

DUKE UNIVERSITY

What happens after you take medicine?

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Description:

Taking over-the-counter medications, vitamins, caffeinated beverages, or prescription medications is an everyday activity for most people. But most people don't spend much time thinking about what happens to those items after they ingest them. Recent studies have shown that common medications, hormones, and stimulants are finding their way into waterways and sources of drinking water. In this module, students will learn that the human body is not a completely closed system; after ingestion drug metabolites are excreted and may ultimately impact the environment and drinking water purity. Even unused medications tossed into the toilet can impact the water supply. In addition, students will explore how certain commonly used pharmaceuticals affect organisms in the wild. This module includes a hands-on activity that permits students to collect water samples from local freshwater sources and critically analyze data obtained from submitting the samples for analysis of drugs and metabolites. In addition, this module ideally includes a visit to a local wastewater treatment facility.

Learning Objectives:

1. The student will be able to describe how medicines/drugs end up in the environment.
2. The student will be able to describe the types of impacts medicines/drugs have on organisms in the environment.
3. The student will be able to provide examples of organisms that have been negatively impacted by medicines/drugs.
4. The student will be able to propose ways that companies can test if their drugs will negatively impact the environment.
5. The student will gain experience first hand how scientists collect water in samples in the field.
6. The student will be able to critically analyze and interpret results of actual water samples subjected to chemical analysis.

Module Components:

1. Slide Show Presentation

The associated slide show presentation is an excellent platform for introducing students to the basic concepts contained in this module. In addition, the presentation facilitates brainstorming by asking the students to call on their previous knowledge and experiences with familiar medications and supplements. The presentation also introduces some of the key terms that the students will need to know when delving deeper into the content material. Most importantly, the students should understand that as stewards of the environment, we cannot forget about medicines and chemicals we ingest. After leaving our bodies, those chemicals and waste products continue to be the responsibility of our communities and ultimately impact our environment and the integrity of our drinking water supply.

The slide show also contains essential background information that the teacher can use to spark interest in associated biological topics. As a result, the teacher can incorporate this module into different units. For example, the teacher may wish to incorporate this module into a unit about the human body and endocrine system. Or, the teacher may use this unit as part of a unit on ecology and/or human impact on the environment.

2. Wastewater Treatment Facility Field Trip

One of the most important components of this module is the trip to a wastewater treatment plant (wwtp). Most students, no matter what learning level, do not know that most of the water that is used on a daily basis is cleaned and ultimately reused. Although not an overly glamorous field trip, visiting a wwtp will provide the students with perspective and a chance to better understand how their daily activities influence the world around them. They need to know that after the toilet is flushed, the story continues!

3. Water Quality Sampling Laboratory

Another key component of this module is taking the students to locations in their greater community and sampling water that is used as a drinking water source and that is associated with a wwtp. This component of the module can be used to incorporate and reinforce numerous different biological concepts. For example, if the teacher would like to incorporate ecological concepts into the sampling and field trip, the students can search for indicators of biodiversity and stream health. Or, if the teacher would like to incorporate more advanced concepts and technology, the water can be tested for specific pharmaceuticals or hormones. Although this type of assessment is too complicated for

the students to conduct on their own, a laboratory can test the water, and the students can analyze and interpret the results.

4. Associated Vocabulary List

The attached vocabulary list contains several terms that are essential to the slide show presentation and both of the field trips

Website References:

USGS Toxics Hydrology Program: <http://toxics.usgs.gov/>

Durham, NC Wastewater Treatment Division:
<http://www.durhamnc.gov/departments/wm/wastewater.cfm>

Go with the Flow (wastewater treatment educational resource):
<http://www.durhamnc.gov/departments/wm/goflow/index.htm>

USGS. (2008). "Endocrine Disruption." from
http://biology.usgs.gov/contaminant/endocrine_disruption.html.

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<http://toxics.usgs.gov/pubs/OFR-02-94/index.html>.

Literature References:

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Filby, A. L., Teresa Neuparth, Karen L. Thorpe, Richard Owen, Tamara S. Galloway, and Charles R. Tyler (2007). "Health impacts of estrogens in the environment, considering complex mixture effects." Environmental Health Perspectives **115**(12): 1704-1707.

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Kolpin, D. W., Edward T. Furlong, Michael T. Meyer, E. Michael Thurman, Steven D. Zaugg, Larry B. Barber, Herbert T. Buxton (2002). "Pharmaceuticals, Hormones, and Other Organic Wastewater Contaminants in U.S. Streams, 1999-2000: A National Reconnaissance." Environmental Science & Technology **36**: 1202-1211.

Lopez de Aldam, M. J., Damia Barcelo (2000). "Determination of steroid sex hormones and related synthetic compounds considered as endocrine disruptors in water by liquid chromatography - diode array detection - mass spectrometry." Journal of Chromatography **892**: 391-406.

Moore M. T., S. L. G., J. L. Farris, B. Guerra (2008). "Assessing Caffeine as an Emerging Environmental Concern Using Conventional Approaches." Archives of Environmental Contamination and Toxicology **54**: 31-35.

Weigel, S., Jan Kuhlmann, Heinrich Huhnerfuss (2002). "Drugs and personal care products are ubiquitous pollutants: occurrence and distribution of clofibric acid, caffeine and DEET in the North Sea." The Science of the Total Environment **295**: 131-141.

Associated Vocabulary Words:

Absorption (drug absorption): movement of the drug or medicine into the bloodstream.

Biological Half-life: time required for half of that substance to be removed from an organism by either a physical or a chemical process

Endocrine Disruptor: A substance that interferes with the synthesis, secretion, transport, activity, or elimination of natural hormones.

Endocrine System: the internal system of chemical communication, including hormones, the glands that secrete hormones, and the receptors on target cells. The endocrine system regulates development, reproduction, metabolism, behavior, and homeostasis. The endocrine system works in concert with the nervous system.

Excretion: elimination of chemicals and other wastes from the body

Metabolite: products of metabolism, usually inactive breakdown and waste products, but many drugs and chemicals have active metabolites.

Metabolism: the conversion or breakdown of a substance from one chemical form to another by a living organism; carried out by enzymes.

Over-the-counter Drug/Medicine: a drug or medicine that does not require a prescription from a physician.

Pharmaceuticals: substances aimed to treat, cure, or prevent diseases.

Pharmacokinetics: the study of the absorption, distribution, metabolism, and elimination of drugs from the body

Wastewater: also known as sewage, the used water and solids that flow from a community into a wastewater treatment plant.

Wastewater Treatment: the process of removing contaminants from wastewater, both runoff and household. It includes physical, chemical and biological processes to remove physical, chemical and biological contaminants.

Watershed: a region draining into a river, river system, or other body of water