5 minute assignment

• Get together w/ your small group.
• Find one interesting fact and make one model (using props or people) for the following:
  – Group 1: CO poisoning
  – Group 2: Flouroacetic acid poisoning
  – Group 3: Botulin toxin
  – Group 4: Lead poisoning
Pufferfish: also called fugu, globefish, blowfish, or swellfish. Its liver and ovaries produce tetrodotoxin (>10 times toxic as CN).
Pufferfish: Japanese Roulette

Anhydrotetrodotoxin 4-epitetrodotoxin
Police: Student died from 'water intoxication'

CHICO, California (AP) -- A California State University student died of "water intoxication" during hazing in the basement of a fraternity, authorities said Thursday.

Matthew Carrington, 21, died early Wednesday while drinking water from a five-gallon jug and doing exercises at the Chi Tau house near the Chico campus, said Chico Police Sgt. Dave Barrow.

An autopsy showed death was triggered by hyponatremia, a condition in which excess water in the body causes sodium levels in the blood to drop. Water is then absorbed into the blood and fluid builds up in the brain.

Matthew Carrington
All things can be poisons

The effect of copper ions on the height of oat seedlings

It depends on: dosage, individual health, and way of administration
Dose Response: Essential Elements

- Positive
- Negative
- State of health
- Deficiency symptoms
- Death

Concentration (dose)
Dose Response: Non-essential Elements

![Graph showing dose response for non-essential elements with positive and negative effects within a tolerance region. The x-axis represents concentration, and the y-axis represents physiological effect.]
Different Types of Poisons

Corrosive poisons:
- Strong Acids
- Strong bases
- Oxidizing Agents

Poisons affecting oxygen transport and oxidative processes:
- CO (blood agents)
- Nitrate (blood agents)
- CN

Chemical mimics of metabolic pathways
- Fluoroacetic acid

Heavy metal poisons
- Pb, Hg, and Cd

Nerve Poisons
- Botulin, atropine, organophosphorus compounds, etc.
Corrosive poisons:

1. Strong Acids and 2. bases:

2. Oxidizing Agents:

Treatment: Wash with large amount of water; Administer reducing agents (vitamin C)
Poisons affecting oxygen transport and oxidative processes

CO: binds and inactivates hemoglobin and myoglobin

Heme Normal binding affinity: CO/O₂: ~28,000
Heme Binding affinity in Mb: CO/O₂: ~28

Treatment: transport patients to air-circulating place
Poisons affecting oxygen transport and oxidative processes

Nitrate (NO$_3^-$): involved in oxidation of hemoglobin to methemoglobin

Hemoglobin/myoglobin (Fe$^{2+}$): can bind O$_2$ (bright red)
Methemoglobin/metmyoglobin (Fe$^{3+}$): cannot bind O$_2$ (brown)
(methemoglobinemia, blue baby syndrome)
Poisons affecting oxygen transport and activation processes

CN: binds and inactivates Cytochrome oxidase

Treatment:

\[ \text{Cyanide ion} \quad \text{CN}^- (aq) \quad + \quad \text{Thiosulfate ion} \quad \text{S}_2\text{O}_3^{2-} (aq) \rightarrow \quad \text{Thiocyanate ion} \quad \text{SCN}^- (aq) \quad + \quad \text{Sulfite ion} \quad \text{SO}_3^{2-} (aq) \]
Chemical mimics of metabolic pathways

**Fluoroacetic acid: blocks citric acid cycle**

**Normal physiological process:**
acetic acid $\rightarrow$ citric acid $\rightarrow$

**Altered physiological process:**
fluoroacetic acid $\rightarrow$ fluorocitric acid $\rightarrow$
(harmless) $\rightarrow$ (toxic)
Heavy Metal Poisons: Pb

- Lead poisoning affects ~ 890,000 pre-school aged children in the US each year
- Source: leaded paint, gasoline, etc.
- Lead is a persistent pollutant
- Lead toxic effects are irreversible in children

<table>
<thead>
<tr>
<th>BPb &gt; 100 ppb (0.5 μM)</th>
<th>BPb &gt; 550 ppb (2.7 μM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IQ/brain development</td>
<td>anemia</td>
</tr>
<tr>
<td>behavioral disorders</td>
<td>seizures</td>
</tr>
<tr>
<td>impaired hearing</td>
<td>brain damage</td>
</tr>
<tr>
<td>deficient fine motor control</td>
<td>kidney failure</td>
</tr>
<tr>
<td>short stature</td>
<td>neurological problems</td>
</tr>
<tr>
<td></td>
<td>death</td>
</tr>
</tbody>
</table>
**Heavy Metal Poisons: Hg, Cd**

**Hg:**
- Only common metal that is in a liquid form
- Hg vapor is much more toxic than its metallic form
- Methyl mercury is the most toxic form
- Fish in lake has increasing amount of Hg
- Hg poison is cumulative ($t_{1/2} \approx 70$ days)
- Toxic effect: retardation and death

**Cd:**
- Cd poisoning leads to loss of calcium
  - Affect bones, leading them brittle and easily broken
  - Cause severe abdominal pain, vomiting, diarrhea, and a choking sensation
- A notable case occurred in upper Zintsu River in Japan (itai-itai, or the “ouch-ouch” disease).
Heavy Metal Poisons

Pb, Hg, and Cd: Exact mechanism not well known, most likely by inactivating proteins/enzymes
Heavy Metal Poison Treatments

Using Chelaters:

- **EDTA**
  - ethylenediaminetetraacetic acid

- **BAI**
  - British Anti Lewisite

- **Lead--EDTA complex**

- **Mercury atom chelated by two BAI molecules**
Nerve system and some diseases

Bipolar (manic-depressive) disorder (too many receptors)

 آلزهای默症 (Alzheimer's disease) (deficient in acetylase)

Acetylcholine (acetylase)

Presynaptic cell

Acetylcholine formed

Incoming impulse

Nerve ending

Outgoing impulse

Receptor cell

Acetylcholine hydrolyzed (cholinesterase)

Alzheimer's diseases (deficient in acetylase)

\[
\text{Acetylcholine} \rightarrow \text{Acetylcholinesterase} \rightarrow \text{Acetic acid} + \text{Choline}
\]
Nerve system and nerve poisons

Nerve ending

Incoming impulse

Acetylcholine migrates to receptor

Outgoing impulse

Atropine (blocks receptor sites)

Presynaptic cell

Acetylcholine formed (acetylase)

Botulin toxins (blocks syn. of acetylcholine)

Choline + acetic acid

Receptor cell

Acetylcholine hydrolyzed (cholinesterase)

Organic phosphorous insecticides (blocks function of cholinesterase)

Acetylcholine

\[
\text{CH}_3\text{COCH}_2\text{CH}_2\text{N}^+\text{CH}_3 + \text{H}_2\text{O} \xrightarrow{\text{acetylcholinesterase}} \text{CH}_3\text{C}\text{OH} + \text{HOCH}_2\text{CH}_2\text{N}^+\text{CH}_3
\]

Acetic acid

Choline
How Botox Works

Botox blocks acetylcholine release, muscle contraction, and wrinkles.

In the nerve endings, acetylcholine is released, muscle contracts, and frown lines form.
**Measuring Toxicity: LD$_{50}$**

LD$_{50}$ values for selected common substances

<table>
<thead>
<tr>
<th>Substance</th>
<th>Test Animals</th>
<th>LD$_{50}$ (g/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethyl alcohol</td>
<td>Rat</td>
<td>10.3</td>
</tr>
<tr>
<td>Vitamin B$_1$</td>
<td>Mouse</td>
<td>8.2</td>
</tr>
<tr>
<td>NaCl</td>
<td>Rat</td>
<td>3.75</td>
</tr>
<tr>
<td>Aspirin</td>
<td>Mouse</td>
<td>1.5</td>
</tr>
<tr>
<td>Acetaminophen</td>
<td>Mouse</td>
<td>0.34</td>
</tr>
<tr>
<td>Nicotine</td>
<td>Mouse</td>
<td>0.23</td>
</tr>
<tr>
<td>Caffeine</td>
<td>Mouse</td>
<td>0.13</td>
</tr>
</tbody>
</table>

LD$_{50}$ (Lethal Dose for 50%): dosage that kills 50% of a population of test animals
Measuring Toxicity: $LD_{50}$

$LD_{50}$ values for selected Lethal poisons

<table>
<thead>
<tr>
<th>Substance</th>
<th>$LD_{50}$ (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NaCN</td>
<td>15</td>
</tr>
<tr>
<td>$As_2O_3$</td>
<td>15</td>
</tr>
<tr>
<td>Aflatoxin B</td>
<td>10</td>
</tr>
<tr>
<td>Rotenone</td>
<td>3</td>
</tr>
<tr>
<td>Strychnine</td>
<td>0.5</td>
</tr>
<tr>
<td>Muscarine</td>
<td>0.2</td>
</tr>
<tr>
<td>Tetanus toxin</td>
<td>0.0000005</td>
</tr>
<tr>
<td>Botulin toxin</td>
<td>0.0000003</td>
</tr>
</tbody>
</table>
Our Liver: A Detoxification Facility

CH₃CH₂OH → CH₃C=H → CH₃C=OH → CO₂ + H₂O

Nicotine → Cotinine

Toluene → oxidation → Benzoic acid → (Glycine) → Hippuric acid

Benefit effect: coverts toxic chemicals into less toxic or more water soluble chemicals for excretions