

LESSON:

Are EDCs Blurring Issues of Gender?

Summary: Students read the article “Are EDCs Blurring Issues of Gender?” and identify and summarize the research cited within the article. Students then decide whether they believe health effects from endocrine-disrupting chemicals (EDCs) exist and whether these effects are of concern. Please note that reproductive and sexual identity issues are discussed within the context of the research on this issue.

EHP Article: “Are EDCs Blurring Issues of Gender?”
EHP Student Edition, January 2006, p. A671–A677
<http://ehp.niehs.nih.gov/docs/2005/113-10/focus-abs.html>

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

1. differentiate between research publications and reviews/reports;
2. summarize research results; and
3. draw conclusions based on opinion and evidence.

Class Time: 3–4 hours (less if assigned as homework)

Grade Level: 11–12

Subjects Addressed: Biology, General Science, Health, Environmental Health, Environmental Science, Anatomy, Physiology, Chemistry

► Prepping the Lesson (15 minutes)

INSTRUCTIONS:

1. Obtain a class set of *EHP Student Edition*, January 2006, or download the article at <http://ehp.niehs.nih.gov/docs/2005/113-10/focus-abs.html>.
2. Make copies of the Student Instructions.

MATERIALS (per student):

- 1 copy of *EHP Student Edition*, January 2006, or 1 copy of “Are EDCs Blurring Issues of Gender?”
- 1 copy of the Student Instructions

VOCABULARY:

- ambient levels
- anomalies
- cryptorchidism
- endocrine-disrupting chemicals (EDCs)
- endocrine system
- epidemiology
- estrogen receptors
- etiology
- *in utero*
- *in vitro*
- *in vivo*
- low-dose exposure
- phytoestrogens
- reference dose
- sex ratio
- steroidogenesis
- transgenderism



BACKGROUND INFORMATION:

The article linked to this lesson provides an in-depth look at the variety of issues potentially associated with endocrine-disrupting chemicals (EDCs). Because the endocrine system is affiliated with the reproductive system and sex hormones, potentially sensitive topics related to reproduction and sexual identity arise. All of these topics are presented within the context of research studies and the scientific discourse related to EDCs. Depending on the maturity level of your students, you may want to prepare them ahead of time that they will be reading about these issues. Students need to understand that human reproduction, and its associated hormones and systems, are innate biological functions that may be disrupted or adversely affected by chemicals in the environment. Conducting research on or reading about such issues is separate from “moral” opinions about those issues.

Two important themes in this lesson are how science builds a body of knowledge over time and how scientific opinion changes as new information and reinforcing information accumulates. You may want to have a class discussion about this issue and frame that discussion around the research, reports, and opinions cited in the article. Students should understand that science, especially in the early stages of a particular research topic, is dynamic, not static. Only after years of evidence from multiple studies supporting similar conclusions does a hypothesis progress to a theory and perhaps “fact.” Once something reaches “fact” level, we are pretty certain it is true.

RESOURCES:

Environmental Health Perspectives, Environews by Topic page. Choose Endocrine Disruptors, <http://ehp.niehs.nih.gov/topic>

Estrella Mountain Community College, Endocrine System, <http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookENDOCR.html>

InnerBody.com, Endocrine System, <http://www.innerbody.com/image/endoov.html>

Kids Health, Endocrine System, http://kidshealth.org/parent/general/body_basics/endocrine.html

University of Cincinnati, Endocrine System, <http://biology.clc.uc.edu/courses/bio105/endocrin.htm>

U.S. National Cancer Institute’s Surveillance, Epidemiology and End Results (SEER) Program, Endocrine Glands and Their Hormones, http://training.seer.cancer.gov/module_anatomy/unit6_3_endo_glands.html

► Implementing the Lesson**INSTRUCTIONS:**

1. Inform students that they will be reading a comprehensive article about potential health effects of endocrine-disrupting chemicals (EDCs) in the environment. The article provides a simple description of the endocrine system, which is sufficient for this activity. If you teach a biology or anatomy/physiology class, you may want to go into more detail about the endocrine system.
2. Discuss potentially sensitive topics related to reproduction and sexual identity as needed (refer to the Background Information section for some talking points).
3. Instruct the students to fill out Tables 1 and 2 as they read. Inform them that Table 1 is for individual research articles about specific research projects and Table 2 is for reports and review articles. Reports and review articles summarize the findings of many different individual published research projects. You may want to go through one or two examples with them to fill out the tables. The first review article example is on page A671, last paragraph. The first research article cited is on page A672, first full paragraph in column 2 (refer to the filled-out tables in the Assessing the Lesson section to guide you). You may need to clarify the difference between an *in vivo* and an *in vitro* study. An *in vivo* study uses “live” subjects (e.g., rats and mice), and *in vitro* uses cell cultures (e.g., liver cells in a Petri dish).
4. After the students have read the article and completed the tables, discuss the nature of the scientific process that is revealed in this article (refer to the Background Information section for talking points).
5. Have students complete Step 2, highlighting the references published after 2001. Discuss and summarize some of the main conclusions reached in these post-2001 articles. For your reference some of the conclusions are:
 - EDCs are affecting hundreds of animal species in nature.
 - EDCs caused reproduction failure in zebrafish.
 - Anogenital distance decreased in boys.
 - EDCs Potentially altered male/female ratios.
 - Low-dose biochemical effects were seen.
 - Sex hormones affect brain differentiation, EDCs may also.



- EDCs may contribute to gender-related disorders.

Some questions you may ask are:

- Do you see any agreement between the animal studies (both in the laboratory and in nature) and the human studies?
 - Are there any contradictions in the research or missing information that may keep us from reaching any conclusions? (e.g., the July 2005 *Human Reproduction* article seems to conflict with the 2005 *EHP* article by Mackenzie et al. with respect to skewed sex ratios, and the brain research in *Nature* 1995 does not have any links to EDCs at this point.)
 - Are there any possible explanations for these contradictions or lack of information? (e.g., the sex ratios may vary depending on the EDC; depending on the population size, sex ratios in small populations may vary normally and average out to 50/50 in the larger population; the lack of information may be a reflection of a new field of study.)
6. Instruct the students to complete Step 3 and discuss the answers as needed.

Discuss with students the importance of knowing the proportion of studies published after the year 2001 that either support or do not support the hypothesis that EDCs affect human health. On page A675, the article does state that there are more than 100 published peer-reviewed articles on the chemical BPA “showing significant biological effects of low doses of BPA . . . compared to 21 reporting no effect.” However, that is for one chemical. It may be useful to know that ratio for the top five or top ten EDCs.

NOTES and HELPFUL HINTS:

- You may want to have students read the *EHP* article “Shift in Sex Ratio: Male Numbers Sink in Great Lakes Community,” <http://ehp.niehs.nih.gov/docs/2005/113-10/ss.html>. This article summarizes one of the research papers referenced in “Are EDCs Blurring Issues of Gender?”
- Although different chemicals have different properties and potential health effects at different concentrations, for simplification you may want to have students simply refer to all the chemicals in this article as EDCs (endocrine-disrupting chemicals).
- If you want to save time, you could assign the reading of the article for homework. Then divide your class into groups that each re-read a specific subsection within the article and fill in the tables for that subsection.
- Students could possibly debate their answers given for the question in Step 3b, “In your opinion are the human health effects of concern?” This could be framed in the context of a healthy scientific debate that would guide the next steps in research. Students could even share ideas for what those next steps could be.

► Aligning with Standards

SKILLS USED OR DEVELOPED:

- Communication (note taking, oral, written—including summarization)
- Comprehension (listening, reading)
- Critical thinking and response
- Experimentation (data analysis)
- Research
- Tables (reading)

SPECIFIC CONTENT ADDRESSED:

- endocrine-disrupting chemicals (EDCs)
- endocrine system
- scientific process
- 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

- Abilities necessary to do scientific inquiry



- Understanding about scientific inquiry

Life Science Standard

- The cell
- Behavior of organisms

Science in Personal and Social Perspectives Standard

- Personal and community health
- Environmental quality
- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

History and Nature of Science Standard

- Science as a human endeavor
- Nature of scientific knowledge
- Historical perspectives

► Assessing the Lesson

Step 1: Read the article “Are EDCs Blurring Issues of Gender?,” January 2006, p. A671–A677. As you read the article fill in the appropriate table to track the research cited. Use Table 1 to list research articles and Table 2 to list reviews and reports. Reviews and reports are listed separately because they do not relate to just one individual study, but instead summarize the results of many different studies.

Table 1: Research Articles Cited in “Are EDCs Blurring Issues of Gender?”

| Author(s) | Journal Title/Date | Type of Study (e.g., mouse–lab, human, animal– in nature) | Study Results |
|---------------------------------------|---|--|--|
| Frederick vom Saal | <i>Journal of Animal Science</i> , 1989 | Mouse (lab) | In multiple-birth species, male and female fetuses transmit small amounts of hormones to each other, which can affect brain structures, behavioral traits, enzyme levels, receptor levels in tissues, and hormonal levels in the blood. This can occur with 1 ppb testosterone and 20 ppt estradiol. |
| Louis J. Guillette, Jr., et al. | <i>EHP</i> , August 1994 | Alligators (in nature) | Alligators in Lake Apopka in Florida have been “feminized.” Penises are shorter, testosterone levels are lower in males, females have excessive levels of estrogens. |
| Guillette, D. Andrew Crain, et al. | <i>EHP</i> , May 1997 | Alligators (lab) | Replicated changes in the production of sex hormones in alligators. |
| Jon Nash et al. | <i>EHP</i> , December 2004 | Zebrafish (lab) | Long-term exposure to environmental concentrations to ethinyl estradiol caused reproductive failure in zebrafish. |
| Retha Newbold | <i>Cancer Research</i> , 1985 and <i>Teratogenesis, Carcinogenesis, and Mutagenesis</i> , 1985 | Mouse (lab) | Developed a mouse model of DES exposure. Her results were predictive of what was eventually seen in humans exposed to DES. |
| Not listed | National Health and Nutrition Examination Survey (no date) | Human | Majority of U.S. population carries a measurable body burden of several phthalates. |



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| Shanna Swan | <i>EHP</i> , August 2005 | Human | Mothers' urine analyzed for presence of phthalates, infant boys aged 2–36 months examined for genital development characteristics including anogenital distance (AGD). Found no signs of obvious genital malformations or disease, did find an association between AGD and phthalate concentrations in the mothers (AGD/AGI was smaller as phthalates increased). Boys with short AGD/AGI also more likely to have incomplete testicular descent. |
| Not listed | <i>Human Reproduction</i> , July 2005 | Human | Analyzed blood and semen samples from 149 fishermen. Found elevated exposure to EDCs had a higher proportion of Y-chromosome sperm, which may alter offspring sex ratio. |
| Constanze Mackenzie | <i>EHP</i> , October 2005 | Human | Observed a skewing of sex ratio within members of the Aamjiwnaang Community in Ontario, found a severe decline in proportion of boys over the last five years. Community is located near several chemical plants. |
| Not listed | 1976 | Human | Saw a shift in sex ratios in Seveso, Italy, after an industrial accident with exposure to EDCs. Did not say whether the shift was more males or females. |
| Frederick vom Saal | <i>EHP</i> , January 1997 | Mouse (lab) | Enlarged prostate in male mice whose mothers were exposed to low doses of an EDC. |
| Not listed | <i>Cancer Research</i> , January 2005, and <i>EHP</i> , April 2005 | Various (these were several individual studies in one journal) | Multiple studies show adverse effects from EDC (BPA) at doses millions of fold below the maximum tolerated dose. |
| Jiang-Ning Zhou | <i>Nature</i> , 2 November 1995 | Human | Studied heterosexual men and women, homosexual men, and male-to-female transsexuals and found a female brain structure in male-to-female transsexuals. |
| Wilson Chung | <i>Journal of Neuroscience</i> , February 2002 | Human | Brain differentiation (BSTc size) became significant in adulthood, implying the phenomenon may be more effect than cause, but does not rule out early gonadal steroid effects on brain-BSTc functions. |
| Scott Kerlin | International Behavior Development Symposium, August 2005 | Human | Conducted a survey of 500 members of DES Sons International Network. More than 150 respondents identified having a gender-related disorder. |



Table 2: Reviews and Reports Cited in "Are EDCs Blurring Issues of Gender?"

| Author(s) | Journal Title/Date, or Title of Report | Report Statements or Conclusions |
|---|---|---|
| Stephen Safe | <i>EHP</i> , June 2000 | The role of EDCs in human disease has not been fully resolved; at that point, evidence was not compelling |
| Scientific Committee on Problems of the Environment/International Union of Pure and Applied Chemistry | <i>Pure and Applied Chemistry</i> , Volume 75, Issue 11/12, 2003 | More than 200 animal species are either known or suspected to have been affected by EDCs. States it's too early to tell if humans are seriously at risk—to date no conclusive findings. Need to look at steroid biosynthesis and metabolism. |
| World Health Organization International Programme on Chemical Safety | <i>Global Assessment of the State-of-the-Science of Endocrine Disruptors</i> , 2002 | Evidence shows EDCs can interfere with normal hormonal processes, weak evidence of adverse effects in humans. Sufficient evidence of effects in wildlife. Need more research. Discusses high exposure of human fetuses to DES—when these fetuses grew to adults, there were rare vaginal cancers in the women, and reproductive effects in men and women. |
| Phthalate Esters Panel/American Chemistry Council | Not listed | No credible evidence for adverse effects due to phthalates in humans at environmentally relevant doses. |
| National Toxicology Program | <i>Report of the Endocrine Disruptors Low-Dose Peer Review</i> , 2001 | Concluded that low-dose effects have been sufficiently documented. They recommend that EPA consider revisiting its current testing paradigm. |
| Bernard Weiss | <i>EHP Supplements</i> , 2002 | Review of literature on sexually dimorphic nonreproductive behaviors as indicators of endocrine disruption. Concluded that gender-specific brain differences and behavior expression are guided by gonadal hormones and are subject to interference by drugs and environmental contaminants. |
| Theo Colborn | <i>Our Stolen Future</i> , 1996 | Believes the time for action is now. She points out that if we wait to see population effects of EDCs in the human population, it's going to be too late. |

Step 2: Earlier reports, those written before the year 2001, state that there is sufficient evidence that EDCs significantly affect animal populations in nature. However, at that time there was little evidence for effects in humans. The lack



of evidence may simply be because there were not many human studies done at the time. The process of science is to build a body of evidence from a variety of studies. Not all studies agree, which may be a function of how the study was conducted. But as more and more studies are done, a pattern begins to form and people begin to reach conclusions from that pattern. On your tables, highlight research and reports dated 2001 and later. Review the conclusions for the studies you highlighted and answer the following questions:

- a. Looking at the research published in 2001 and later that was cited in this article, does there appear to be a pattern supporting or not supporting human health effects from environmental EDCs?

The research seems to support that there are human health effects from exposure to EDCs.

- b. In your opinion are the human health effects of concern? Explain your reasoning. List specific research examples to support your position.

Answers will vary. Students need to sufficiently and logically justify their answer. For example, they could argue that the health effects are not of concern because, although there is evidence that EDCs are affecting things like anogenital distance, potential sex ratios, and brain patterns, there is no evidence that they are shortening the life span of people or causing a specific disease. Conversely a student could argue that if EDCs are affecting brain patterns and the sexual identity of people, these people will have a potentially life-long, emotionally disruptive outcome. Another argument could be that the decreased descent of testicles and effects on sperm could have long-term reproductive outcomes at either the population or individual level. An inability to reproduce could also have a life-long emotional impact and/or result in the use of very expensive medical procedures.

- c. Describe any additional information you would need to know to reach a firmer conclusion. Why do you need this information?

Answers will vary. Look for thoughtful and logical explanations.

► Authors and Reviewers

Author: Stefani Hines, University of New Mexico Community Environmental Health Program

Reviewers: Susan Booker, Liam O'Fallon, Lisa Pitman, Wendy Stephan, Kimberly Thigpen Tart, Tanya Tillett, Heather Valli



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