

## LESSON: Toxic Tic-Tac-Toe

**Summary:** Students read an article about neurotoxicants in the environment and their effects on children. Then they assess what they have learned about the health effects, standards, and sources of these neurotoxicants by playing Toxic Tic-Tac-Toe.

**EHP Article:** "New Thinking on Neurodevelopment"  
*EHP Student Edition*, May 2006, p. A100–108  
<http://www.ehponline.org/members/2006/114-2/focus.html>

**Objectives:** By the end of this lesson, students should be able to

1. compare the different health effects, standards, and sources of various neurotoxicants in our environment; and
2. explain why neurotoxicants are an important area of study.

**Class Time:** 45 minutes

**Grade Level:** 9–12

**Subjects Addressed:** Environmental Sciences, Biology, Health

### ► Prepping the Lesson (15 minutes)

#### INSTRUCTIONS:

1. Download the entire May 2006 *EHP Student Edition* at <http://www.ehponline.org/science-ed/> or download just the article "New Thinking on Neurodevelopment" at <http://www.ehponline.org/members/2006/114-2/focus.html>.
2. Review the lesson instructions.
3. Read the article "New Thinking on Neurodevelopment."
4. Make copies of the Student Instructions and article, if necessary.

#### MATERIALS (per student):

- 1 copy of *EHP Student Edition*, May 2006, or 1 copy of the article "New Thinking on Neurodevelopment," preferably in color.

#### VOCABULARY:

- *in utero*
- neurotoxicants
- polybrominated diphenyl ethers (PBDEs)
- polychlorinated biphenyls (PCBs)
- reference dose
- tolerance levels

#### BACKGROUND INFORMATION:

The article provides an excellent overview of the concerns regarding impaired neurodevelopment and the possible environmental neurotoxicants that may be contributing to the problem. In order to prevent neurotoxicants from exerting their harmful effects, the U.S. Environmental Protection Agency sets safe levels of exposure to contaminants in air and water, often set around the reference dose, the lowest oral intake level likely to have no effect. The U.S. Food and Drug Administration also sets standards for contaminants in foods called tolerances. Water, air, and food are tested regularly to help ensure that contaminants do not surpass safe levels.

#### RESOURCES:

*Environmental Health Perspectives*, Environews by Topic page, <http://ehp.niehs.nih.gov>. Choose Chemical Exposures, Neurology  
Children's Environmental Health Network, Neurodevelopmental Effects and Environmental Factors, <http://www.cehn.org/cehn/CongBriefNeuro.html>  
Toxicology Data Network (ToxNet), <http://toxnet.nlm.nih.gov/>. Various databases maintained by the National Library of Medicine containing information about various chemical hazards in our environment, searchable by chemical



## ► Implementing the Lesson

### INSTRUCTIONS (Note—this lesson does not include Student Instructions):

1. Have the class read the article “New Thinking on Neurodevelopment,” telling them to focus on the **identified neurotoxicants, their health effects, any related standards, and their source**. (You may want to write these points on the board so students focus on this information by underlining/highlighting or taking notes as they read the article. Or, if assigning the reading as homework, be sure students underline/highlight or take notes on this information.)
2. Discuss with the class why neurotoxicants are an important area of study. Highlight the following issues raised in the article:
  - 17% of school-age children in the United States suffer from a disability that affects their behavior, memory, or ability to learn, including attention deficit/hyperactivity disorder (ADHD), autistic spectrum disorders, epilepsy, Tourette syndrome, mental retardation, and cerebral palsy. All of these are believed to be the result of an abnormal process occurring when the brain was developing *in utero* or in the young child.
  - Children with these disorders have higher rates of mental illness and suicide, are more likely to engage in substance abuse, and are more likely to commit crimes as adults.
  - The economic costs of these disorders in the United States are estimated to be \$81.5–167 billion per year.
  - The incidence of autistic spectrum disorders and ADHD, and the number of children in special education programs, is increasing.
  - Neurotoxicants could be responsible for some of these problems and should be studied.
3. Split the class into two groups. Have each group assign themselves a group name.
4. Draw a tic-tac-toe board as shown in Figure 1 on a blackboard, flip chart, or overhead large enough for everyone to see.

**Figure 1: Tic-Tac-Toe Game One**

	Lead	Methylmercury	Manganese
Health Effects			
Standard			
Sources			

Group: \_\_\_\_\_ = O

Group: \_\_\_\_\_ = X

5. Tell the class that they are going to play tic-tac-toe using the information learned from the article. Assign one group the Os and the other group the Xs. Write down each group’s name and their symbol under the game board. Ask each group to appoint a spokesperson for the group.
6. Toss a coin to determine which group goes first.
7. The starting group picks any cell and, through the spokesperson, provides one correct answer based on the article that satisfies the box’s criteria. (You will want to decide how much information is needed for a correct answer. For example, under “health effects” it may not be sufficient for students to say the chemical causes “brain damage.” Students should list a specific symptom or outcome.) If the group’s answer is correct, they get the square. If the group’s answer is incorrect, ask the second group to respond. If the second group is correct, they get the square. If the second group’s answer is also incorrect, then move on to another square.



8. Have the second group then pick a new box and provide the needed information. Repeat the same steps as before and continue alternating between groups to have them pick a box until there is a winner. The first group to complete a line of three cells in a row in any direction, to get the four corners, or to get five of their symbols on the game board wins. In the first round, no one is allowed to look at the article to find the answers. If there is no winner after the first round, then continue with a second round where the groups can look at the article before responding.
9. Repeat the game with a new board as shown in Figure 2.

**Figure 2: Tic-Tac-Toe Game Two**

	PCBs	PBDEs	Pesticides
Health Effects			
Standard			
Sources			

Group: \_\_\_\_\_ = O  
 Group: \_\_\_\_\_ = X

**NOTES & HELPFUL HINTS:**

- The reading could be assigned as homework.
- You may vary the rules by allowing answers to be challenged.
- You may expand the lesson by asking students to find additional information about each of the neurotoxicants.

► **Aligning with Standards**

**SKILLS USED OR DEVELOPED:**

- Classification
- Communication
- Comprehension

**SPECIFIC CONTENT ADDRESSED:**

- Impaired neurodevelopment
- Neurotoxicants
- Nervous system
- Environmental health

**NATIONAL SCIENCE EDUCATION STANDARDS MET:**

**Unifying Concepts and Processes Standard**

- Systems, order, and organization
- Evidence, models, and explanation
- Change, constancy, and measurement
- Form and function



**Science As Inquiry Standard**

- Understanding about scientific inquiry

**Life Science Standard**

- The cell
- The interdependence of organisms
- The behavior of organisms

**Science in Personal and Social Perspectives Standard**

- Personal and community health
- Environmental quality
- Natural and human-induced hazards

**History and Nature of Science Standard**

- Nature of scientific knowledge

## ▶ Assessing the Lesson

**Figure 1: Tic-Tac-Toe Game One**

	Lead	Methylmercury	Manganese
<b>Health Effects</b>	<ul style="list-style-type: none"> <li>• Deficits in IQ</li> <li>• Deficits in attention</li> <li>• Deficits in language</li> <li>• Changes in the brain</li> <li>• Increased violent crime</li> <li>• Increased risk for delinquency</li> <li>• Increased aggression</li> <li>• Increased criminality</li> </ul>	<ul style="list-style-type: none"> <li>• Exposure in womb leads to mental retardation, cerebral palsy, seizures, deafness, blindness, and speech difficulties</li> <li>• Exposure during pregnancy leads to children with cognitive deficits, neurological changes, and decreased nervous control of the heart</li> </ul>	<ul style="list-style-type: none"> <li>• Manganism, a condition like Parkinson disease that includes tremors, rigidity, and psychosis</li> <li>• Diminished intellectual function for children</li> </ul>
<b>Standard</b>	<ul style="list-style-type: none"> <li>• 10 µg/dL of lead in blood, although some believe the standard should be lower</li> </ul>	<ul style="list-style-type: none"> <li>• 0.1 µg/kg/day as a reference dose, the lowest oral intake level likely to have no effect</li> </ul>	<ul style="list-style-type: none"> <li>• 0.14 mg/kg/day as a reference dose, the lowest oral intake level likely to have no effect</li> </ul>
<b>Sources</b>	<ul style="list-style-type: none"> <li>• Lead-based paint</li> <li>• Leaded-gasoline contamination</li> </ul>	<ul style="list-style-type: none"> <li>• Consumption of contaminated fish</li> <li>• Emissions from coal-fired power plants</li> <li>• Note: thimerosal, a preservative in vaccines, contains ethylmercury</li> </ul>	<ul style="list-style-type: none"> <li>• Ingestion of well water contaminated by natural sources</li> </ul>



## Tic-Tac-Toe—Game 2

	PCBs	PBDEs	Pesticides
<b>Health Effects</b>	<ul style="list-style-type: none"> <li>• Children born to women who ingested PCBs had developmental abnormalities including psychomotor delay and lower scores on cognitive tests</li> <li>• Children born to women who were exposed to PCBs had delayed cognitive development and lower IQ</li> <li>• Children exposed to PCBs through breast milk scored lower on tests of psychomotor and mental development</li> </ul>	<ul style="list-style-type: none"> <li>• In animals, PBDEs can cause permanent learning and memory impairments, hearing deficits, and behavioral changes</li> </ul>	<ul style="list-style-type: none"> <li>• Children born to fumigant phosphine applicators were more likely to display adverse neurological and neuro-behavioral developmental effects</li> <li>• The herbicide glyphosate was linked to neurobehavioral effects</li> <li>• Children of women exposed to organophosphate pesticides had adverse neurodevelopmental effects</li> <li>• Newborn children of women with higher levels of pesticide metabolites had abnormal reflexes</li> </ul>
<b>Standard</b>	<ul style="list-style-type: none"> <li>• Tolerance level (FDA allowed level) for milk and manufactured dairy products: 1.5 parts per million</li> <li>• Tolerance level (FDA allowed level) for poultry: 3.0 parts per million</li> <li>• Tolerance level (FDA allowed level) for baby food: 0.2 parts per million</li> </ul>	<ul style="list-style-type: none"> <li>• 2 mg/kg/day as a reference dose, the lowest oral intake level likely to have no effect</li> </ul>	<ul style="list-style-type: none"> <li>• The reference dose varies from one compound to another</li> </ul>
<b>Sources</b>	<ul style="list-style-type: none"> <li>• Ingestion of food, especially animal fat</li> <li>• PCBs were used in electrical equipment, computers, furniture, and pesticides</li> </ul>	<ul style="list-style-type: none"> <li>• Used as flame retardants in consumer products (can be inhaled)</li> <li>• Found in breast milk (bio-accumulated from external sources)</li> </ul>	<ul style="list-style-type: none"> <li>• Ingestion of contaminated food</li> <li>• Pesticides are used in all phases of food production</li> </ul>

### ► Authors and Reviewers

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**Give us your feedback!** Send comments about this lesson to [ehpscienceed@niehs.nih.gov](mailto:ehpscienceed@niehs.nih.gov).

