# Flash forward to problem-based science

*It's the year 2252, ten years after the Great Plague that ran through the Earth's population, killing millions, and causing the collapse of civilization. Now the Earth has entered a new Dark Age—a time when much of the knowledge from the past has been lost.*

*You are a member of an elite group known as The Reconstructors. You help the People by recovering lost medical knowledge. Your skills are urgently needed because painkillers have almost disappeared. Stories and documents refer to powerful pain-relieving medicine from the past.*

*Your mission is to reconstruct the knowledge and uncover this medicinal mystery.*

So begins the first episode of a website designed by and for middle school students: *reconstructors.rice.edu*. In designing *The Reconstructors*, our goal was to combine aspects of problem-based learning and science standards and deliver them over the Web via interesting multimedia. We had conducted a thorough survey of over 500 adolescents to determine their technology habits, preferences, and favorite websites (Miller, Schweingruber, and Brandenburg 2000; Miller 2000). Our findings revealed that both males and females enjoy mystery stories and that they spend the majority of their computer time playing games.

Problem-based learning specialists suggest that the problem should be situated in complex and meaningful contexts (Barrows 1986), and that students should want to solve the problem for its own merit, not for some extrinsic reward. We decided that the science problem would focus on the biology and history of drugs, specifically opioids—a class of powerful, analgesic drugs derived from the poppy plant. Our underlying motivation was to teach adolescents about the use and abuse of drugs, but from a scientifc analysis. Our goal was for students to understand *why* they should "just say no." Next, we turned to the National Institute on Drug Abuse for funding; to teachers and students for help with the design; and to Macromedia's Flash for a way to deliver our interactive materials efficiently over the Internet. Sandy Bankston, a veteran middle school science teacher, helped us construct the learning objectives and align them with science content, teaching, and assessment standards. Joyce Ramig, another experienced middle school science teacher, allowed us time with her seventh grade students to conduct focus groups over several months.

First, the focus groups tackled the 'problem.' Boys and girls were divided into two different groups, and each group gave us ideas for characters, names, and the setting. Next, we presented sketches of all the website elements to the groups for their votes. The only idea from the focus groups that we did not use was the boys' request to give the characters weapons.

With the problem in hand, we began to weave together the learning objectives. Solving the problem meant engaging students in several of the concepts that align with the *National Science Education Standards* (NRC 1996) and the *Benchmarks for Scientific Literacy* (AAAS 1993):

- Scientific investigations sometimes result in new ideas and phenomena for study, generate new methods or procedures for investigations, or develop new technologies to improve the collection of data.
- Specialized cells perform specialized functions in multicellular organisms.
- Technological solutions have intended benefits and unintended consequences.
- Some drugs change how the body functions and can lead to addiction.
- Scientists formulate and test their explanations

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of nature using observation, experiments, and theoretical and mathematical models.

• Tracing the history of science can show how difficult it was for scientific innovators to break through the accepted ideas of their time to reach the conclusions that we currently have today.

All of these content standards are wrapped around the history and neurobiology of naturally occurring and synthetic opioids, beginning with the ancient use of the opium poppy (Papaver somniferum) to relieve pain. In *The Reconstructors*, students are challenged to use higher-level thinking skills to construct their knowledge about opioids. For example, the virtual experiments engage students in analyzing data and drawing conclusions.

The conceptual flow if the adventure series goes something like this:

*Episode 1: Plaguing Problem*—There is a mystery substance. The substance is tested for its analgesic properties against a non-steroidal anti-inflammatory drug (NSAID—aspirin) and a control (saline) in a virtual experiment. Students analyze the data, report conclusions, and study discussions about the differences in pain relief between the NSAID and the mystery substance.

*Episode 2: Ancient Alarm*—Because the mystery substance proves to have pain-relieving properties and we know it comes from a plant, we want to determine its botanical source by using a taxonomic key. Students identify the source as the poppy plant and the mystery substance as opium. As students read through historic documents, they learn that a war was fought between China and Britain in the late 1800s because the British were making opium widely available to the Chinese. The opium caused widespread addiction.

*Episode 3: Analgesic Anxiety*—Using virtual High Performance Liquid Chromatography, several compounds (alkaloids) are separated from opium in an attempt to remove its addictive components from the analgesic ones. Students test two alkaloids, morphine and codeine, for their pain relieving effectiveness in a virtual experiment—they find that both are addictive. Finally, students examine the historical development of heroin, which was assumed to be a non-addictive alternative to morphine.

*Episode 4: Mystery of Morpheus*—Now knowing that the compounds relive pain, students investigate how they work in the body. Conducting a virtual re-enactment of the original experiment using frog hearts by Loewi (for which he later won the Nobel Prize), students deduce that the signals between neurons are both electrical and chemical. Students verify the existence of neurotransmitters, and explore the notion of how both endogenous opioids and poppy-derived opioids are able to bind to the same receptors.

Why use this Web adventure in the classroom? As Joyce explains, "A big component for middle school integrated science is a study of living things. In human biology, this study includes labs to establish an understanding of each body system and activities that highlight the fact that these body systems work together. Studies of disease and medicine and drug abuse are also an important focus. In my science class, we use *The Reconstructors* to culminate our Human Body Systems Unit. It allows my students to become involved in a wonderful detective story while reviewing an aspect of the human body." See Figure 1 for more reasons to engage your students in *The Reconstructors*. When you are ready, go to *reconstructors.rice.edu* and let the adventure begin.

## References


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FIGURE 1 Why you should use *The Reconstructors* website in your classroom


**Content**

From a content standpoint, the history of opium, as well as its biological consequences, is relevant to understand how, when, and why we use opioids today. The basics of brain biology and neuron structure and function are covered, and the episodes answer 'why' opioids have the potential to be addictive. More importantly, the episodes help establish the biological basis of addiction. The game features questions that change on a random basis. This was done so students could not simply tell each other the answers and continue in the "happy click" mode without actually taking time to think about the questions. We continue to revise the game based on teacher and student suggestions.

**Efficiency**

The adventure episodes are free and relatively easy to download. All it takes is a Flash plug-in that is included in the latest version of any Internet browser or can be downloaded in minutes, depending on the speed of your classroom connection. If there are technology issues such as firewalls that prevent you from playing the game, we can send you a CD-ROM version.

**Support materials**

Each lesson includes a pretest, posttest, answer keys, and learning objectives, which are located on the website's Teacher Pages. When you click on the screen to access the tests and answer keys, you will be prompted to enter a password. Simply click "OK," as no password is required. Classroom activities designed to accompany the Web adventure will be available on the website's Teacher Pages in the spring of 2002. The classroom components for each episode include one hands-on experiment and one activity that involves technology integration, such as using a spreadsheet or creating a Power Point presentation.

**Effectiveness**

The initial two episodes have been field-tested with over 150 students. Given a pretest and posttest on the science concepts, students demonstrated significant gains in knowledge and comprehension. We believe that this demonstrates the efficacy of both the content and the novel format.

**Enrichment**

If you are looking for an activity that can be done independently, for extra credit, or as enrichment for students who desire material that go beyond the textbook, consider *The Reconstructors.* At home or even in a one-computer classroom, the episodes are easily available and normally take about 20 minutes each to complete. Concluding each episode is a set of "cool links" that will take students to information of interest at other websites.

**Design process**

You and your student can also become part of our design team. We encourage you to try out the learning environment with your students and provide us with feedback. We welcome input from anyone who plays the adventure. We're listening and we'd love to hear from you.