ehp

LESSON:
Build a Personal Sensor

Summary: Students read an article on current research into how pollutants impact individuals differently by interacting with genes, behaviors, and lifestyle factors. Then they design their own prototype sensor.

Lesson Type: Extension Lesson—This lesson extends a topic in the *EHP Student Edition* article.

***EHP* Article:** "Monitoring Environmental Exposures: Now It's Personal"
EHP Student Edition, December 2006, p. A529–A534
http://www.ehponline.org/docs/2006/114-9/focus-abs.html

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

1. describe the "mismatch" between research into the genome and environmental exposure science;
2. identify various environmental factors that are associated with disease;
3. design a hypothetical sensor to monitor various environmental and individual factors specific to a given scenario; and
4. discuss the potential positive public health impact of data generated by personal exposure studies.

Class Time: 3–4 hours

Grade Level: 11–12

Subjects Addressed: Health, Physiology, Environmental Health, Engineering

Prepping the Lesson (15 minutes)

INSTRUCTIONS:

1. Download the entire *EHP Student Edition* at http://www.ehponline.org/science-ed/, or download just the article "Monitoring Environmental Exposures: Now It's Personal" at http://www.ehponline.org/docs/2006/114-9/focus-abs.html.
2. Review the Instructions and Student Instructions.
3. Make copies of the Student Instructions.
4. Assemble poster materials if needed.

MATERIALS (per student):

- 1 copy of "Monitoring Environmental Exposures: Now It's Personal"
- 1 copy of the Student Instructions
- Poster board (optional)
- Materials for making a sensor mock-up: cardboard, wiring, tape, glue, stapler, markers, electronic timers, etc. (optional)

VOCABULARY:

- accelerometer
- adducts
- ambient
- biomarkers
- biosensors
- dosimeter
- epidemiologist
- exposure assessment

- exposure metrics
- foci
- genome
- genotyping
- geographic information system (GIS)
- Global Positioning System (GPS)
- interdisciplinary
- mass spectrometry
- metabolites
- microtransducers
- nanoscale
- pathogen
- sensors
- spore
- stimuli
- toxicology

BACKGROUND INFORMATION:

The article provides sufficient information about the emerging science of personal environmental health monitoring to complete the exercise. Additional articles discussing specific applications of personal monitoring devices are listed below.

RESOURCES:

Environmental Health Perspectives, Environews by Topic page, http://ehp.niehs.nih.gov. Choose Innovative Technologies

Environmental Protection Agency. "Draft Report on the Environment 2003" (a good review of the current science comparing different approaches to environmental monitoring), http://www.epa.gov/indicators/roe/html/roeHealthMe.htm.

Johnson K. A change is in the air as new ideas on pollution emerge. *New York Times*, May 20, 2001.

Sarnat SE, Coull BA, Schwartz J, Gold DR, Suh HH. 2006. Factors affecting the association between ambient concentrations and personal exposures to particles and gases. *Environ Health Perspect* 114:649–654, http://www.ehponline.org/members/2005/8422/8422.html.

Schwartz DA, Weis B, Wilson SH. 2005. NIEHS director's perspective: the need for exposure health sciences. *Environ Health Perspect* 113:A650, http://www.ehponline.org/docs/2005/113-10/director.html.

Weis BK, Balshaw D, Barr JR, et al. Personalized exposure assessment: promising approaches for human environmental health research. *Environ Health Perspect* 113:840–848, http://www.ehponline.org/members/2005/7651/7651.html.

Implementing the Lesson

INSTRUCTIONS:

1. Have students review the Student Instructions, and introduce the concept of a creative design project based on the article.
2. Have the students read the article. Encourage students to take notes and highlight as necessary.
3. Students complete the exercises described in the Student Instructions.
4. Post or allow students to present their sensor posters/prototypes.
5. Lead a discussion about the future of environmental health research as these devices generate increasing amounts of real-time data about the relationship between genes, environment, and behavior.

NOTES & HELPFUL HINTS:

1. If you would like to expand this exercise, have students build full-size or scale models of their sensors.
2. Another extension of this lesson would be to have students write down personal exposure information for themselves for one week then use the information they gather to guide sensor creation. For example, a student might choose deep fried foods, cigarette smoke, or auto exhaust. Make sure students have identified specific means of qualifying and quantifying their exposure before beginning their log (e.g. timing their exposure, quantifying the amount of food, qualitatively describing the concentration of the exposure). This will help call attention to the types of things that could be measured by a sensor. How can their qualitative descriptions become quantitative? How might a quantitative measurement become more accurate?
3. Students may choose to create a sensor for an exposure of particular concern to them. Assessment would involve seeing that the student did sufficient research on the health effects, agent, and biomarker(s) particular to their subject.

Aligning with Standards

SKILLS USED OR DEVELOPED:

- Communication (note-taking, oral, written—including summarization)
- Comprehension (listening, reading)
- Critical thinking and response
- Research
- Technological design

SPECIFIC CONTENT ADDRESSED:

- Exposure assessment
- Environmental health research methods
- New technology in research
- Biomarkers of physiological change
- The interaction of genes, environment, and disease

NATIONAL SCIENCE EDUCATION STANDARDS MET:

Science Content Standards

Unifying Concepts and Processes Standard

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

Science as Inquiry Standard

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Science and Technology Standard

- Abilities of technical design
- Understanding about science and technology

Life Science Standard

- Interdependence of organisms
- Matter, energy, and organization in living systems
- 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

Assessing the Lesson

Step 1: Students should read the entire article and fill in the table with factors related to asthma as discussed in the article. Answers should include many or most of the following:

Environmental Factors	Individual Biological or Physical Factors
Air pollution	Genes/DNA
Cigarette smoke	Behavior patterns such as diet
Ozone	Metabolites
Cockroach dander	Protein adducts in the blood

Lipopolysaccharide
Particulate matter
Mold
Pollen
Temperature*
Humidity*

Geographic location
Physical activity
Heart/respiratory rate
Inflammation
Oxidative stress levels

* These factors are not in the article but may be known to students, especially those with asthma.

Step 2: Design a personal monitoring device to track environmental exposures associated with one of the following scenarios:

- A child with severe allergies
- A person who works long hours in a closed office environment
- A teen with poor eating habits and/or low physical activity
- A farmworker who applies pesticides in a rural environment
- A soldier on the battlefield

A. Students should do basic research on the health problems associated with the chosen scenario. Health problems can vary with each scenario, so you may need to guide students to focus on one health problem for their chosen scenario (such as sneezing and respiratory irritation in a closed office environment). The selected health problem may be caused by one or several factors in the environment, so students must identify specific indicator chemicals, gases, toxicants, or dietary factors to measure (such as formaldehyde, VOCs, and/or specific pesticides in the office example). The sensor should be designed with an established hypothesis in mind that links the factors being recorded with the health effect of interest. They should also have a unit of measurement (parts per million, for example) and ideally a reference value, for instance, an EPA safe level, or LD_{50} for a known toxicant. Students should also list what information will be collected that is individual-specific, for instance, geographic location or biological factors like respiratory rate, blood pressure, heart rate, previous allergies. The choice of these factors should be logically related to each other and to the larger health issue being addressed.

B. Students should make a detailed drawing indicating the scale of the device and show how it would be attached to the person. The device should incorporate a number of technical features mentioned in the article such as:

Biological warfare technology
Blood sampling
Cell phone–based technology
Data entry keypad
Dosimetry
Electronic interface
Geographic information systems technology
Geographic Positioning System technology
Indicators that light up or change color
Air, surface or liquid sampling instruments
"Lab on a chip" technology
Laser-based measurements
Mass spectrometry
Motion sensing

Multiplexed sensors

Nanoscale biosensors

Pedometry

Transdermal readings

Wireless data transmission

C. In the class discussion, students should identify what would be involved with collecting and analyzing the data once they are generated by the sensor. This can be a less specific answer, such as "a team of researchers would analyze the data and publish their findings in a journal so others could learn from their work." As for the final discussion question regarding using the monitor to improve public health, ideally scientists and doctors would identify individuals vulnerable to a given toxicant or exposure so that they could avoid or minimize that exposure as a preventive measure. Alternatively, screenings could be developed so that employers might be able to hire only employees at low risk of harm from an occupational exposure. These answers should be imaginative and future-oriented.

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Give us your feedback! Send comments about this lesson to ehpscienceed@niehs.nih.gov.

STUDENT INSTRUCTIONS: Build a Personal Sensor

PART 1

Step 1: Read the article "Monitoring Environmental Exposures: Now It's Personal." The article describes the use of personal monitoring to study asthma. Complete the table below with factors related to asthma that can be monitored. List as many as you can find in each category.

Environmental Factors	Individual Biological or Physical Factors
___	___
___	___
___	___
___	___
___	___
___	___
___	___
___	___
___	___
___	___
___	___

Step 2: Design a personal monitoring device to track environmental exposures associated with one of the following scenarios:

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A. Based on your selection, write a one-page description of your proposed sensor. In your description, you should:

- identify the health hazards or symptoms associated with your scenario;
- select the environmental and individual factors your sensor will monitor; and
- include a reference value for chemical environmental factors you plan to monitor. Be sure to include units, describe the source of the reference values (for instance, the EPA), and justify why you chose those values.

B. On a separate sheet or poster, draw your personal sensor. Include the following:

- its technological features and useful properties (be sure to incorporate some of the features mentioned in the article);
- the size of the sensor and if/how it will attach to the person; and
- potential limitations of the sensor.

C. All monitoring devices collect data. In your class discussion describe what will be done with the data your sensor collects and how it might it be used to improve public health.