

**NSF Research Experiences for Teachers
Northeastern University, 2006
Emily Simpson**

Lesson Title	Pharmacology Expedition
RET Project Connection	<p>The engineering of new medical technology is a dynamic field that incorporates aspects of many different traditional fields of science. From creating a new drug, or improving an already existing prosthetic device, all medical engineering goes through similar phases. First, using theory and experimentation, researchers design a solution to mitigate the problem. Then the solution must be tested for both effectiveness and safety over both a short and a long term, and finally if a solution is found to be both safe and effective, the solution can be implemented. One such solution currently being tested in Dr. Shashi Murthy's lab at Northeastern is biopassivation coatings for neurological implants. These implants are currently used in cochlear implants, which returns hearing to deaf patients, and for deep brain stimulation to reduce the symptoms of Parkinson's disease. In the future it is hoped that these implants will also help victims of strokes and spinal cord injuries, as well as patients with ALS.</p> <p>Before a coated device can be considered for implantation, extensive testing needs to be done to make sure that the coating is safe. This summer I did initial cytotoxicity tests for two different polymer coatings created by the CVD process. One coating is a novel organosilicon polymer, and the other coating is a fluorosilicon copolymer that has the combined attributes of its constituent fluorocarbon and organosilicon polymers. Both coatings were deposited on glass slides using CVD.</p> <p>Although I was personally only working on the final phase of the pharmacological process, I was able to see how this whole process could incorporate many of the concepts and skills I wanted to teach to my chemistry students this year. As a result I have designed a year long expedition that will take the students through each of the phases of the pharmacology process, allowing them to practice many of the skills and concepts that we will be studying in our Living By Chemistry curriculum.</p>
RET Teacher	Emily Simpson
School	Codman Academy Charter Public School
Town/District	Dorchester, MA
Subject(s) Taught	Chemistry and Biology
Subjects covered in lesson	Elements and Compounds Bonding Chemical Reactions Concentration and Molarity Toxicity and Dosage Processes in science
Grades Appropriate	9-12
Lesson Duration	Full year with periodically recurring lessons
Goals/Objectives of lesson	Students should understand these "Big Ideas" <ul style="list-style-type: none">○ There is overlap in the various fields of science during the process of finding or designing new drugs.○ The pharmacological process includes various stages including (but

not limited to) creating a new chemical compound, testing the effectiveness of that compound, testing the safety of the compound *in vitro*, testing the safety of the compound *in vivo*, and receiving approval to manufacture and market the drug.

- There are many factors that can influence the safety and effectiveness of a new drug.
- Any chemical can be toxic.

Students should meet these individual learning targets

- I can describe what the physical and chemical properties of acetylsalicylic acid (aspirin). (Chemistry Standard 1.1)
- I understand the difference between a pure substance and mixture, and how to extract a specific substance from a mixture (Chemistry Standard 1.2)
- I know what elements salicylic acid is composed of (Chemistry Standard 5.4).
- I can define ethnobotany and its importance to the field of modern pharmacology.
- I can explain why it is important, from a pharmacological perspective to study and maintain biodiversity.
- I can extract salicylic acid from willow bark and synthesize it into acetylsalicylic acid (aspirin). (Science Inquiry Skill: Follow procedures to replicate an experiment).
- I can test for the presence of salicylic acid in a compound. (Science Inquiry Skill: Use appropriate tools and techniques to gather, analyze, and interpret data)
- I can draw the chemical structure of salicylic acid.
- I can read and identify the big ideas in an FDA Patient Information Sheet.
- I can read and identify the big ideas in an FDA Prescribing Information Sheet.
- I can read, make text connections to, and summarize, a current news article about ethnobotany and/or drug discovery.
- I can write an analytical description of the physical and chemical properties of salicylic and acetylsalicylic acid.
- I can determine the present composition of acetylsalicylic acid in different brands of aspirin (Chemistry Standard 5.4)
- I can explain how the chemical composition of aspirin makes it more or less effective.
- I can explain how the chemical composition of aspirin affect its rate of dissolution (Chemistry Standard 7.1)
- I can define the terms, analgesic, antipyretic, and anti-inflammatory medication, and explain how they relate to aspirin.
- I can make a cost-benefit analysis using scientific information.
- I can calculate the percent composition in a mixture.
- I can make a hypothesis based on my experiences.
- I can determine the concentration of *Daphnia* in a sample.
- I can determine the concentration and dosage of active drug ingredients (Chemistry standard: 7.2)
- I can name and explain factors that lead to a chemical being more or less toxic.
- I can create a testable question about factors affecting the toxicity of

- active ingredients in over the counter medication.
- I can write a hypothesis for my question based on my previous experiences.
- I can design a method to test my question.
- I can collect and analyze data to answer my question.
- I can discuss the results of my data in relation to my question and hypothesis.

Background Information

Students will gain background information on the basic concepts of chemistry through completing all or portions of the following “Living By Chemistry” modules: Alchemy, Smells, and Toxins.

Essential Questions

- How do we use chemistry to create new drugs and medical technologies?
- How do we know if a drug is effective?
- How do we know if a drug is safe?
- What factors influence toxicity of a drug (or any chemical)?
- How can something be both a medicine and a poison?
- What are the ethical considerations of designing and patenting a new drug?

Links to Frameworks and Standards:

* National

By the end of the 12th grade, students should know that

- Atoms are made of a positive nucleus surrounded by negative electrons. An atom's electron configuration, particularly the outermost electrons, determines how the atom can interact with other atoms. Atoms form bonds to other atoms by transferring or sharing electrons.
- The nucleus, a tiny fraction of the volume of an atom, is composed of protons and neutrons, each almost two thousand times heavier than an electron. The number of positive protons in the nucleus determines what an atom's electron configuration can be and so defines the element. In a neutral atom, the number of electrons equals the number of protons. But an atom may acquire an unbalanced charge by gaining or losing electrons.
- Neutrons have a mass that is nearly identical to that of protons, but neutrons have no electric charge. Although neutrons have little effect on how an atom interacts with others, they do affect the mass and stability of the nucleus. Isotopes of the same element have the same number of protons (and therefore of electrons) but differ in the number of neutrons.
- When elements are listed in order by the masses of their atoms, the same sequence of properties appears over and over again in the list.
- Atoms often join with one another in various combinations in distinct molecules or in repeating three-dimensional crystal patterns. An enormous variety of biological, chemical, and physical phenomena can be explained by changes in the arrangement and motion of atoms and molecules.
- The configuration of atoms in a molecule determines the molecule's properties. Shapes are particularly important in how large molecules interact with others.

- The rate of reactions among atoms and molecules depends on how often they encounter one another, which is affected by the concentration, pressure, and temperature of the reacting materials. Some atoms and molecules are highly effective in encouraging the interaction of others.

*** State**

Massachusetts High School Chemistry Standards

- 1.1 Identify and explain physical properties (such as density, melting point, boiling point, conductivity, and malleability) and chemical properties (such as the ability to form new substances). Distinguish between chemical and physical changes.
- 1.2 Explain the difference between pure substances (elements and compounds) and mixtures. Differentiate between heterogeneous and homogeneous mixtures.
- 2.1 Interpret and apply the laws of conservation of mass, constant composition (definite proportions), and multiple proportions.
- 2.2 Write the electron configurations for the first twenty elements of the periodic table.
- 4.1 Explain how atoms combine to form compounds through both ionic and covalent bonding. Predict chemical formulas based on the number of valence electrons.
- 4.2 Draw Lewis dot structures for simple molecules and ionic compounds.
- 4.3 Use electronegativity to explain the difference between polar and nonpolar covalent bonds.
- 4.6 Name and write the chemical formulas for simple ionic and molecular compounds, including those that contain the polyatomic ions: ammonium, carbonate, hydroxide, nitrate, phosphate, and sulfate.
- 5.1 Balance chemical equations by applying the laws of conservation of mass and constant composition (definite proportions).
- 5.2 Classify chemical reactions as synthesis (combination), decomposition, single displacement, double displacement, and combustion.
- 5.3 Use the mole concept to determine the number of particles and the molar mass of elements and compounds.
- 7.1 Describe the process by which solutes dissolve in solvents.
- 7.2 Calculate concentration in terms of molarity. Use molarity to perform solution dilution and solution stoichiometry.
- 7.3 Identify and explain the factors that affect the rate of dissolving, such as, temperature, concentration, surface area, pressure, and mixing.
- 7.4 Compare and contrast qualitatively the properties of solutions and pure solvents (colligative properties such as boiling point and freezing point). Identify the factors that affect the rate of a chemical reaction (temperature, mixing, concentration, particle size, surface area, and catalyst).

Materials Required

Living By Chemistry: Alchemy Module, Smells Module, and Toxins Module
 Synthesis of Aspirin Microchemistry Kit (from Carolina Biological)
 A Closer Look at Aspirin Kit (from Carolina Biological)
 The Effect of Drugs Kit (from Carolina Biological)

Lesson Development

Stage 1: Creating A Compound

Connects to “Alchemy” Module

Learning Experiences:

- Extract and synthesize acetylsalicylic acid

- On-line “Aspirin Adventure” information search
- Examine FDA Prescribing Information Sheets
- Characterize aspirin
- Read current media coverage of pharmacological advancement
- Possible visit to research facility

Product: “Description” section of Prescribing Information Sheet.

Stage 2: Is It Effective?

Connects to “Smells” and “Toxin” Modules

Learning Experiences:

- Testing composition of different brands of aspirin
- Testing dissolution rates of different brands of aspirin.
- Which brand would I recommend? Cost benefit analysis of different brands.

Product: “Clinical Pharmacology” and “Indications and Usage” sections of Prescribing Information Sheet.

Stage 3: Is It Safe?

Connects to “Toxin” Module

Learning Experiences:

- Observing/quantifying model organism (*Daphnia*)
- What makes it toxic? Students develop a question and an experiment to test their question. Each group will perform a unique “clinical trial” testing various factors such as dosage, drug interactions, and population response.

Product: “Clinical Trials” section of Prescribing Information Sheet.

Groups will need to share their results as a scientific community, and they will need to cite trials done by other students in their section.

Assessment

Assorted Lab Sheets
Class Participation and Discussions

Modified Prescribing Information Sheet

References

National Science Education Standards, National Research Council

Massachusetts State Science Standards:

<http://www.doe.mass.edu/frameworks/scitech/0106standards.doc>

“Living By Chemistry” curriculum

Aspirin Expedition

Overview

- ✂ Class: Chemistry (Juniors)
- ✂ Context: Connected to Living by Chemistry “Alchemy” and “Toxins” Modules
- ✂ Big Idea: Students understand and participate in three stages of the pharmacological process.
- ✂ Duration: Entire Year
- ✂ Time: 7 full Fridays + 5.5 hours class time
- ✂ Assessment: Simplified FDA Prescribing Information Sheet.

Stage 1: Creating A Compound

- ✍ Connection to “Alchemy” Module
- ✍ Learning Experiences:
 - ✍ Extract and synthesize acetylsalicylic acid
 - ✍ Examine FDA Prescribing Information Sheets
 - ✍ Characterize aspirin
 - ✍ Read current media coverage of pharmacological advancement
 - ✍ Possible visit to research facility
- ✍ Product: “Description” section of Prescribing Information Sheet.

Stage 2: Is It Effective?

- ✍ Connection to “Alchemy” and “Toxin” Modules
- ✍ Learning Experiences:
 - ✍ Testing composition of different brands of aspirin
 - ✍ Testing dissolution rates of different brands of aspirin.
 - ✍ Which brand would I recommend? Cost benefit analysis of different brands.
- ✍ Product: “Clinical Pharmacology” and “Indications and Usage” sections of Prescribing Information Sheet.

Stage 3: Is It Safe?

- ✍ Connection to “Toxin” Module
- ✍ Learning Experiences:
 - ✍ Observing/quantifying model organism (*Daphnia*)
 - ✍ What makes it toxic? Students develop a question and an experiment to test their question. Each group will perform a unique “clinical trial” testing various factors such as dosage, drug interactions, and population response.
- ✍ Product: “Clinical Trials” section of Prescribing Information Sheet. Groups will need to share their results as a scientific community, and they will need to cite trials done by other students in their section.

Connection To Summer Research

- ✍ I worked on a “Stage 3: Is it safe?” type problem.
- ✍ Investigated cytotoxicity of two possible coating for neurological implants using neural rat cancer cells.
- ✍ Students will perform similar toxicity studies using a safer model organism.