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Curriculum Units by Fellows of the National Initiative
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Introduction

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This seminar was designed to explore the relations between environmental quality and human health in urban settings. One unexpected effect of twentieth century prosperity has been a change in the chemistry of the human body. Most people are exposed daily to thousands of chemicals in mixtures that were never experienced by previous generations. Many are recognized by the US and other nations to be carcinogens, neurotoxins, reproductive and developmental toxins, or endocrine disruptors that mimic or block human hormones. Each year hundreds of billions of pounds of chemicals are released to the environment as commercial products and they include plastics, solvents, pesticides, flame-retardants, waterproofing agents, adhesives, fuels and their additives, cleansers, fragrances, preservatives, dyes. Trillions of additional pounds of pollution are discharged to the atmosphere, surface and ground water, oceans and land as by-products of industry, fuel combustion, or as wastes. Often the distinction between commercial chemicals and pollutants is only a matter of time as products lose their utility, are discarded, and slowly degrade releasing their ingredients.

The US Centers for Disease Prevention and Control (CDC) began widespread human tissue testing to detect the presence of hazardous chemicals in 1999 and several years later reported that most individuals carry a complex mixture in their bodies. The government focused some testing on chemicals that the US has banned such as chlorinated pesticides and numerous polychlorinated biphenyls formerly used in the electronics industry, and these demonstrate declining body burdens, indicating the success of prohibitive policies. All of us however have experienced growing exposure to newer unregulated chemicals such as plastic ingredients, some pesticides, fire-retardants, and waterproofing agents. Their concentrations in human tissues vary by age, gender, and ethnicity; children for example often carry higher concentrations than adults.1 2

As society's chemical footprint grew during the past half century, many illnesses increased in prevalence. These include respiratory diseases, neurological impairments, declining sperm counts, fertility failure, immune dysfunction, some types of cancer, and developmental disorders among the young. Environmental contaminants are now recognized to contribute to all of these conditions. There is little doubt that that tobacco, lead, mercury, radionuclides, solvents, vehicle exhaust, combustion by-products, dioxins, PCB's, and many pesticides have caused serious human illness, although those who profit from the sale or release of hazardous substances will always challenge the relation between chemical exposure and illness.

Several trends help to explain the growing chemical burden on the environment and human health. The US population surpassed 300 million in 2006 having doubled in both the first and second half of the century. The US economy expanded 45 times larger than it was in 1950. Life expectancy increased from 47 to 78 years since 1900, doubling the duration of adulthood. People are now living longer with higher incomes while

consuming more goods and energy, all as they create more pollution and waste per capita than any previous generation or any other nation. By 2008 those in the wealthiest countries consumed 32 times more energy and raw materials than those in the poorest. Inexpensive energy has been a primary catalyst for many of these trends. 3 4

The effect is a synthetic chemical burden on the environment that is enormous by any measure and it is accelerating. The US Chemical Abstract Service maintains a registry of over 32 million organic and inorganic chemicals, 14 million of which are commercially available. Fewer are traded in significant quantities: nearly 100,000 are registered and reportedly traded in the European Union (EU); and by 2000, 300 were produced in volumes exceeding 1 billion pounds annually, and about 2,700 others exceeded 1 million pounds each year. These are termed "high production volume chemicals" (HPV) and no hazard data exist for nearly 20 percent while sufficient data necessary to judge basic health risks are available for fewer than 15 percent. Among all chemicals traded, the EU in 2007 found that information necessary to understand chemical use, environmental fate, and health risks existed for fewer than 1,000 chemicals, or only 1 percent of all that are traded. This burden is most dangerous in urban settings where people, fuel combustion, commercial products, vehicles, and wastes are concentrated. Population density is positively correlated with intensity of chemical exposures; and population growth together with rising petroleum prices will encourage ever-increasing density.5

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To better understand the origin and scale of challenge we face, our seminar examined numerous histories of dangerous technologies and practices that have changed the chemistry of the environment and our bodies. These include the plastics industry, atmospheric testing of nuclear weapons, contaminated military sites, pesticides, and vehicle emissions. Each example includes the discovery that children have been exposed more intensely than others and each problem has been potent, persistent, and transnational if not global in scale. The five case studies exhibit different dimensions of risk, variety in human susceptibility, and considerable opportunity to reduce future exposure. Two of the cases we explored grew from government pursuit of national security: nuclear weapons testing and defense facility contamination. Two others evolved from private pursuit of profits: pesticides and motor vehicle emissions. Each history is considered in separate parts that follow.

The plastics industry well illustrates the chemical challenges to health we all will continue to face through the 21st century given its scale, global reach, product diversity, and ubiquitous human exposure. Plastic manufacturers introduce nearly 100 billion pounds of resins to markets each year and fewer than 5 percent of products containing them are recycled in the US. Plastics have entered every aspect of our lives, and their chemical residues now can be found in air, water, soils, and the tissues of nearly every human tested. Government studies confirm that children carry the highest concentrations of some plastic compounds produced in enormous volume that either mimic or block human hormones. These are known to induce reproductive and developmental disorders in several species of animals often tested to infer human health risks. Despite compelling evidence of danger, plastics remain virtually unregulated under US law. Chemical production and manufacturing occurs in so many parts of the world that no national government has the capacity to control sales, product ingredients, dangerous exposures, or wastes. Collectively these trends demonstrate the chronic and growing environmental experiment on human health being conducted by the chemical industry, one predominantly neglected but seemingly authorized by the federal law. The plastics overview follows this introduction.

The US nuclear weapons program unintentionally produced the very first paradigm for understanding global environmental problems such as climate change, ozone depletion, and mercury contamination in marine food chains. Discovering the hazards of nuclear testing in the atmosphere had enormous influence on the future of environmental science and law. Nuclear weapons were intended to produce massive loss of human life and environmental ruin, but the Atomic Energy Commission's discovery of global fallout and human exposure was a surprise. The pattern of discovery that radionuclides persist, move through the atmosphere, follow complex ecological pathways that lead to human exposures, and produce life threatening health effects became a paradigm for later efforts to understand and manage pollution and hazardous chemicals.

The history of pesticides provides a different paradigm to understand how society might protect itself from hazardous exposures. Each year 3 billion pounds of pesticides are sold in the US, and nearly 400 million acres of the national landscape are chemically treated. Pesticides are intended to kill different species of insects, bacteria, fungi, algae, parasites, and other species that can harm economic productivity and human health. Their intentional release to the environment causes residues to linger in air, foods, water, soils, and human tissues. They are added to commercial products such as plastics, fabrics, paints, fuels, wood products, swimming pools and spas, personal care products, and some pharmaceuticals. Many pesticides may legally be sprayed in indoor environments including homes, offices, restaurants, schools, hospitals, hotels, and vehicles. Some are encapsulated within tiny plastic beads that slowly dissolve and can cling to insects, but also to clothing, skin and foods. Nearly every home in the nation contains some registered pesticide. Among all chemicals pesticides have the longest history of scientific inquiry to understand their health and environmental effects and to manage human exposure and associated illnesses. Despite these efforts, everyone in the nation still carries pesticide residues in their tissues and tens of thousands of people report their exposures to poison control centers each year. Understanding the successes and failures of pesticide law could help to guide effective control of plastics and the larger chemical universe just described.

The history of Vieques, a small island off the east coast of Puerto Rico illustrates how the nation's consuming pursuit of national security produced severely degraded military sites. The US government in 1941 chose Puerto Rico as an Atlantic Basin counterpart to the Pearl Harbor naval base and acquired land for training and conventional weapons testing. The island has long been home to 9,000 residents who have lived between a munitions training range on the east end and weapons storage bunkers to their west. US and allied forces bombed and shelled the east end of the island for 50 years releasing nearly 150 million pounds of munitions, chemical warfare agents, depleted uranium, pesticides, solvents and fuels. The Navy closed the facility and left the island in 2003, leaving behind an enormous burden of chemical wastes and a cratered, toxic moonscape created by the explosions. The toxic substances continue to seep into the coastal environment as they have for nearly half a century.

Vieques is hardly unique as a recipient of government abuse. The US Congress in 2005 estimated that 50,000 sites under the authority of the Departments of Defense, Energy and Interior are intensely contaminated. Costs to contain site hazards but not restore their original conditions, were then projected to be at least $337 billion. Some bases lie on remote islands such as Pacific atolls or the Aleutian Islands in Alaska, while others include highly urban settings such as Hunter's Point Naval Shipyard in San Francisco. Most of these sites are being transferred to private developers for homes, schools, offices and parks without being fully restored to their pre-military and far more natural condition. The Defense Department has often left a toxic chemical soup behind for surrounding communities that have neither to expertise nor resources to identify the precise threat to their human health.

The last history we considered is that of vehicle emissions. The US fleet by 2008 exceeded 240 million motor

vehicles, one for every person in the nation eligible to drive. This passion for movement has had an important effect on air quality, human health, climate change, and national dependence on foreign oil. By 2007 US vehicles consumed twice the amount of petroleum produced in the nation. Each year US drivers burn almost 175 billion gallons of fuel as they travel 2.5 trillion miles. They accomplish this remarkable act while sitting less than ten feet from exhaust pipes emitting highly hazardous chemicals to the air. I recently sat on the freeway between Los Angeles and San Diego while traffic was either crawling or stalled in both directions in all 14 lanes. Several thousand drivers idled or crept along for several hours while inhaling each other's emissions. This is considered a normal "rush hour" in Southern California leaving most who experience it exasperated by the wasted time but unaware of their loss of health.

Vehicle exhaust can cause and exacerbate human respiratory illness and public acceptance of these trends rests on a collection of false impressions and collective ignorance that grew from a failure to test new technologies before allowing them to work into the fabric of daily life and human tissues. These include beliefs that: any individual's contribution to the problem is inconsequential; fuel chemistry could have little effect on health; gradual improvements in new model vehicle engines have improved air quality; pollution is dangerous only if visible; living, working or exercising near highways creates no special threat to health; chemical concentrations should be averaged across large regions and time periods to judge the severity of health threat; pollution only threatens respiratory health; and that risk of health loss is uniformly shared in the population. Within the seminar we challenged all of these premises, while exploring the growing burden of air pollution on health.

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The protagonists in this seminar included the Atomic Energy Commission (AEC), the Department of Defense (DOD), and the plastics, pesticide, and vehicle industries. The similarities in their patterns of environmental neglect and public deception are surprising. Each organization thought carefully and creatively how it could shape favorable public perceptions of their products or programs. Whether government official or corporate leader, each developed "narrative advantage" by controlling scientific inquiry that often included conscious choices to avoid investigation. They explained results in stories claiming the benefits and safety of their actions and that any risks were easily recognized and managed. These narratives had profound influence in forming public acceptance of technologies, products, or practices that left many exposed and ill. Their stories were difficult and costly for skeptics to contest, and they left responsible parties unaccountable for damages. The concentration of authority, wealth, and expertise overwhelmed competing interpretations of risk.

Secrecy played a special role in the histories allowing both the public and private sectors to control imagery and representations of danger, remaining unchallenged. Claims of safety were inflated while hazards were either neglected or hidden from the electorate or consumers. The primary intent of trade secrecy and classified information is to protect competitive advantage either in markets or international relations. The effects are menacing; secrecy ensures that the public will be ignorant of hazards. Secrecy empowers public and private officials. It also creates false impressions of naturalness, wildness, purity, and safety and led generations to experience dangerous environments without their knowledge or consent. Yet all secrets have limited lifecycles, and gradually the credibility of government and corporate narratives disintegrated as independent scientists challenged claims of safety with new evidence; or they developed credible alternative interpretations of information disclosed by governments or corporations. The effect was new understanding of the sources danger, patterns of human exposure, and the seriousness of health effects. And this new understanding led government officials to ban numerous chlorinated pesticides, to stop testing nuclear weapons in the atmosphere, and to eliminate lead from paints and gasoline.

The case studies we examined also illustrate how understanding the vulnerability of children affected government choices to ban risky products or programs. Regulators in all of these instances justified intervention based upon belief in children's heightened susceptibility and exposure. Before you conclude these are success stories, consider carefully that decades often passed before convincing challenges to conventional wisdom led to regulatory action. This delay between chemical release, problem recognition, and government response often induced widespread and serious environmental damage and health loss. If thorough testing of chemicals or technologies had been required prior to their deployment, and if the government reacted by controlling chemical testing, production, sales, and environmental release, the chemistry of the planet and our bodies would be very different.

Together in the seminar we imagined a world where everyone understands the distinction between the dangerous and the benign. This would demand knowledge of chemical presence in everyday environments such as foods, air, water, soil, buildings, and consumer goods. It would also require understanding the association between exposure and the likelihood of health loss. The gulf between what we know and what we need to know is what might be termed the "intelligence deficit". We struggled to explain its origin, prevalence, and causes. The Fellows' curriculum units provide excellent examples of innovative and inspired teaching methods to address these challenges.

The most fundamental antidote is what we termed "green intelligence". To us this meant not just information but the capacity to interpret it to judge the nature and severity of environmental threats to human health. Only if this intelligence exists could prevention become a possibility. Teaching society how to navigate safely among life's imperceptible chemical dangers will demand an enormous investment in public science to produce basic knowledge of chemical behavior and hazard. Students need to be taught to integrate and interpret this information historically, ecologically, and in narrative form. All are necessary to make sense of otherwise overwhelming complexity.

Why do we all carry residues of synthetic commercial chemicals such as plasticizers, pesticides, and pollutants in our bodies? Didn't Congress pass laws to prevent this? What ethical principles should guide corporate and government behavior to create more sustainable urban environments? While waiting for more responsible leadership, how can you learn to reduce your personal exposure, and how could your teach these lessons to students and others? I urge you to read the Fellows' curriculum plans that follow as you will discover many of the answers.

John Wargo

See www.cdc.gov/exposurereport/3rd. See also: www.ewgoorg/reports/bodyburden/.

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