Course Learning Outcomes for Unit II

Upon completion of this unit, students should be able to:

6. Evaluate the effects of toxins on target organs of the body.
   6.1 Identify the factors that modify toxicity.
   6.2 Discuss the beneficial applications of toxins.

Course/Unit Learning Outcomes	Learning Activity
6.1	Unit Lesson, Unit Reading
6.2	Unit Lesson, Unit Reading

Reading Assignment

Chapter 3:
Toxicity and the Factors That Modify Toxic Responses

Chapter 4:
Biological Poisons: Plant and Animal Toxins

Unit Lesson

The first part of this unit lesson discusses the factors that modify toxic responses and biological poisons. The second part discusses biological poisons, including bacterial toxins, mycotoxins, and animal and plant toxins.

Toxicity and Toxic Responses

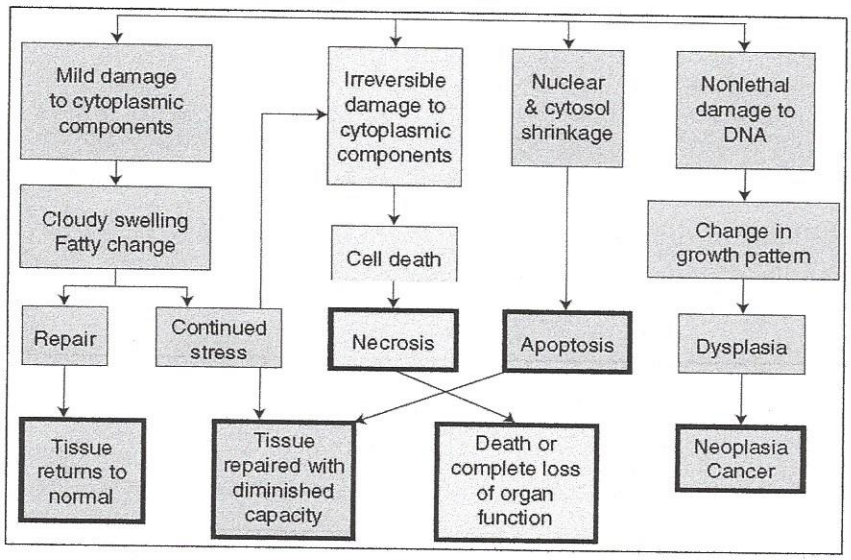
There is a large variation in the effects of chemicals on the body. Some examples of chemical injury include the scenarios below.

- Cells and tissue self-repair and return to normal function.
- A repair is incomplete but is sufficient to return to normal function.
- There is death of an organ or organism.
- Neoplastic growth occurs, resulting in the death of the organism (Richards & Bourgeois, 2014).

The following chart demonstrates the variability in the toxic damage to cells. From the chart, you can see how the tissue will either return to normal, be a complete loss of organ function, or result in cancer.

The effects of exposure can also be classified as acute or chronic effects. *Acute effects* are the immediate effects, evident in days to months. *Chronic effects* are delayed responses that occur from months to years after exposure. An example is carbon monoxide exposure where the acute effects include asphyxiation through carboxyhemoglobin. The *chronic effects* of carbon monoxide exposure include heart and brain toxicity.

One cannot prevent exposure to all toxic chemicals. The toxicity is determined by the physical and chemical properties, the duration of exposure, the route of exposure, and the health of the individual. The routes of exposure include *inhalation, ingestion,* and *absorption. Inhalation* is the most common route of exposure. Ingestion of a substance is usually accidental. Absorption through the skin usually occurs when a substance dissolves in the oils of the skin and passes through the pores (Richards & Bourgeois, 2014).



The graphic depicts toxic damage to cells.
(*Richards & Bourgeois, 2014*)

Factors that modify toxicity are age, disease, gender, lifestyle, diet, and genetics. For age, the decreased organ functions in elderly persons leave them more susceptible to hepatic and renal toxicants. Examples of lifestyle factors are cigarette smoking, drug use, alcohol abuse, and caffeine consumption. A classic example is cigarette smoking and exposure to a substance such as asbestos. If one is exposed to asbestos and smokes, his or her risk of developing lung cancer can increase by about 80%.

There is growing research as to how genetics affect toxicity. *Toxicogenetics* examines the effects of chemical exposure on gene activity and protein expression. According to Rouquie et al. (2015), *toxicogenomic technologies* and computational tools are available to provide mechanistic insight in toxicological mode of action (MOA) of the adverse effects observed in laboratory animals. The vision described as Tox21 (ToxicologyTesting in the 21st century) aims at predicting *in vivo* toxicity by using a bottom-up approach that starts with understanding MOA based on *in vitro* data to ultimately predict adverse effects in humans. This is a fairly new approach to toxicity studies and how chemicals can affect an organism. The individual variations in people make some more susceptible or resilient to exposure to hazardous substances than others. There is a difference in the expression of the detoxification enzymes, which results in different rates of biotransformation. Obviously, there are many factors that can modify the toxic response.

Biological Poisons: Plant and Animal Toxins

Biological poisons include *bacterial toxins, mycotoxins*, and *animal* and *plant* toxins. Toxins are a poisonous substance produced by living things. The categories of toxins, based on what produces them, include the list below:

- bacteria,
- fungi (mycotoxins),
- algae (phycotoxins),
- plants (phycotoxins), and
- animals (zootoxins).

An example of a bacterial toxin is the *botulinum toxin* produced by the bacteria *Clostridium botulinum.* The *botulinum toxin* is the most acutely toxic substance known, and the spores are found in the soil. The bacterium *Clostridium tetani* produces the toxin tetanus. This toxin causes the skeletal muscles to contract, and death results from respiratory and heart failure. This bacteria can enter the body through wounds or from piercings and tattoos.

Staphylococcus aureus (Staph infection) is another bacteria that produces an alpha toxin. *Staphylococcus aureus* is the most common cause of *nosocomial infections* and is frequently responsible for food poisoning. The symptoms of exposure include nausea, vomiting, stomach cramps, and diarrhea.

Nerium oleander is an evergreen shrub or small tree in the dogbane family Apocynaceae. It is most commonly known as oleander but has many other names. Oleander is one of the most poisonous of commonly grown garden plants and can be very toxic if ingested in sufficient quantity.
(Enking, 2010)

Mycotoxins are produced by fungi, some of which are found everywhere in the environment, both indoors and outdoors. Common indoor fungi include *Cladosporium*, *Aspergillus*, and *Penicillium*. These fungi grow on any damp surface in the building environment. Some fungi are associated with a condition known as sick building syndrome. *Stachybotrys* is known to cause irritation of the mucus membranes, headaches, itchy skin, nausea, and fatigue. There is considerable controversy in this area because of the individual susceptibility to the fungus.

Fungal toxins that come from mushrooms cause four main types of responses: *gastrointestinal effects*, *disulfiram-like effects, neurotoxic effects*, and *cytotoxic effects*. The *gastrointestinal effects* include nausea, vomiting, and abdominal cramps. Some mushrooms produce coprine, which interferes with the metabolism of ethanol. If alcohol is consumed within 3 days of exposure to coprine, the effects include nausea, headache, and vomiting. Some mushrooms can have neurotoxic effects, which include hallucinations, fever, coma, blurred vision, and difficulty breathing. Cytotoxic effects of mushrooms are not common but include organ failure, jaundice, and a coma.

Animal toxins are probably the best-known toxins. For example, scorpions produce a toxin that is neurotoxic but relatively harmless to humans. Another example is venomous snakes. There are many different categories of snakes and the venom they produce. The snake venom contains enzymes that produce the toxic effects. Acetylcholinesterase is an example of a venom that causes paralysis.

An example of a plant that produces a toxin is poison ivy. It produces an organic oil called urushiol that causes an allergic reaction on the skin upon contact. Another example is the giant hogweed. This plant has a clear, watery sap that is a photosensitizer. A photosensitizer sensitizes the skin to ultraviolet light. Exposure to the sap and sunlight can cause swelling, burns, and blisters. Other examples of plants that are dangerous when consumed are listed below:

- oleander (contains cardio-glycosides),
- lilies,
- privet (produces berries that contain syringin and ligustrin),
- wolfsbane (contains aconitum in the seeds and roots), and
- mayapple (contains podophyllotoxin) (Richards & Bourgeois, 2014).

Some examples of outdoor workers who may be exposed to hazardous plants while performing their jobs are listed below:

- construction workers,
- road crews,
- forestry workers,
- loggers,
- farmers, and
- land surveyors.

Some corals also have toxic chemicals, the most deadly being *Palythoa*. It can kill a human with only four micrograms of toxin. *Palytoxin* is one of the most toxic organic poisons and includes symptoms of chest pains, breathing difficulties, and a racing pulse. Death can occur within minutes, and there is currently no treatment.

An example of an animal toxin is spider venom. The venom of the widow spider is neurotoxic, and exposure results in pain in the lymph nodes, nausea, muscle cramps, profuse sweating, respiratory distress, and even death.

Leaves in threes characterize poison ivy. This plant is common in the eastern United States.
(Centers for Disease Control and Prevention, 1998)

References

Centers for Disease Control Prevention. (1998). *Public Health Image Library (PHIL)* [Photograph]. Retrieved from https://phil.cdc.gov/phil/details_linked.asp?pid=1110

Enking, E. (2010). *Nerium oleander* [Photograph]. Retrieved from https://www.flickr.com/photos/33037982@N04/4964872248/in/photolist-8yJgxE-anuKGE

Richards, I. S., & Bourgeois, M. M. (2014). *Principles and practice of toxicology in public health* (2nd ed.). Burlington, MA: Jones & Bartlett Learning.

Rouquie, D., Heneweer, M., Botham, J., Ketelslegers, H., Markell, L., Pfister, T., . . . Hennes, C. (2015). Contribution of new technologies to characterization and prediction of adverse effects. *Critical Reviews in Toxicology, 45*(2), 172–183. Retrieved from http://www.tandfonline.com/doi/full/10.3109/10408444.2014.986054?scroll=top&needAccess=true

Suggested Reading

Click here to access the Chapter 3 PowerPoint presentation. Click here to access a PDF version of the presentation.

Click here to access the Chapter 4 PowerPoint presentation. Click here to access a PDF version of the presentation.

In order to access the following resource, click the link below:

The following article is on biological toxins as related to toxicity.

Morales, P. J. (2012). The need to establish the organisation for the prohibition of biological weapons: A proposal for the future. *Public Organization Review, 12*(1), 57–70. Retrieved from [redacted]

Learning Activities (Non-Graded)

Non-Graded Learning Activities are provided to aid students in their course of study. You do not have to submit them. If you have questions, contact your instructor for further guidance and information.

Research two extreme cases of plant or animal toxins from the county or municipal health department websites in your area. Find the exposure, the symptoms, and the treatment for each case.