Chapter 9 Forensic Toxicology

By the end of this chapter you will be able to:

9.1 Provide examples of drugs, poisons, and toxins.
9.2 List factors that affect drug toxicity.
9.3 Describe the role of a toxicologist in analyzing substance evidence.
9.4 Compare and contrast presumptive testing and confirmatory testing.
Chapter 9 *Forensic Toxicology*

By the end of this chapter you will be able to:

9.5 Describe how people get exposed to environmental toxins (e.g., pesticides, carbon monoxide), and describe their effects on the body.

9.6 Distinguish among the terms tolerance, addiction, dependence, and withdrawal.

9.7 Relate the signs and symptoms of overdose with a specific substance or combination of substances.

9.8 Show the relationships between the law, crime, and the use of drugs.
Chapter 9
Vocabulary

- addiction
- controlled substance
- Controlled Substances Act
- dependency
- depressant
- hallucinogen
- illegal drug
- narcotic
- poison
- stimulant
- tolerance
- toxicity
- toxicology
- toxin
Introduction

- Toxicology is the study of substances that can harm a person.
  - Poisons
  - Toxins
- A person may be exposed to a substance in any of the ways below:
  - Intentionally
  - Accidentally

The only way toxicology would come into play in the workplace is through drug testing.
Brief History of Forensic Toxicology

- Socrates is one of the earliest reported victims of poisoning (Hemlock, 399 B.C.)
- By the 1600s, poisoning had become a profession.
- During the 1800s, methods of chemical analysis were developed to identify poisons.
- In 1980, standardized techniques and testing were developed to help determine the cause of death.
Brief History of Forensic Toxicology (continued)

- In 1959, the FDA was formed.
- In 1970, Congress passed the Controlled Substances Act.
- Today, less than one-half of one percent of all homicides result from poisoning.
- Mathieu Orfila is known as the father of toxicology. (1787-1853)
Brief History of Forensic Toxicology (continued)

- In 1978, Bulgarian dissident Georgi Markov was stabbed in the leg with an umbrella armed with a ricin toxin.
What does LD mean in toxicology?

- Lethal dose
Evidence Detection, Collection, and Storage

- Evidence may be in the form of:
  - Pills, powders, liquids
  - Botanical matter (seeds, leaves, mushrooms)
  - Crystals (methamphetamine)
  - Evidence found on clothing, objects, or liquid soaked fabrics
  - Urine, blood, sweat, or saliva

- Correct packaging of the evidence is important to preserve the evidence and to protect individuals working with the evidence.
Evidence Testing and Reporting of Drugs, Poisons and Toxins

- A toxicologist needs to answer three basic questions:
  1. What substances are there? (qualitative testing)
  2. Might there be any illegal components?
  3. How much of each substance is present? (quantitative testing)
- Presumptive testing may be performed at the crime scene.
- Postmortem fluid concentrations will be done at the crime scene for comparison to levels at the lab. (Some fluids may dissipate if it is present for too long.)
Evidence Testing and Reporting of Drugs, Poisons and Toxins (continued)

- Confirmatory testing is a multistep process that provides a positive identification of the substance.
- Toxicologists must also distinguish between:
  - Acute poisoning
  - Chronic poisoning
What to look for in a forensic autopsy when poison is suspect:

- Irritated tissues
- Characteristic odors
- Mees lines

These lines appear after an episode of poisoning with arsenic, thallium or other heavy metals, and can also appear if the subject is suffering from renal failure. They have been observed in chemotherapy patients.
Human specimens taken for analysis when looking for poison:

- Blood
- Urine
- Brain tissue
Heavy Metals, Gases, Poisons, and Toxins

### Figure 9-4 Heavy metals with typical symptoms of overexposure.

<table>
<thead>
<tr>
<th>Heavy Metal</th>
<th>Source</th>
<th>Symptoms of Overexposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>Naturally occurring element, additive to gas and older paints, weights, bullets</td>
<td>Nausea, abdominal pain, insomnia, headache, weight loss, constipation, anemia, kidney problems, vomiting, seizure, coma, and death. Blue discoloration appears along the gum line in the mouth.</td>
</tr>
<tr>
<td>Mercury</td>
<td>Ingested in fish, coal-fired power plant pollutant</td>
<td>Mad Hatter’s Disease (hat makers in England used a mercury compound), a progressive disorder; acute poisoning from inhalation causes flu-like symptoms such as muscle aches and stomach upset. Chronic poisoning causes irritability, personality changes, headache, memory and balance problems, abdominal pain, nausea, and vomiting; excessive salivation and damage to the gums, mouth, and teeth. Long-term exposure can cause death.</td>
</tr>
<tr>
<td>Arsenic</td>
<td>Naturally occurring element In groundwater</td>
<td>Profound acute exposure quickly produces severe gastrointestinal symptoms, difficulty speaking, muscle cramps, convulsions, kidney failure, delirium, and death. Lesser chronic exposure produces skin lesions and changes in pigment, headache, personality changes, and eventually coma.</td>
</tr>
</tbody>
</table>
Lethal Gases and Lethal Injections

- Lethal gas chambers
  - Nazis during World War II
  - Carbon monoxide from engine exhaust and hydrogen cyanide
  - Cyanide smells like burnt almonds

- American penal systems
  - Hydrogen cyanide

- Carbon monoxide gas - Shows up as a red or pink patches on the chest and thigh.

- Injections of potassium chloride or sodium pentothal
## Pesticides and Herbicides

**Figure 9-5** Common pesticides with symptoms of overexposure

<table>
<thead>
<tr>
<th>Pesticides or Herbicides</th>
<th>Symptoms of Overexposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aldrin, Dieldrin (Pesticides)</td>
<td>Anxiety, seizures, twitching, rapid heartbeat, muscle weakness, sweating, excessive salivation, diarrhea, coma, death</td>
</tr>
<tr>
<td>Glyphosate Mixture (Herbicide)</td>
<td>Ranges from gastrointestinal problems, skin and eye irritation, kidney malfunction, to death</td>
</tr>
</tbody>
</table>
Toxins

- Toxins may be produced by plants or animals.
  - Ricin (Castor bean)
  - Rattlesnake venom

Figure 9-6  Some snake venoms are deadly toxins.
Drugs and Crime

- Almost half of the individuals in federal prisons are there because of drug-related offenses.

- More than $600 billion is spent annually on costs related to crime, lost work productivity, and healthcare because of drug abuse.

- Continued use of a drug can lead to addiction and dependency.
Five Schedules of Drugs

- **Schedule I**
  - No medical use, high potential for abuse
  - Ex: Heroine, LSD, peyote, MDMA, bath salts

- **Schedule II**
  - Severely restricted medical use, high potential for abuse
  - Ex: Cocaine, methamphetamine, methadone, oxycodone

- **Schedule III**
  - Accepted medical use, moderate potential for abuse, moderate to low risk of dependence
  - Ex: Barbiturates, steroids, ketamine
Five Schedules of Drugs (continued)

- **Schedule IV**
  - Medical use, low potential for abuse and the risk of dependency
  - Ex: Xanax, Valium, sleeping pills, other tranquilizers

- **Schedule V**
  - Widely used for medical purposes, very low potential for abuse, contains limited quantities of narcotics
  - Ex: Robitussin® AC, Tylenol® with codeine
Illegal Drugs

- Hallucinogens
  - Affect perception, thinking, self-awareness, and emotions
  - Flashbacks may occur long after the drugs wear off

- Heroine
  - Narcotics are addictive, sleep inducing drugs that act as central nervous system depressants and suppress pain.
  - Highly addictive

- Combining drugs, such as heroin and alcohol, can be fatal.
### Illegal Drugs (continued)

**Figure 9-8** *Table of hallucinogenic drugs and characteristic symptoms of overdose*

<table>
<thead>
<tr>
<th>Drug</th>
<th>Source</th>
<th>Characteristics of Overdose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mescaline</td>
<td>Cactus Peyote</td>
<td>Dizziness, vomiting, diarrhea, headaches, anxiety, irrational thoughts</td>
</tr>
<tr>
<td>LSD</td>
<td>Rye fungus</td>
<td>Dilated pupils, loss of appetite, sleeplessness, increase in body temperature, sweating, confusion</td>
</tr>
<tr>
<td>Psilocybin</td>
<td>Mushroom</td>
<td>Altered perceptions, panic, paranoia, confusion</td>
</tr>
<tr>
<td>Marijuana</td>
<td>Plant</td>
<td>Heightened sensory perceptions, impaired memory, judgment</td>
</tr>
<tr>
<td>Synthetic Marijuana (Spice)</td>
<td>Herbs sprayed with synthetic THC</td>
<td>Similar to marijuana but variable because of variable levels of active ingredient</td>
</tr>
<tr>
<td>PCP (Angel Dust)</td>
<td>Synthetic</td>
<td>Feelings of invulnerability and exaggerated strength, seizures, coma, hyperthermia</td>
</tr>
<tr>
<td>MDMA (Ecstasy)</td>
<td>Synthetic</td>
<td>Euphoria, increased energy, empathy, sweating, impaired cognition and motor function, irritability, anxiety</td>
</tr>
</tbody>
</table>
Controlled Substances

- Stimulants
- Narcotics
- Depressants

**Figure 9-7**
Marijuana is a Schedule I substance, although its medical use is legal in several states, and its recreational use is no longer a crime in a few others.
Alcohol

- Alcohol is a central nervous system depressant.
- The amount of alcohol in a beverage is expressed as a percentage by volume or in proof, which is twice the percentage.
- A liquor that is 80 proof contains 40% alcohol.
- Someone with a blood alcohol concentration of .15 percent will retain alcohol in his or her body for approximately 10 hours.
- It takes 30-90 minutes for alcohol to be fully absorbed.
- Isopropyl alcohol poisoning causes nausea and vomiting, unconsciousness and possible blindness. (Rubbing alcohol)

- Ethyl alcohol is colorless or clear. This is drinking alcohol. (Also called ethanol)
### Alcohol

#### General Information

- Alcohol is the most abused drug in America.
- 40% of all traffic deaths are alcohol related.
- Detoxification: the process of removing toxic substances or qualities.
- 90% of detoxification of alcohol takes place in the liver.

#### BAC

- BAC stands for blood alcohol content.
- BAC is influenced by:
  1. Alcohol content of the beverage
  2. Body weight
  3. Number of drinks consumed
  4. Quantity and type of food present.
  5. Time passed between drinking.
Alcohol continued:

- Legal limit for DUI in Georgia for someone under the age of 21 is 0.04.
- The legal limit for DUI in Georgia for someone 21 years or older is 0.08 unless they are involved in an accident; then the limit of DUI is 0.04.
Henry’s Law

- Law that states there is a fixed ratio between the concentration of alcohol in the blood and the air.

- This is the basis for a “breathalyzer test”.
  - Breath analyzers do not directly measure blood alcohol content or concentration, which requires the analysis of a blood sample. Instead, they estimate BAC indirectly by measuring the amount of alcohol in one's breath. (They measure the alcohol content of alveolar breath.)
False Positive

- A chemical known as acetone in diabetics can give a false positive for alcohol during a breathalyzer.
The Horizontal Gaze Nystagmus Test, or the HGN evaluation, is a field sobriety test that is often used by police force.

It uses the involuntary jerking or twitch of one's eye when it gazes to the side at an angle more than 45 degrees. Since this jerking becomes exaggerated by alcohol consumption, it is used as evidence of impairment in DUI cases.
Anabolic Steroids

- Anabolic steroids promote cell and tissue growth and division.
  - They have a chemical structure similar to testosterone.

- Negative side effects may include:
  - Acne, increased body hair, and baldness
  - Increased aggression, high blood pressure, high cholesterol levels, impaired fertility in males, blood clotting, kidney and liver cancers, and heart attacks
Chemicals in the Workplace

- **OSHA**: is responsible for monitoring exposure to chemicals in the work place. (Occupational Safety and Health Administration)
- **EPA**: Works on agricultural and industrial chemicals released into the Environment. Environmental Protection Agency
- **FDA**: Approves new pharmaceuticals. (Food and Drug Administration)
What group watches over the shipment of toxic chemicals?

- DOT: Department of Transportation.
- The only time toxicology would come into play in the workplace would be drug testing.
Summary

- Toxicology is the study of poisons, toxins, drugs, and other substances a person may use for medical, recreational, or criminal purposes. Forensic toxicologists study the harmful effects of these substances on the body, typically after a death.

- The toxicity of a substance depends on the dose, the duration of exposure, the nature of exposure, interactions with other substances, and the byproducts formed when metabolized.
Exposure to heavy metals, poison gases, other poisons, toxins, or radiation may occur accidentally or as a result of a crime (or punishment) and have harmful or lethal effects on the body.

Drugs are classified by their effect on the body as stimulants, depressants, narcotics, hallucinogens, or anabolic steroids; drugs are classified under five schedules created by the 1970 Controlled Substances Act.
Use of drugs can affect a person’s health, mood, awareness, metabolism, and/or perception of reality.

Extended exposure to drugs can lead to tolerance, dependence, addiction, and illness.

Drug combinations can have compounding effects and result in accidental death.