Forensic Chemistry

https://www.youtube.com/watch?v=_HIw9XVLMDI

Central Focus

Students can describe how Forensic chemists analyze unknown drugs through presumptive and confirmation tests.
Students can analyze and interpret data from techniques used to identify drugs/chemicals.

Learning Standards

GA. SFS1. Students will recognize and classify various types of evidence in relation to the definition and scope of Forensic Science.

b. Distinguish and categorize physical and trace evidence (e.g. drugs and toxins).

GA.SFS2. Students will use various scientific techniques to analyze physical and trace evidence

e. Determine the appropriate uses of chromatography and spectroscopy in evidence analysis.

Day 1 Essential Questions

- How are drugs classified?

Learning Targets. I can…

- **SFS1b – LR1:** Compare/contrast drug, controlled substance, and illegal drug
- **SFS1b – LR2:** Classify drugs by their effects on the body.
- **SFS1b – LK1:** Explain physical and psychological drug dependence

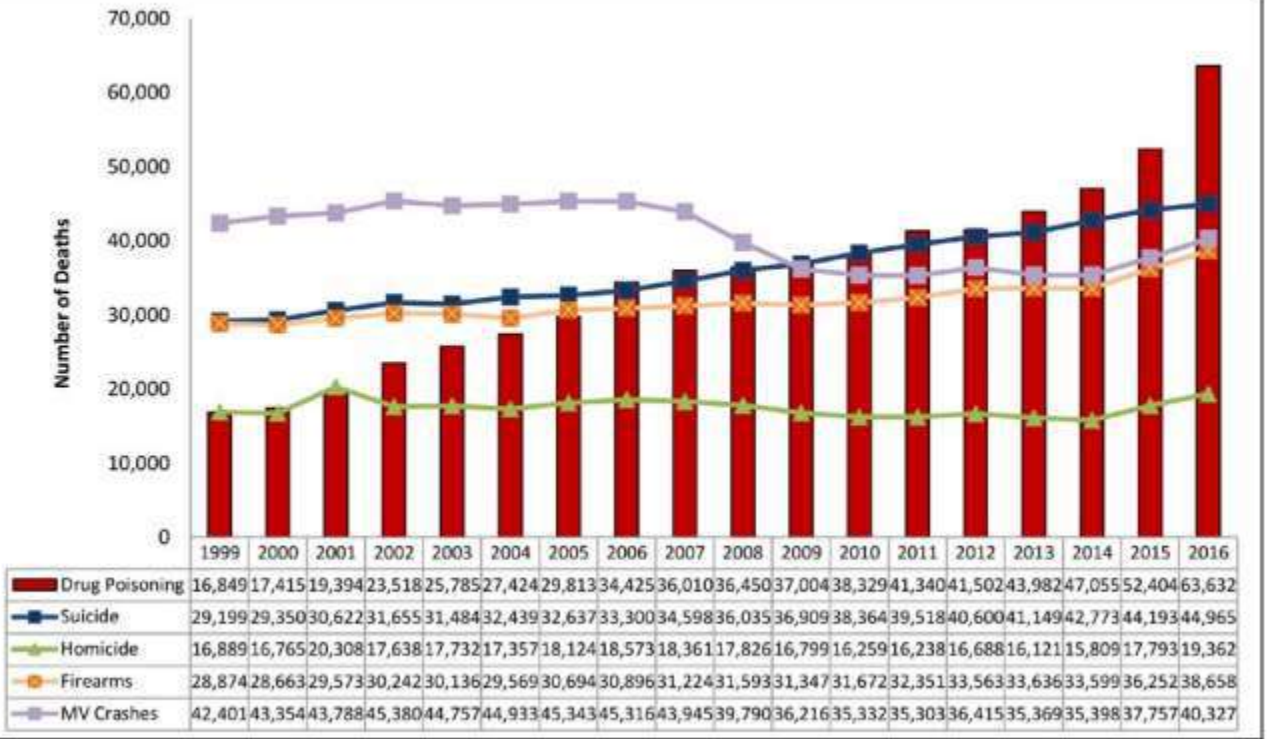
Forensic Chemists

- BS in chemistry, clinical chemistry, or related field
- ~$28k-52k/year salary
- Work in laboratories for local, state, or federal governments
- Responsible for all of the techniques we described above
- Must be able to write up detailed reports and act as expert witnesses

Illegal Drugs

- 2016: ~1.2 million arrests for drugs; ~85% for possession of a controlled substance
- Most common drugs analyzed by crime labs: marijuana, cocaine, methamphetamine, amphetamine, heroin, prescription and designer drugs

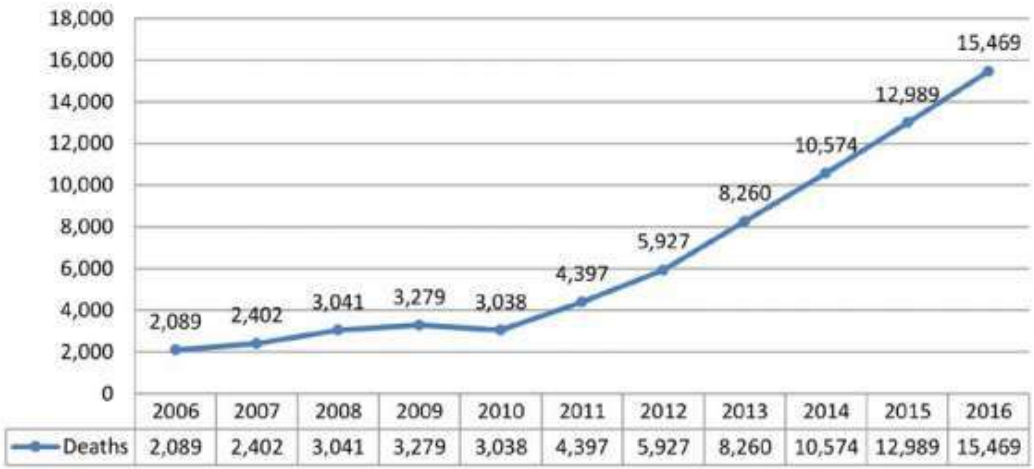
Figure 1. Number of Injury Deaths by Drug Poisoning, Suicide, Homicide, Firearms, and Motor Vehicle Crashes in the United States, 1999 – 2015[2]



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Drug Poisoning	16,849	17,415	19,394	23,518	25,785	27,424	29,813	34,425	36,010	36,450	37,004	38,329	41,340	41,502	43,982	47,055	52,404	63,632
Suicide	29,199	29,350	30,622	31,655	31,484	32,439	32,637	33,300	34,598	36,035	36,909	38,364	39,518	40,600	41,149	42,773	44,193	44,965
Homicide	16,889	16,765	20,308	17,638	17,732	17,357	18,124	18,573	18,361	17,826	16,799	16,259	16,238	16,688	16,121	15,809	17,793	19,362
Firearms	28,874	28,663	29,573	30,242	30,136	29,569	30,694	30,896	31,224	31,593	31,347	31,672	32,351	33,563	33,636	33,599	36,252	38,658
MV Crashes	42,401	43,354	43,788	45,380	44,757	44,933	45,343	45,316	43,945	39,790	36,216	35,332	35,303	36,415	35,369	35,398	37,757	40,327

Source: Centers for Disease Control and Prevention

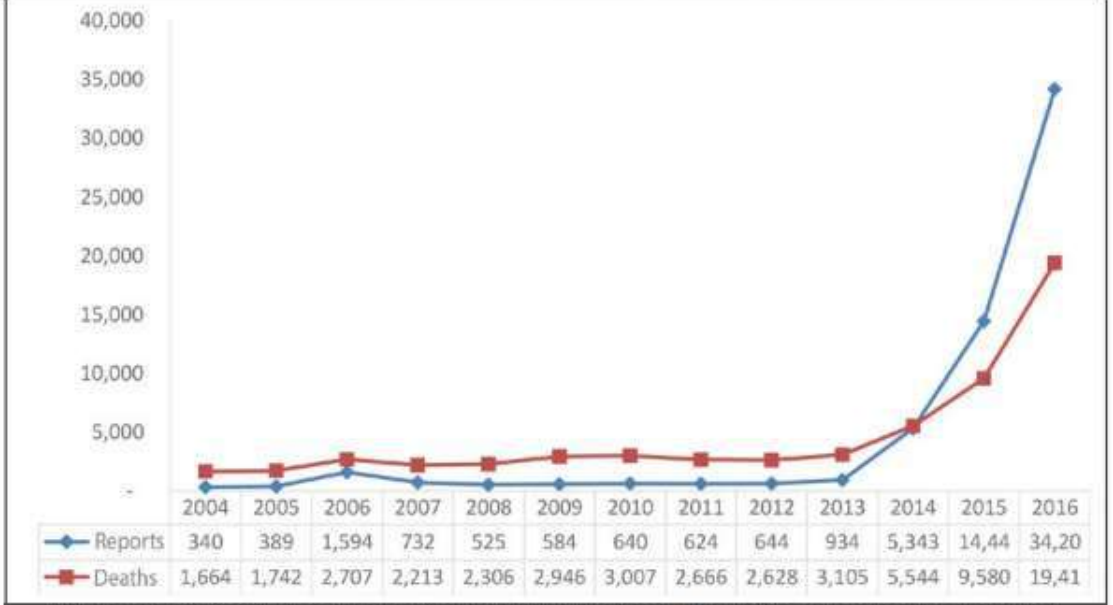
Figure 23. Heroin Deaths in the United States, 2006 –2016.



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Deaths	2,089	2,402	3,041	3,279	3,038	4,397	5,927	8,260	10,574	12,989	15,469

Source: Office of National Drug Control Policy/Centers for Disease Control and Prevention

Figure 34. Number of Synthetic Opioid[26]-Involved Deaths and Fentanyl Reports in NFLIS by Year, 2004-2016.

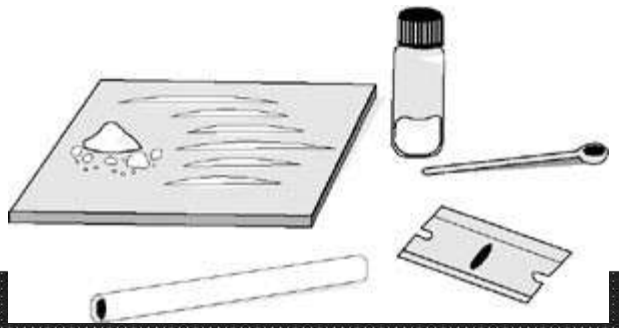


	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Reports	340	389	1,594	732	525	584	640	624	644	934	5,343	14,44	34,20
Deaths	1,664	1,742	2,707	2,213	2,306	2,946	3,007	2,666	2,628	3,105	5,544	9,580	19,41

Source: Centers for Disease Control and Prevention and DEA National Forensic Laboratory Information System

Drugs and Crime

- What is a drug?
  - a natural or synthetic substance designed to affect the subject **psychologically** or **physiologically**.
- What is a psychoactive drug?
  - A drug that affects the brain.

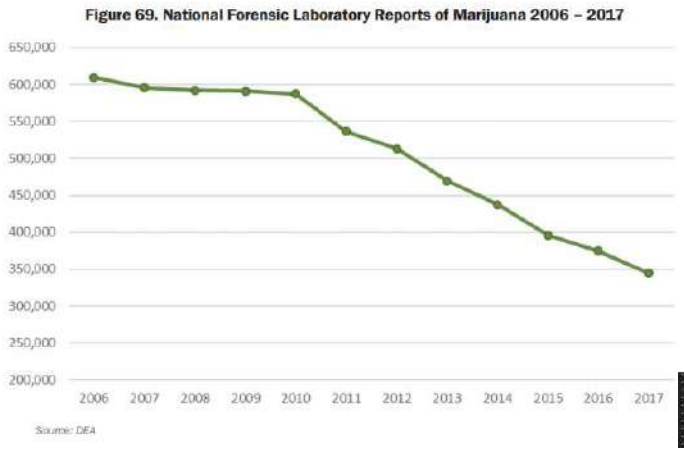


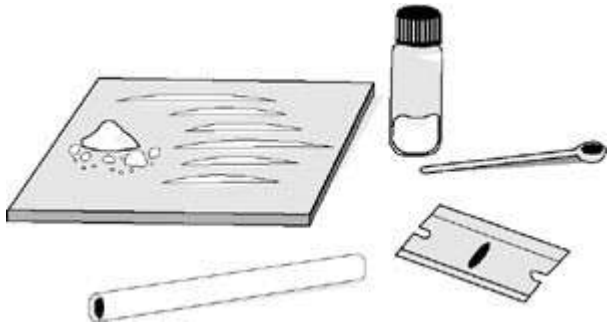
Drugs and Crime

- What are controlled substances?
  - Drugs regulated by state and federal laws.
  - May be declared illegal for sale/use, but may be dispensed by a doctor's prescription
- What are illegal drugs?
  - drug whose production or use is prohibited or strictly controlled by prescription

Drugs and Crime

- Drugs affect **all** social and ethnic classes
- 75% of evidence in the crime lab is drug related
  - Marijuana*-most widely used illicit drug
    - legalized recreationally in 11 states
  - Alcohol- most abused legal drug





Dependence

- Psychological: https://www.youtube.com/watch?v=5f1nmqiHIII
  - Conditioned use of a drug caused by underlying emotional needs
- Physical:
  - Physiological need for a drug because of regular use; experience withdrawal sickness without it
- Some drugs (marijuana, LSD, cocaine) cause anxiety instead of physical dependence

Drug Classifications

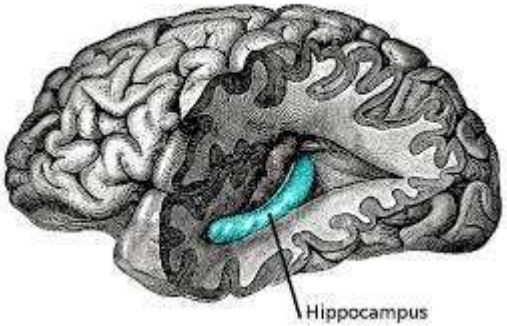
- All drugs, legal and illegal, are classified into different categories based on their similar effects on the mind and body.

Drug Classifications

- Depressants
- Stimulants
- Hallucinogens
- Narcotics
- Anabolic Steroids

Depressants

- Drugs that slow down the central nervous system
- Relieves anxiety and produces sleep
- Slows down bodily functions (ex. breathing and heart rate); side effects include slurred speech and loss of coordination
- Mixing depressants with alcohol and other drugs increases potency and health risks



Common Depressants

- Alcohol
- Barbiturates
- Tranquilizers
- Ambien

Stimulants

- Drugs that *speed up* the central nervous system.
- Highly addictive; more side effects than other drugs
- Increased feelings of energy and alertness, often followed by depression
- Suppresses appetite and makes sleep difficult
- Overdose affects: high blood pressure, agitation, confusion, seizures

Common Stimulants

- Nicotine
- Cocaine
- Amphetamines
- Bath salts
- Ritalin

Meth Addiction

Hallucinogens

- Often derived from plants
- Effect and intensity of response varies from person to person.
- Changes the way people see, hear, feel, or think.
- Effects of an overdose:
  - Increased heart rate
  - Increased blood pressure
  - Panic attacks, anxiety, or psychosis

Common Hallucinogens

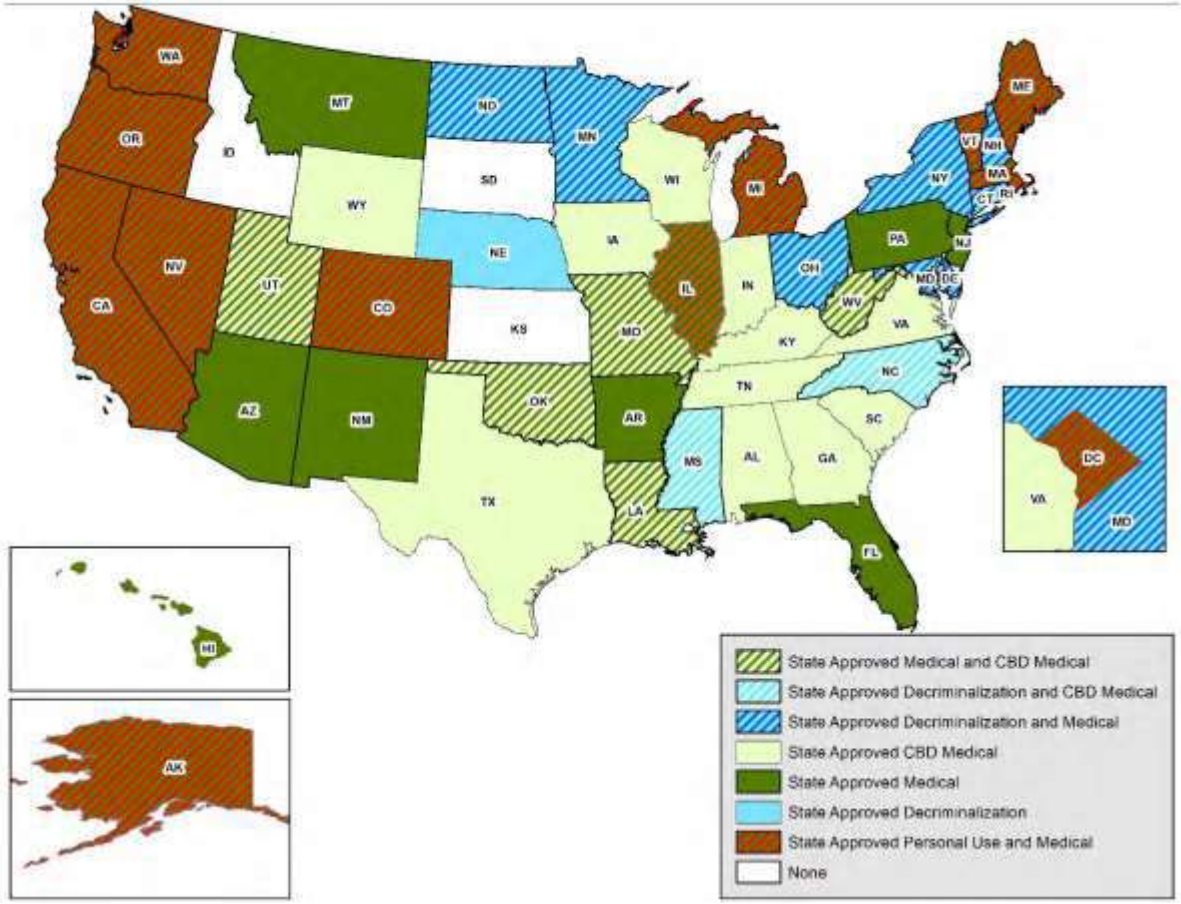
- Marijuana (mild)
- Mushrooms
- LSD
- Spice/K2/Synthetic Marijuana

Marijuana

- Has over 400 different chemicals; THC causes distortions; CBD-anti-inflammatory
- can be classified as a stimulant, depressant, or hallucinogen based on the strand or potency*.
- Similar effects as alcohol:
  - Slows reaction time
  - Impairs judgment

Legalization of marijuana

Figure 70. Current State-Approved Marijuana Status – July 2019

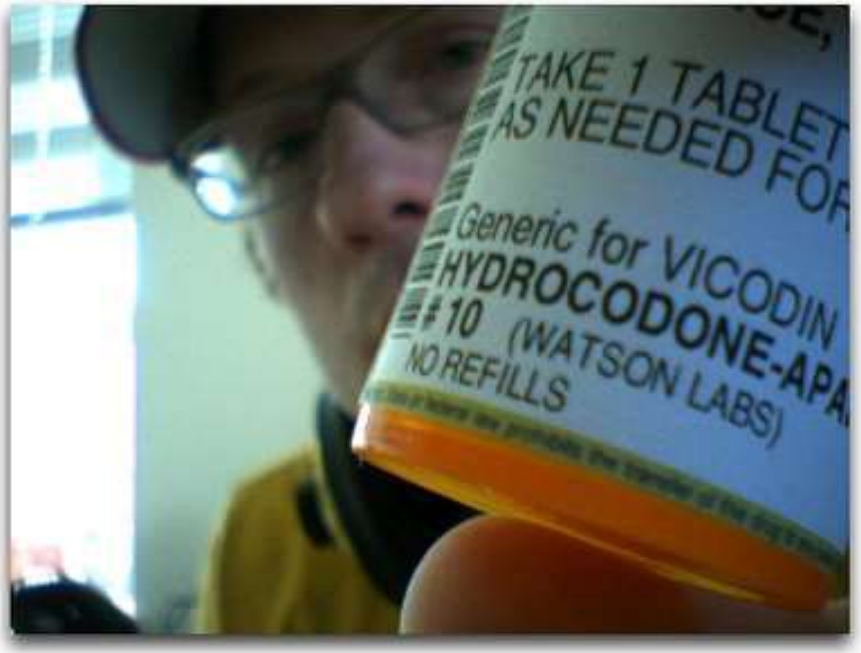


Narcotics

- Powerful, highly addictive
- Relieve Pain/induce sleep
- Derived from the poppy plant
- Opiates

Common Narcotics

- Morphine
- Heroin
- OxyContin
- Percocet
- Vicodin/hydrocodone



Anabolic Steroids

- A synthetic version of the male hormone, testosterone
- Promotes cell/tissue growth increasing bone mass and body muscle.
- Popular amongst bodybuilders and weightlifters

Anabolic Steroids

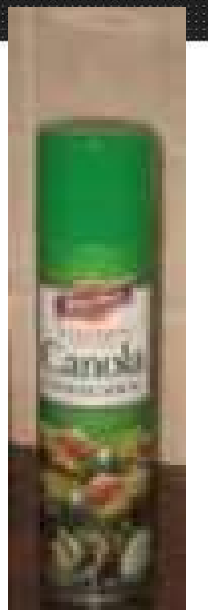
- Can cause breast tissue growth in men
- Shrinks testes/reduces sperm count
- Feelings of paranoia, panic attacks, depression, anxiety, suicidal thoughts.
- Can make users irritable
- “Roid Rage”?

Other drugs

- Club/designer drugs
  - Psychoactive drugs abused by teens/young adults in clubs and raves
  - Similar to hallucinogens or narcotics, but altered chemical structure (**derivatives**)
  - Unsuspecting victims become drowsy or dizzy; when combined with alcohol, can lead to blackouts, memory loss, and death (“date rape drugs”)
  - Ex. Ecstasy/Molly, GHB, ketamine, Roofies (Rhohypnol)

Other drugs

- Huffing
  - Chemicals **inhaled** as vapors
  - Central nervous system depressants
  - Causes hyperactivity, loss of coordination, anxiety, fear, slurred speech, difficulty thinking, death
  - Ex. Tolune, freon, gasoline, antifreeze, etc



Day 2 Essential Questions

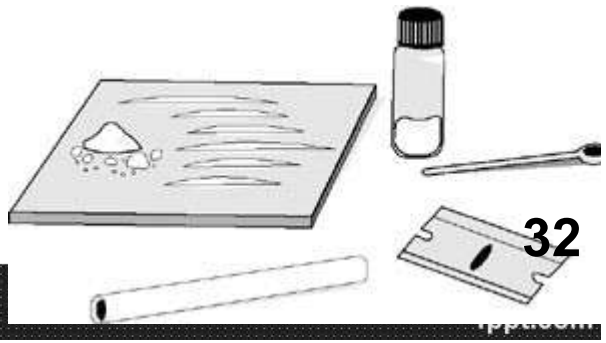
- What is the Controlled Substances Act and how are drugs scheduled?

Learning Target. I can…

- **SFS1b – LR3:** Classify drugs based on the Controlled Substance Act scheduling
- **SFS1b - LP1:** Construct an argument on the scheduling of marijuana by the federal government

Controlled Substances Act

- 1970 act- regulated the manufacture, importation, possession, use and distribution of certain substances
- lists illegal drugs, their category and their penalty for possession, sale or use.
- Five Schedules: I – V
- GA: drug possession conviction also results in loss of driver's license



Schedule I Drugs

- carry the most severe penalties
- have a “high potential for abuse”
- for research *only* (no “accepted medical use”) with a permit
- secured in vault/safe
- Examples: heroin, marijuana, LSD, ecstasy
- GA law: felony (except mj) – 1st offense: 2-15 years prison. 2nd? Up to 30 years

GA Penalties: Marijuana

Statute(s)	Section 16-13-30, et seq.
Possession Penalties	• *1 oz or Less*: Misdemeanor, 1 yr. or $1,000 fine • *Between 1 oz and 10 lbs.*: Felony, 1-10 yrs. • *Over 10 lbs:* This is considered trafficking (see below)
Sale or Trafficking Penalties	• *10 lbs or Less*: Felony, 1-10 yrs • *10-2000 lbs.*: Fellony, 5 yrs. and mandatory $100,000 fine • *2000-10,000 lbs.*: 7 yrs. and mandatory $250,000 fine • *Over 10,000 lbs.*: 15 yrs. and mandatory $1,000,000 fine
Medical Marijuana	Eligible patients may possess up to 20 ounces of low-THC (high-CBD) cannabis oil; possession of the whole plant is not allowed, nor is cultivation. Although low-TCH cannabis oil is legal in the state, it is not clear how it should be obtained.

***Note**: State laws are always subject to change through the passage of new legislation, rulings in the higher courts (including*

https://statelaws.findlaw.com/georgia-law/georgia-marijuana-laws.html

Schedule II Drugs

- have a high potential for abuse but have an accepted medical use with restrictions
- must have a permit and secured in vault/safe
- Ex. Morphine, methadone, oxycodone, codeine, amphetamine, methylphenidate (Ritalin®).
- GA law: Felony narcotics/non-narcotics: – 1st offense: 2-15 years prison. 2nd? Narcotics: up to 30 years; non-narcotics: 5-30 years

Schedules III –V Drugs

- have an accepted medical use and decrease in potential for abuse
  - Schedule III—ketamine, anabolic steroids
  - Schedule IV--diazepam (Valium®), lorazepam (Ativan®), other stimulates and depressants
  - Schedule V—cough medicines with <200 mg codeine
  - GA law: Felony 1st offense: 1 – 5 years. 2nd? 1 – 10 years

Day 3: Essential Questions

- Why is chromatography alone NOT useful for conclusively determining the identification of an unknown substance?
- How can chromatography be used to identify an unknown substance?
- What is spectrophotometry; how can it be used to determine the identity of unknown drugs?

Learning Targets. I can…

- **SFS2e – LR4:** Compare and contrast presumptive and confirmatory tests and explain the probative value of each.
- **SFS2e – LK2:** Explain how drugs are identified using chromatography and spectrophotometry.
- **SFS2e – LR5:** Predict the identification of a drug using chromatography or spectrophotometric information.

Evidence

- Presumptive
  - screening tests used to determine that it is a drug/narrow down to a few possibilities
- Confirmation
  - Gas chromatography in conjunction with mass spectrometry (GC/MS) or infrared spectrophotometry **specifically** identify a drug or poison and its components.

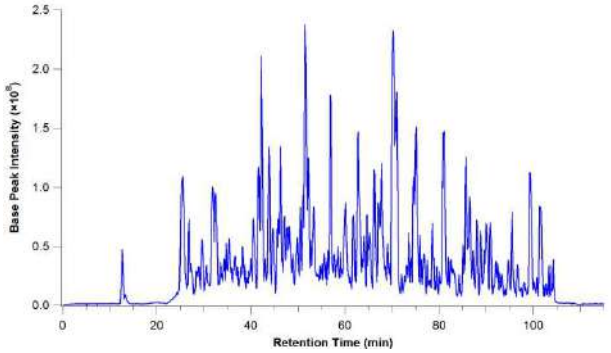
DRUG IDENTIFICATION

Field Tests → Screening or presumptive tests

- Spot test – colored tests
- Microcrystalline test--a reagent is added that produces a crystalline precipitate which are unique for certain drugs.

Lab Tests → Confirmation tests; identifies the drug

- Chromatography*
- Spectrophotometry*
- Mass spectrometry



Chromatography: steps to confirming a drug

- two phases--one mobile and one stationary that flow past one another
- separate mixtures into their component compounds based on chemical properties of the drug and interaction with the 2 phases

***note: chromatography NOT confirmatory on its own

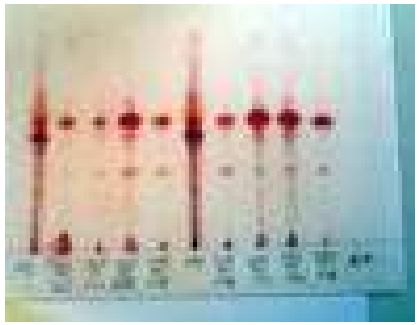
Presumptive

Types of Chromatography

- Paper
- Thin Layer
- Gas
- High Pressure Liquid (HPLC)

Remember: For this part of the unit, we're discussing identification of chemicals/drugs OUTSIDE of the body (i.e. NEVER ingested/consumed)

Thin Layer Chromatography

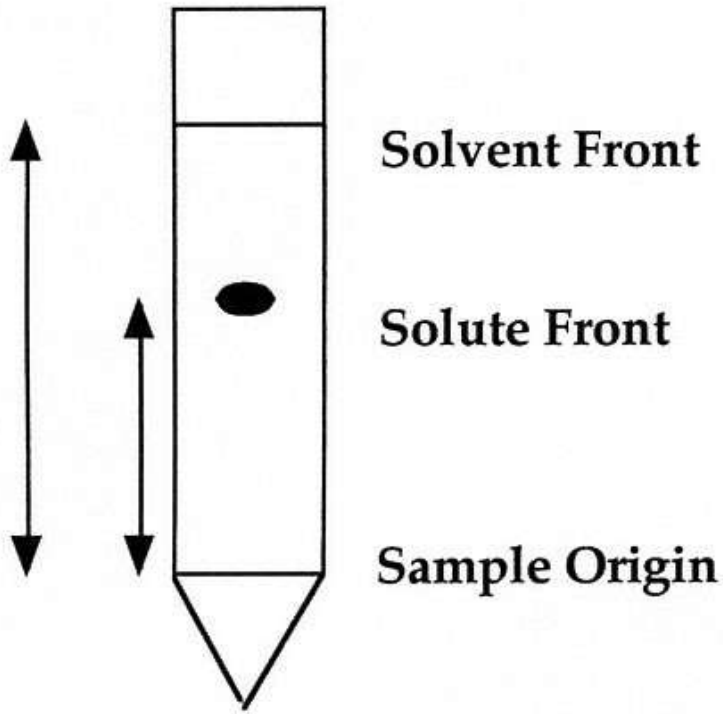


from www.lbp.police.uk

- Stationary phase--a thin layer of coating on a sheet of plastic or glass (usually aluminum or silica)
- Mobile phase--a liquid solvent

Retention Factor (R_f)

- number that represents how far a compound travels in a particular solvent
- determined by measuring the distance the compound traveled and dividing it by the distance the solvent traveled.



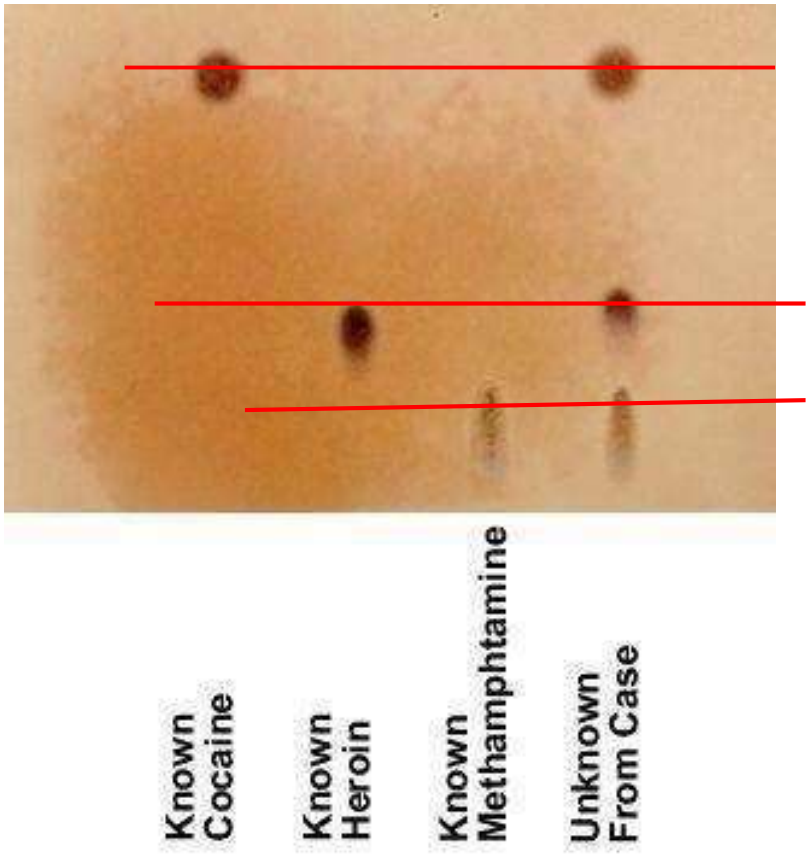
Retention Factor (R_f)

If the R_f value for an unknown compound is close to or the same as that for the known compound, the two compounds are **most likely** similar or identical (a match).

However, TLC is not conclusive.

i.e. PRESUMPTIVE, not CONFIRMATORY test

Results from Thin Layer



- What was **LIKELY** in the unknown sample?

- Next step????

Confirm if cocaine and meth are actually present (as well as amount)

Gas Chromatography

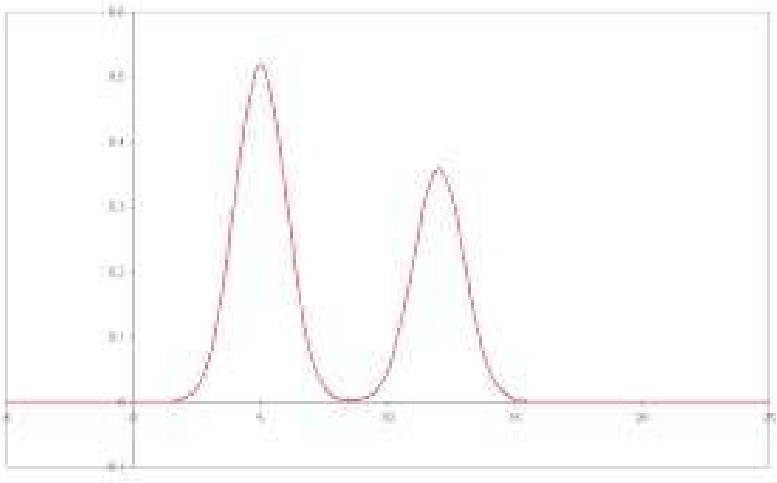
- Stationary phase--a solid or very syrupy liquid line a tube or column
- Mobile phase--an inert gas like nitrogen or helium

https://www.youtube.com/watch?v=0m8bWKHmRMM
https://www.youtube.com/watch?v=OnQglXDvzTc&list=PLXaIHn5J8MDOBABj7KMQ0By5vJybx-JOw&index=21

GC Analysis

- Shows a peak that is proportional to the quantity of the substance present
- Uses retention time instead of Rf for the quantitative analysis

Quick check: What does "retention" mean?



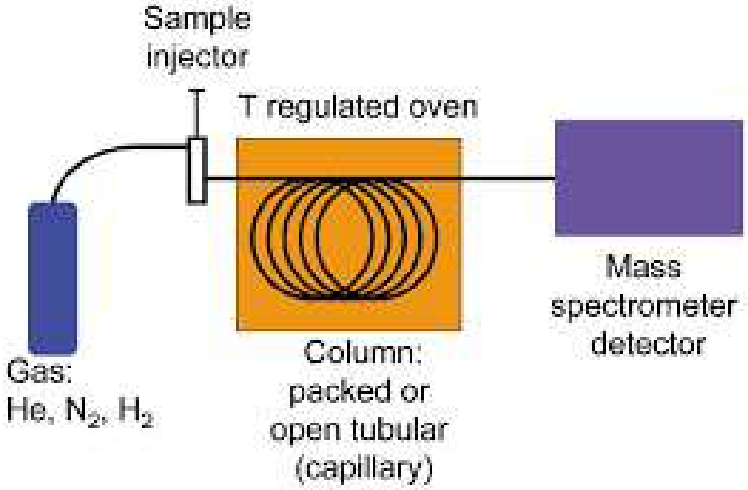
Retention Time

- Time between sample injection and when it exits the column reaching the detector.
- Tm: time taken for the mobile phase to pass through the column
- Very fast BUT does not give a specific identification.

Meaning: Alone it is PRESUMPTIVE (chemically similar compounds could have same/similar Tm)

Mass Spectrometry

- By pairing a gas chromatograph with a mass spectrometer (GC/MS), *exact* chemical identification is accomplished.



GC/MS

presumptive

confirmatory

GC/MS

- 1st: separate drug mixture in a gas chromatograph.
- The GC column directly attaches to the mass spectrometer….
  - where a beam of electrons is shot through the sample molecules.

Charge of an electron???

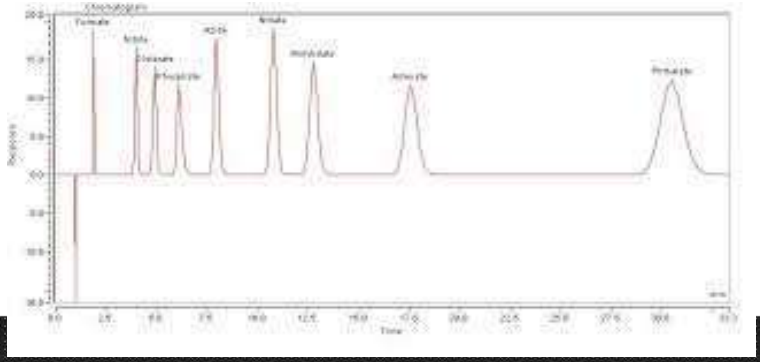
- The electrons cause the molecules to lose electrons and become **positively charged**.

MS (cont.)

- The **positively** charged molecules are unstable and decompose into many smaller fragments.
- These fragments pass through an electric or magnetic field and separate according to their masses.

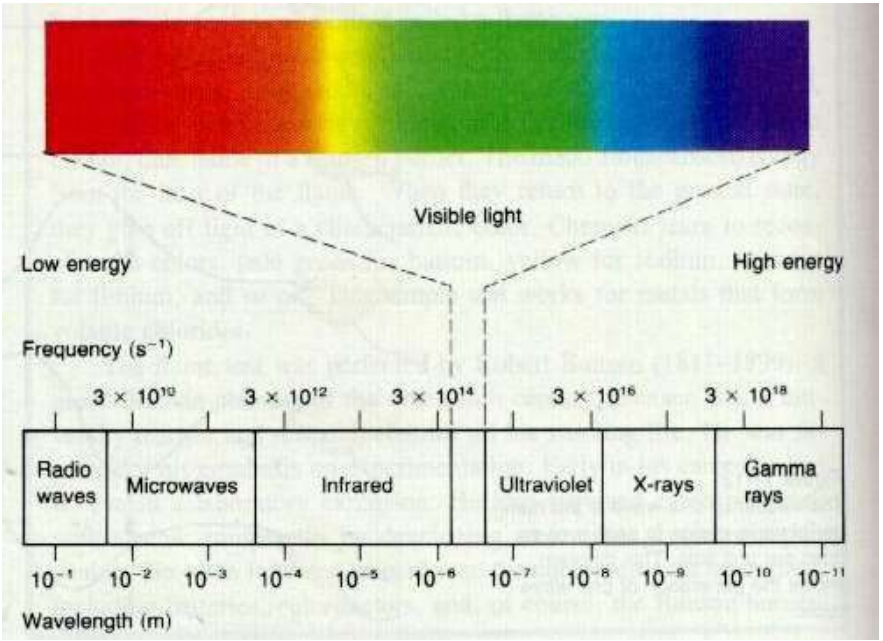
NO TWO SUBSTANCES PRODUCE THE SAME FRAGMENTATION PATTERN.

Note: Mass spec can be used on its own to identify a chemical, but pairing with GC helps simplify results as it separates the mixture



Spectrophotometry

- an analytical method for identifying a substance by its selective absorption of different wavelengths of light

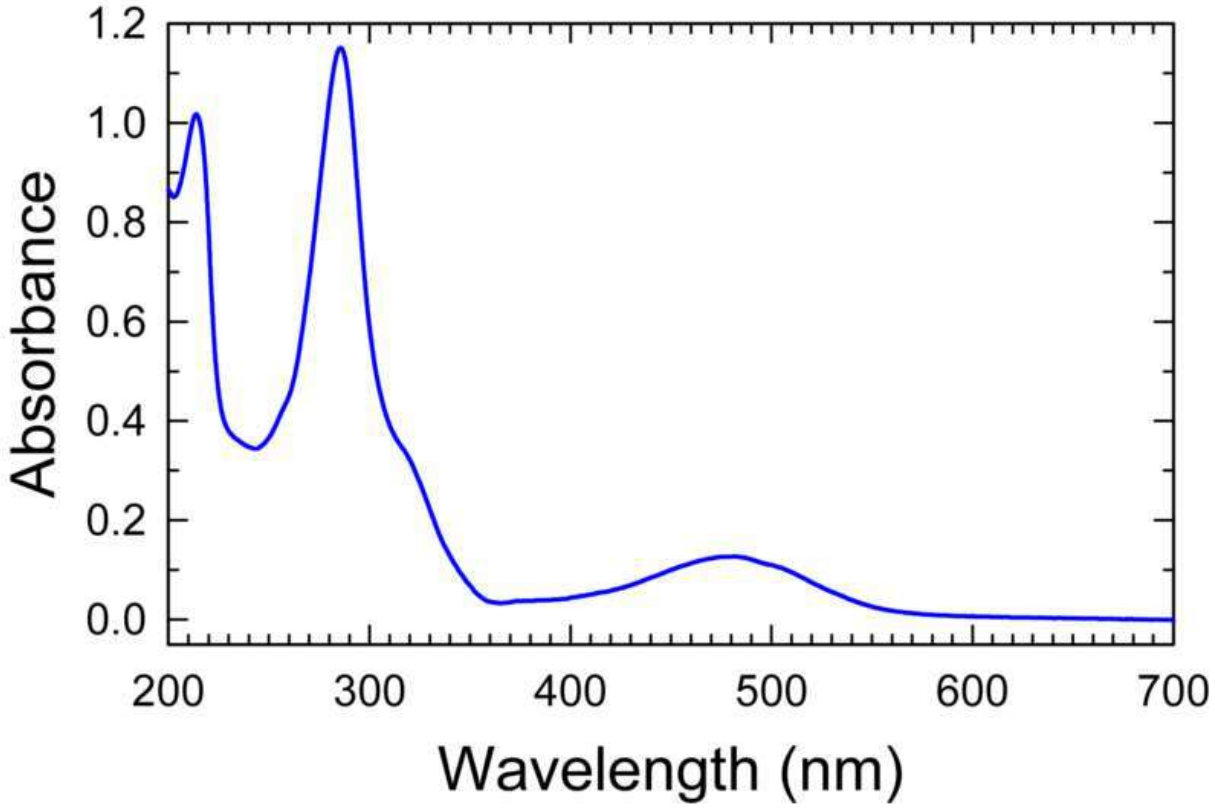


Spectrophotometry

- Ultraviolet and Visible Spectrophotometry- spectrophotometer emits UV or visible light and the amount that is absorbed is measured.
  - Not conclusive, but eliminates numerous compounds
  - Search a UV drug spectra database for matches

PRESUMPTIVE

UV/Vis spectroscopy sample image



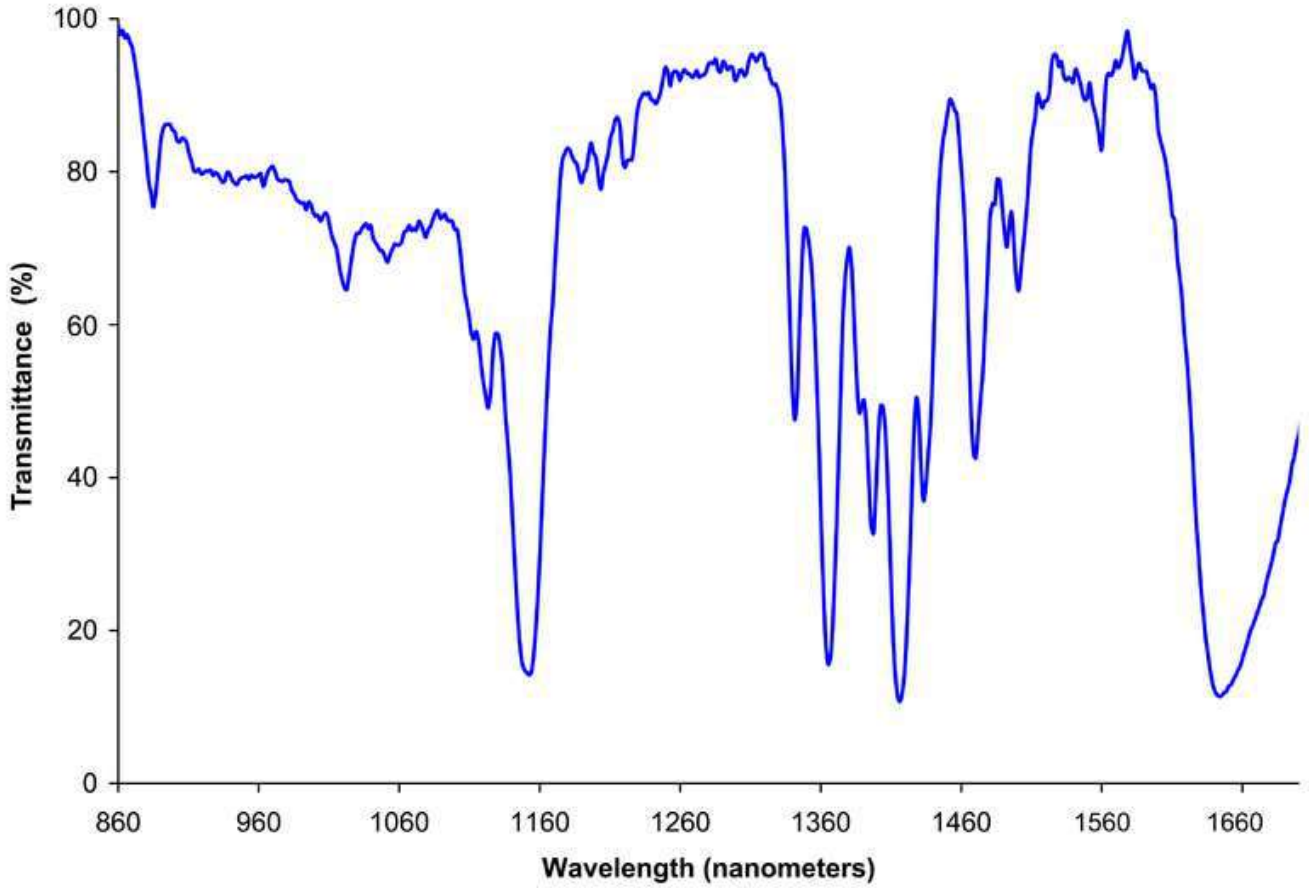
https://commons.wikimedia.org/wiki/File:Ethidium-bromide-abs.png

Spectrophotometry

- Infrared Spectrophotometry – every substance has a different infrared spectra
  - Creates a unique “fingerprint”
  - IR spectra for 1000s of organic compounds have been collected

Confirmatory

Sample IR Spec data



https://commons.wikimedia.org/wiki/File:Dichloromethane_near_IR_spectrum.png