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Eat, Drink, and Be Wary: Recognizing Toxic Chemicals in Foods and Beverages

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Introduction

Eating in class is one of the least enforced rules at my school. Students consume a mixture of salt, sugar, fat, additives, preservatives and unknown substances throughout the day. They drink an array of sodas, juices, energy drinks and bottled water. When I suggest healthy alternatives, they react like chemically dependant addicts. The two most frequent remarks that I hear are, "but it tastes so good and you have to die from something. Instead of just making students put away their "junk food," I want to inspire them to make healthy choices.

The recent national campaign to reduce pediatric obesity has attempted to reduce the fat and sugar consumption of school age children, but most of them still prefer processed food. The food industry has created myriad products and a convenient delivery system to satisfy the palates of youthful consumers. In addition to their negative impact on health, convenience foods are producing deleterious effects on the environment.

Most foods and beverages consumed by youth are packaged in plastic, including soda and energy drinks (with can linings made of BPA epoxy), chips, juice boxes, lunchables, candy, and single-use plastic water bottles. "The growth of bottled water consumption that has occurred in the last decade is a prime example of the dramatic increase in the use of plastic for food packaging. Snack-sized food and beverage packages made of plastic are on the rise due to their convenience. As package size diminishes, use of plastic increases (1)."

Once the contents inside the single-use plastic package are ingested, what happens to the remaining container? Another important question is what are the components in plastic packages? Furthermore, how do these constituents react in the body and how do they impact the environment? Discovering the answers to these essential questions is the crux of this curriculum unit.

The title Eat, Drink and Be Wary: Recognizing Toxic Chemicals in Foods and Beverages contends that there are harmful substances in the Standard American Diet (SAD). In fact, it proposes we need to know what they are in order to protect ourselves. However, the primary purpose of this unit is to explore the effects and potential dangers of plastic packages on environmental and human health.

"Toxic chemicals are ubiquitous, mysterious, and insidious. Plastics, solvents, pesticides, PCBs, phthalates, and others form chemical cocktails that may act together or on their own to damage human cells (2)." "Two plastic ingredients, bisphenol A (BPA) and Di (2-ethylhexyl) phthalate (DHEP) have been detected in the blood and urine of nearly everyone who has been tested. Studies indicate that BPA and DHEP disrupt the normal growth and development in many different species of animals due to their hormonal activity (1)" Although chemicals in plastics have been linked to serious health risks and environmental deterioration; most high school students are unaware of this complex problem.

Objectives

Students must be informed about this important issue in order to understand the consequences of their actions or inaction. Through this curriculum unit, I plan to lead an investigation of the impact of plastic packaging on Urban Environmental Quality and Human Health, as previously stated. To engage my students, I will focus on plastic packages used for various foods, beverages, and cosmetics that American teenagers consume. Initially, I will introduce my students to the periodic table of elements. We will cover atomic theory and periodic trends. After a comprehensive study of subatomic particles, isotopes, half lives, radioactive decay, electron configuration, families or groups, chemical and physical properties; valence electrons, and oxidation numbers (see Appendix 1A), I will facilitate an in-depth study of nomenclature.

The students will analyze different types of chemical formulas (empirical, molecular, and structural), chemical equations, bonding types (ionic and covalent), reaction types (synthesis, decomposition, single and double replacement, oxidation-reduction, neutralization, exothermic, and endothermic), and some organic compounds (see Appendix 1B). Consequently, the students will develop the ability to recognize and identify certain chemicals in foods, beverages, and cosmetics. For a pragmatic activity, they will examine a plethora of packages and create a glossary of common additives and preservatives in foods, beverages and cosmetics (see Activity 1).

After the section on nomenclature is completed, I will organize the students into cooperative learning groups to embark on "a journey to an effective labeling system" for plastic packages. Ideally, I will form four groups of four (students) times three classes (12 groups). They will research how the organic foods certification process evolved, to serve as a precursor for their labeling system for plastics. Employing Inquiry-Based Chemistry is difficult at first because it is so different from the norm, which is driven by standardized testing. Yet, when students have freedom and responsibility, they become active participants and actually enjoy science (see Appendix 2). "Active participants take lessons above and beyond expectations (3)."

These groups will operate concurrently within the course framework. In addition to the labeling system project associated with nomenclature, the students will investigate the toxicology of specific components of plastics. This investigation will coincide with a comprehensive analysis of molar relationships that examine concepts such as molar mass, stoichiometric relationships, and molarity. It will also include a discussion of dosage as it relates to toxicity. The students will describe the health risks and environmental hazards of various components used in plastic packaging. They will also consider the current recycling methods for plastics. As a culminating research project, students will develop a recycling program for the various types of plastic packaging used for single-use plastic bottles (see Activity 2).

The underlying goal of this unit is to stimulate youth activism. In order to build the momentum of the students towards involvement in social change, I will integrate this curriculum unit into three sections of the course (atomic structure, nomenclature, and molar relationships) over a twelve to eighteen week period. During the final stage of this educational process, I will guide the students in the production of an Earth Day performance (Eco Arts and Science Project) that demonstrates the knowledge and insight gained throughout the semester (see Activity 3).

Rationale

A prerequisite to activism is thorough research that produces understanding of the facts surrounding the issues at hand. "Being a student researcher not only helps one look at things from another perspective, but it also helps one look past the things that are obvious. Being a student researcher has its own way of causing one to think. With student research, there is an endless trail of questions. Ultimately, student research is a cooperative endeavor (4)."

"When you're dealing with students that come from conditions of poverty who bring

urban youth culture to the table, keep in mind that it gets denied by the school," Tobin explains. "It's very difficult for teachers who are usually from some other ethnic background, to empathize with urban minority youth. Teachers have to learn new cultures and students have to learn a new culture in order to make the classrooms click (4)."

"Conventional wisdom is the dominant consciousness of any culture. It is a culture's most taken-for-granted understandings about the way things are and about the way to live. It is a culture's construction of reality and the internalization of that construction within the psyche of the individual (5)." " When culture serves the ends of conquest and the preservation of oppression, it always involves a parochial view of reality; a static perception of the world and the imposition of one world view upon another. It denotes an invasion and implies the "superiority" of the invader on the one hand. The opposite hand symbolizes the "inferiority" of those who are invaded, as well as the imposition of values by the former. The invaders posses the latter and they are afraid of losing them (6)."

"Man's attitude toward nature is today critically important simply because we have now acquired a fateful power to alter and destroy nature. Since Rachel Carson spoke these words, our war on nature, and thus ourselves, has continued to accelerate. Despite numerous warnings, the United States continues to act as if the global environment has an unlimited capacity to provide its citizenry with natural resources and to absorb the continued production of toxic materials (7)."

Changing our world view is the fastest and most effective way to expand our consciousness. "By shifting our consciousness, then our culture and institutions, we can create a world that works for all. The most effective way to promote change is to show a person that it is in his own self-interest. When we catalyze a shift in consciousness that benefits all 303 million of us in this country and all 6 billion of us on this planet, profound change will unfold (5)."

What catalyzes deep change is an appeal to the heart. "Compassion has been the most potent force for

positive change. People move when they are reminded of their highest values and ideals, and when they see those values embodied in authentic leaders (8)." Although teachers complain about their lack of status in the community, I espouse that we are some of the most influential people in the lives our students. Many of them believe that whatever we say is true, to a certain extent. At least in terms of content knowledge. Therefore, it is critically important for us to demand that our students understand their inseparable connection to the environment. The way we treat the environment is the way it in turn treats us. When humans pollute the Earth with toxic chemicals, then our tissues become contaminated as well. Consequently, we must protest to our students that the planet must be respected!

Understanding intelligence is imperative for significant improvement in pedagogy. "According to the theory of multiple intelligences, the mind's problem-solving capacities are multifaceted, exceeding the traditional view of intelligence as being verbally and mathematically bright. In 1983, Gardner identified seven forms of intelligence: linguistic, logical-mathematical, visual-spatial, bodily-kinesthetic, musical, interpersonal, and intrapersonal. A dozen years later, he added an eighth intelligence, that of the naturalist, one who specializes in recognizing and classifying natural and human-made phenomena. Recently, Gardner has suggested an additional intelligence; existential intelligence, which refers to the human desire to understand and pursue the ultimate questions, meanings, and mysteries of life (9)."

"The gulf between what we know and what we need to know is called the '*intelligence deficit*,' according to Wargo. The antidote is what he terms '*green intelligence*:' the types of knowledge and ways of thinking necessary to navigate among life's imperceptible chemical dangers. The causes of our intelligence deficit are many and include illiteracy, secrecy, deception, privacy, fiction, language diversity, and perhaps most importantly the control and ownership of science by powerful private and public institutions. Collectively, these cultural conditions have overwhelmed individual capacity to identify and avoid important environmental and health threats (10)."

Constructivist theory suggests that effective learning only occurs when our students are participating in a meaningful way in the interpretation of their environment. "This active participation in the learning process is by far the best way for students to acquire knowledge (3)." I think the purpose of public education is to provide every student with a learning experience that insures proficiency in diverse subject knowledge, critical thinking, creative problem solving, and technological literacy in order for upcoming citizens to cooperate in a global marketplace. Furthermore, I feel public education should cultivate the emotional intelligence of all students in order for every graduate to actively support a sustainable world for the next generation.

Engaging students in community change has far reaching benefits that not only support but also extend beyond academic achievement. "Rapport feels good, generating the harmonious glow of being simpatico, a sense of friendliness where each person feels the other's warmth, understanding, and genuineness. These mutual feelings of liking strengthen the bonds between them, no matter how temporary. When people are in rapport, they can be more creative together and more efficient in making decisions (11)."

"We need to train children in the personal intelligences in school (12)." Helping students to enhance their creative thinking, communication and cooperative learning skills is much more important to me than having them memorize facts. Active learning is at its best, when students are actually responsible for and involved in their own intake of information, with minimal transmission from the teacher. "Classrooms like these, where students take responsibility for their own learning, as they engage with problems, ask thoughtful questions, connect ideas, and work together, are the catalysts for student-led scientific communities (3)."

"Youth learn their role in improving the health of the community by exploring current health concerns and

developing authentic interventions. Some people feel schools cannot or should not take on health issues. Yet, students who participate in such efforts become better connected to their schools and communities while learning and practicing the principles of democratic citizenship. By focusing on real community health issues, our students have the opportunity to develop critical thinking and problem-solving skills which foster their ability to make smart decisions about their own health (13). And when teachers invite parents into the classroom to share with their children in this climate of deep respect and caring, even more possibilities emerge in schools for fulfilling the human spirit (14)."

Content

What are the components in plastic packages?

"Although the world is varied and complex, everything in it—air, water, rocks, living tissue, and the almost infinite number of other objects and materials around us—is actually made up of only a limited number of chemical elements. We know today that only 91 such elements exist naturally on the Earth. They range from hydrogen, the lightest element, to uranium, the heaviest. Actually, several more elements do exist, but these have to be made artificially in laboratories (15)."

"The basic components of each chemical element are atoms. The atoms of an element consist of three kinds of particles: protons, neutrons, and electrons. Protons and neutrons exist at the core, or nucleus, of the atom. One of the important ways in which these two kinds of particles differ from one another is that each proton carries a single, positive electric charge, whereas a neutron carries no electric charge. Electrons, which are much smaller than either protons or neutrons, each carry a single negative electric charge. Electrons are present at some distance away from the nucleus of a particular atom and travel rapidly around it in complex paths known as orbits. Under normal circumstances, the number of electrons orbiting around the nucleus of a particular atom is exactly equal to the number of protons in the nucleus of the atom, so that the overall positive electric charge provided by its proton is exactly balanced by the overall negative charge provided by the electrons orbiting in the nucleus (15)."

"The unique properties of each of the chemical elements are determined by their number of protons, neutrons, and electrons. Besides determining the properties of a pure chemical element, the neutron, proton, and electron content of its atom also determines its behavior in relation to other chemical elements. Although each element behaves differently and has different properties from all of the others, the atoms of different elements can combine with one another to form clusters of atoms called molecules. It is this combination that accounts for the enormous variety of chemical substances that can be found in nature and created by modern technology (15)."

"Each year hundreds of billions of pounds of commercially valuable chemicals are released into the environment as pesticides, fertilizers, paints, fuels, solvents, plasticizers, pharmaceuticals, cosmetics, metals, coloring agents, flavors, fragrances, and ingredients in millions of consumer products. Nearly 100,000 of these chemicals are traded in the world's market, yet 80% of these molecules have never been tested to know their potential to induce human disease (10)."

In 2005, journalist David Ewing Duncan engaged in a guinea-pig experiment of chemical self-discovery. "He was tested for 320 chemicals that he could have picked up from food, drink, the air, and products that

touched his skin—his own secret stash of compounds acquired by merely living. It included older chemicals that he might have been exposed to decades ago, such as DDT and PCBs; pollutants like lead, mercury, and dioxins; newer pesticides and plastic ingredients; and the near-miraculous compounds that lurk just beneath the surface of modern life, making shampoos fragrant, pans nonstick, and fabrics water-resistant and fire-safe (2)."

These tests are too expensive for most people. Yet, "illnesses plausibly associated with synthetic chemical exposure are increasing in prevalence; these include some respiratory and cardiovascular diseases; some forms of neurological impairment among the young; declining fertility; immune dysfunctions; and developmental disorders among the young. Collectively, these trends suggest we are conducting a dangerous and continual experiment on the resilience of human health (10)."

Plastic Resins in Food, Beverage, and Cosmetic Packages

"Nearly 100 billion pounds of plastic are produced in the U.S. each year and they play an integral role in food and beverage packaging. Plastics now comprise nearly 70% of the synthetic chemical industry in the nation and are extremely important because of the evidence that they disrupt normal growth and development in many different species of animals due to their hormonal activity. It is virtually impossible to know for certain, what is in plastic packages. Ingredients used to make plastics are not required to be labeled, and many manufacturers are unwilling to disclose their "trade secrets." Given the complexity of international plastics markets, it would be surprising if many manufactures or distributors could identify ingredients or sources of plastics in their products (1)."

"From 70 to 80 percent of food is packaged in various polymers, some of which contain potential carcinogenic (cancer-causing) agents that migrate into our food everyday. The World Health Organization (WHO) and U.S. governmental agencies are concerned about certain direct and indirect food additives, but efforts at identification and protection move slowly (16). Currently the Federal Trade Commission (FCC) only offers guidelines for environmental marketing claims, designed to have an effect on labeling but not requiring or enforcing it (1) "

"Present in everyday items like panty hose and perfume, computers and catheters, baby rattles and billiard balls, plastics are so ubiquitous we seldom give them a second thought (17)." The type(s) of plastic resin found in various packaged products can be identified by their recycling symbol. An identification code identifies the six resins that account for most of the plastics used in packaging.

Here are a few examples of the plastic resins found in various packages. "Most convenience-size beverage bottles, mouthwash bottles and boil-in pouches contain Polyethylene Terephthalate (PET - #1). Milk jugs, ice cube trays, and storage containers are made of High Density Polyethylene (HDPE - #2). Cooking oil bottles, packaging around meat, baby bottle nipples, and beverage pictures contain Polyvinyl Chloride (PVC - #3). Produce bags, food wrap, bread bags, zip-lock bags, and bottle liners are composed of Low Density Polyethylene (LDPE - #4). Yogurt containers, margarine tubs, and spice containers are made of Polypropylene (PP - #5). Styrofoam cups and containers, take-home boxes, egg cartons, and meat trays contain Polystyrene (PS - #6). Polycarbonate baby bottles, 5 gallon water cooler bottles, meat trays, and toddler fruit cups contain Bisphenol A (Other - #7). The code for BPA provides an excellent example of why it is so confusing to identify ingredients in plastics, given its title: Other (1)."

How do these constituents react in the body?

"Figuring out whether plastics are toxic to people at current levels of exposure is quite complex. One way scientists find out whether or not chemicals are dangerous to humans is to give high doses to animals, looking for threshold levels at which signs of toxicity appear and trying to understand the nature of the damage (17)." Consequently, most of the current data is from animal studies. Furthermore, the long-term consequences of exposure to plastics are difficult to establish, in part because early exposure can have effects observed much later in life.

"Back in the 1940s when plastics were being developed, no one suspected that chemicals leaching out of these marvelous materials could have pernicious biological effects. What industrial chemists did know was that by tinkering with a highly reactive molecule called a phenol they were able to devise countless synthetic chemicals for use in materials. Only through subsequent studies has it been shown that the estrogen receptor has a particular affinity for a characteristic molecular component of phenols (17)."

"Ninety-nine percent of what turn out to be chemical estrogens have a phenolic hydroxyl group on the molecule, and any of those can bind to the estrogen receptor," says Wade Selshons, a University of Missouri cell biologist and endocrinologist who has spent his career studying estrogen. Moreover, everything that binds to the estrogen receptor turns it on in some way. I've run across only two chemicals that fully antagonize, or switch off, the receptor (17)."

"If plastic harms, it does so by stealth; by mimicking our own hormones, by scrambling signals during development, by stimulating our own pathways excessively. And it may have that power at astonishingly low exposure levels, amounts that by typical toxicological measures look just fine. With plastics, less may be more, and a little may be a lot (17)."

"In toxicology studies, dose is everything," says Karl Rozman, a toxicologist at University of Kansas Medical Center, who contends these doses are too low to be dangerous. "One part per billion (ppb), a standard unit for measuring most chemicals inside us, is like putting half a teaspoon of red dye into an Olympic-size swimming pool. What's more, some of the most feared substances, such as mercury, dissipate within days or weeks, unless a person is constantly re-exposed (2)."

Yet, "several illnesses are rising mysteriously. From the early 1980s through the late 1990s, autism increased tenfold; from the early 1970s through the mid 1990s, a type of leukemia was up 62 percent, male birth defects doubled, and childhood brain cancer was up 40 percent. Some experts suspect a link to the man-made chemicals that pervade our food, water, and air." "There's little firm evidence. But over the years, one chemical after another that was thought to be harmless turned out otherwise once the facts were compiled. From DDT to PCBs, the chemical industry has released compounds first and discovered damaging health effects later." "Regulators have often allowed a standard of innocent until proven guilty in what Leo Trasande, a pediatrician and environmental health specialist at Mount Sinai Hospital in New York City, calls an uncontrolled experiment on America's children (2)"

"Each year the Environmental Protection Agency (EPA) reviews an average of 1,700 new compounds that industry is seeking to introduce. The 1976 Toxic Substances Control Act requires that they be tested for any ill effects before approval, only if evidence of potential harm exists, which is seldom the case for new chemicals. Subsequently, the agency approves about 90 percent of the new compounds without restrictions. Only a quarter of the 82,000 chemicals in use in the U.S. have ever been tested for toxicity (2)."

"Last year the Centers for Disease Control and Prevention (CDC) took a step toward closing the gap when it released data on 148 substances, from DDT and other pesticides to metals, PCBs, and plastic ingredients, measured in the blood and urine of several thousand people. The study said little about health impacts on the people tested or how they might have encountered the chemicals. "The good news is that we are getting real data about exposure levels," says James Pirkle, the study's lead author. This gives us a place to start (2)."

"Although governments demand testing of some chemicals individually to learn their danger to human health, most people are exposed to chemical mixtures in air, foods, water, soil, consumer products, pollution or wastes. During the last half of the 20 th century scientists found that numerous synthetic chemicals can interfere with the normal function of human hormones. Colborn and Colwell in 1992 termed these hormonally active substances to be 'endocrine disrupting contaminants' (1)."

"Wildlife studies provide supporting evidence that some industrial chemicals and pollutants could also unintentionally behave like hormones. Alligators exposed to the insecticide dicofol developed reproductive abnormalities following a 1980 spill in Lake Apopka, Florida. Their egg survival rates declined and both males and females developed abnormal sexual organs. Alligators studied in nearby unpolluted lakes exhibited none of these conditions (1)."

"When pregnant mice are exposed to chemicals in plastic, the mammary and prostate tissue of their developing embryos proliferates abnormally, and sensitivity to hormones is intensified. Perhaps most disturbing is the significant increase in chromosomal abnormalities in the eggs forming in those embryos. Those are the eggs that will make up the next generation. Thus, if the worst case scenario proves true, early exposure to plastics can reshape not just our children but their children too (17)."

"Many scientists now believe that the developing fetus, infants and children may be more vulnerable to harm than adults following exposures to hormonally active chemicals. This is because organ systems, hormone pathways, and metabolic systems are still developing. In addition, young children breathe more air, consume more food and drink more water per pound of body weight than adults, and this increases their relative exposure to any chemical present in the environment. A prominent committee convened by the U.S. National Academy of Sciences (NAS) to consider the nature of risk posed by hormonally active chemicals has agreed that the health effects seen in animals are important signals of human health risks, especially when well correlated with increasing trends in human illness (1)."

Phthalates

"Researchers found that 80 percent of babies tested had been exposed to a class of potentially harmful chemicals called phthalates. The findings, released in the February 2008 issue of Pediatrics, shows a direct link between use of baby shampoos, lotions and powder—which contain phthalates to stabilize fragrances—and the presence of phthalates in babies' urine samples (18). Phthalates are molecules that dissolve fragrances, thicken lotions, and add flexibility to PVC, vinyl, and some intravenous tubes in hospitals. The dashboards of most cars are loaded with phthalates, and so is some plastic food wrap. Heat and wear can release phthalate molecules, and humans swallow them or absorb them through the skin. Because they dissipate after a few minutes to a few hours in the body, most people's levels fluctuate during the day (2)."

"At least a dozen studies have shown the effects of phthalates on human reproduction," says University of Rochester epidemiologist and biostatistician Shanna "Swan, the lead author of a much-cited study that showed higher exposure to some phthalates in mothers correlates with reduced "ano-genital distance" in newborn boys. Swan published the study in 2005, which was the first that looked for evidence of an obvious

effect among boys. Among 134 boys aged 2 months to 30 months, she found that sons whose mothers had higher levels of certain phthalates in their urine had a shorter distance between the anus and penis. These boys were likelier to have smaller penises and incompletely descended testicles. About one-quarter of American women have the higher phthalate levels she found in her study (17)." "This was particularly evident among women working in poorly ventilated nail salons, where one especially harmful phthalate, Dibutyl Phthalate (DBP), is released (18)."

"Every day we are exposed to low doses of phthalates in food containers, perfumes, hairsprays, floorings, paints, toys and medical devices. These low doses may be toxic by mimicking and disrupting the body's natural reproductive chemicals. But according to the Phthalate Information Center, whose panel members include BASF Corporation, Eastman Chemical Company, Exxon-Mobil Chemical Company and Ferro Corporation, there's no need to worry. The center calls these warnings 'highly misleading' and brought by 'anti-chemical lobbies' (19)."

"A new study gives evidence that infants and toddlers exposed to lotions, shampoos, and powders with phthalates may have up to four times as much of it in their urine as those whose parents do not use the products. The study, recently published in Pediatrics by Sheela Sathyanarayana of the University of Washington, looked at 163 children between the ages of 2 months and 28 months between the years 2000 and 2005. The results were alarming because manufacturers are not required to list phthalates as ingredients on labels (19)."

"The evidence on phthalates is strong enough for the European Union to have banned them in children's toys, and last October California Governor Arnold Schwarzenegger signed legislation, to take effect in 2009, setting stringent limits on the concentrations of phthalates in child-care products for children under age 3. The ban focuses on baby books, soft rattles, plastic bath ducks, and teething rings (2)."

Bisphenol A

"On the other hand, BPA is becoming the poster child for all our doubts and fears about the safety of plastic. New research highlighting the possible dangers of BPA has received tremendous media coverage. In mice, at least, BPA exposure at crucial stages of development includes observable changes (such as breast or prostate abnormalities) that last a lifetime (17)."

"In November 2006, a panel sponsored by the National Institutes of Health (NIH) determined that there was at least "some concern" about BPA's effect on the fetal and infant brain. Criticism of the report began even before its publication, and has dogged it ever since. Around the same time, the CDC reported that researches there had found BPA—the United States produces 6 billion pounds annually—in 93 percent of urine samples from 2,500 Americans aged 6 to 65. Children under age 12 had the highest concentrations (17)."

In response to the controversial report, "the NIH agreed to a thorough review of the findings in January of the following year. This decision came as a result of claims from scientists and public health advocates that members of the panel worked for the chemical industry and cherry-picked the data in favor of industry-funded studies, which did not test low-dose exposure to BPA. An August 2007 statement by the American Chemistry Council claims that 'BPA is not a risk to human health at the extremely low levels to which consumers might be exposed' (17)."

However, "a panel of 38 researchers headed by Biologist Frederick vom Saal of the University of Missouri published a report in Reproductive Toxicology last summer, warning that BPA (much like the synthetic

estrogen diethylstilbestrol) is a potential chemical time bomb that may lead to multiple problems, including a higher risk of cancer, especially if exposure occurs in the womb or an infant's early life and on an unrelenting daily basis (17)."

"Chemicals like BPA pose a challenge for conventional toxicology, vom Saal says. To determine what level of toxin is safe, researchers take a dose that has no observed toxicological effect in an animal and divide it by 10 once (to account for the differences between the species) and then again (to account for the variations among humans' ability to handle toxins); for pesticides, the dose is then divided by 10 a third time (to allow for the extraordinary sensitivity of babies and children). Although this is somewhat arbitrary, it generally gives enough room to provide protection. The first studies of BPA toxicity in the 1980s tested rats at high levels of exposure (50 milligrams of BPA per kilogram of body weight per day). Lower levels were not tested; hence, BPA was deemed safe (17)."

"When it comes to reusable bottles, however, consumers still need to do their homework. Research shows that clear bottles made of polycarbonate plastic (such as the original 32-ounce Nalgene) can leach BPA. By sipping water after a workout, you could be exposing yourself to an ingredient, in rigid plastics from water bottles to safety goggles, that causes reproductive system abnormalities in animals (20)."

"BPA has been linked to low sperm count and an increased risk of breast and prostate cancer; therefore, scientists like vom Saal and Patricia Hunt suggest avoiding reusable bottles made from plastic. They also raise serious concerns about the potential for other plastic chemicals to leach out of typical PET water bottles—especially if they sit in the hot sun. A paper released in the Journal of Reproductive Toxicology showed that the federal panel that had approved the use of BPA for use in baby bottles and food can liners did so after disregarding hundreds of relevant studies. These studies showed that BPA can cause "breast cancer, testicular cancer, diabetes, hyperactivity, obesity, low sperm counts and miscarriage in laboratory animals (17)."

"Although the US government has authority under several federal statues to regulate or prohibit the production, use, sale, and disposal of this chemical, BPA remains virtually unregulated (1)." "While chemists, biologists, geneticists, and toxicologists are piecing together the puzzle, some consumers have concluded they should simply try to limit their exposure to plastics in their own lives. 'But how do you do that?' asks Ana Sato, professor of cellular biology at Tufts University School of Medicine, who herself uses glass containers at home. For instance, the milk you're drinking was pumped through plastic tubes. And you can't store milk in permeable paper cartons — they have plastic lining (17)."

"Even if you try, you don't know whether you're limiting your exposure by 5 percent or 95 percent." BPA has been found in drinking water, in 41.2 percent of 139 streams sampled in 30 states, even in house dust. Even if we could regulate BPA to levels that were safe, Sato cautions, "zero plus zero is actually not zero. By that I mean, you can take 10 estrogenic chemicals at doses that on their own don't have an effect, but if you add them together, you end up with problems. BPA is only one of many estrogenic chemicals in our environment (17)."

"Hunt who demonstrated that BPA exposure in utero disrupts the earliest stages of egg development, hopes along with other scientists that their research will catch the attention of the public even more so than industry or policymakers. 'I'm struck by how fast companies respond to consumer demand,' she says. When our study broke in 2003 and the media came calling, I kept saying that what concerns me the most are baby bottles. They're polycarbonate, and it doesn't stand up well. I got a call from a baby bottle manufacturer one day, and he said, 'What's going on? We're getting calls from consumers.' And I was amazed to see how rapidly new

polymers came on the market for baby bottles. Indeed, sales of glass and non-polycarbonate baby bottles are rising (17)."

How do they impact the environment?

"At the center of the Pacific Ocean in a windless, fishless oceanic desert twice the size of Texas, a swirling mass of plastic waste converges into a gyre containing an estimated six pounds of non-biodegradable plastic for every pound of plankton. Called the Great Pacific Garbage Patch, it is an indelible mark of human domination of the planet. But plastic has also left its mark in us. Plastics make their way in our urine, saliva, semen, and breast milk. Two in particular stand out: BPA (used in polycarbonates and resins) and phthalates (used to make plastic soft and pliable). Both upset the way certain hormones function in the body, earning them the designation of endocrine disrupters (17)."

"Environmental endocrine disrupters can be categorized into three sources: pharmaceuticals, "phyto-estrogens" that occur naturally and include soybeans and peas; and environmental disruptors including pesticides, industrial chemicals, metals, BPA, phthalates, and some solvents. Increasing attention has more recently been directed to PCB's, dioxins, and numerous pesticides. Other elements that may affect reproductive health include arsenic, cadmium, lead and mercury (1)."

"The Associated Press reported in March 2008 that 'a vast array of pharmaceuticals— including antibiotics, anti-convulsants, mood stabilizers and sex hormones—have been found in the drinking water supplies of at least 41 million Americans.' Environmental Health Perspectives reported in 2005, 'roughly 100 pharmaceuticals have now been identified in rivers, lakes and coastal waters throughout Europe and the United States' (18)."

"Given the stakes, why take a chance on potentially toxic chemicals? Why not immediately ban them? Except for some pollutants, every industrial chemical was created for a purpose. Even DDT, the arch villain of Rachel Carson's 1962 classic book Silent Spring, which launched the modern environmental movement, was once hailed as a miracle substance because it killed the mosquitoes that carry malaria, yellow fever, and other diseases. It saved countless lives before it was banned in much of the world because of its toxicity to wildlife (2)."

"The key is learning more about these substances, so we are not blindsided by unexpected hazards, says California State Senator Deborah Ortiz, chair of the Senate Health Committee and the author of a bill to monitor chemical exposure. We benefit from these chemicals but there are consequences, and we need to understand these consequences much better than we do now (2)."

What happens to the container of a single-use plastic package?

"Packaging has rapidly become an integral part of how all of us meet our daily needs. One might even say that a tendency toward over packaging is ingrained in our culture, psyche, and economy. Nearly 60 percent of all packaging is made for food and beverages. The global market for packaging is estimated at $500 billion, with a growth rate of 4 percent per year (21)."

"There is no doubt that packaging fulfills invaluable functions in a global economy that provides basic necessities as well as consumer and commercial goods to billions of people every day. Modern packaging's essential services—product protection, transportation, convenience, safety, hygiene, nutrition, spoilage prevention, information, branding, merchandising, theft-proofing, and regulatory compliance — are widely

acknowledged. These services should not be underestimated (21)."

"However, nearly one-third of the gross weight and half of the volume of America's municipal solid-waste stream are composed of packaging materials—-at least 300 pounds per person per year. A study by the Grassroots Recycling Network reported that, between 1990 and 1997, plastic packaging grew five times faster by weight than plastic recovered for recycling. Each year more than 150 billion single-use beverage containers are sold in the United States (21)."

"The American Plastics Council estimates that only about 5% of all plastics manufactured are recycled, and this is optimistic. Some types of plastic are recycled more frequently, including PET soft drink bottles (34% recycled) and HDPE milk and water bottles (29%). However, others including DEHP-containing PVC plastics, BPA-containing polycarbonate plastics, and polystyrene (its production involves the use of known and suspected human carcinogens) are rarely recycled (1)."

"Plastic is recyclable depending on the resin type(s) and whether local systems exist to reuse, recover, and reprocess them. The resin identification code which was designed to facilitate recycling does not identify chemical ingredients in plastic products. There is no federal law requiring this code, although many states have legislation mandating the use of the codes on some types of bottles. There are no federal methods to ensure the proper use of the codes (21)."

"Although two plastic types (HDPE and PET) achieve relatively high reuse and recovery rates in some countries, overall plastic packaging recycling remains abysmally low. In fact, the current trend is toward layering different plastic material into single-use "smart" packages, making recycling impossible or economically impractical. Also, the manufacturing and incineration of some plastics, such as polyvinyl chloride (PVC), are so toxic that many experts argue that they should be banned outright (21)."

"Environmental concerns are sending people back to their taps. It takes 15 million barrels of oil per year to make all of the plastic water bottles in America, according to the Container Recycling Institute (CRI). Once people drain the bottles, they rarely recycle them. CRI says 8 out of 10 water bottles end up in landfills. It takes 1,000 years for plastic bottles to break down, CRI estimates. If more states added deposits on bottled water bottles, it might spur recycling. Congressman Ed Markey (D-MA) has even proposed a national beverage bottle bill (20)."

"We have such a consumption mentality, which leads to our throw-away society, says David Wilk, a Connecticut publisher and tap water activist who started the website Turntotap.com to help reduce the amount of plastic going into landfills. Others, like Richard Girad, a corporate researcher for the Ottwa-based Polaris Institute, dislike the hypocrisy they perceive in the marketing of bottled water. More than half of all bottled water is simple filtered tap anyway. We want the bottled water corporations to be held accountable for their actions (20)."

"Nestle has been seeking environmental approval for what would be the largest water bottling plant in the U.S—one million square feet in McCloud, California—against community protests. High school activists are raising questions about why their school board members are locking them into a contract with Coke or Pepsi (makers of Aquafina and Dasani bottled water) when they have access to drinking fountains for free. Bottled water industry groups, such as the International Bottled Water Association (IBWA), say they are being unfairly targeted. They argue that bottled water companies are responding to environmental concerns by making lighter bottles that require less plastic in the manufacturing process (20)."

"The dramatic increase in plastic packaging, single-use disposable food containers, and shopping bags, collectively know as "white pollution," has prompted increasing numbers of Asian cities and national governments to impose bans on certain types of disposable packaging. Transforming our packaging systems is necessary, not just through simple materials substitution or incremental changes of eco-efficiency, but through the deeper systems approach. The time has come to address what has become an absurdly over packaged world. We must establish systems that honorably and rationally support trade but at the same time protect natural systems and habitats from which all things are derived. This is a vision of not only a better world but also one with a conscious, self-healing capacity (21)."

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 Children of the Sun the time has come for us to work together to make the world
better
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"Envision a zero-waste society, one in which consumer goods and the packaging that wraps them are no longer repositories of spent energy and materials. Those sacred materials feed new jobs, new forms of economic development, and new durable goods. Now imagine a society powered by 100 percent renewable energy. Imagine it in less than 25 years as is the policy and plan for both San Francisco and Oakland, California (21)."

"Because we are faced with pressing problems such as global climate destabilization, total destruction of irreplaceable ecosystems, and widespread species extinction, you might think issues such as industrial and household packaging are low on the list of environmental priorities. But packaging is part and parcel of lifestyles that have become almost completely disconnected from Earth's natural cycles and capacity to process our industrial wastes (21)."

Strategies

Eat, Drink, and Be Wary is an experiential method of teaching students how to connect the principles of Chemistry to relevant environmental issues. In technical terms, this approach combines the tenets of aesthetic education, science education, and environmental activism (ASE). Put simply, this method integrates the performing arts, specifically drumming, dance, and drama, along with design (3D and 1) into the Chemistry curriculum. Furthermore, this process incorporates an inquiry-based curriculum model that propels student activism into urban environmental quality and human health issues.

"When well taught, the arts provide young people with authentic learning experiences that engage their minds, hearts and bodies. Engagement in the arts—whether the visual

arts, theatre, dance, music or other disciplines—nurtures the development of cognitive, social and personal competencies. When the arts become central to the learning environment; schools and other settings become places of discovery (22)."

"Children and adults have the capacity to respond to a work of art in ways that can stimulate fresh insights, encourage deeper understandings, and challenge preconceived notions. Without the limitations imposed by "right or wrong" answers, the process of responding to a work of art develops each student's ability to think in fundamental and powerful ways (23)."

"Through an educational process of aesthetic inquiry, the Lincoln Center Institute (LCI) approach cultivates two interrelated capacities: receptivity to experiencing any given artwork, and the ability to reflect on that experience. By cultivating these capacities, the LCI approach helps students develop an inside understanding of the artistic choices that contribute to any given work of art. Students gain practical insights and strengthen core skills that readily apply across the curriculum and throughout life. Two examples include abstract thinking and problem solving—skills as relevant to studying a ballet performance as to conducting a Chemistry experiment or solving a mathematical equation (23)." This mode of thinking will help the students examine and classify plastic packages in the marketplace, as well as create a glossary of common additives and preservatives in foods, beverages and cosmetics.

As a result, unexpected connections are made, alternative points of view are considered, complexities explored, and doors to new and imagined worlds opened. The Institute's experiential approach to art and education brings students into the world of the work of art through explorations that actively engage students in perception, research, reflection and discussion. This process is a catalyst for change in the way teachers teach and students learn (23). It compels us to feel inside the box and think outside of it.

"Accuracy of analysis depends on the tools of analysis. Science is first and foremost an empirical discipline that provides humanity with powerful access to understanding the nature of the physical and living world (24)." It provides us with a mode of inquiry—the scientific method—to investigate the possible causes and effects of various phenomena. Although scientific results are limited by the sophistication of available technology and even the parameters of the questions posed, we have learned a tremendous amount about life in our Universe, using the scientific method.

I think it is so important to teach science in a creative way. It is frustrating for students to hear boring lectures for hours each week. This one dimensional approach misleads students. They learn to detest science and consider it a bland subject. "According to the Dalai Lama, through education, through training the mind and using intelligence, we can see the value of compassion and the harmfulness of anger and hatred. Research has shown that we can successfully teach children to overcome and manage emotions such as

fear, hatred, anger, and anxiety through Social and Emotional Learning (SEL) programs. These programs have proven that children can develop lifelong abilities such as self-awareness, anger management, impulse control, and positive qualities such as empathy and compassion. This is the educational ideal of the Dalai Lama, as well as of Western educators pioneering the new field of SEL (8)."

"Today we are so interdependent, so closely interconnected with each other, that without a sense of universal responsibility, a feeling of universal brotherhood and sisterhood, and an understanding and belief that we really are part of one big human family, we cannot hope to overcome the dangers of our very existence, let alone bring about peace and happiness (8)."

"It's not good enough to know about reality; you need to change how you see reality. Real education is transformative. The conscious student is caring, compassionate, peaceful, and tolerant; the student who sees all humanity as brothers and sisters; the student whose heart is as well-educated as their mind (8). Thus, working together in cooperative learning groups, students will create an effective labeling system for plastic packages."

"People who work to change our world can be called advocates or activists. An activist is someone who believes strongly in a cause and who stands up for that belief. Being an activist is satisfying and gives meaning to your life. It is a way to make your behavior match your beliefs. And it is a way to take control

of—and responsibility for—the events in your own world. All activists have to learn to set realistic goals. They have to be reminded that no matter how hard they work as an activist the world will *never* be perfect. There will *always* be problems to solve (26)."

"We must work on ourselves first, and then be prepared to do the work on our culture and institutions. If each of us adopts the attitude, "change begins with me," we will be able to create a consciousness, the compassion, and the action for fundamental change.

While both statistics and intuition indicate that most of us support a shift to an inclusive society, a movement has not yet coalesced (5)."

If we are going to create a self-healing society, "we have to mobilize enough people to catalyze a profound transformation. In innovation diffusion theory, researchers have discovered that a change becomes inevitable when 5 to 15 percent of a population accepts the change. This means that activists will need to mobilize around 26 million people in the United States. To paraphrase Lao Tzu, a movement of 26 million signatures begins with a single pledge; mine (5)."

Experiential learning can help students develop their social emotional learning aptitude and connect with the essence of their humanity. Therefore, I will guide the students in the production of an Earth Day performance (*Edu~Concert*) that educates as well as entertains the community about the environmental health concerns of single-use plastic bottles.

Drumming

Eat, Drink and Be Wary is an experimental and experiential curriculum unit. My overall goals are to motivate urban minority youth to develop creative problem-solving skills and enhance their social and emotional intelligence through the performing arts, particularly drumming. "Because music evokes emotions, the playing of music accelerates and enhances the ability of learners to make rapid emotional assessments and to act accordingly. Music making forces us to create, reflect, bare our souls, and formulate in ways we have never done (26)." Ultimately, I want to inspire my students to formulate a viable set of solutions to the mounting problems associated with single-use plastic H_2O bottles. Using the drum as a catalyst for change, students will experience the power of rhythm to unify cultures from Africa to America and throughout the world.

The reason the drum is a universal element in the world is that Aborigines use it to synchronize the disparate energies in a village. Their ceremonial drumming is at the same rate as the heartbeat of a healthy person at rest. "One of the things that is hard-wired into our bodies is a phenomenon called entrainment. Simply put, the cells in our bodies try to synchronize with the rhythms of the environment. If you took a cell from my heart and a cell from your heart and put them in separate dishes, they would beat independently. On the other hand, if you placed them side by side in the same dish, they would synchronize their beats. We learned how to do this millions of years ago. The first and most prevalent rhythm to which we entrained was the roughly one beat per second of our mother's heart (5)".

Classroom Activities

Once the students build a conceptual framework of the content material, through a series of structured lessons and assessments, my students and I will embark on a process-oriented excursion. We will engage in a "seminar style" learning format where students become participants and the teacher assumes the role of a facilitator. The following classroom activities are prototypes of instructional maps to help us navigate through the abstract realm of interpretation and experiential world of activism.

Lesson 1: Plastic Nation

Purpose

How much plastic packaging does an urban high school student encounter in a week? The goal of this activity is for students to determine the quantity and quality of plastics within their lifestyle.

Materials

Composition Notebook

Human Footprint (see Teachers Resources)

Scale

Directions

After viewing and discussing "The Human Footprint" by National Geographic, the students will weigh (employing SI Units), classify, and tabulate all of the plastics that they utilize during the course of a week. In addition, the students will identify the chemical composition of the products contained by the various packages.

Evaluation

The final product must be a weekly (7 days) plastic consumption table or chart that categorizes daily utilization of plastics. Also, a glossary of common additives and preservatives must be created.

Lesson 2: R ^{3} (Reduce, Reuse, Recycle)

Purpose

How effective is the plastic recycling process in your community? The goals of this activity are for students to identify the distinct stages of the plastic "life cycle" and to evaluate the effectiveness of plastic recycling in their home, school, and community.

Materials

Composition Book

Koyanisquatsi (see Teacher Resources)

Internet

Directions

After viewing and discussing Koyanisquatsi, by Godfrey Reggio; observing the Great Pacific Garbage Patch (in real time); visiting a mega market (e.g. Walmart); and touring a local recycling center, the students will research, develop, and propose a consumer friendly labeling and recycling system for plastics.

Evaluation

The final product must convey understanding, technical precision, and consumer value. Proposals must be presented on standard science fair poster board.

Lesson 3: Children of the Sun

Purpose

How can a high school science class contribute to the environmental movement? The goal of this activity is for students to produce an Earth Day edu~concert, to inform the community about the mounting environmental and human health concerns associated with plastics.

Materials

Composition Book

Indigenous Drums and Percussion Instruments

Paper or Plastic (see Student Resources)

Directions

After reading and discussing "Paper or Plastic," by Daniel Imhoff; and studying African, Brazilian, and Caribbean drumming with a guest artist, students will analyze verses from selected Spoken Word Performance Artists—the classical African American griots—facilitated by a poet activist. Subsequently, the students will create an original piece of choreographed spoken word poetry (in concert with an world percussion ensemble) to express the urgency of the plastics crisis.

Evaluation

The final product must reveal the essence of Imhoff's perspective, infusing powerful musical imagery into a sequence of excerpts. Similarly, the spoken word choreography must reflect the social, political, and spiritual nature of the issue. Children of the Sun must connect to the lives of the participants and capture the imagination of the world via MySpace, YouTube, and other electronic venues.

Teacher Resources

Carson, Rachel.1962. *Silent spring.* Boston: Houghton Mifflin Company.

This eloquent book was instrumental in launching the environmental movement

Gallagher-Bolos, Joan A. and Smithenry, Dennis W. 2004. *Teaching inquiry-based*

chemistry. Portsmouth: Heinemann.

Discover how helping your students capitalize on their innate scientific curiosity will lead you to new levels of professional and personal satisfaction.

National Geographic. 2007. *The human footprint*. Documentary film. (USA).

A social critique that reveals the lifetime consumption of an average American including the resources needed to produce, package, and transport everything consumed.

Reggio, Godfrey. 1983. *Koyanisquatsi:life out of balance*. Documentary film. (USA).

A thought provoking movie composed of images and music depicting the extremities of the modern world. Powaqqatsi and Baraka are also highly recommended.

Smith, Jenny. 2003. *Education and public health.* Alexandria: Association for

Supervision and Curriculum Development.

This book describes how schools and community public health agencies can work together to improve student achievement, behavior, and health.

Tobin, Kenneth 2006. *Improving urban science education: new roles for teachers,*

students, and researchers. New York: Rowman and Littlefield, Publishers.

This book explains how teachers and students can work together to enact meaningful science education when social and cultural differences as well as inappropriate curricula often make the challenges seem insurmountable.

Winter, Ruth. 1994. *A consumer's dictionary of cosmetic ingredients*. New York: Three

Rivers Press.

With this enlarged fourth edition, you will be able to determine from cosmetic labels the desirability or toxicity of the ingredients listed.

Winter, Ruth. 1994. *A consumer's dictionary of food additives*. New York: Three

Rivers Press.

This valuable listing of more than 8,000 food additives includes those that indirectly end up in your food as a result of processing

techniques and explains the new food labels.

Student Resources

Field, Simon Quellen. 2008. *Why there's antifreeze in your toothpaste*. Chicago:

Chicago Review Press.

This helpful guide can be used as a basic primer on commercial chemistry or as an indexed reference to specific compounds found on a product label.

Imhoff, Daniel. 2005. *Paper or plastic: searching for solutions to an overpackaged*

world. San Francisco: Sierra Club Books.

The author unwraps the packaging problem and gives consumers, product designers, and policymakers the information they need to take steps toward a more sustainable future.

Appendix 1A: Implementing Virginia Standards of Learning

VA SOL CH.2

The student will investigate and understand that the placement of elements on the periodic table is a function of their atomic structure. The periodic table is a tool used for the investigation of a) average atomic mass, mass number, and atomic number; b) isotopes, half lives, and radioactive decay; c) mass and charge characteristics of subatomic particles; d) families or groups; e) series and periods; f) trends including atomic radii, electronegativity, shielding effect, and ionization energy; g) electron configurations, valence electrons, and oxidation numbers; h) chemical and physical properties; and i) historical and quantum models.

Appendix 1B: Implementing Virginia Standards of Learning

VA SOL CH.3

The student will investigate and understand how conservation of energy and matter is expressed in chemical formulas and balanced equations. Key concepts include a) nomenclature; b) balancing chemical equations; c) writing chemical formulas (molecular, structural, and empirical; and Lewis diagrams); d) bonding types (ionic and covalent);

e) reaction types (synthesis, decomposition, single and double replacement, oxidation-reduction,

neutralization, exothermic, and endothermic);

Appendix 2: Implementing National Science Education Standards

The central facts, ideas, and skills of Chemistry are clearly mapped within the eight defined categories of NSES content standards: unifying concepts/processes in science, science as inquiry, physical science, life science, earth/space science, science and technology, science in personal/social perspectives; and history/nature of science.

As content, inquiry includes both understanding about scientific inquiry and the abilities needed for students to do inquiry. Thus both the "knowing about" and "doing" aspects of scientific inquiry are integral parts or what it means to teach standards-based science content. It is no longer inquiry versus content in the teaching of Chemistry; it is now inquiry as content.

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