Chapter 7
Drugs
Objectives

You will understand:

How to apply deductive reasoning to a series of analytical data.

The limitations of ________________ (Presumptive Screening) tests.

The relationship between the electromagnetic spectrum and spectroscopic analysis.

The dangers of using ________________ Prescription drugs, Controlled substances, over-the-counter medications, and ________________ illegal drugs.

You will be able to:

Chemically identify ________________ drug types.

Classify the types of illicit drugs and their negative effects.

Discuss the ________________ Federal Penalties for possession and use of controlled substances.

Explain the need for ________________ Confirmatory tests.

You will be able to:

Describe ________________ IR, UV-VIS Spectroscopy and GC - MS.

Present and interpret data with ________________ Graphs.

Use the Physicians’ Desk Reference (PDR) to identify pills.

Use technology and mathematics to improve investigations and communications.
Drugs & Crime...

-A **Drug** is a natural or synthetic substance designed to affect the subject psychologically or physiologically.
-Can affect the **Function** or **Structure** of living tissue through various chemical reactions.

-Most drugs are legitimately manufactured by drug **Companies** and are **Prescribed** for particular medical problems.

**PDR**—A **Physicians’ Desk Reference**:
-Is used to **identify** manufactured **Pills**, tablets, and capsules. It is updated each year. This can sometimes be a quick and easy identifier of the **Legally** made drugs that may be found at a scene.
-The reference book gives a **Picture** of the drug and states whether it is prescription, over-the-counter, or a controlled substance; it gives more **Detailed** information about the drug as well.

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**Over the Counter** (OTC) drugs: medicines sold directly to a consumer without a prescription from a healthcare professional, as compared to prescription drugs, which may be sold only to consumers possessing a valid prescription.

**Prescription** (Rx) Drug: is a pharmaceutical drug that legally requires a medical prescription to be dispensed.

**Controlled Substances**: drugs that have a potential for abuse or dependence. These drugs are regulated by the federal Controlled Substances Act (CSA) – this law helps the US Government fight against the abuse of these drugs.

-The CSA was enacted in 1970
-It lists **illegal** drugs, their **Category** and penalties for **Possession**, **Sale**, or **Use**. The CSA divides controlled substance drugs into five categories called schedules.
**Controlled Substances Act**

**Schedule I**—illegal substances. High potential for Abuse: no currently accepted Medical use in the U.S.

Examples: marijuana, cocaine, heroin, meth, LSD, mushrooms

**Schedule II**—High potential for abuse; a currently Accepted medical use with Severe restrictions; abuse may lead to severe Psychological or Physical dependence.

Examples: amphetamine, oxycodone, morphine, fentanyl, hydrocodone

**Schedule III**—High potential for abuse than the drugs in I or II; Currently Accepted for medical use in the U.S.; abuse may lead to moderate physical dependence or High psychological Dependence.

Examples: steroids, Tuessenex, ketamine, barbiturates

**Schedule IV**—Lower potential for abuse relative to drugs in Sch. III; a currently accepted Medical use in the U.S.; abuse may lead to Physical or Psychological dependence.

Examples: Xanax, Ambien, Klonopin, Valium, Darvon

**Schedule V**—Lower potential for abuse relative to drugs in IV; accepted for medical use in the U.S.; abuse may lead to Limited physical or psychological dependence relative to drugs in IV.

Examples: codeine (cough syrup), Sudafed, Mucinex-DM
...Drugs & Crime

- Recreational use of drugs may cause Dependency
- Can lead to Theft or violence to support such a habit

- Drug abuse can lead to extreme Mental and Physical health problems
  - Creates a burden on Public Health Systems

- Also there are social, moral, and religious stigmas associated with drug abuse
  - As much as 75% of evidence being examined in forensic labs are drug related

- Forensic chemists have many tests for identifying Drugs and Poisons
Illicit or Illegal?

-An illegal drug is a drug that is against the law to have, use, or distribute.

-An illicit drug is a legal drug used in an inappropriate or illegal way.

Scenarios:

A student has recently had surgery and is prescribed Oxycodone. The directions on the bottle say: "Take one tablet by mouth at breakfast, one at lunch, and one at dinner". The student goes to the bathroom at lunch to take the Oxycodone and is caught by the principal. illegal / illicit / or neither?

A student has recently had surgery and is prescribed Oxycodone. The directions on the bottle say: "Take one tablet by mouth at breakfast, one at lunch, and one at dinner". The student goes to the bathroom at lunch and is caught snorting the medication by the principal. illegal / illicit / or neither?

A student has recently had surgery and is prescribed Oxycodone. The directions on the bottle say: "Take one tablet by mouth at breakfast, one at lunch, and one at dinner". The student gives their friend one of their pills and the other student goes to the bathroom at lunch and is caught taking the medication by the principal. illegal / illicit / or neither?

A student has recently had surgery and is prescribed Oxycodone. The directions on the bottle say: "Take one tablet at breakfast, one at lunch, and one at dinner". The student goes to the bathroom at lunch and is caught snorting the medication by the principal. illegal / illicit / or neither?
Classification scheme for illicit drugs, based on their pharmacological effects:

1. **Hallucinogens**: Mostly occurring substances that can change normal mental processes, perceptions, and moods. The most widely used hallucinogen in the US is **Marijuana**.

Some Examples:

1. **Marijuana**
   - The active ingredient can range from 1-10% in sinsemilla (a cultivated female cannabis).
   - A resinous oil (“hash oil”) extracted from the plant can contain as much as 30-50% of the active ingredient.
   - Marijuana decreases ability to concentrate, slows reactions, and impairs coordination.

2. **LSD**
   - Chemically derived from ergot alkaloids found in a fungus that grows on grain.
   - As little as 25 micrograms can cause visual and auditory hallucinations.
   - Often sold soaked into blotter paper as tiny colored tablets.
   - It is an extremely dangerous drug that can cause psychosis flashbacks and impaired memory and attention span.
   - It is also a possible teratogen (agent that can cause birth defects) in an embryo or fetus.

3. **PCP**
   - Formerly sold as an intravenous anesthetic, but was dropped because of its side effects.
   - Side-effects include: insensitivity to pain, feelings of super strength, rage, memory loss, and paranoia.

4. **MDMA (methylenedioxymethamphetamine)**
   - Also known as ecstasy, a synthetic drug that both stimulates the user and causes hallucinations.
   - Side-effects include: psychological problems such as confusion, depression, addiction, severe anxiety, paranoia, and increased blood pressure and heart rate, which may cause sudden death.
   - Recent research links MDMA use to long-term damage to the parts of the brain that are important in thought and memory.
2.) **Stimulants**:  
Act on the central nervous system to make the user feel better and 
**Increase** his or her energy alertness while 
**Decreasing** appetite and fatigue. Side effects include restlessness, **Anxiety**, & **Depression**.

1- **Cocaine**  
-An alkaloid that comes from the leaf of the **Coca** plant (grown almost exclusively on the Amazon slopes of the Andes)

-It takes about **500** pounds of coca leaves to produce **1** pound of cocaine powder.

-Most cocaine used to be snorted as powder, but now smoking the recrystallized freebase (“crack”) is more popular. Crack is highly **Addictive**.

2- **Nicotine**  
-also a **Habit** forming stimulant, but it is not a controlled substance
3.) **Narcotics / Analgesics**: Substances that affect the central Nervous system to relieve pain. Illicit narcotics come from Opium.

- **Opium**: contains from 4 to 21 percent Morphine, often used medicinally as a powerful painkiller.

- **Heroin**: easily made from morphine and is highly addictive. Overdoses can cause Death.

- **Codeine**: commercially prepared from morphine and is often found in OTC drugs in Canada.

-Synthetic Narcotics (Opiates) are often prescribed for pain but are also abused.

- **Methadone**: used as a Heroin substitute to wean addicts from heroin.

- Darvon & Oxycodone are 2 other prescription drugs commonly abused.

- **Fentanyl**: an anesthetic that is 300 times stronger than morphine.

  - It spawned a series of designer drugs known as “China White”
4.) **Depressants**: Ethyl alcohol is a common depressant.

-Alcohol is a $\text{\underline{40}}$ billion industry in America.

-Alcohol is \underline{Not} a controlled substance.

-Barbiturates ("\underline{Downers}") are highly addictive with difficult and dangerous withdrawals

-Most are prescribed to reduce \underline{Anxiety} and help the user \underline{Sleep}

-Examples: \underline{Valium, Klonopin, Ambien}}
### Human Components Used for Drug Analysis

<table>
<thead>
<tr>
<th>Blood</th>
<th>Liver tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urine</td>
<td>Brain tissue</td>
</tr>
<tr>
<td>Hair</td>
<td>Kidney tissue</td>
</tr>
<tr>
<td>Gastric contents</td>
<td>Spleen tissue</td>
</tr>
<tr>
<td>Bile</td>
<td>Vitreous humor of the eye</td>
</tr>
</tbody>
</table>
## Tests Used For Drug Identification

<table>
<thead>
<tr>
<th>Screening or presumptive tests</th>
<th>Confirmatory tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spot or Color tests</td>
<td>Spectrophotometry</td>
</tr>
<tr>
<td>Microcrystalline test —</td>
<td>- Ultraviolet (UV)</td>
</tr>
<tr>
<td>a reagent is added, producing</td>
<td>- Visible</td>
</tr>
<tr>
<td>a crystalline precipitate that</td>
<td>- Infrared (IR)</td>
</tr>
<tr>
<td>is unique for a certain drug</td>
<td></td>
</tr>
<tr>
<td>Chromatography</td>
<td></td>
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</tbody>
</table>

- Not Conclusive if positive.
- Requires a **Confirmatory** test to prove the presence of a substance.
- Only 100% conclusive if test is **Negative**.
Spot / Screening / Presumptive Tests

- Screening or presumptive tests only tell that the drug is Possibly present.
- Not conclusive because a few substances may give a False positive
- (Only Confirmatory tests tell that the drug is Positively present)

- So why use a screening test?
  - Screening tests are Easier, Cheaper, and Quicker to use
  - And are great at indicating if a substance IS NOT present

- A presumptive test (aka screening test) is based on Spot tests that produce specific Colors for specific Drugs.

Examples of Presumptive Color Tests

- You can use a number of spot tests to determine the presence of a particular drug or type of drug.
  - A positive result Implies the presence of the drug, but these tests are NOT conclusive

- **Duquenois-Levine Test**: creates a Purple color when active ingredients of Marijuana are present in a sample

- **Marquis Test**: turns Purple in the presence of most Opium derivatives and Orange - Brown with Amphetamines.

- **Dille Koppany Test**: turns Violet - Blue in the presence of Barbiturates

- **Van Urk Test**: turns a Blue-Purple in the presence of LSD

- **Scott Test**: turns Blue in the presence of Cocaine
Chromatography

-In all types of chromatography, there is contact between a **Stationary** phase and a **Mobile** phase.

-the sample is carried through the system by the **Mobile** phase and interacts with the **Stationary** phase.

-the interactions of each component in the sample are based on their **Physical** and chemical properties.

-separation takes place as each component is repeatedly adsorbed or desorbed from the **Stationary** phase at different rates.

Thin-Layer Chromatography

- **Chromatography**: a way to separate the components of a mixture.

1- **Paper** chromatography

2- **Thin - Layer** chromatography (TLC)

3- **Gas** chromatography

4- **Liquid** chromatography (LC)

5- **High** performance liquid chromatography (HPLC)
Paper Chromatography

Stationary phase— _______ Paper
Mobile phase—a _______ Liquid solvent

Capillary action moves the mobile phase through the stationary phase.
Thin - Layer Chromatography

Stationary phase—a Thin Layer of coating (usually alumina or silica) on a sheet of Plastic or Glass.

Mobile phase—a Liquid solvent.

Retention Factor ($R_f$)

This is a number that represents how far a compound travels in a particular solvent.

It is determined by measuring the distance the compound traveled and dividing it by the distance the solvent traveled.

If the $R_f$ value for an Unknown compound is the same as that for the Known compound, the two compounds are most likely identical (a Match).
Gas Chromatography

**Phases**
- **Stationary**—a solid or a viscous liquid that lines a tube or column
- Mobile—a **Gas** such as nitrogen or helium

**Analysis**
- Shows a peak that is proportional to the **Quantity** of the substance present
- Uses retention **Time** instead of $R_f$ for the qualitative analysis

**Uses of Gas Chromatography**
- **NOT** considered a confirmation of a **Controlled** substance
- Used as a **Separation** tool for mass spectroscopy (MS) and infrared spectroscopy (IR)
- Used to quantitatively measure the **Concentration** of a sample. (In a courtroom, there is no real requirement to know the concentration of a substance. It does not affect guilt or innocence.)
Confirmatory Tests

- In court, forensic scientists are often required to explain the testing method to the _____________

- _______________ tests: tests that specifically identify one substance

- _______________: the interaction of electromagnetic radiation with matter.

- Most confirmatory tests for drugs are based on one of two analytical techniques:
  1. _______________ Spectroscopy (IR)
  2. _______________ Spectrometry (MS)
Confirmatory Tests: Spectroscopy

**Spectrophotometer**—an instrument used to measure and record the absorption spectrum of a chemical substance.

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**Spectrophotometry**

**Components**

- A **Radiation** source
- A **Frequency** selector
- A **Sample** holder
- A detector to convert electromagnetic radiation into an **Electrical** signal
- A recorder to produce a **Record** of the signal

**Types**

- Ultraviolet (UV)
- Infrared (IR)
- Visible
Infrared Spectrometry

Material absorbs energy in the **IR** region of the electromagnetic spectrum

Compares the IR light beam **Before** and **After** it passes through a transparent sample

Result—an absorption or transmittance spectrum

Gives a **Unique** view of the substance; like a **Fingerprint**

-The IR spectrum of each substance is a combination of the many different **Bonds** that make up that substance

**Pros & Cons of IR Spectrometry**

-you can compare known samples to unknown samples to identify **Compounds**

-The basic instrument for taking IR spectra is the Fourier Transform Infrared (FTIR)
  -costs about $25,000
Mass Spectrometry

Gas chromatography has one major drawback: It does not give a specific identification. Mass spectrometry cannot separate mixtures. By combining the two (GC-MS), constituents of mixtures can be specifically identified.

Mass Spectrometry, continued

-In a mass spectrometer, an Electron beam is directed at Sample molecules in a vacuum chamber. The electrons Break Apart the sample molecules into many Positive-charged fragments (the fragments lose an Electron and, therefore, have a net Positive charge). These are sorted and collected according to their Mass-to-Charge ratio by an oscillating electric or magnetic field.

-you can identify this pattern by comparing it to a catalog of Known spectra.

Mass Spectra

Each molecular species has its own Unique mass spectrum.
IR Spectrophotometry and Mass Spectrometry

Both work well in identifying Pure substances.

Mixtures are difficult to identify in both techniques.

Both are compared to a catalog of Knowns.

In Summation:

Mixtures are difficult to identify in both techniques because their spectra becomes Superimposed (chemicals run together and make it harder to identify)

-chromatography can separate a Mixtures into its component parts, but the problem is that this technique doesn’t specifically identify what those components are.