Case Teaching Notes

for

"PCBs in the Last Frontier: A Case Study on the Scientific Method"

by

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Introduction / Background

This case study was developed after reading an article by Krümmel et al. in the journal *Nature* (vol. 425, pp. 255–6, 2003) concerning the bioaccumulation and transport of polychlorinated biphenyls (PCBs) by sockeye salmon from the Pacific Ocean to Alaskan lakes. It involves students reading basic background information before proposing hypotheses to explain the information. The emphasis is on making predictions and explaining the reasoning behind a prediction.

PCBs are a good example of a persistent pollutant that has a global distribution. The example shown in the case study is one of 209 possible congeners. The precise mixture of congeners depends upon the original source and is quite variable. The compounds are excellent insulators and were used mainly in heavy electrical equipment. Examples of other uses include polymer manufacturing and carbonless copy paper production. The persistence of PCBs in the environment is related to their thermal stability and general resistance to biodegradation. The acute toxicity of PCBs was first recognized on a large scale in the 1960s from an accidental contamination of cooking oil in Japan (Spiro and Stigliani, 2003). Several thousand people suffered a variety of illnesses ranging from skin discoloration to higher mortality for infants born to exposed mothers. The long term health effects have been harder to identify, but it is suspected that PCBs cause endocrine disruption by binding to the Ah (aryl hydrocarbon) receptor (Spiro and Stigliani, 2003) and can affect thyroid function in the hydroxylated form (Oliver Cheek et al., 1999).

This case was designed to be used early in a course such as general or introductory chemistry, general biology, or environmental science. Since little background knowledge is needed, it can be used with majors or non-majors. The case could also be extended for use in a course such as analytical chemistry where it could involve reading and discussing the original paper from *Nature* and subsequent work.

Objectives

- To help students review the scientific method.
- To teach students how to better state hypotheses.
- To encourage students to design experiments that test a hypothesis.
- To give students an introduction to the scientific literature with a relatively easy-to-read article.

Classroom Management

I have used this case in a General Chemistry I class of 40 students working in groups of three. As written, the case can be completed in a 50-minute lecture session or in a lab setting.

The case is broken up into four parts, which the instructor distributes one part at a time with discussion after each part. (In large classes this may be less practical and the instructor may want to pass out the entire case and instruct students not to look ahead.) Students read each part and then spend about five minutes discussing the questions as a group. After each part there is a short class discussion with a summary of the best answers.

Before beginning the case, I run a short class discussion on the steps of the scientific method. With input from the class, I draw a diagram showing the steps of the scientific method as a refresher. Most students have seen the steps to the scientific method enough times that as a class the basics can be discussed. Added discussion can also occur during the case study on the difference between an experiment where a variable is manipulated and making observations to answer a question. This more subtle distinction can be emphasized while students are discussing ways to test hypotheses. The case presents several opportunities for students to propose experiments and the discussion from the early part of the case will likely lead to improved answers later.

After completing the case, I provide copies of the article to any students who are interested in reading more. The article can be found in *Nature* (vol. 425, pp. 255–6, 2003). It is also available on the web site of one of the paper's original author's web site as of June 16, 2005:
http://www.biology.mcgill.ca/faculty/gregory_eaves/articles/KRUMME~1.pdf

A possible extension of this case comes from recent work showing that organohalogens transferred by migrating salmon end up in the resident fish of the lake where spawning occurred (Mu et al., 2004). In that work, arctic graylings residing in lakes with returning salmon showed higher levels of chlorinated fatty acids than arctic graylings in lakes with no returning salmon. The transfer mechanism is not known at this time. This touches on issues of bioaccumulation that instructors can cover to the extent they desire depending on the time available. Areas related to this are lipid solubility and movement through the food chain. These are especially good topics for students in environmental science courses.

Answer Key

Answers to the questions posed in the case study are provided in a separate answer key to the case. Those answers are password-protected. To access the answers for this case, go to **the key**. You will be prompted for a username and password. If you have not yet registered with us, you can see whether you are eligible for an account by reviewing our **password policy and then apply online** or write to **answerkey@sciencecases.org**.

References

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