

Unit 11: Drugs & Toxicology



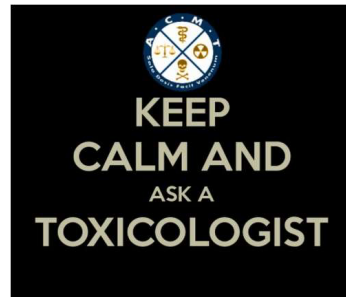
What is toxicology?

- Toxicology is the study of the combination of **chemistry** and **physiology** that deals with **drugs, poisons, and other toxic substances** and how these substances effect **living organisms**
- Types:
 - Environment: air, water, soil
 - Consumer: foods, cosmetics, drugs
 - Medical
 - Clinical
 - Forensic



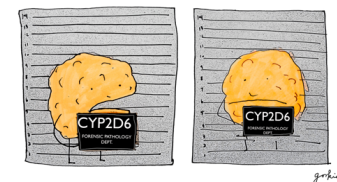
What is a toxicologist?

- A toxicologist is a person responsible for detecting and identifying the presence of **drugs and poisons in body fluids, tissues, and organs**



Toxicology Used to Prove a Case

- Prove a crime was committed
- **Motive**
- **Intent**
- Access to **poison**
- Access to **victim**
- Death was **homicidal**
- Death was caused by poison



Forensic Toxicology

- **Postmortem**: medical examiner or coroner
- **Criminal** - motor vehicle accidents (MVA)
- **Workplace** - drug testing
- **Sports** - humans and animals
- **Environment** - industrial, catastrophic, terrorism



How much is too much?

- The degree of toxicity of any substance depends on how much enters your body and over a period of time it does so



Aspects of Toxicity

- **Dosage**
- Chemical or physical **form** of the substance
- **Mode of entry** into the body
- Body weight and physiological conditions of victim (including age and gender)
- The time period of exposure
- **Presence of other chemicals** in the body or in the dose

THEORETICAL LETHAL DOSE



WATER: 6 liters



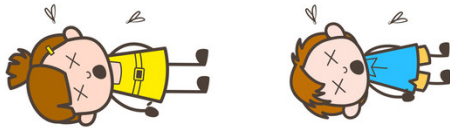
COFFEE: 118 cups



ALCOHOL: 13 shots

What is a lethal dose?

- **LD₅₀** refers to the dose of a substance that kills **half the test population** usually within **4 hours**
- Testing is usually done on **animals** that compare well to the **metabolism** of humans
- Expressed in **milligrams** of substance per **kilogram** of body weight



Toxicity Classification

| LD ₅₀ (rat, oral) | Correlation to Ingestion by 150-lb Adult Human | Toxicity |
|------------------------------|--|----------------------|
| <1 mg/kg | A taste to a drop | Extreme |
| 1-50 mg/kg | To a teaspoon | High |
| 50-500 mg/kg | To an ounce | Moderate |
| 500-5,000 mg/kg | To a pint | Slight |
| 5-15 g/kg | To a quart | Practically nontoxic |
| Over 15 g/kg | More than 1 quart | Relatively harmless |

Intoxicant vs. Poison

- **Intoxicant:**
 - Requires a **large** amount to be ingested to be lethal
 - Example: **alcohol, carbon monoxide**
- **Poison:**
 - Requires a **very small** amount to be ingested to be lethal
 - Example: **cyanide**



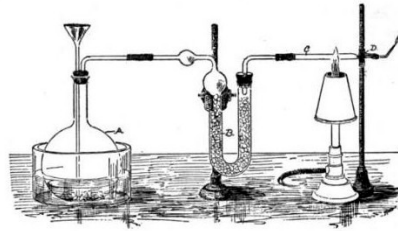
The Father of Toxicology

- Mathieu Orfila
- Studied mostly **arsenic** (the poison of choice in the 1800's)
- Found in **rat poison** – favorite murder method of the poor



The Marsh Test

- A test developed in **1836** by James Marsh that was very sensitive for detecting **arsenic**
- Not used much anymore because of technological advancements



POISON CHEMISTRY - WHITE ARSENIC

Arsenic is a notorious poison; colourless, odourless white arsenic was a popular choice for poisoners, and was commonly known as 'The King of Poisons'.

| HISTORY | As ₂ O ₃ ARSENIC (III) OXIDE | TREATMENT |
|---|--|---|
| <p>White arsenic has been known for centuries. In Ancient Rome, Nero's supposed use of it to poison his brother & become emperor is one of the first documented cases.</p> <p>In the 17th & 18th centuries, white arsenic's use as a poison was widespread, and earned it the nickname 'inheritance powder'. However, its usage as a poison rapidly declined after the development of chemical tests.</p> <p>Around 50,000 tonnes of arsenic trioxide are still produced annually, and used as a precursor to a range of compounds. It's also been used as a treatment for some leukaemias.</p> | <p>ARSENIC (III) OXIDE</p> <p>MEDIAN LETHAL DOSE: 15.1mg/kg</p> | <p>TREATMENT</p> <p>CHELATING AGENTS: DIMERCAPROL, DIMERCAPTOSUCCINIC ACID</p> <p>Chelating agents, such as the above compounds, bind the arsenic ions and prevent them from inhibiting enzymes. However, chelation therapy itself can have side effects. Dimercaprol has been largely superseded by 2,3-dimercapto-1-propanesulfonic acid.</p> |
| <p>EFFECTS</p> <p>HEADACHE, DISCOLORATION OF NAILS, SWELLING & PAINFUL BITE, SILVER SMELLS OF URINE, STOMACH PAIN & VOMITING, TAP WORMS, CONVULSIONS, CONVULSIONS, COMA & DEATH</p> | | <p>DETECTION</p> <p>SAMPLE, ZINC & SULFURIC ACID</p> <p>HEAT</p> <p>SILVER-BLACK RESIDUE FORMS</p> <p>The Marsh Test involves reaction of a sample with zinc and acid. If arsenic is present, it is converted to arsine gas. Heating arsine decomposes it, a silver-black deposit of arsenic is formed on cooling. Modern spectroscopic methods are now used instead of this test.</p> |
| <p>Symptoms usually appear around 30 minutes after ingestion. Arsenic interferes with cell enzymes, respiration and mitosis. The skin, lungs, kidneys and liver are the major organs affected, with death occurring either from circulatory insufficiency, or liver or kidney failure.</p> <p>© COMPOUND INTEREST 2015 - WWW.COMPOUNDINTEREST.COM Twitter: @compoundchem Facebook: www.facebook.com/compoundchem This graphic is shared under a Creative Commons Attribution-NonCommercial-ShareAlike license.</p> | | |

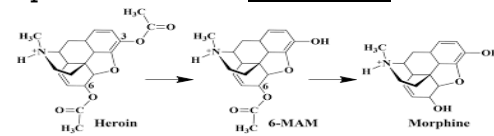
Looking for poison?

- Most poisons **don't visibly change** the body
- The **medical examiner** won't notice poisoning is most cases until **fluids and tissue samples are examined** in the lab



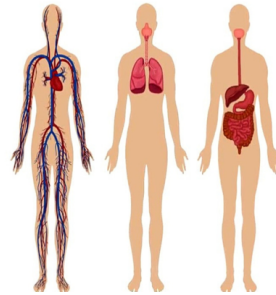
Biotransformation

- The **metabolism or break down** of chemicals by the body in order to **eliminate** it
 - Example: **Heroin**
 - If you look for heroin the the body...good luck finding it
 - Heroin is broken down by the body into **morphine**
 - If you find morphine, you found signs of heroin use
 - The products are called **metabolites**



Where should samples be collected from?

- Where the chemicals **enter**
- Where the chemical **concentrates**
- Along the **route of elimination**



Where do the toxins go?

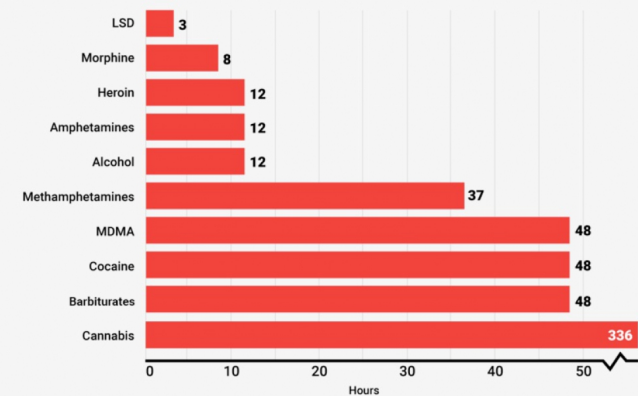
- **Ingested** : Appear in the stomach, intestines, or liver
- **Inhaled (gases)**: concentrated in the lungs
- **Injected (intramuscularly)**: concentrated around the injection site
- **Intravenously**: high concentrations in bloodstream and low concentrations in stomach and liver
 - The drugs **bypass the stomach and liver** as they are directly absorbed into the blood

What is the best sample to search for poisons?

- **Blood**
 - Most useful tool
 - Shows **chemical** and **metabolites**
 - Blood levels show what was going on at the **time of death**



HOW LONG DRUGS STAY IN YOUR BLOOD



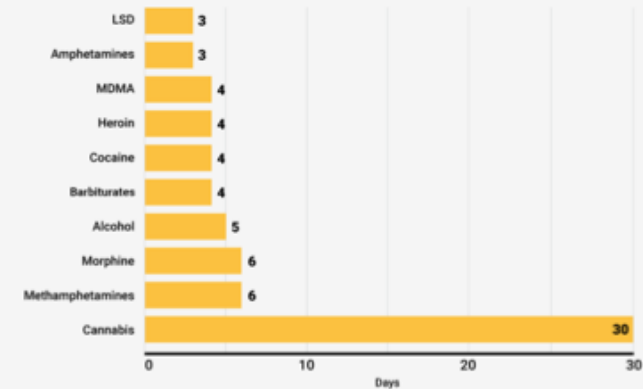
What is the best sample to search for poisons?

• Urine

- **Easy** to obtain
- **High** concentrations
- **Kidneys** are along the **elimination route**
- **Stomach contents**
 - Digestions stops at the **moment of death**



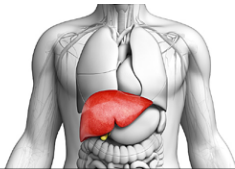
HOW LONG DRUGS STAY IN YOUR URINE



What is the best sample to search for poisons?

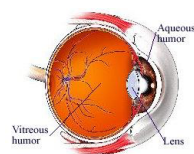
• Liver

- The **toxin sponge** of your body
- Can reflect level of toxins that even the **blood** may not reveal



• Vitreous Humor

- **Eyeball fluid**
- Very slow to decay so it will retain toxins even longer than most other organs



What is the best sample to search for poisons?

• Hair

- Chemicals take about **5 days** to show up in the core of the hair shaft
- **Nature's timeline**



• Insects

- Toxins can accumulate in the bodies of insects that feed off **decomposed bodies**



Determining Manner and Cause of Death

- **Natural:**
 - ex: heart attack
- **Accidental:**
 - ex: children eating random things, mixing dangerous chemicals
- **Suicidal:**
 - ex: CO poisoning, overdose
- **Homicidal:**
 - ex: purposeful tampering, weapons



Symptoms of Poisoning

- **Caustic Poison (lye)**
 - Characteristic burns around the lips and mouth of victim
- **Carbon Monoxide (CO)**
 - Red or pink patches on the chest and thigh
- **Sulfuric acid**
 - Black vomit
- **Hydrochloric acid (HCl)**
 - Greenish-brown vomit



Symptoms of Poisoning

- **Cyanide**
 - Seizures, burnt almond odor
- **Arsenic**
 - Diarrhea, vomiting, blood in the urine, cramping muscles, stomach pain, and convulsions
- **Methyl (wood) or isopropyl (rubbing) alcohol**
 - Nausea and vomiting, unconsciousness possibly blindness



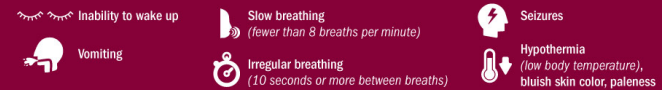
Alcohol

- One of the **most commonly** abused drug
- **Blood-alcohol levels (BAC)** are directly proportional to the degree of intoxication
- Expressed in **grams percent** (# grams of alcohol/100 mL blood)
- Acts on **central nervous system** favoring the brain
- Blood carries alcohol to all cells in the body, but mostly the **watery areas** of your body

Alcohol Absorption

- Alcohol is absorbed through the **stomach and the small intestines**
- The **rate** of absorption depends on
 - Total time to **consume**
 - Alcoholic **content**
 - **Amount** consumed
 - Body **weight**
 - Stomach **contents**

Life-threatening signs of alcohol poisoning include:



What is a “standard drink” in the US?



SOURCE: National Institute for Alcohol Abuse and Alcoholism.

Presumptive Tests - Alcohol

- **Breathalyzer**
- **Field sobriety**
 - Nystagmus
 - Pupil dilation
 - Walk and turn (heel to toe)
 - One leg standing (and counting)
 - Finger to nose
- Each which listening to instructions



Alcohol and the Law

- You may think that giving into a breathalyzer test violates your Fifth Amendment but you are not testifying against yourself.
- Giving physical evidence such as blood samples, physical measurements, photographs and fingerprints are not viewed as self-incriminating.

Other Common Poisons

- **Cyanide:**
 - One of the most lethal chemicals known
 - Used for execution
 - Causes a bright cherry red blood
- **Strychnine**
 - Rat poisons
 - Causes so much pain that it is rarely used in suicide
- **Ethylene glycol**
 - Antifreeze
 - a favorite (deadly) beverage among alcoholics when they can't get ethanol



Other Common Poisons

- **Heavy metals:**
 - Arsenic, mercury and lead
- **Insulin:**
 - lifesaving for diabetics but deadly overdoses
- **Corrosive chemicals:**
 - Strong alkalis (Iye...NaOH) (bases)
 - Acids (HCl, H₂SO₄)
 - burn the mouth, esophagus, and stomach

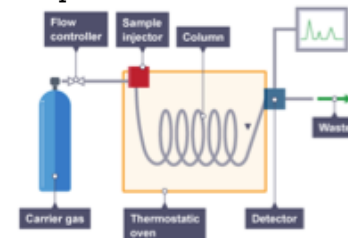


Presumptive Tests for Poisons and Intoxicants

- **Marquis test** – opium and derivatives
- **Duquenois-Levine test** – Marijuana (THC)
- **Van Urk test** – LSD
- **Scott test** – Cocaine
- **Dillie-Koppanyi test** – Barbituates
- *** These are all color changing tests for detection.

The Confirmatory Tests

- **Gas chromatography** is by far the **most widely used confirmatory test** for toxins and poisons.
- **Mass spectrometry** is next



Gas Chromatography

- The GC separates the sample into its components, while the MS represents a unique “fingerprint” pattern that can be used for identification.
- Once the drug is extracted and identified, the toxicologist may be required to provide an opinion on the drug’s effect on an individual’s natural performance or physical state.

