Rationale:
According to the new California Science Standards, students begin learning formally about ecosystems in the 3rd and 4th grades. In the 5th grade, students learn that substances may be separated using their chemical and physical properties. The idea that substances combine via chemical reactions to form products having different properties is introduced. In the 6th grade, students study natural resources. They learn about the ecology of the food web and how matter is transferred between organisms and the environment. While the new science standards have not yet been implemented in most schools, these modules were designed to complement these standards.

Specific science standards addressed in this Materials and the Environment lesson plan are:

3rd grade:
• Students know that when the environment changes, some plants and animals survive and reproduce; others die or move to new locations.

4th grade:
• Students know that ecosystems can be characterized by their living and nonliving components.
• Students know that in any particular environment, some kinds of plants and animals survive well, some survive less well, and some cannot survive at all.

5th grade:
• Students know that during chemical reactions, the atoms in the reactants rearrange to form products with different properties.
• Students know that differences in chemical and physical properties of substances are used to separate mixtures and identify compounds.

6th grade:
• Students know that matter is transferred over time from one organism to others in the food web and between organisms and the physical environment.
• Students know about different kinds of natural resources.
• Students are asked to use appropriate tools and technology to perform tests, collect data, and display data.
• Students are asked to construct appropriate graphs from data and to develop qualitative statements about the relationships between variables.
• Students are asked to communicate the results from an investigation in an oral presentation.

8th grade:
• Students know that reactant atoms and molecules interact to form products with different chemical properties
• Students know how to determine whether a solution is acidic, basic, or neutral.
**Disclaimer:** These activities were adapted from the book\(^1\): “The Extraordinary Chemistry of Ordinary Things, 3\(^{rd}\) Ed.” written by Carl. H. Snyder.

**Part 2: Pollution**

**Objectives:**
After participating in the program *Materials and the Environment, Part 2*, students will be able to:

- explain that pollution is a relative term
- demonstrate how to calculate the concentration of a solution
- describe the origin of acid rain

**Vocabulary:**
- **pollution**: contaminating substance(s) that makes another substance (especially water, air, or the environment) unclean or impure
- **concentration**: amount (mass or weight) of one substance found in a given volume of another substance, usually a solution (e.g., g/ml)
- **acid**: an acid is characterized by a sharp or sour taste, turns blue litmus paper pink, and reacts with a base to form salt and water
- **base**: a base is characterized by a slippery feel, turns red litmus paper blue, and reacts with an acid to form salt and water
- **neutral**: a substance which does not react as would and acid or base
- **pH**: a scale used to indicate the relative basic or acidic nature of a solution; low pH numbers (0 to 7) indicate acids and high numbers (7 to 14) indicate bases; 7.0 is the pH of a neutral solution
- **sulfur**: a pale yellow, non-metallic element that burns with a blue flame and a very characteristic odor

**Lesson Notes:**
1. This section is meant to get students thinking about pollution. You don’t need to provide any answers to the following questions, just ask the students to answer thoughtfully. To keep track of student responses, appropriate lists can be written on the blackboard. What is pollution? Can you give some examples of polluting substances? Is anything really pure? What would you consider pure to be? Is pollution when one substance is contaminated with a bit of some other substance? What about just one molecule? How do we decide on acceptable levels of pollution?

2. Explanations are included below as needed for the concentration experiment.
   - **Step 4:** Concentration tells us how much of a substance is contained in a given volume of another substance. Typical units for concentrations are g/ml or g/cm\(^3\), but we could also use tsp/cup or some other appropriate unit system.
   - **Step 5:** If the cup sides are not straight, students should be made to understand that further concentration calculations are going to be estimates only. The objective of the experiment will still be achieved, but the calculated concentrations will be off by

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some amount. How much of the unknown is now in cup S? 
(1/10 tsp) Has the concentration in cup A changed? (No)

- **Step 9:** Answers to the following questions will vary. When do you become able to sense the presence of the added substance. What is the substance? When would you consider the solution undrinkable?
- **Step 10:** Does this experiment help you to understand that the extent of pollution is the real issue? Answers to this question will be subjective.

3. Have you heard about acid rain?
What kind of damage to the environment can be caused by acid rain? (Acid rain damage includes destruction of vegetation, destruction of marine life, etching and corrosion of buildings and works of art that are exposed to weather.)
Do you know about acids and bases?
Can you name some common acids? (Lemon and other citrus juices, vinegar, etc.)
What are some characteristics of an acid? (Tastes bitter, burns, etc.)
Can you name some common bases? (Ammonia, lye (used in soaps), Draino™, etc.)
What are some characteristics of a base? (Slippery feel, etc.)
If you don’t know what a substance is, how could you tell if it were an acid or base? (You could use pH paper (litmus paper) or an acid/base indicator.)
What color is the end of the paper towel with the cabbage juice on it? (It is blue, so it has a neutral pH.)
Is there any change in the paper towel? (There should be no color change.)
What happened to the paper towel? (This question is asked after the match is blown out. There is now a pink spot on the paper towel directly over the match.) If the students wish, a drop of vinegar can be placed on the paper towel in a new spot to confirm that acid is what makes the paper towel turn pink (make sure you do this in a place that has indicator or no color change will take place).
How did the acid get on the paper towel? (There was a chemical reaction on the part of the paper towel that turned pink.)
Was it the match paper (or wood) burning? (Your demonstration should show that burning the match (or wood) paper does not produce a pink spot on the paper towel.)
Do you remember the flare and the smell when the match was lit? (Match heads often contain sulfur, S, and phosphorus, P, to help the match light easily and burn hot. The gas SO₂ is often produced when the materials in the match head burns. This gas is what you smelled.)
When the SO₂ gas is combined with the water on the paper towel, sulfurous acid (H₂SO₃) is produced. That is where the pink spot came from. SO₂ is released into the air by the burning of sulfur in petroleum and coal products. SO₂ gas can react with oxygen in the air to form SO₃ gas. When this gas combines with water droplets in clouds, sulfuric acid (H₂SO₄) rain can result. The main contribution of sulfur gases to the atmosphere are from human activities (90%) and most of that comes from energy generation. Do you think that concerns about this type of pollution would make energy generation an international issue?

Answers to the worksheet are located in the file: envir_2_wksht_key.
References and Extension Ideas:

These activities were adapted from the book¹: “The Extraordinary Chemistry of Ordinary Things, 3rd Ed.” written by Carl. H. Snyder. Background information on acid rain may be found at the website listed below.