

BREAKFAST FOR THE BRAIN[®]

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Subscription to **Breakfast for the Brain[®]** is free to K-12 educators throughout the Northeastern U.S. (New England and New York) and to employees of MSMR member institutions. Others may subscribe at the rate of \$100 annually. See **MANAGING YOUR SUBSCRIPTION** below for further information.

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JANUARY 2002 – VOLUME 1 - TOXICOLOGY

ISSUE NO. 3: WEDNESDAY, JANUARY 9, 2002

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OPENING MESSAGE

This is the third issue of **Breakfast for the Brain[®]**, Volume 1, **Toxicology**, January 2002. Issue No. 1 contained, among other things, an introduction to the science of toxicology. We offer you today a glossary of toxicology terms, another lesson of the day, as well as some toxicology trivia, and Internet resources to learn more about concepts in toxicology. Please also read the **MSMR Announcements** section below if you are having trouble reading and/or printing **Breakfast for the Brain[®]** messages.

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MSMR ANNOUNCEMENTS

A few subscribers have written that they cannot access and/or print **Breakfast for the Brain[®]** messages or that portions of the messages are unreadable. Individual issues are prepared in Microsoft Word (PC format) and cut-and-pasted into e-mail, so it is understandable that this may not work for some.

An ASCII version of each issue will be prepared for subscribers that cannot access the Word-formatted version. Please send an e-mail to Leslie Nader at lnader@concentric.net if you prefer to receive the plain-text versions of **Breakfast for the Brain[®]**.

Transparencies and other attachments will be available only in PC formats; Mac users may send a request for special arrangements to receive these.

In the event that none of these efforts produce the results you need, please do not hesitate to let us know. We appreciate the feedback received to date, and will do our best to accomodate all subscriber needs. Please bear with us while we work out the bugs.

The MSMR offers a full-range of programs and materials to classroom educators on topics in biomedical science, biotechnology, and the use of animals in research and testing. Most of the MSMR's outreach programs and materials are available free of charge to K-12 educators throughout the Northeast (New England and New York). To request a copy of the MSMR's catalogue of programs and materials, send an e-mail request to Leslie Nader, Ph.D., *Vice President for Education*, at lnader@concentric.net.

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A GLOSSARY OF TOXICOLOGY

ADI (acceptable daily intake)...	the amount of a substance calculated to be safe if taken daily throughout a person's lifetime, usually expressed as a function of body weight
Acute ...	in toxicology, a single exposure or dose which is sufficient to cause and adverse reaction
Aflatoxin ...	a naturally-occurring toxin produced by moulds on substances such as peanuts
Ames Test ...	a test which measures the potential of a chemical to cause mutations in bacteria; those causing mutations are probably capable of causing cancer in mammals
Antagonism ...	action between two or more compounds in which one interferes with the action of the other so that there is less effect from a similar dose than if it were present alone
Bioaccumulation ...	the build-up of a substance in an organism due to the presence of the chemical in the food supply (or in the case of plants or aquatic organisms, in the water supply). Accumulation only occurs if the substance is slow to be excreted or metabolized. Sometimes, incorrectly use as a synonym for biomagnification.
Biochemical ...	relating to chemical processes which occur in living organisms
Biomagnification ...	the build-up of a chemical in a particular organism high on the food chain because of ingestion of prey containing the chemical e.g. a buildup of mercury in people eating fish from waters contaminated with organomercurial compounds, sediment - bacteria - invertebrates - fish - birds - humans
Biotransformation ...	the sum of the processes by which a xenobiotic is subjected to chemical change by living organisms
Biotechnology ...	the use or manipulation of living systems to improve their value to humans e.g. genetic engineering of plants, use of bacteria to produce particular substances
Cancer ...	uncontrolled growth of cells which can damage body organs and lead to sickness and death
Carcinogen ...	an agent which can contribute to the development of cancer
Chronic ...	long-term; may be used to refer to a) a disease or b) exposure to a particular substance at a low level which does not cause an immediate

	adverse effect but which may, if continued for a long period of time be detrimental to health
Contaminant...	any undesirable substance in food, water or air
Cost-benefit analysis....	an evaluation of the relative costs and benefits of an action or behaviour
DNA (deoxyribonucleic acid)...	the substance which carries the genetic information in most cells; it carries codes for the building of proteins which control the development and metabolism of organisms
Dose...	the amount of a substance taken into the body
Effluent...	outflow; liquid waste which is discharged into a water (e.g. river) system
Enzyme...	a chemical (protein) produced by a cell to act as a catalyst in a particular biochemical reaction
Epidemiology...	the study of the occurrence and causes of diseases in humans
Exposure...	the does of a substance capable of causing toxic effects actually taken into the organism (in the case of a person, through ingestion, inhalation or dermally).
Gene...	a unit of heredity; each gene is a length of DNA which carries the code for a particular protein
Hazard...	the potential of a substance to cause harm
Heavy metal...	a metal of high atomic mass e.g. lead or mercury; these can have toxic effects in living organisms
Immune system...	the system in mammals which helps a body to fight infection
LD50...	the dose of a toxin which kills half of a test population of a particular species; it can differ among species
Metabolism...	the biochemical processes which occur in living organisms, including the use of nutrients to provide energy and materials for growth and maintenance of a body
Mitogenesis...	the stimulation of cell division
Monitor...	to keep track of
Mutagen...	a substance that can cause a change or mutation in genetic material
NOEL (no observed effect level)	a level of exposure to a chemical that produces no observable effect; usually it is used to consider adverse effects so NOAEL is "no observed adverse effect level."
Organic...	chemical compounds which contain carbon atoms
Pollutant...	a substance present in greater than natural concentration as a result of human activity and having a net detrimental effect on its environment
Promotion...	enhancement of the action of a chemical by another chemical which, on its own, has no observable effect
Risk...	probability that a substance will cause harm under specific conditions of use, i.e., hazard
Risk assessment...	the identification of a danger and estimation of the probability of occurrence
Risk-benefit analysis...	an evaluation of a risk versus the benefit to be expected from accepting that risk
RNA (ribonucleic acid)...	the genetic material of some viruses; in other organisms, it uses the information from DNA to direct the synthesis of cell proteins
Synergism...	the effect of two chemicals which, in combination, each act more strongly than either alone

Teratogen...	a chemical that can cause birth defects when experienced by a female before or during pregnancy
Threshold dose...	the lowest dose at which effects may be observed
Tolerance...	the increased ability of an organism to resist the effects of a toxic substance
Toxicologist...	a scientist specially trained to examine the nature of adverse effects of chemical substances and to assess the probability of their occurrence
Toxicology...	the study of the adverse effects of chemicals on living organisms
Toxicity...	the measure of the capacity of a chemical to harm an organism
Toxigenic...	an organism producing toxins or poisons
Toxin...	a poisonous substance of natural origin (plant, animal, bacterial, fungal)
Toxicant...	a poisonous agent, e.g. chemical compound
Toxoid...	a toxin that has been treated to destroy its toxicity
Xenobiotic...	compounds external to normal metabolism of an organism, i.e., foreign compounds

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TOXICOLOGY TRIVIA

*The following trivia questions relating to toxicology are fun – many with fascinating stories behind them -- and can be used as a springboard for teaching in science, history, and other disciplines. Use the questions as the basis of a scavenger hunt, for example, or have students research a question of their choice and write an essay about their findings. Answers will be posted in the next issue of **Breakfast for the Brain**[®].*

1. Which chemical or substance, naturally occurring or man made, can claim to be the most toxic substance known to science? (*Acute toxicity, not including nerve gases.*)
2. Which continent has the widest range of venomous animals in the world?
3. How does a blue-ringed octopus protect itself from its own poison?
4. In 1960, the American U-2 Spy Plane pilot Francis Gary Powers was shot down by a missile while flying on a spy mission over the Soviet Union. He carried a poison with him to be used for suicide if he was ever captured. What was the poison he was to use?
5. In 1881, Derek Humphry, authored and published a highly controversial book which involved advice on the giving and taking of poisons. What was the title of this work?
6. Just after July 3, 1863, many trees around this small Pennsylvania town began dying from lead poisoning due to the large number of leaded foreign bodies embedded in the wood. Name the town.
7. In 1992, the L.A. Gear company began production of high-tech sneakers with colored lights that flashed when the heels hit the ground. Some states considered these shoes a potential pollution hazard when disposed because of what toxic material in the lighting mechanism?

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LESSON OF THE DAY

Toxic Substances: What We Knew Then, What We Know Now

Grade Level

High School

Teaching Objectives

The teaching objectives of this lesson are:

1. to help students understand how toxins and toxicants get into the body;
2. to look at some occupational health issues; and
3. to explain some factors which influence a toxicant's effect on the body.

Background Information

"The Mad Hatter" was not totally a figment of Lewis Carroll's imagination. In the 19th century, mercury nitrate was used in the production of top-hats to prevent the growth of fungi in the natural fibers during damp London weather. Repeated exposure to this mercuric compound caused hatters to develop tremors and brain damage. Hatters often really did go mad. It was an occupational hazard. Today regulations are in place to limit workplace exposure to chemicals that are known to be hazardous.

Still, we are exposed to toxic substances every day of our lives. While some of these compounds have been introduced into our environment in recent years (many the result of new industrial processes), humans and all other organisms have been exposed to a variety of toxins throughout history. Many foods contain natural toxins, often developed as a defense by the plant against insects or other organisms. Water may contain substances dissolved from the soil and carried in run-off. Air contains many gases which, in larger proportions, could prove dangerous. As a result of these exposures, we have evolved systems that help our bodies cope with such materials. These systems generally involve *enzymes* (proteins produced by our bodies to mediate biochemical reactions). Consequently, genetics can help explain why not every individual reacts to the same extent to a given *toxicant* (toxic substance).

Toxic substances can enter our bodies in three ways - *ingestion* (through the digestive system), *inhalation* (through the respiratory system), and *dermally* (through the skin.) The effects of the toxicant will depend on the dose and on how the body deals with that dose. Some substances are very poorly absorbed by the body and others may be excreted rapidly. Poorly absorbed substances are less of a risk because poor absorption reduces the exposure. Some toxic substances are distributed throughout the body and may be stored in particular tissues, in which case a buildup may occur so that over time a dangerous level is reached. This property is found in relatively few substances. These *bioaccumulative* substances have special chemical and physical properties that prevent their breakdown in the organism and cause them to accumulate in fats. Examples of these substances include the polychlorinated biphenyls (PCBs) that have been banned because of their tendency to bioaccumulate in organisms. Toxic chemicals can build up through the food chain by bioaccumulation.

There can also be interactions between chemicals. This is a particular concern when medications are prescribed. Sometimes one chemical will interfere with the action of another. For example, the vitamin K in broccoli can reduce the effectiveness of anticoagulant drugs. That is called *antagonism*. Sometimes a chemical which is not toxic itself increases or promotes the toxicity of another. When two chemicals act more strongly in combination than the combined effects of each separately, it is known as *synergism*.

The body has developed some mechanisms to detoxify certain chemicals. The liver and kidneys contain enzymes which function to protect the body and are the main sites of detoxification. The functioning of these enzyme systems and the body's overall response depend on a number of factors:

- **Genetic** - Some families or groups may not produce a particular enzyme, so the detoxification process is impaired.
- **Age** - Children are more susceptible because their systems are not fully developed. Seniors too may have some impairment of such metabolic functions.

- **Size** - Size affects concentration, so a large person can usually tolerate more than a small person. This is an important factor to be considered by doctors when they prescribe many types of drugs.

A person whose body is under stress is less able to deal with toxic substances. Poor nutrition or poor health usually make a body more susceptible to damage. There are also differences between males and females. The most significant difference occurs during pregnancy when something of minimal risk to an adult may cause severe problems in a developing baby. This effect is known as *teratogenicity*. Alcohol, tobacco and many commonly-used drugs, if taken during pregnancy, can affect the health of the newborn.

Normally, although factors such as age may affect the degree of response, the type of response, for example the organs affected, will be similar in all individuals. In the case of allergies, the response is different. Here, some individuals develop antibodies after an initial exposure to a product that most people tolerate without difficulty. Immune reactions are most often to proteins, for example, those associated with seafood, peanuts or grass pollen. This is an immune system response and in severe cases, the slightest subsequent exposure may be life-threatening.

Lesson Activities

1. Ask students to name hazards associated with chemicals in the workplace.

Some examples include: Lung damage to miners (silicosis) or those who work with asbestos (e.g. insulators). Asbestos is no longer used as insulation but is still present in many older buildings. It is safe in place but when buildings are remodeled, it may get into the air. Some solvents (e.g. tetrachloroethylene used in dry cleaning or some used in industrial processes) can cause liver damage. Skin disorders may result from exposure to a number of industrial chemicals.

2. Use the attached student worksheet to help students understand key terms used in toxicology.

Answers to student worksheet:

Part A - See A Glossary of Toxicology (above).

Part B -

1. synergism
2. promotion
3. antagonism

Part C -

1. digestive system, respiration system, skin
2.
 - a) Improve air circulation and use filters to clean the air as it passes through the system.
 - b) Limit the amount of time worked in that atmosphere.
 - c) Some labs are equipped with fume chambers for work with hazardous chemicals. These are vented separately from the regular air circulation system.
 - d) Use safety equipment such as particle masks or respirators.
3. Farmers are exposed to exhaust fumes from farm equipment, pesticides, dust and molds in stored crops.
4.
 - a) Calcium is used for bones and teeth.
 - b) He could cut his rhubarb intake but he could also eat calcium-rich foods such as dairy products.
 - c) Eat a balanced diet without concentrating too much on any one food.
5.
 - a) $C_2H_5OH \rightarrow$ alcohol dehydrogenase \rightarrow CH_3CHO (acetaldehyde) + energy
 - b) $CH_3CHO \rightarrow$ aldehyde dehydrogenase \rightarrow CH_3COOH (acetic acid) + energy
 - c) Individuals without the *aldehyde dehydrogenase enzyme* will be unable to detoxify alcohol fully so will show effects at lower doses than other people.
 - d) If the kidney and liver are functioning less efficiently, there will be less ability to detoxify chemicals so there will be a lower tolerance e.g. to alcohol, some drugs.

Source: Adapted from *Toxicology Educator's Resource Guide*, published by Alberta Environmental protection and the Canadian Network of Toxicology Centres, 1997. Copies of the *Guide* are available from the MSMR; send requests to lnader@concentric.net.

Note: If attached transparencies cannot be viewed / downloaded / printed -- or you prefer not to open them - order a copy of the *Toxicology Educator's Resource Guide*; see instructions directly above.

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WEB WATCH

Chemicals & Human Health

<http://www.biology.arizona.edu/chh/default.html>

The Biology Project is an interactive online resource for learning biology developed at The University of Arizona, designed for biology students at the college and high school level. The "Chemicals and Human Health" section of *The Biology Project* contains problem sets and tutorials in toxicology, exploring ways in which chemicals can affect human health and develop an understanding of fundamental principles of toxicology; lung toxicology, reviewing the basics of lung anatomy and function and exploring toxicology in the lungs, diseases of the lungs, and environmental tobacco smoke; and kidneys and metals, exploring the world of renal toxicology and the effect of metals on the kidneys and on kidney cells.

Cluster Busters: A Game of Disease Mystery Solving

<http://swehsc.pharmacy.arizona.edu/coep/clusterbusters/>

Cluster Busters is a mystery game in which students research disease clusters that might be induced by environmental toxicants. In the process, students utilize a range of skills, draw from various academic subjects, and learn the issues and processes of disease cluster investigation. The game introduces the concepts of epidemiology, risk assessment, and toxicology. The process of investigation encourages logical thinking and problem solving and enhances student familiarity with research techniques and statistics. The curriculum has two cases (one is colon cancer the other is infant pulmonary hemorrhaging), each based upon actual disease cluster investigations published in refereed scientific journals.

Project Greenskate

<http://depts.washington.edu/hereuw/greensk8/>

Developed by the University of Washington, *Project Greenskate* is a project that involves students in investigating potential health concerns surrounding the hypothetical development of a city park on a former industrial site contaminated with certain common environmental pollutants.

National Institute of Environmental Health Sciences (NIEHS)

<http://www.niehs.nih.gov/>

Kids' Page has fun activities for kids, including games, brainteasers, and current hot topics in environmental health sciences. *Teacher Support* has information and curricula for teachers. NIEHS also publishes *Environmental Diseases from A-Z*, which can be found at <http://www.niehs.nih.gov/external/a2z/home.htm>.

BioRAP (Biological Research for Animals and People)

<http://www.biorap.org/br7contents.html> (Product Safety Issue)

<http://www.biorap.org/br9/br9contents.html> (Risk Assessment Issue)

BioRAP is a topical middle school newsletter series, produced by Connecticut United for Research Excellence. Includes students issues and teacher guides.

Note: These and other issues of *BioRAP* are also available through the MSMR. Contact Leslie Nader at lnader@concentric.net.

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OPEN FORUM

Contribute! Send comments, questions, interesting Web sites, lesson plans, or articles that you would like to share with other educators to Leslie Nader, Ph.D., *Editor*, **Breakfast for the Brain**[®], at lnader@concentric.net. Subscriber feedback will be included through the **Open Forum** section of **Breakfast for the Brain**[®], as well as guest articles, and other venues.

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Look for the next issue of **Breakfast for the Brain**[®], Volume 1 - **Toxicology**, later this week.

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