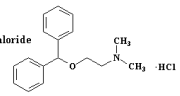
Think about it: Why do this matter?

Benadryl

Diphenhydramine Hydrochloride

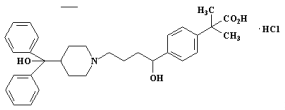
$C_{17}H_{21}NO \cdot HCl$



Allegra

Fexofenadine Hydrochloride

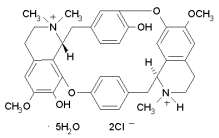
$C_{32}H_{39}NO_4 \cdot HCl$



17

Think about it: The problem of curare

Strychnos toxifera M. R. Schomb. ex Benth.
Image processed by Thomas Schoepke
www.plant-pictures.de



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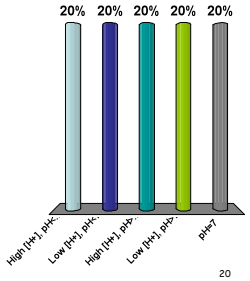
Let's talk more about drug charge…

19

You have an acidic solution. Which of the following is true about that solution?

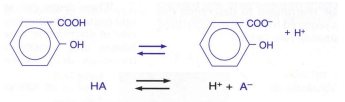
1. High [H+], pH<7
2. Low [H+], pH<7
3. High [H+], pH>7
4. Low [H+], pH>7
5. pH=7



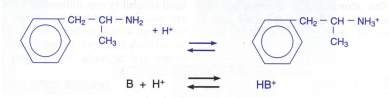
20

Most drugs are weak acids and bases

Salicylic acid



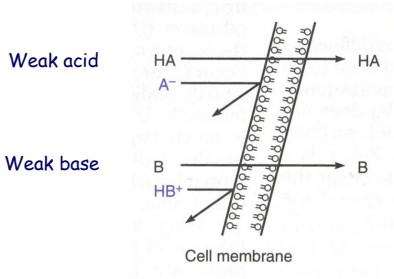
Amphetamine



Most drugs can be charged or uncharged (ionized or un-ionized)

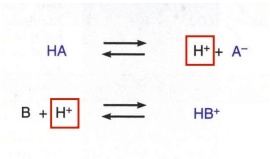
21

Charged drugs DO NOT diffuse passively



22

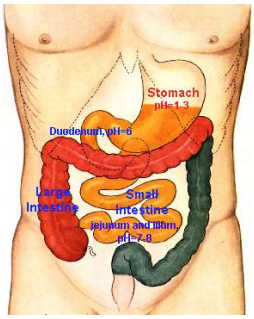
Most drugs are weak acids and bases



pH dictates drug charge…
and therefore movement across cell membranes!

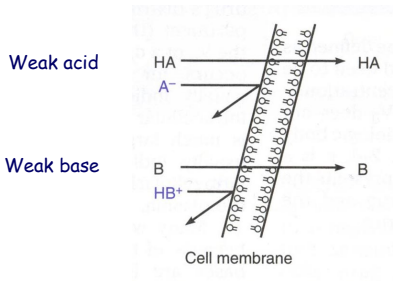
23

pH differences in the body



24

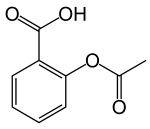
Charged drugs DO NOT diffuse passively

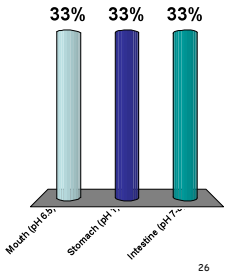


25

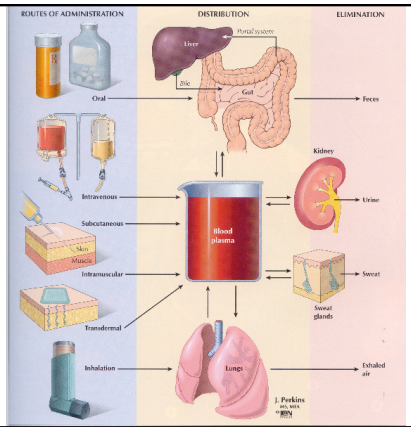
Where is aspirin best absorbed in the body?

1. Mouth (pH 6.5)
2. Stomach (pH 1)
3. Intestine (pH 7-8)





26



27

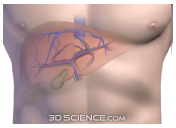
Getting drugs out of the body: Drug elimination

- Mainly requires the actions of the liver and kidney
- Liver
  - Changes drugs to become more hydrophilic
- Kidney
  - Excretes hydrophilic drugs (or metabolites) in urine

28

Drug metabolism in the liver

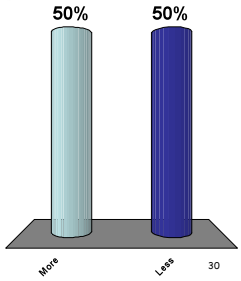
- Drug is altered by enzymes to a more polar form



29

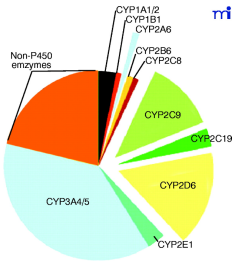
If a drug is metabolized to a more polar molecule in the liver, will MORE or LESS of the drug then be absorbed back into the body?

1. More
2. Less



30

Cytochrome P450 enzymes: Important for drug metabolism

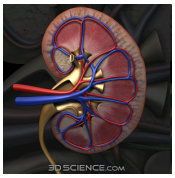


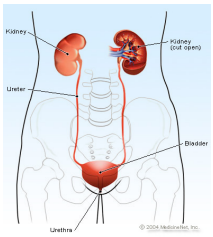
- Something to think about…
  - All CYPs are not created the same!

31

Excretion in the kidney

- Important organ: kidneys
- Hydrophilic drug metabolite is concentrated in urine





32

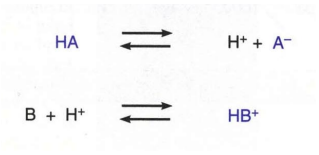
Other ways to get out

- Lungs
  - Major organ of excretion for gaseous drugs
- Sweat, snot, tears, and spit
  - mainly for water-soluble drugs

33

Think about it:
If a nursing mother uses cocaine, will she pass that cocaine onto her baby?

- Info that you need:
  - pH of breast milk: ~6.6
  - pH of blood: 7.4



Hint: Cocaine is a weak base!

34

Breast milk:
A "minor" excretion route?

Cocaine In Breast Milk Caused Death, Prosecutors Say

May 19, 2006

WEST BRANCH, Mich. -- A Michigan woman is charged with involuntary manslaughter after prosecutors say her 5-month-old daughter died from drinking breast milk containing cocaine.

Sara Shelby was arraigned Thursday. If convicted, she faces up to 15 years in prison.

Prosecutors claim Shelby used cocaine and the drug was passed on to the baby through her breast milk.

35

Red Rover, Red Rover, can this drug cross over?

Your Challenge:

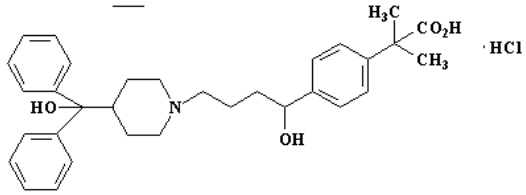
- In your team, determine if the drug in question can cross the identified biological membrane in each problem listed below.
- Perform your answer by playing 'Red Rover' with a twist!

Rules for Red Rover:

- For each problem:
  - Decide who will play the drug molecule (i.e. who is the runner?). All remaining team members will link arms to play the biological membrane.
  - As a team, decide if your drug molecule should attempt to cross through the opponent's biological membrane. Similarly, decide if the remaining team members playing the biological membrane will allow the opponent's drug molecule to cross through your "membrane".
- Both teams will animate their answers to each problem simultaneously.

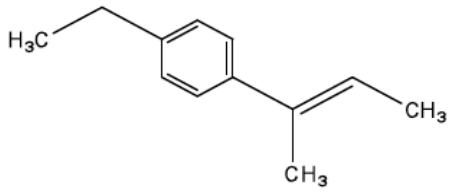
Problems:

1. Scientists designed the drug below to treat seasonal allergies. Did they design a drug that produces drowsiness as a side effect? (Hint: Which target organ does it need to reach to cause drowsiness? Can this drug cross that membrane?)

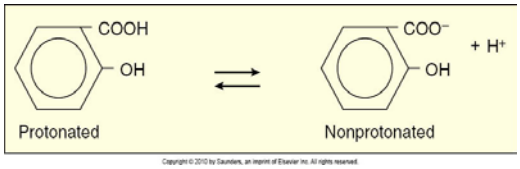


Pills, Potions, and Poisons
Red Rover

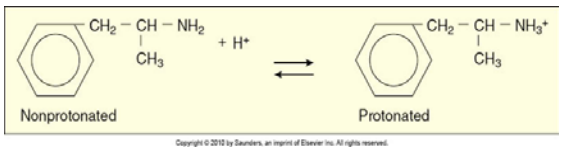
2. You need to design an antagonist drug to treat nicotine addiction, but you have to deliver the drug through a dermal skin patch. You design the drug below. Will it readily cross the biological membrane and enter the bloodstream?



3. Aspirin is a weak acid. Upon swallowing aspirin, it enters our stomachs, which is at a pH = 3. Is aspirin readily absorbed from the stomach?



4. A woman is charged with involuntary manslaughter after prosecutors say her 5-month-old daughter died from drinking breast milk that contained methamphetamine. Methamphetamine is a weak base, and the pH of breast milk is 6.6. Given this information, is this a true or false assertion? (Hint: Once in the milk, is the meth trapped?)



5. A patient enters the hospital and you believe they have overdosed on a drug that is a weak acid. You decide to enhance elimination of the drug by making the patient's urine more basic. Did you make the right decision? (Hint: Once in the basic urine, is the drug trapped?)

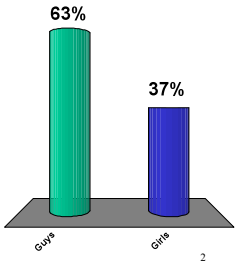
Acids, Bases, and Cocaine Addicts

Pills, Potions, and Poisons

1

Please select a Team.

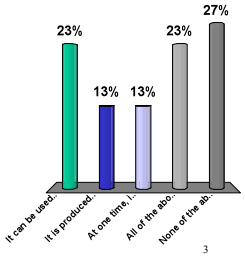
1. Guys
2. Girls



2

Which of the following statements about cocaine is true?

1. It can be used therapeutically.
2. It is produced in plants as a defense mechanism.
3. At one time, it was an important component of soda.
4. All of the above
5. None of the above



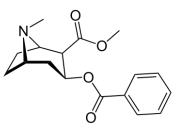
3

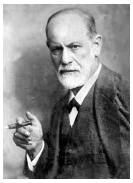
Team Scores

26.09 Guys
16.67 Girls

4

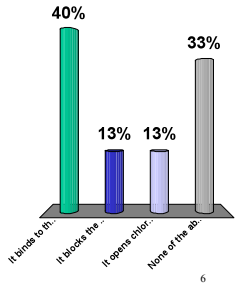
Cocaine





Look it up: How does cocaine work?

1. It binds to the opiate receptor.
2. It blocks the dopamine transporter.
3. It opens chloride channels.
4. None of the above



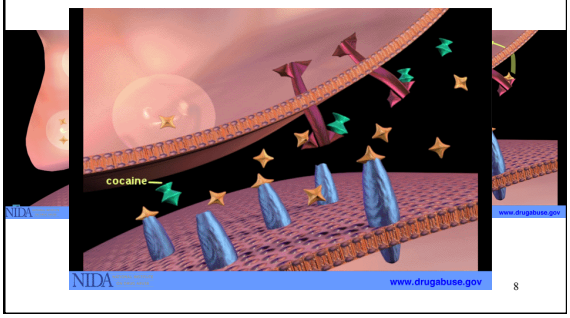
6

Team Scores

39.13 Guys
27.78 Girls

7

How cocaine works

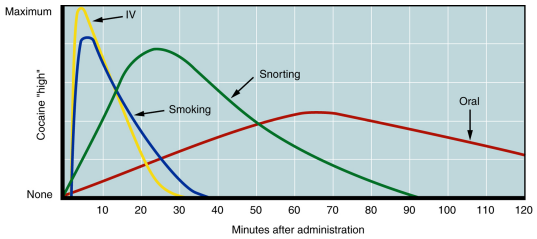


8

The problem of cocaine abuse

9

Take a look at this data…

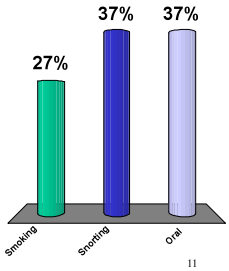


How can the same drug cause different highs?

10

Which method of cocaine administration elicits the quickest high?

1. Smoking
2. Snorting
3. Oral



11

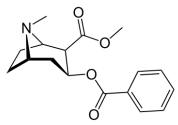
Team Scores

39.13 Guys
27.78 Girls

12

Is cocaine a weak acid or weak base?

1. Weak acid
2. Weak base
3. Neither



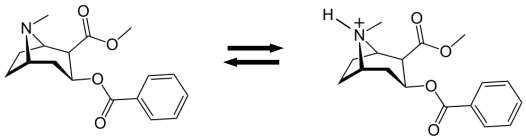
13

Team Scores

0 Team 1
0 Team 2

14

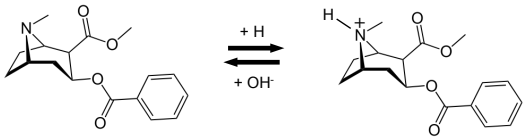
Cocaine is a weak base



$B + H^+ \rightleftharpoons HB^+$

15

Changing how the drug gets in by changing the pH

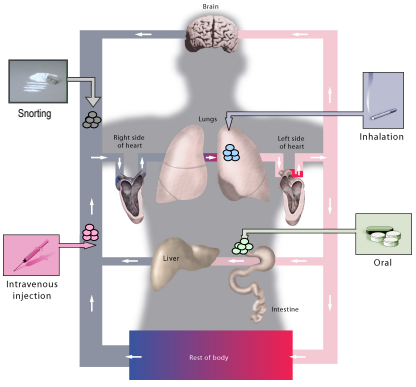


"Free basing"

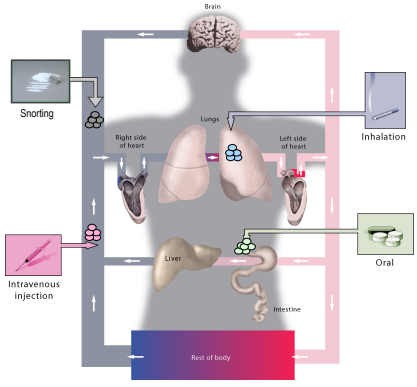
"Crack"
Can be vaporized
(and smoked)

Acid salt
Water-soluble
Can be snorted

16

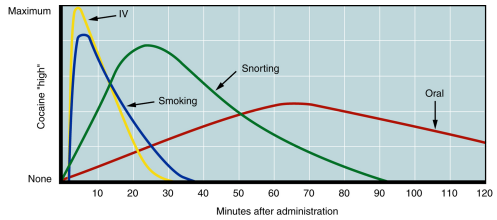


17



18

Method of administration affects the rate that cocaine reaches the brain…

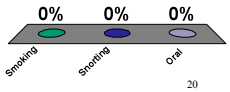


And the likelihood that the user will become addicted!

19

Which method of cocaine administration elicits the greatest addiction potential?

1. Smoking
2. Snorting
3. Oral



20

Team Scores

0 Team 1

0 Team 2

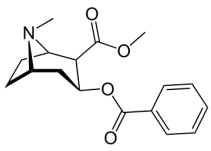
21

Drug abuse and addiction

- Slowest absorption route: oral
- Fastest absorption route: smoking
- Route of administration predicts addiction potential
  - Faster drug gets to brain, higher chance of becoming addicted

22

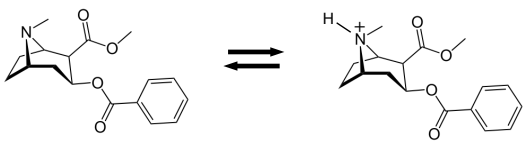
Can this guy absorb cocaine by "chewing" it?

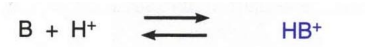


23

Cocaine is a weak base

pH of saliva: 6

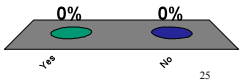




24

Can this guy absorb cocaine by "chewing" it alone?

1. Yes
2. No



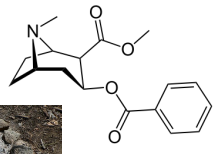
25

Team Scores

0 Team 1
0 Team 2

26

Can this guy absorb cocaine by "chewing" it?



27

Critical Evaluation
True Life: I'm on Steroids

1. What reason(s) does each character give for using steroids? In your opinion, do any of these reasons justify steroid abuse? Explain your thoughts.

    a. Peter

    b. Roger

    c. Brian

2. a. Roger mentions that he will need to stop using steroids for a designated period before a potential drug testing appointment. Does he understand the science of anabolic steroid elimination? Explain why or why not.

    b. Within the sport of martial arts, would you define Roger's steroid abuse as cheating? Why or why not?

3. How are the side effects of steroid use affecting the relationships of the characters?

4. Explain how the men are obtaining the steroids. Should access to these drugs be more tightly regulated? If so, how?

5. a. What negative side effect(s) of steroid use do you see? How are the men dealing with these symptoms?

   b. As told by his parents, how was Rob affected by steroid use?

6. Roger believes that steroids are not drugs. Do you agree or disagree?

7. Two of the men mention the word 'addiction'. Do you think that steroids are addictive? Why or why not?

Wednesday:
Dose Response and Drug Factors

Activities:

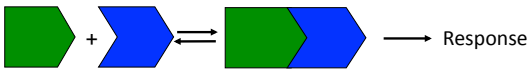
- Factors that modify Drug Response (interactive lecture)
- Frenzied Fleas (experiment)
- "Who Done It?"—Drug Factor Skits (skits)
- Biomedical research lab visits (career field trip)

Factors that modify Drug Response

1

How does a drug work?

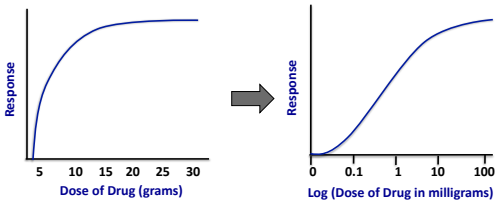
1. The drug molecule and its target interact.
2. The selective interaction must result in a **response**.



Drug Target Bound Drug-Target

2

Dose Response Curves

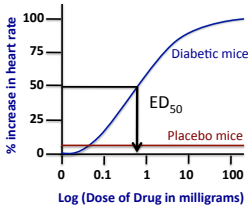


Linear Scale Log Scale

3

Detailed dose-response curve

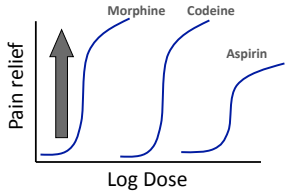
ED_{50}: the Effective Dose that produces 50% of the maximal response



4

Efficacy

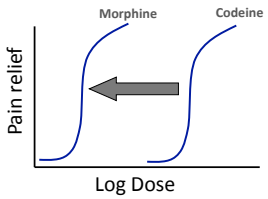
- Capacity to produce a desired effect or effectiveness



5

Potency

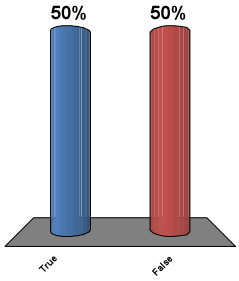
- Dose needed to produce a desired effect



6

True or False: The higher the potency, the higher the EC_{50}.

1. True
2. False



7

Summary

- Potency
  - The amount of drug needed to create the same response (as another drug)
  - Higher the potency → Lower the EC_{50}
- Efficacy
  - How much response a drug elicits (compared to another drug)

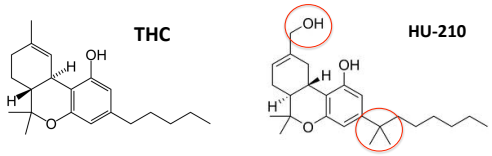
8

Let's apply: What is K2?

- Mixture of herbs and spices
  - Contain **synthetic** compounds chemically similar to THC
- Marketed as incense that can be smoked
  - Spice, "Fake Weed"

9

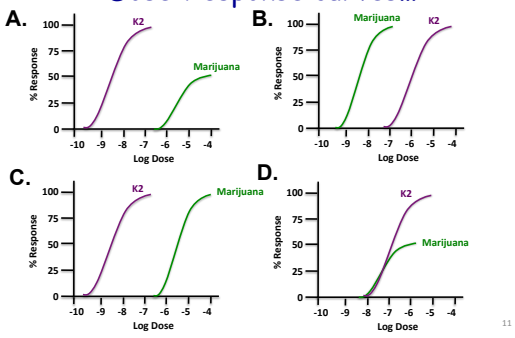
Is K2 the same as Marijuana?



- Do you think they bind the same biological target?
- Key difference: K2 is far more potent than Marijuana

10

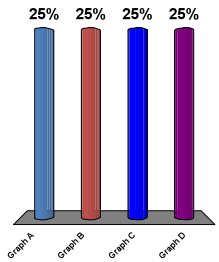
Take a look at these Dose-Response curves…



11

Which graph demonstrates that K2 is more potent than Marijuana, but they both have the same efficacy?

1. Graph A
2. Graph B
3. Graph C
4. Graph D



12

Factors that modify a drug's response

1. Age
2. Disease
3. Genetics
4. Drug-drug interactions
5. Body's handling of the drug

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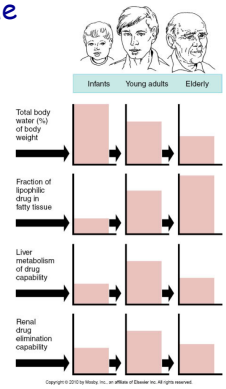
1. Age: infants & the elderly



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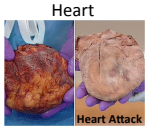
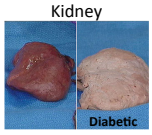
2. Disease

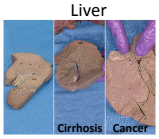
Heart



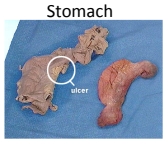
Kidney



Liver



Stomach



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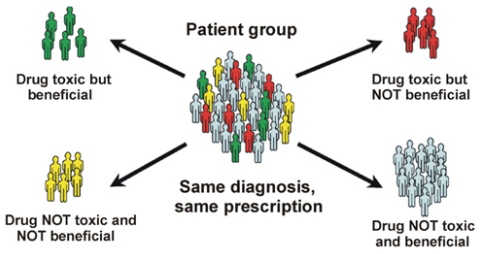
3. Genetics



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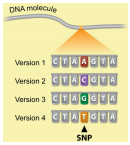
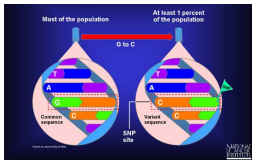
Genetic Variation: SNPs and Mutations



- SNP: one nucleotide is exchanged for another at a given position
- Occurs in at least 1% of population

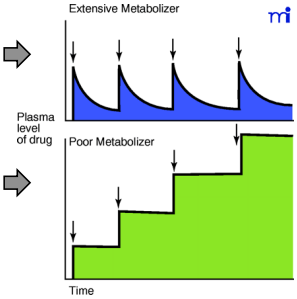


17

CYP450 enzymes subject to SNPs

Enzymes work quickly… drug levels decline

Enzymes work slowly… drug levels accumulate



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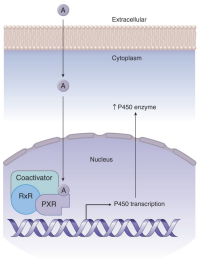
4. Drug-Drug Interactions: enzyme induction

Enzyme Induction

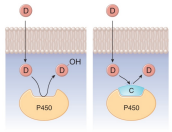


1. Drug B metabolized by a CYP450
2. Drug A induces expression of CYP450 (more enzyme)
3. Metabolism of Drug B increases
4. Reduces levels of Drug B

19

4. Drug-Drug Interactions: enzyme induction

Enzyme Inhibition



1. Drug D metabolized by a CYP450
2. Drug C inhibits CYP450 (less enzyme)
3. Metabolism of Drug D decreases
4. Increases levels of Drug D

20

Factors that modify a drug's response

1. Age
2. Disease
3. Genetics
4. Drug-drug interactions
5. Body's handling of the drug

21

Pills, Potions, and Poisons
Frenzied Fleas

Frenzied Fleas Lab

Main Questions:

1. How do drugs modify heart rate?
2. What is the relationship between the dose of a drug and the response it elicits?

Pre-Lab and Hypotheses:

1. Drug you are making:

	Drug:	
	Low Dose	High Dose
Amount of drug		
Volume of water		
Concentration (mM, % soln, etc.)		

2. Drugs from other teams:

	Concentration	
Drug	Low Dose	High Dose

3. For each drug, hypothesize whether each drug will increase or decrease heart rate. Will increasing the dose produce a greater effect? Explain your hypothesis:
    a. Alcohol:

    b. Nicotine:

    c. Sleeping pills:

    d. Caffeine:

Pills, Potions, and Poisons
Frenzied Fleas

Experimental Design and Data Collection:

- How will you design the experiment to test your hypotheses?

Drug (conc.)	Baseline HR (bpm)	HR after drug (bpm)	% Change

Pills, Potions, and Poisons
Frenzied Fleas

Think about it:

1. How do drugs modify heart rate? Did your results support your initial hypotheses? What reasons could explain your answer?

2. Did increasing the dose of each drug produce a greater effect? Do you think continuing to increase the dose of any drug will always produce a greater effect?

3. Graph and display the relationship between dose and response:

Who Done It?: Drug Factor Skits (Instructor)

Scenarios:

1. Lisa and her friend Sam decide to abuse OxyContin at a party one weekend. Lisa swallows the OxyContin tablet whole. However, Sam (who doesn't like to swallow pills) decides to crush it up, and then swallow the crushed tablet. After they both take the drug, Sam's breathing begins to slow and he tragically dies. Why didn't Lisa die too?

2. It's allergy season, and a man wakes up one morning to a horrible stuffy nose and itchy eyes. He starts taking an antihistamine to help with these symptoms, and then eats his normal breakfast of eggs, bacon, toast, and grapefruit juice. He continues with this routine each morning but then dies unexpectantly 4 days later. What happened?

3. Joe, an Asian college student, dresses in his finest new clothes and goes to a frat party one night. He consumes a hot dog, chips, and several beers. Ten minutes later, his face turns bright red and he is violently ill. What happened?

4. Your friend John picks apples at an orchard that regularly sprays pesticides. Having recently moved to the US, John became quite overweight from constantly eating fast food. He decided to go on an aggressive diet and lost about 15lbs in just 1 month. He is now complaining of muscle problems (weakness and twitching), headaches, and some visual disturbances. He is also sweating and salivating excessively. He even became dizzy one day and fainted. What happened?

5. Your friend Jane is taking birth control to avoid getting pregnant. One day, she was slicing fruit and cut her finger, requiring stitches at the ER. About 1 month later, she finds out she is pregnant. What happened?

6. Your grandfather signs up for a clinical trial testing the efficacy of fetal cells implanted into the brain for the treatment of Parkinson's Disease. He undergoes the cranial surgery, recovers well, and is satisfied with the results. A few months later, the lead investigator tells him that he can now have the actual procedure done. What's going on?

7. Jim binge drinks regularly and usually "treats" his hangover with an over-the-counter pain medicine and a strawberry milkshake. Eventually, his skin begins to appear yellow and he feels quite ill. What happened?

8. Without consulting her doctor, an HIV-positive woman decides to take St. John's Wort to treat her mild depression. A month later, the virus levels are highly elevated, and her immune system has started to fail. What happened?

Who Done It?: Drug Factor Skits

Notes from my scenario:

Which drug factor(s) played a role in your scenario? Explain:

Thursday:
Drug Abuse and Addiction

Activities:

- Drug Abuse and Addiction (interactive lecture)
- Drunk Drosophila (experiment)
- Pharmacology Debate (debate)
- Pharmacy Practice Lab (career field trip)

Drug Abuse and Addiction

1

Which Drugs/Behaviors are Addicting?

	Yes	No
Cocaine		
Heroin		
Caffeine		
Aspirin		
Chocolate		
Alcohol		
Video games		
Aspartame		
Nicotine		
Gambling		
Running		
Sex		
THC		

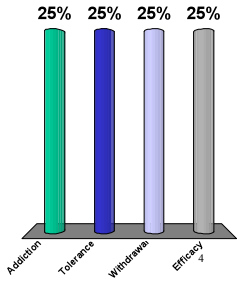
Drug Abuse

Excessive and persistent use of any drug without regard for accepted medical practice.

3

Joe finds that he needs to drink more and more alcohol to get drunk. He is experiencing what?

1. Addiction
2. Tolerance
3. Withdrawal
4. Efficacy



4

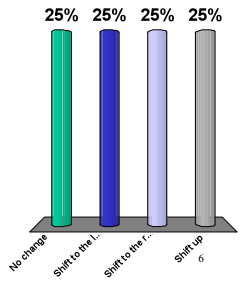
Drug Tolerance

It takes more drug to achieve the same effect

5

How would a drug's dose-response curve change with tolerance?

1. No change
2. Shift to the left
3. Shift to the right
4. Shift up



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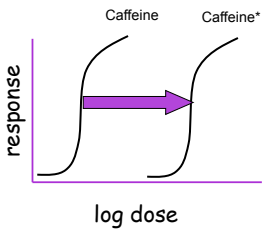
Drug Tolerance

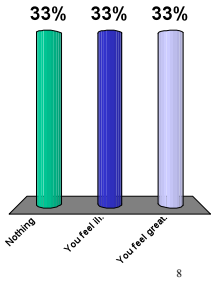
It takes more drug to achieve the same effect



7

You drink a Red Bull 3 times a day. One morning, you realize that you're out. What happens?

1. Nothing
2. You feel ill.
3. You feel great.



8

Drug Dependence

The body functions normally only in the presence of the drug

Removal of the drug leads to 'withdrawal'

9

Drug Addiction

The uncontrolled use of a drug, even if negative consequences occur

10

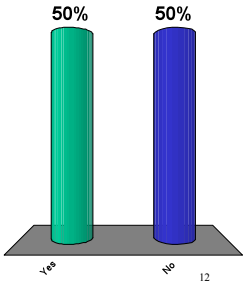
Classic Features of Addiction

- craving
- loss of control

11

Do drug addicts gain pleasure from their drug-taking?

1. Yes
2. No



12

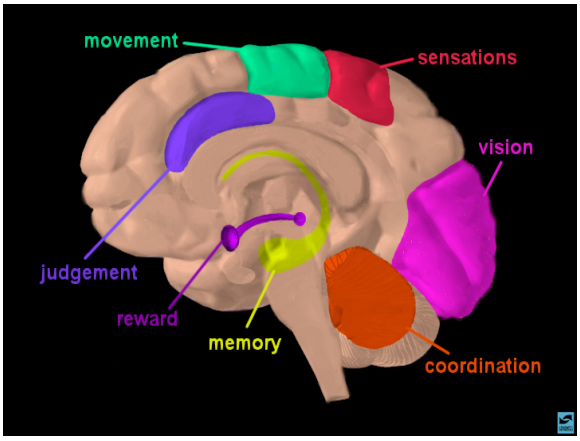
Which Drugs/Behaviors are Addicting?

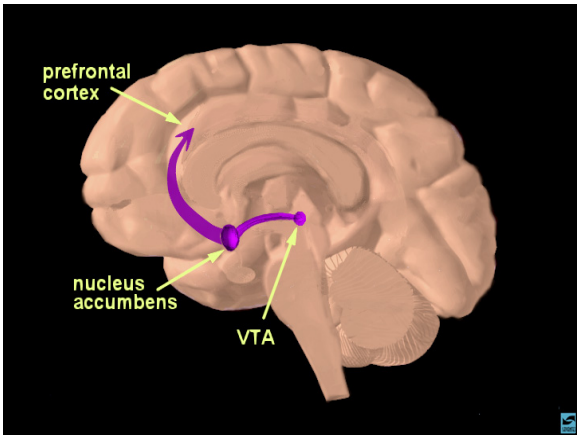
	Yes	No
Cocaine		
Heroin		
Caffeine		
Aspirin		
Chocolate		
Alcohol		
Video games		
Aspartame		
Nicotine		
Gambling		
Running		
Sex		
THC		

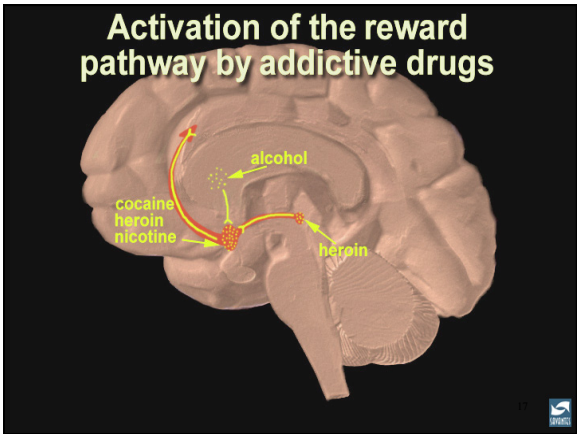
Why are only some drugs abused?

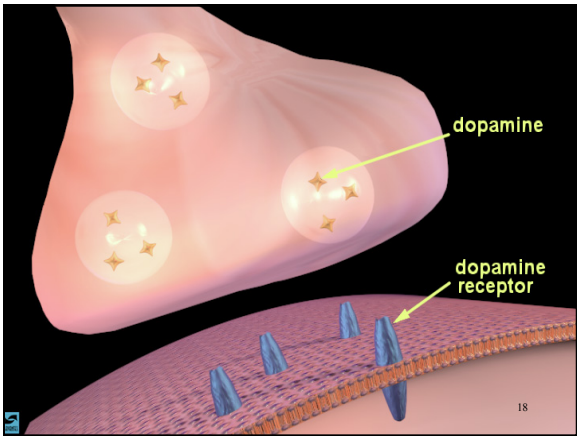
In other words,
why aren't there penicillin addicts?

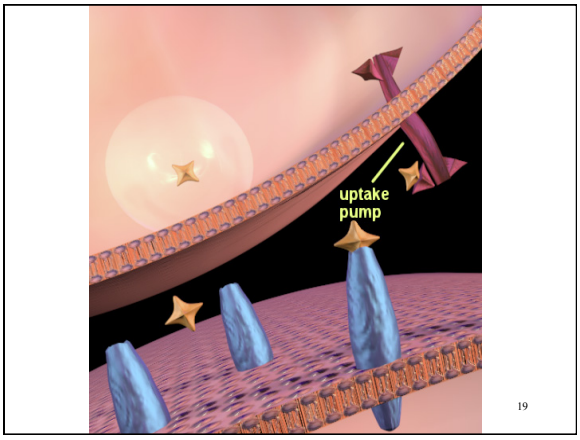
14

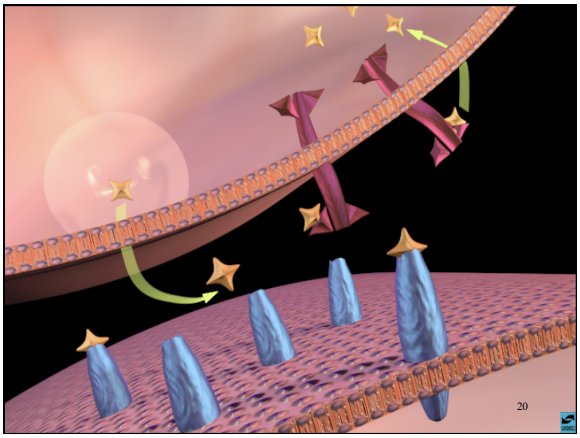



prefrontal cortex
nucleus accumbens
VTA


Activation of the reward pathway by addictive drugs
alcohol
cocaine
heroin
nicotine
heroin


dopamine
dopamine receptor
18


uptake
pump
19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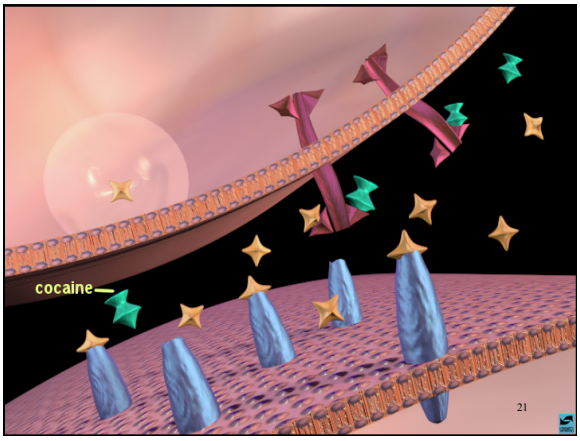

cocaine
21

So, we know why drug dependence is happening.

But HOW is it happening?

22

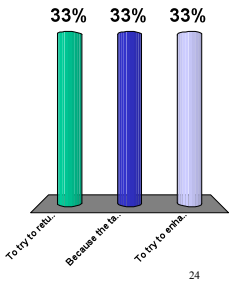
Mechanisms of drug dependence

Repeated exposure of addictive drugs to neurons causes drug targets to adapt

23

Why might drug targets adapt with repeated exposure?

1. To try to return things to normal
2. Because the targets are damaged
3. To try to enhance the drug's effects



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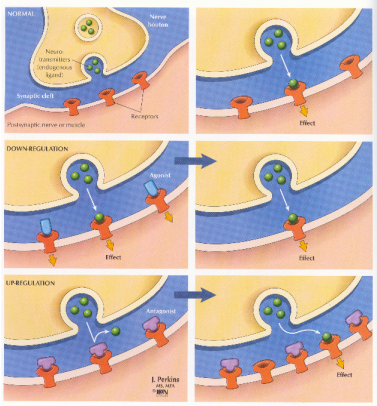
Types of target adaptations

Receptors	change their number change their sensitivity
Transporters	change their number
Neurotransmitters	reduced levels
Genes	make new proteins

25



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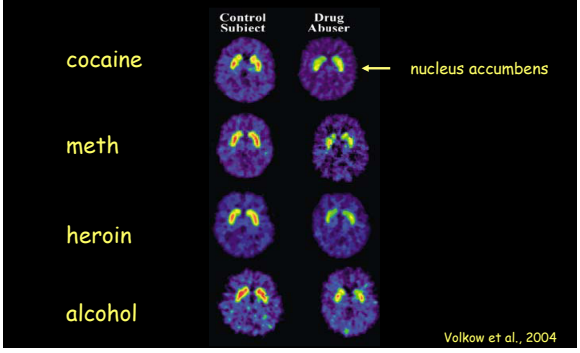
Dopamine receptors are decreased in addictive states in humans

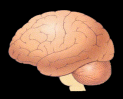
- Alcoholics
- Cocaine abusers
- Heroin abusers
- Methamphetamine abusers
- Obesity

27

Dopamine receptors are decreased in drug abusers



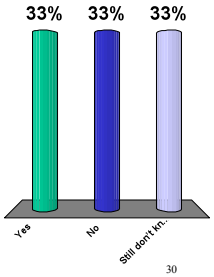
Adaptations occur in disease



Addiction	Congestive heart failure
• dopamine decreases	• norepinephrine increases
• DA receptors decrease	• ß-receptors decrease
• dendrites change structure	• myofibrils change structure
• synapses remodel	• muscle cells remodel
• brain circuits dysfunctional	• ventricles dysfunctional

What do you think: is addiction a disease?

1. Yes
2. No
3. Still don't know

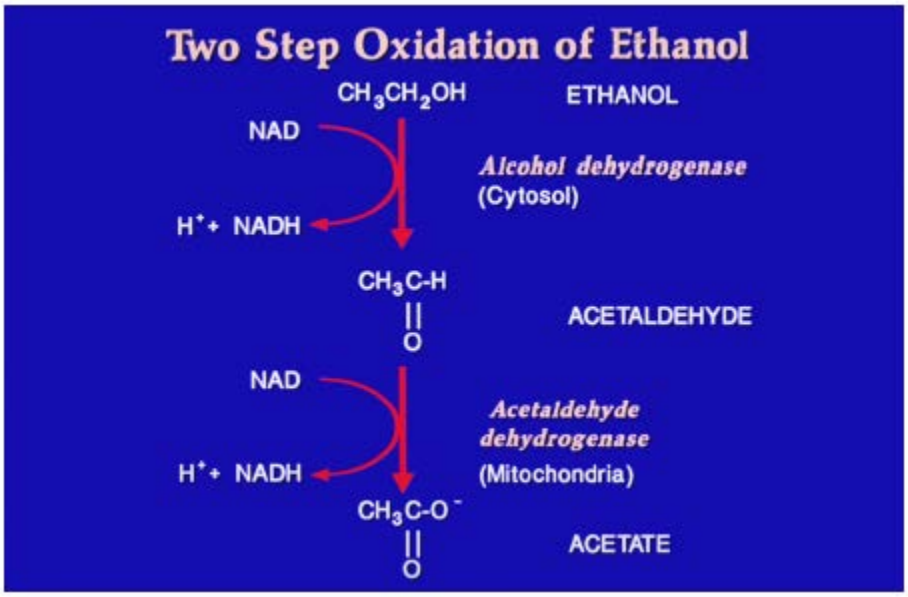


30

Drunk Drosophila

Background Information

How do humans metabolize alcohol? Through an enzymatic process involving two-step oxidation, of course! Review this diagram and then complete the table below.



In humans, if you inhibit:	What substrate will accumulate?	Biological Consequence:
Alcohol dehydrogenase		
Acetaldehyde dehydrogenase		

Pills, Potions, and Poisons
Drunk Drosophila

Main Question

1. How does DNA impact drug response? More specifically, how does the absence of the alcohol dehydrogenase gene in drosophila impact its response to alcohol?

Pre-Lab and Hypotheses:

You have two genotypes of drosophila fruit flies to work with: Wildtype (Wt, "normal" flies) & Alcohol Dehydrogenase knock-outs ($ADH^{-/-}$, flies that do not express the alcohol dehydrogenase gene). Record your expected response upon exposing each genotype to alcohol:

Genotype & Treatment	Expected Response	Explain your reasoning

Experimental Design and Data Collection:

- How will you design the experiment to test your hypotheses?
- Think About:
    - You'll expose the flies to alcohol using a cotton ball. How much alcohol should you add to the cotton ball?
    - What are the controls for your experiment?

Our experimental design:

Pills, Potions, and Poisons
Drunk Drosophila

Experimental Design and Data Collection:

Fill-in the table below using your experimental design, observations during the experiment, and experimental results.

Genotype	Treatment & Amount	Observations during vial preparation	Results and Conclusions

Pills, Potions, and Poisons
Drunk Drosophila

Think about it:

1. Did your results support your initial hypotheses? What reasons could explain your answer?

2. In this experiment, how did DNA impact drug response?

Pharmacology Debate

Topic:

Position:

Perspectives to debate:

- Medical
- Social
- Ethical

Friday:
Drug Discovery and Development

Activities:

- Antibiotic Discovery Lab (experiment)
- From Bench to Bedside (group project/game)
- Clinical Pharmacy visits (career field trip)

Antibiotic Discovery Lab

Main Question:

1. Can you discover a novel antibiotic from a natural product?

Pre-Lab and Hypotheses:

For each compound tested, predict whether or not it will kill the bacteria, "*Bacillus Subtillus*". Explain your prediction.

Compound	Prediction: Will it kill bacteria? Defend your answer.

Experimental Design:

- How will you design the experiment to test your hypotheses?
- Think about:
    - What are the controls for the experiment?
    - Is the volume of solvent important?
    - Is the polarity of the solvent important?

Our experimental design:

Pills, Potions, and Poisons
Antibiotic Discovery Lab

Data Collection:

Compound	Zone of Inhibition (units)	Result and Conclusion

Think about it:

1. Did your results support your initial hypotheses? What reasons could explain your answer?

2. Did the polarity of the solvent impact your results?

3. Did you discover a novel antibiotic?

Saturday:
Student Showcase

Activities:

- Bachelors of Science in Pharmaceutical Science Program Overview
- Student Showcase

What should I do to get into college and professional school?

An interview with past and present PPP TAs

To begin our interview, please tell us where you are currently and what professional path you plan to take:
Student 1: I am currently an undergraduate in the BSPS program at OSU and I plan on attending pharmacy school.
Student 2: I am also an undergraduate in the BSPS program, but I plan on attending medical school.
Student 3: I graduated from the BSPS program and am currently working on my PhD in pharmacology.

I'm a high school student now and am interested in attending college. When you were in high school, what did you do to stand out on your college applications?
Student 1,2 and 3: We all took honors and AP courses and were involved in many extracurricular activities. We would also recommend being well prepared for the ACT and/or SAT and to start applying for scholarships early.

What do you recommend I do in college to best prepare for professional school?
Student 1: I worked very hard to maintain a competitive GPA. I am interested in going to Pharmacy school, so I got a job as a technician at a local Kroger and volunteered at clinical pharmacies. It's difficult to get a tech position at a clinical pharmacy, but it's much easier to volunteer! I also recommend forming relationships with your professors. These come in handy when you need recommendation letters and if the professor knows you well they are much more likely to write a good letter.
Student 2: I recommend you find a research position for at least a year if you are interested in medical school. This looks very good on your application and will help you stand out. I also highly recommend you take the MCAT early and fill out your applications the day they become available.
Student 3: I entered the BSPS program as a freshman but was much more interested in research than pharmacy school. I decided to find a position in a lab and get research experience. I joined a lab in the College of Pharmacy my sophomore year and completed an honors thesis. I decided research was my passion so I decided to apply to graduate school. If you're interested in graduate school, I highly recommend you gain as much research experience as possible and maintain a competitive GPA.

Do you have any final advice for current high school students who wish to follow a similar path as you?
Student 1: I recommend you be proactive and get experience in the field you're interested in as early as possible. Shadow different professionals, volunteer, do whatever it takes to make sure this is what you really want to do.
Student 2: My advice would be to find your passion and keep in mind it might not be what you originally thought it was. Also, network and maintain contacts with everyone you meet... you never know who may be able to help you down the road!
Student 3: My biggest piece of advice is to not be afraid to try new things. College is a time to figure out what you want to do with your life, but also a time to explore new opportunities you may never get again!

Is a Career in Pharmacy For You?

If you've never thought about a career in pharmacy, think again. Today's pharmacists are more than just "pill-counters"; they're highly-trained and specialized professionals that are changing how we deliver healthcare. Take a look at how pharmacists fit into the healthcare team.

	Pharmacist	Doctor	Registered Nurse	Biomedical Research Scientist
Primary Role	Medication Expert	Diagnoser and Director	The Face of Patient Care	Drug and Disease Discoverer
Training Required	Bachelors (BA or BS) and Doctor of Pharmacy (PharmD) **OR** Doctor of Pharmacy (PharmD) alone	Bachelors (BA or BS) **AND** Doctor of Medicine (MD) or Doctor of Osteopathic Medicine (DO) **AND** Medical Residency	Diploma in Nursing (DN) **OR** Associate of Science in Nursing (ASN) **OR** Bachelors of Science in Nursing (BSN)	Bachelors (BA or BS) **AND** Doctor of Philosophy (PhD)
Time To Career	BA or BS: 4 Years PharmD: 4 Years **OR** PharmD: 6 Years	BA or BS: 4 Years MD or DO: 4 Years Res: 3-5 Years	DN: 2-3 Years ASN: 2 Years BSN: 4 Years	BA or BS: 4 Years PhD: 4-6 Years
Typical Duties	- Check prescriptions - Fill prescriptions - Advise patients on medication use	- Diagnose patients - Determine treatment plans - Coordinate care	- Educate patients - Assess patient progress - Administer medications	- Research diseases - Discover new drugs - Share knowledge
Typical Traits	- Resourceful - Articulate - Organized	- Confident - Dedicated - Adaptable	- Compassionate - Outgoing - Patient	- Innovative/Creative - Problem Solver - Self-Disciplined

All pharmacists are not created equal, though. In a world that uses more medicines now than ever before, the opportunities for healthcare's "medication experts" have grown, and are still growing! You've seen pharmacists in pharmacies or grocery stores, but have you seen pharmacists like this?

- **Ambulatory care pharmacists dispense information, not drugs**, and work in doctor's offices, or may even own their own practice! They interview and educate patients with complicated diseases or medicines, and work with other healthcare providers to keep those patients safe and healthy.
- **Clinical pharmacists are pharmacy's specialists,** as they tend to be experts in a specific group of patients (such as cancer patients or children). Clinical pharmacists usually work in hospitals, where they answer tough medication questions, and even recommend drug options or doses to doctors!
- **Consultant pharmacists respect their elders**, and know a lot about the medication needs of senior citizens. They usually work in nursing homes or other long-term care facilities, where they educate patients and staff about using medications safely, and eliminating unneeded or ineffective drugs.

Want to learn more?

To learn more about general careers, visit: *www.bls.gov/ooh*
To learn more about careers in pharmacy, visit:
www.pharmacy.ohio-state.edu/academics/introduction-to-pharmacy

Pharmaceutical Sciences

The Bachelor of Science in Pharmaceutical Sciences (BSPS) is a unique undergraduate program that prepares students for careers in a variety of health professions and biomedical research. Students select one of two tracks, enabling them to focus in areas that would be most relevant to their post-baccalaureate goals:

The **Health Care Professions Pathway** is designed for students interested in pursuing clinical careers in pharmacy, medicine, veterinary medicine, dentistry and other health care professions.

The **Drug Discovery and Development Pathway** is designed for students intending to pursue graduate school and/or research-based careers in pharmaceutical sciences.

In learning the disciplines of medicinal chemistry, pharmaceutics, pharmacology and pharmaceutical administration, BSPS students study the areas of drug discovery, delivery, action and therapy. Students also have the opportunity to engage in clinical, laboratory, and community-based research.

Pursuing Pharmaceutical Sciences at Ohio State

All freshman applicants are considered within a competitive admission process for the Columbus campus. Find admissions criteria at go.osu.edu/admissions. Students with an ACT composite score of at least 25 (or combined SAT Critical Reading and Math scores of 1150) and who rank in the top 25 percent of their high school class may directly enroll in the BSPS program.

Other students wishing to major in the pharmaceutical sciences, must first apply to and be accepted to Ohio State as an undergraduate student. Upon successful completion of the prerequisite courses, a student may then request a transfer to the College of Pharmacy.

Pharmaceutical Sciences Prerequisites

If students are interested in transferring to the pharmaceutical sciences major, they are required to talk with an academic advisor in the College of Pharmacy. Students may request a transfer into this major once the following prerequisites are met:

- Biology 1113 and 1114
- Chemistry 1210 and 1220
- Mathematics 1151
- A minimum of 30 credit hours
- Cumulative GPA of at least 2.7 (subject to change)
- Completion of all university admissions conditions

Pharmaceutical Sciences Requirements

Pharmaceutical sciences courses in the BSPS curriculum include drug discovery and development, biochemistry, ethics and professionalism, and instrumental analysis. Major course work includes courses in the core pharmaceutical sciences: pharmaceutics, pharmacology, medicinal chemistry and pharmacy practice. Students must also take course work in organic and general chemistry, biology, physics, physiology, anatomy, microbiology and calculus, as well as electives within an area of specialization. Various courses incorporate lecture/recitation sections and laboratory experiences. BSPS students must also satisfy the university's General Education requirements.

Co-Curricular Opportunities

Ohio State offers many opportunities for students to learn and grow outside of the classroom. These range from internships and study abroad programs to student organizations. Internships place students in professional environments while they are Ohio State students.

Ohio State offers more than 100 study abroad programs in 40 countries around the world. The College of Pharmacy offers an annual study abroad trip over spring break, allowing students to earn elective credit towards their degree and to explore pharmacy in different cultures around the world.

In addition, there are hundreds of student organizations on campus to meet the interests of a diverse student population. For instance, the Pharmacy Club is for those with an interest in learning more about the profession and professional school admissions.

Honors & Scholars Programs

The College of Pharmacy provides opportunities for students to participate in the Honors Program, various Scholars Programs and the Early Admissions Pathway (EAP) for the Doctor of Pharmacy program. All of these students have the opportunity to live in Pharmacy House, a living-learning community for students of all majors with an interest in pharmacy.

The EAP program provides admission to the College of Pharmacy's Doctor of Pharmacy (PharmD) program for a select group of freshman. The pathway is intended to guarantee talented students the opportunity to enter the PharmD program after the completion of prerequisites and a bachelor's degree with Honors.

For more information, check these websites:

College of Pharmacy: pharmacy.osu.edu
Ohio State: osu.edu
Admissions: undergrad.osu.edu
Multicultural Center: multiculturalcenter.osu.edu
First Year Experience: fye.osu.edu

Curriculum Sample

This is a sample list of classes a student will take to pursue a degree in pharmaceutical sciences. Since university students need more than specific education in a narrow field, they also will take classes to complete General Education (GE) requirements. Because GE courses come from a variety of academic areas of study, this course work helps students develop fundamental skills essential to collegiate success and allows them to tailor these courses toward their interests. Note: This sample represents one of several possible paths to a degree in pharmaceutical sciences. Consult the college website, pharmacy.osu.edu for further details.

First Year:	
Survey course	1
Careers in Pharmaceutical Sciences	1
Chemistry	10
Mathematics	10
English	3
GE/Electives	6
Total hours:	**31**

Second Year:	
Organic Chemistry	8
Organic Chemistry Lab	4
Biology	8
Drug Discovery, Development and Delivery	3
Human Physiology	3
GE/Electives	9
Total hours:	**35**

Third Year:	
Physics	10
Biochemistry	5
Evidence-Based Medicine	3
Integrated Pharmaceutical Sciences I	5
Statistics	3
Anatomy	4
GE/Electives	3
Total hours:	**33**

Fourth Year:	
Integrated Pharmaceutical Sciences II	5
Microbiology	4
Ethics and Professionalism	2
Pharmaceutical Sci Lab	2
GE/Electives	15
Total hours:	**28**

To be eligible for admission to the EAP, students must meet the following requirements:

- Be current high school seniors
- Be admitted to Ohio State's Columbus campus for the autumn term
- Submit a separate application to the College of Pharmacy Office of Student Affairs
- Achieve test scores of 1300 on SAT or 29 on ACT

For more information regarding the Early Admissions Pathway, visit pharmacy.osu.edu/eapapp or email eap@pharmacy.ohio-state.edu.

Pharmacy House is a living-learning community in Canfield Hall on south campus. Students living in Pharmacy House have access to on-site academic advising, dinners with faculty, and pharmacy-related events designed to introduce students to the science and profession of pharmacy. Students enrolled in various majors have the opportunity to live in Pharmacy House; however, EAP students are required to live there for one year. While living in Pharmacy House, students will enjoy social activities in a relaxed atmosphere that allow them to interact with current pharmacy students, students in other majors with an interest in pharmacy, and faculty and staff.

Career Prospects in Pharmaceutical Sciences

Graduates of the BSPS program will be prepared for graduate education, graduate professional education or a health-related career. The pharmaceutical industry offers career opportunities in sales and marketing, drug research and development, quality assurance, and professional services.

The BSPS is a non-licensure undergraduate major. It is intended as preparation for graduate studies in the pharmaceutical sciences, graduate professional studies or entry-level employment in the pharmaceutical industry. In order to become a licensed pharmacist, graduates must complete the Doctor of Pharmacy program.

More About the College of Pharmacy

The College of Pharmacy at Ohio State is a leader in both scientific and clinical education. Faculty have been recognized by their peers at national and international levels for their research, practice and teaching. The PharmD program is ranked 7th in the nation by U.S. News & World Report. We are proud of the personal attention we provide to pharmacy students as we strive to deliver a small college feel within the setting of a major university.

Revised June 2015. Information subject to change. For the most up-to-date information on the pharmaceutical sciences program, visit pharmacy.osu.edu.

Contact information:

College of Pharmacy | 150 Parks Hall | 500 West 12th Avenue
Columbus, Ohio 43210-1291 | 614-292-5001 | Fax 614-292-6396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