

Introduction to Toxicology

Course

Pathophysiology

Unit V

*Process of
Pathology*

**Essential
Question**

*How do poisons
work?*

TEKS

*130.206(c)
2B,2C,2G,2H
6A,6B
10A,10B,10C,
10D*

**Prior Student
Learning**

*General
Anatomy of the
body.*

Estimated time

3 hours

Rationale

The science of toxicology studies the effects of toxic substances such as drugs, environmental contaminants, and naturally occurring substances in food, water, air and soil. Toxicology is important to protect health and the environment.

Objectives

Upon completion of this lesson, the student will be able to:

- Explain the history of poisons
- Describe the difference between occupational and environmental toxicology
- Define common terms related to toxicology
- Identify fundamental rules of toxicology
- Explain basic concepts of exposure
- Explain how xenobiotics become toxic

Engage

Teacher has the option of engaging students with any of the following:

Ask students what a chemical is and to name some things made of chemicals. List the responses on the board. After generating a list, go through the list with students and identify listings as: synthetic (manmade), natural, toxic, nontoxic, good, or bad. Explain that all substances are made of chemicals. This is an important first step in understanding the science of toxicology.

Key Points**I. History of Poisons****A. 2700 – 800 BC**

Chinese, Egyptians and Hindus documented vast amounts of information related to the collection, preparation and administration of many plants and animals used as medicines and poisons.

B. 50-400 A.D.

1. Greek physicians classified over 600 plant, animal, and mineral poisons.
2. Romans used poisons for executions and assassinations.
3. The philosopher Socrates was poisoned using hemlock for teaching radical ideas to youths.

C. 980-1200 AD

1. In Islamic culture, Avicenna becomes the authority on poisons and antidotes.
2. In Spain, Rabbi Maimonides wrote a first-aid book on poisonings.

D. 1493-1541 AD

Swiss physician Paracelsus is credited with being “the father of modern toxicology”. He introduced the notion that too much of anything, even if it is good for you, can be a bad thing.

E. 1700’s - 1800’s

1. Ramazzini, an Italian physician, first discussed environmental diseases such as those with asthma-like symptoms in laymen workers like bakers, farmers, glass-workers, tanners, millers, grain-sifters and stonecutters.
2. In Spain, toxicology was established as a formal scientific discipline by Dr. Orfila.

F. 20th Century

1. While trying to create different tissue stains and procedures, Dr. Paul Ehrlich found how toxicants affected biological tissues.
2. Rachel Carson alarmed people about dangers of pesticides in the environment.
3. Dr. Alan Scot accidentally invented Botox, a neurotoxin caused by the one of nature’s deadliest bacteria.

II. Toxicology Defined:

- A. Toxicology -- the study of poisons and their mechanism of action
- B. Toxicity -- the adverse effects that a chemical may produce
- C. Dose -- the actual amount of substance introduced into a body
- D. Exposure – contact providing the opportunity of obtaining a poisonous dose
- E. Hazard – the likelihood that the toxicity will be expressed

III. Basics in Toxicology

A. It’s All in the Dose

1. You have heard that too much of a good thing can be bad for you. A normally benign and harmless substance can become toxic at high doses.
2. On the opposite end of the spectrum, highly toxic chemicals can be life-saving when given in small controlled doses.

B. Exposure Concepts – toxic responses may arise from different:

1. Routes of exposure
2. Frequencies of exposure

- 3. Duration of exposure (acute vs. chronic)
- C. Routes of Exposure
 - 1. Ingestion
 - 2. Injection
 - 3. Inhalation
 - 4. Absorption
- D. Duration & Frequency of Exposure are also important components of exposure and contribute to dose.
 - 1. Acute exposure -- less than 24 hours; usually entails a single exposure
 - 2. Subacute – repeat exposure up to a month
 - 3. Subchronic -- repeated exposure up to three months
 - 4. Chronic – repeated exposure for more than three months
- E. Exposure Concepts -- chemicals may come from many sources:
 - 1. Environmental
 - 2. Occupational
 - 3. Therapeutic
 - 4. Dietary
 - 5. Accidental
 - 6. Deliberate
- IV. Xenobiotics
 - A. Defined as foreign chemicals which are synthesized within a living body (*Xeno*- meaning “strange”)
 - B. Many of these poisonous xenobiotics are defense mechanisms used for survival or are simply waste products in chemical form produced by plants, microorganisms, or animals, including humans.
 - 1. Clostridium botulinum – waste product, not bacteria alone causes paralysis; use: Botox for relaxing muscles ; still lethal
 - 2. Clostridium tetani -- spores of bacteria found on rust cause paralysis; uses -- NONE
 - C. Some chemicals are inactive until in the presence of another chemical to make their effects poisonous.
 - D. Xenobiotics may also be produced by humans or bovine such as insulin converted into synthetic form for use
 - E. Ancient plant Xenobiotics: digitalis for heart problems vs. hemlock for poisoning
- V. Toxicokinetics -- Movement of Poisons
 - A. Distribution -- the movement of poison through different routes
 - B. Metabolism – the breakdown of chemicals from active to inactive forms starting with enzymes in the stomach and then in the liver

C. Elimination -- removal of all by-products of poisons

VI. Influencing factors affecting movement of poisons

A. Different molecular weights

B. Concentration of solutes versus solvent

C. Victim's status of health

VII. Mechanisms of Action for Xenobiotics

A. Sometimes xenobiotics will work better once metabolized and the by-products become the harmful substances

B. Substances work by disrupting normal cell function

1. Denature proteins

2. Cause a defect in DNA

3. Target lipids

VIII. Types of Toxic Effects

A. Death – absence of cell function; causes -- cyanide and arsenic

B. Organ Damage – loss of cellular function causing chronic diseases that have no cure; causes -- lead and ozone exposure

C. Mutagenesis – a process by which the genetic information of an organism is changed, resulting in a mutation. May occur in nature, or as a result of exposure to mutagens; causes -- UV light

D. Carcinogenesis -- process by which normal cells are transformed into cancer cells; causes -- benzene, asbestos

E. Teratogenesis – process by which congenital malformations are produced in an embryo or fetus; cause – thalidomide

IX. Challenges / Potential Dangers in Herbal Medicines

A. Not enough / too much chemical isolated

B. Plant variations leading to poor chemical production

C. Variations in extraction techniques

D. Not endorsed by Food and Drug Administration

1. Growth requirements not standardized as in pharmaceuticals

2. Variations in standards of growth and isolation can affect final prices

X. Occupational Versus Environmental Toxicology

A. Environmental

1. Environmental toxicants -- agents hazardous to air, sea or land and potentially all humans

2. Agents can be naturally occurring and synthetic in nature and BOTH can be just as deadly

- B. Occupational: many examples of diseases are associated with specific occupations
 - 1. Miner's Disease came from inhaling metal vapors, and became foundation for chemotherapy
 - 2. Linked chewing tobacco to cancer
 - 3. Radium dial painters developed masses in mouth when they licked their brushes to make a fine point
 - 4. Chimney sweepers were linked to scrotal cancer
 - 5. Shoe salesmen who used fluoroscopes to take radiographs of client feet for fitting began to develop cancers
- C. High cancer-risk occupations
 - 1. Health care workers
 - 2. Pharmaceutical
 - 3. Laboratory workers
 - 4. Refinery workers
 - 5. Rubber workers
 - 6. Furniture makers
 - 7. Pesticide workers

V. Methods of extracting poisons

- A. Gel-filtration chromatography -- separate particles by size
- B. Ion-Exchange chromatography -- separate particles by charge
- C. Electrophoresis -- separate particles by charge
- D. Affinity chromatography -- dependent on number of hydrogen bonds

Activity

- I. Complete Toxicology Key Term Worksheet.
- II. Read Scenario #1 or Scenario #2 and complete the Disease Report.

Assessment

Disease Report Rubric

Materials

Internet access

For free brochures and videos on poison prevention log on to :

<http://www.poisonprevention.org/materials.htm>

Resources:

Case Studies in Environmental Medicine

<http://wonder.cdc.gov/wonder/prevguid/p0000017/p0000017.asp#head002001000000000>

National Institute of Environmental Health Sciences
<http://www.niehs.nih.gov/>

The Center for Environmental and Rural Health
<http://cerh.tamu.edu/>

Accommodations for Learning Differences

For reinforcement, the student will visit the National Institute of Health website at <http://www.niehs.nih.gov/health/scied/scientists/index.cfm> to complete the “Name That Poison” activity.

For enrichment, the student will research and report on one herbal remedy that could have both beneficial and toxic effects. Describe its uses and list the negative effects.

National and State Education Standards National Health Science Cluster Standards

HLC01.01 Academic Foundations

Health care workers will know the academic subject matter required in their area. They will use this knowledge as needed in their role.

HLC10.01 Technical Skills

Health Care Workers will apply technical skills required for all career specialties. They will demonstrate skills and knowledge as appropriate.

TEKS

130.206 (c)(2)(A) know the definition of science and understand that it has limitations, as specified in subsection (b)(2) of this section;

130.206 (c)(2)(B) know that hypotheses are tentative and testable statements that must be capable of being supported, or not supported, by observational evidence. Hypotheses of durable explanatory power which have been tested over a wide variety of conditions are incorporated into theories;

130.206 (c)(2)(C) know scientific theories are based on natural and physical phenomena and are capable of being tested by multiple independent researchers. Unlike hypotheses, scientific theories are well-established and highly-reliable explanations, but they may be subject to change as new areas of science and new technologies are developed;

130.206 (c)(2)(D) distinguish between scientific hypotheses and scientific theories;

130.206 (c)(3)(A) in all fields of science, analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking by the student;

130.206 (c)(4)(C) analyze the effects of energy deficiencies in mal-absorption disorders such as diabetes, hypothyroidism, and Crohn's.

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Texas College and Career Readiness Standards**English Language Arts**

II. B. Understand new vocabulary and concepts and use them accurately in Reading, writing and speaking.

III. B. Develop effective speaking styles for both group and one-on-one situations.

IV. A. Apply listening skills as an individual and as a member of a group in a variety of settings.

IV. B. 2. Listen actively and effectively in one-on-one communication situations.

Science

1.E.1. Use several modes of expression to describe or characterize natural patterns and phenomena. These modes of expression include narrative, numerical, graphical, pictorial, symbolic, and kinesthetic.

1.E.2. Use essential vocabulary of the discipline being studied.

3.A.1. Use correct applications of writing practices in scientific communication.

Toxicology Key Terms

A. Absorption	
B. Acute	
C. Bacteriotoxins	
D. Carcinogenesis	
E. Dose	
F. Duration	
G. Exposure	
H. Excretion	
I. Frequency	
J. Hazard	
K. Ingestion	
L. Injection	
M. Inhalation	
N. Metabolism	
O. Mutagenesis	
P. Phytotoxins	
Q. Redistribution	
R. Route	
S. Subacute	
T. Susceptibility	
U. Teratogenesis	

V. Toxicant	
W. Toxicity	
X. Toxicology	
Y. Toxicokinetics	
Z. Toxin	
AA. Xenobiotics	
BB. Zootoxins	

Toxicology Key Terms

Absorption	Introduction of poison across the skin through the body's pores
Acute	A short and severe episode of occurrence
Bacteriotoxins	Poison produced by bacteria
Carcinogenesis	The origin of a cancer
Dose	The amount of chemical that will reach the target site
Duration	The length of time exposed to a poison
Exposure	The condition of being vulnerable to having something influence or cause an effect
Excretion	The process of being eliminated or evacuated from the body
Frequency	The number of times a subject has been exposed to a poison within a given time
Hazard	Something that causes risk or danger
Ingestion	Swallowing poison
Injection	Introducing poison through breaking the skin
Inhalation	Introduction of poison through breathing
Metabolism	The process of changing an agent into by-products
Mutagenesis	The origin of something mutant
Phytotoxins	Poison produced by plants
Distribution	The state or manner in which an agent is being distributed again in the body
Route	The passage in which a poisonous substance is able to get into the body to cause damage
Subacute	A moderately severe episode of occurrence
Susceptibility	To have the tendency to be more exposed
Teratogenesis	The development of malformations in an embryo or fetus

Toxicant	The specific poisonous chemical
Toxicity	A specific degree the dangerous substance is to a subject
Toxicology	The study of the effects of poisons
Toxicokinetics	The movement of poisons within the body
Toxin	A poisonous substance
Xenobiotics	Foreign to the body
Zootoxins	Poisons produced by animals

Scenario #1

Ethan is a 6 year-old boy who lives with his mother, father, and 8 year-old sister Janie. A week before Thanksgiving, Ethan found a bottle of ammonia under the kitchen sink while his mother was cleaning the floor. He decided he would see what this tasted like. About one hour later, Ethan finally told his mother he drank something strange when he could no longer handle the burning in his throat and chest. His mother rushed him to the emergency room.

Ethan arrived at the ER with burning in his mouth, throat and chest; decreased oral intake; wet cough; had washed his mouth with water; no vomiting, abdominal pain, stridor. His mother stated he has asthma. On examination, Ethan was in respiratory distress, acyanotic, not drooling. His vitals were T=101.5F; PR150/min. RR 34/min; O2 sat. 96%. The mouth showed signs of erosion on tongue and posterior oropharynx; hyperemia of tonsils.

The ER doctor started IV fluid and called a specialist. The specialist started Hydrocortisone 50mg IV and a rigid esophagoscopy: 'slough' at the base of the tongue, posterior pharyngeal wall hyperemia.

Ethan was discharged one day later on steroids and antibiotics. A week later at a follow-up visit with his doctor he was doing well.

Scenario #2

Jason, a 5-year-old boy is brought to your office by his mother, who is concerned that he is hyperactive. At a parent teacher conference last week, his kindergarten teacher said that Jason seems impulsive and has trouble concentrating, and recommended evaluation by a physician. His mother states that he has always seemed restless and easily distracted, but that these first 6 months in kindergarten have been challenging.

Jason lives with his mother, sister, and maternal grandparents in an older suburb of the community. Jason's monthly weekend visits to his father's house are working out fine. However, he seems to be fighting more with his sister, who has an attention-deficit disorder and is repeating first grade. Since his mother moved in with her parents after her divorce 4 years ago, she has worked with her father in an automobile radiator repair shop, where her children often come to play after school. She worries about her father, Jason's grandfather, who has gout and complains increasingly of abdominal pain.

On chart review, you see that Jason was last seen in your office for his preschool physical 1 year ago; results were normal. A note describes a very active 4-year-old who could dress himself without help but could not correctly name the primary colors. His vision was normal, but hearing acuity was below normal, and speech and language were slightly delayed. Immunizations are up to date.

Further history on that visit indicated adequate diet. At that visit he was found to have "mild iron deficiency anemia," and iron therapy was prescribed. The child completed the prescribed 3-month course of iron supplements. He is taking no medications at this time and has no known allergies.

On physical examination today, you note that Jason is in the tenth percentile for height and weight. His attention span is very short, making him appear restless, and he has difficulty following simple instructions. Except for language and social skills, he has reached most important developmental milestones.

Adapted from <http://www.atsdr.cdc.gov/csem/lead/docs/lead.pdf>
1/8/2014

Disease Report

Disease
Alternate Names
Definition
Etiology
Signs & Symptoms
Diagnostic Tests
Treatment
Complications
Prognosis
Bibliography

Disease Report Rubric

Criteria	Possible Points	Points Awarded
Disease Correctly names the disease.	3	
Alternate Names If applicable, includes any alternate names for the disease/disorder.	2	
Definition Includes in-depth discussion of the history and general description of the disease with interesting facts.	10	
Etiology Includes the cause or origin of the disease/disorder.	15	
Signs & Symptoms Accurately describes common physical and medical symptoms.	15	
Diagnostic Tests Identifies tests performed to aid in the diagnosis or detection of disease/disorder.	15	
Treatment Identifies the mode or course pursued for remedial ends for the disease/disorder.	15	
Complications Identifies any diseases or injuries that may develop during the treatment of the disease/disorder.	10	
Prognosis Includes the prediction of the probable course, outcome, frequency, and life expectancy of the disease/disorder.	10	
Bibliography Follows proper format and includes more than 3 sources.	5	
TOTAL	100	