



Effects of Plastics on Top Predators' Health

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Introduction

When I came back to live in the United States after a decade and a half absence I was surprised to discover a number of physical and behavioral changes in the population. The first and most obvious was the alarming number of very stout people that included teenagers and college students. Another change was the number of people complaining of allergies, depression, hyperactivity and autism. "Gee", I thought. "What a bunch of hysterical individuals these people have become!" But as time went by I began to notice that these problems were real and that people were honestly concerned but unable to identify the reasons for their poor health.

These people were exceedingly careful to buy products that would reduce the amount of germs, arachnids, and insects that could collect in their houses and lawns. They continuously used gels to sanitize their hands; tightly tied up a garbage in plastic bags to avoid smells and of course, germs. For the sake of expedience prepared meals were bought in microwavable containers which only required a few minutes to go from frozen to hot and on the table. So many marvels! Mankind had resolved so many difficulties: Houses did not need to be repainted, the walls within could be washed with soap and water; soiled diapers could be disposed of with hardly a thought. Children could have all the toys their little hearts could desire because they were made of plastic and therefore disposable. In this fascinating world even your teeth could be whitened with just a few strips applied for a short while. Why then, in this fairyland, were people constantly sick taking pills for their allergies, headaches, acid reflux and depression?

I wondered about the layers of garbage that were forming in the not so sanitary land fills and thought of how the sealed plastic garbage bags would possibly contain, for untold years, germs that would perhaps mutate. I thought maybe allowing the garbage to be exposed to the air might be healthier for future generations. I also wondered about the miracle of food being able to resist the natural processes of decay so that it could be shelved at the store a bit longer than normal, but questioned the food's ability to disintegrate adequately in the consumer's digestive system. Could the preservatives in our food be at least partially responsible for the unnatural numbers of obese people?

After thinking about these and other evidences of material well being versus ill health I began to consider the possibility that the people were ingesting something that was not readily identifiable, but which was negatively affecting their well being. I was not, however, prepared to learn that it was the ever present plastic that was causing these and greater, more devastating health problems not only for people but for all life forms

of the earth

Background

It seems that in our efforts to improve upon nature, to make materials which will be more durable, less expensively, more comfortable and more efficient we have inadvertently unleashed great problems on the fauna of the earth. Among the products that were supposed to resolve many of our problems were pesticides, synthetic estrogens, and plastics.

At first the products did seem to produce the desired effects, mosquitoes that cause so many diseases were dying, women were having fewer problems during their pregnancies and plastics were keeping our foodstuff clean. With time however, we have come to realize that there were, and are, many and complicated unsuspected secondary effects to the production and use of these products. Foremost among the effects are the health issues that have affected various aspects of the endocrine systems in a wide variety of fauna including humans. Among these are: impaired immune function, early puberty, underdeveloped reproductive organs, infertility, behavioral changes, diabetes, and obesity ¹

The Endocrine System

The endocrine system is composed of various glands; the adrenal, gonads, ovaries, pancreas, parathyroids, pineal, testes, thymus, and thyroid. The system is responsible for the hormone or internal secretion produced by the endocrine gland regulating the body's vital internal processes and guides critical phases of prenatal development. The system is formed of those body organs whose function is to prepare internal secretions and deliver them to the blood or lymph. ²

The endocrine glands produce and release hormones into the bloodstream. They are chemical messengers that circulate in the blood and regulate many critical biological functions through intricate signaling mechanisms. ³ The pituitary gland lies beneath the brain and acts as a control center for the endocrine system. It informs the thyroid or ovaries when to send their chemical messages, and how much to send. The pituitary gets its cues from the hypothalamus, a nearby small center under the brain that constantly monitors the hormone levels in the blood. It sends a message to the pituitary if levels of a hormone get too high or too low. The pituitary then signals the gland that produces this hormone to gear up, slow down or shut off. Thus a woman's ovaries release estrogens - the female hormones that travel in the bloodstream to the uterus, where they trigger growth of the tissue lining of the womb in anticipation of a possible pregnancy. ⁴

The pituitary is also responsible for making the luteinising and follicle stimulating hormones. In men these hormones are sent to the testes where the luteinising hormone stimulates the production of the male hormone testosterone. The follicle stimulating hormones in turn are important in sperm production. ⁵

In normal healthy vertebrates the endocrine system works smoothly sending and receiving messages that

keep the body functioning properly and reproducing healthy offspring. But, during the past forty or so years more and more animals including humans have developed infirmities, abnormalities, and behavior changes that were either unknown or were extremely rare. Scientists have been able to determine that many can be attributed to synthetic chemicals that mimic hormones and confuse the messages in the endocrine system, causing it to malfunction.

Since one of the endocrine systems functions is to insure the replication of the organism to which it belongs; abnormalities in the gonadal region would certainly be an impediment toward achieving the goal. Some of the abnormalities are easily detectable at birth but others only become obvious in adulthood when undeveloped reproductive organs or infertility stand in the way of normal reproduction. Early adolescence is another example of disrupted endocrine with girls reaching menarche as early as eight years of age. Behavioral changes that have been found to relate to endocrine disruption are hyperactivity and autism. ⁶

Evidence of Disruption in the Endocrine Systems of Diverse Animals

Before the middle of the twentieth century there were a number of recurrent illnesses that killed large numbers of people. Many of these diseases were carried by insects such as mosquitoes, flies, and fleas. Malaria, yellow fever, typhus, and bubonic plagues have all been attributed to them. Furthermore, locusts, aphids and other creatures could destroy crops in a matter of days leaving the farmers destitute. Insects were viewed as threats to Man's well being that needed to be stopped. So, around the world, for thousands of years man has waged war against them.

The Romans used sulfur on the crops. Sometimes the extract of some plants helped rid the areas of the offending insects. In Mesoamerica smoking pine resin was used to keep them away. Burning tobacco leaves also helped. But none of the insecticides were as effective as the one that our twentieth century scientists invented and called dichlorodiphenyltrichloroethane (DDT). After World War II campaigns were made around the world to eradicate those insect born diseases. ⁷ DDT was amply sprayed in all coastal or wetland regions from the temperate to the tropical zones. Farmlands around the world were sprayed from the air by small airplanes thereby saving the crops to feed growing populations. For a number of years man considered himself to have won the war.

So focused on the success of the insecticide were the people that neither chemists nor biologists thought about the effects that DDT would have on insectivores or herbivores. In the late 1940s however; it was noticed that the bald eagle population was declining rapidly. Biologists observing the eagles noticed that the adults seemed to be uninterested in mating and for those who did nest the eaglets did not hatch. Abandoned eggs were studied and discovered to have very weakened shells, the babies inside had languished and died. As the studies progressed it was determined that the eagle populations in North America and Europe were declining to the point of near extinction because of DDT. Although the substance had never been intended to threaten any organism except insects it had somehow affected the might and proud eagles.

It is hard to accept that scientists and industrialists focused solely on insecticides and their benefits without taking into account the notion of food chains. Eventually however; they did ban the use of DDT in the United States. In tropical countries where insects could breed faster and the threat of disease was still great their governments did not forbid its use. ⁸

But scientists were excitedly creating new synthetic chemicals for an array of human wants and perceived needs. Their attention was more focused on the wants of the industrialists and ultimately the economy of their respective nations. If one insecticide had proven to be noxious to some animals new, more effective compounds could be created. Attention was not concentrated however solely on insecticides. The plastic revolution had begun and the boundaries of the uses to which the products could be applied were limitless. Couched in the certainty of usefulness the industrialists overlooked effects on the ecosystems beyond the purpose for which their product was designed. And so, synthetic fertilizers and insecticides seeped into the ground and, helped with rain or irrigation water, found their way into the rivers and eventually the oceans. Petrochemical plants, plastics factories, paint companies, and oil refineries - to mention just a few industries - dispose of their wastes into the water ways near them. Those wastes too, find their way into the oceans and are considered xenobiotics. It is easy to understand that some geographic areas would be more easily contaminated than others. For example: large water features with limited exchange of water such as the Mediterranean Sea and the Great Lakes Basin are surrounded by some of the most industrialized countries or cities in the world would be the most threatened. Fossi ⁹ points out that it is precisely in this type of settings where xenobiotic levels can rise to extraordinarily high degrees threatening the lives and offspring of the organisms in them.

In 1990 dead dolphins began to wash up on the Mediterranean coasts of Spain. They appear to have died of partially collapsed lungs, breathing difficulties and abnormal movement and behavior. Spanish biologists identified the cause of death as a virus of the distemper family and thought that these were isolated cases. But, as the year progressed more dolphins died at sea and washed up in various shores around the Mediterranean: about 1,100 dead dolphins. International teams of biologists discovered that all victims showed high levels of PCB in the fatty tissues. These estrogenic chemicals which affect the reproductive functions primarily also affect the immune system as can be seen in the Mediterranean dolphin population. To Fossi and her team it was evident that the death of so many top predators in the Mediterranean Sea could be taken as a warning of potential reproductive alterations and immune malfunctions suggesting that measures should be taken to avoid reductions in population and biodiversity. ¹⁰

These observations came a bit too late to save a number of species in the Great Lakes basin where they began to experience failure to reproduce in the decade of the 1960s. Among the fatalities were the fish fed mink in ranches established around the Great Lakes where after a few years of successful breeding, the ranch populations began to dwindle as a result of mysterious reproductive problems. Normal mink females usually gave birth to four pups at a time, but the number of natants descended to two and eventually, by 1967, to zero. In the rare instances in which females did give birth the pups died along with their mother. ¹¹

Shortly thereafter on the Ontario side of the Great Lakes Basin entire potential flocks of Herring gulls were found lying on the shores in un-hatched eggs. All of the dead chicks had some grotesque deformity: missing eyes, twisted bills, club feet, or adult feathers instead of down. The deformities and failure to thrive of the chicks suggested dioxin contamination in the lakes. ¹²

Gulls in California were, at the same time, behaving in very peculiar manners. Observing biologists noted unusually large numbers of eggs in various nests. As they continued their observations they noticed that pairs of females were caring for the infertile eggs as a couple while the males seemed to be totally uninterested in them or in nesting.

Another closed body of water with limited exchange of water that had endured pesticide spills was Lake Apopka in Florida. In 1980 disaster killed off 90% of the alligator population. Emergency clean up of the

waters was hoped to bring back the alligators to the ecosystem's sustainable levels. However, toward the middle of the decade only 18% of alligator eggs hatched but only half the brood survived after a few days. Of the young males that did reach adulthood 60% had abnormally small penises.

Otters also became part of the devastating statistics. In the 1950s the otter populations in England's rivers and streams began to dwindle dramatically. By the mid 1980 their numbers had reduced so much that in some rivers and streams they disappeared completely. Pollutants in the form of pesticides were suspected to be the cause of their disappearance. ¹³

In July of 1998 the *Journal of Wild Life Diseases* reported that Norwegian scientists had been surveying polar bears near the Svalbard Islands and had discovered that seven out of the four hundred and fifty surveyed bears had both male and female genitalia. Although these were genetic females and some had even given birth to cubs they all had small penises in front of their vaginas. ¹⁴ Although the researchers admitted that hermaphroditism does occur in nature the percentage represented here was outside of the expected norms. The researchers suspected that polychlorinated biphenyls are to blame.

More recently still, is the evidence from Cardiff, Wales where starlings are showing signs of endocrine disruptions. Cardiff University researchers have a set of starlings in aviaries where their nutrition is controlled. The other group consists of free starlings living at sewage treatment plants and eating earthworms from the rocky filter beds. The worms survive on microbes that degrade the sewage. As the treatment plant starlings ingest the worms they are also consuming natural human estrogen along with DEHP, DBP, and BPA. The researchers noticed that in spring the males who consumed the estrogen mix had developed larger vocal centers, singing five times as long as uncontaminated birds and composing more complex songs. These songs appear to be very attractive to the female starlings - even the ones in captivity. However, blood tests show that the singing male starlings have compromised immune systems and are, perhaps less fit as mates. ¹⁵

Fish are not exempt from the effects of PCBs or other toxicants. Swordfish, salmon and rainbow trout are three types of fish that have demonstrated to have negative effects to chlorinated compounds. Some of them help to reduce the fish's levels of ascorbic acid which in turn reduces the hatchability of eggs, increases the number of deformed fry, and negatively affects the growth of fry, their food utilization and survival. In the males the deficiency has indicated a reduction in sperm concentration and effective motility. ¹⁶

Spread of Synthetic Chemicals

Unfortunately we have all contributed to the spread of synthetic chemicals: benign and malignant. Our demands upon industry to provide us with materials which will make our lives more comfortable in all senses of the word have encouraged the industrialists to come up with ever greater amounts of synthetic chemicals to satisfy our wants. And so, we have chemicals such as phthalates that make vinyl flexible giving lotions the right consistency; PFAs that make fabrics scratch and stain resistant; dioxins, an industrial byproduct of great toxicity; bisphenols which give rigidity to plastics; and PBDEs that act as fire retardants. All of these chemicals are released into the air by such innocuous items as mattresses, aromatic candles; shower curtains, plastic containers, baby bottles and so on. Of course none of us really gives a thought to the effects of the chemical compounds within the products we purchase or how they will interact with other organisms. The products meet our needs and that is really all that most of us think about.

Perhaps a few of us have begun to think of alternate means to fertilize our lawns or to reduce the amount of pesticides and insecticides that we use. But we still use them. We still use and buy products that use treated wood because we feel that they will last longer and resist termites. We still use plastic containers to store our food in the refrigerator or freezer knowing that the containers are imperceptibly thermo degradable. Then we warm the preserved food in the same container by means of the microwave.

But, how do these chemicals infiltrate our bodies as well as those of other animals? These chemical compounds are very persistent. They leach into liquids through heat or cold, they ride in the wind; float in the water; become part of sediments; rocks, or plants where they might have fallen. There they will stay until some activity dislodges them, carries them away and deposits them elsewhere. If the item upon which they came to rest is an edible organism then the feeder will ingest them and harbor them until it dies or is eaten. Helped by rain or irrigation pesticides, insecticides, and fertilizers filter into water features through the ground. More directly, industrial waste from refineries, paper mills and chemical plants, is disposed of into the water. There the chemicals enter the food chain. Some fish, thinking that the chemicals are either phytoplankton or zooplankton feed on them: So will bottom dwelling creatures such as mollusks and crustaceans. These in turn will probably be eaten by herons, gulls and cormorants. Animals at the top of the food chain ingest and retain a logarithmically increased amount of synthetic chemicals along with their food. Eagles, swordfish, porpoises, gulls, polar bears, alligators, and otters are all top predators. So are humans.

Smoke rising from industrial chimneys or refineries is another way in which synthetic chemicals spread. As the air borne molecules descend they can be inhaled. The rest will repose on whichever surface they happen to land on until dislodged and consumed by herbivores if the surface is a plant. The cycle begins again.

One more way in which the chemicals spread is through our rubbish. Because we have become such avid consumers and prone to disposing our refuse in the easiest manner; we toss out enormous amounts of rubbish everyday. The organic portion of the rubbish works its way into the ground and becomes part of the soil, but the inorganic matter degrades much more slowly, perhaps in hundreds of years, releasing its toxic compounds into the soils, water and air. Among the inorganic materials that we dispose of most frequently are the plastics. They are not biodegradable although they break down into very tiny portions (but not disappear) by thermal effects over a very long time.

An unintended monument to our way of life that has been forming during the past century is to be found in the North Pacific Gyre, a gigantic circle of currents thousands of miles wide in that ocean. There, the slow moving winds and currents naturally collect all of our debris carried by the rivers, streams, wind, etc. The debris that collects there is one form of plastic or another. Since most plastics are lighter than sea water, they float on the surface for years, slowly breaking down into smaller and smaller fragments. In the process they often end up in the ocean's drifting, filter-feeding animals, like jellyfish.¹⁷ Other marine animals like the dolphins and sea turtles confuse the plastic bags for jellyfish or medusas swallow them and choke. Many fish that gulp down nurdles (plastic pellets produced to be formed into all kinds of plastic products) discover that they are not fish eggs. Still other marine animals such as the monk seals are trapped and die in the large masses of fishing nets in the Pacific Garbage Patch. So plastics mimic food for many marine animals that not only do not derive any nutrition from the plastics, they are also poisoned because these frequently leach out diverse chemicals such as D.D.T., DEHP, BPA, natural and synthetic dioxins.

Endocrine disrupting chemicals

According to a report on plastics made by the American Chemical Council nearly 100 billion pounds of plastics are produced in the United States each year. The plastic products are found in everything: the packaging of food and beverages, furniture, toys, medical devices, building products, electrical wiring, and vehicles. Two ingredients found in plastics: Diethylhexylphthalate (DEHP) and bisphenols A (BPA) deserve mention in this paper because of increasing evidence that their tendency to mimic hormonal activity disrupts normal endocrine systems in many different species of animals.

Bisphenol A (BPA)

To the great majority of the population one plastic is very much like other plastics. We are aware that some are softer and more flexible than others. But in general, we are ignorant of their compositions. By way of explanation for us then I will say that those plastics used in food and beverage packaging such as drinking water containers, baby bottles and the interior coating of cans are called polycarbonate plastics and epoxy resins. They contain the molecular building block bisphenol A. These products are not recycled so they usually end up in landfills as solid waste where their chemical compounds leach into the underground water. Bisphenol A, one of the most harmful compounds to the reproductive health of animals is frequently found in surface water, sewage effluents, sludge, and treated wastewater discharge.¹⁸ One of the most fascinating aspects of these compounds is that the amount necessary to cause lifetime damage to the endocrine system is very low - parts per trillion. This is well below the concentrations suggested by the EPA in 1988.

At that time the EPA also considered that the safe upper limit of 50 micrograms per kilogram of body weight was acceptable and has maintained that standard. However, since then there have been a great number of experiments on laboratory animals and in human cells, the results of which prove differently. A recent statement by Consumer Reports.org says that studies suggest that adverse health effects can be reached from exposures of only 0.025 micrograms per kilogram of body weight.¹⁹ Another recent report mentions the potential human health effects caused by endocrine disrupting chemicals to be: Breast and reproductive organ tissues cancers, fibrocystic disease of the breast, polycystic ovarian syndrome, endometriosis, uterine fibroids and pelvic inflammatory diseases and declining sex ratio. For males it is poor semen quality, testicular cancer, malformed reproductive tissue, prostate disease and other recognized abnormalities of male reproductive tissues. Other potential effects are impaired behavior and mental health, immune and thyroid function in developing children: osteoporosis, and precocious puberty.²⁰

Few human studies have explored possible associations between BPA exposures and adverse health effects. While it is illegal to do laboratory studies of the effects of any kind of substance on human beings they are done on animals. It does not seem possible that a biologist or zoologist should not make a correlation between disrupted endocrine systems of vertebrates around the world and similar disruptions in humans. Nor has it taken long for scientists working independently of chemical corporate and governmental laboratories to make the connection. These scientists' interests are more in tune with avoiding further disruptions and return and a return to healthier lifestyles. The latter are more interested in the continued elaboration and distribution of their products while claiming that there is not incontrovertible scientific evidence linking BPA to any hormonal malfunction.²¹ While the FDA and the EPA consider it important to regulate commercial chemical industry our children are being the subjects of experimentation; only not in laboratories.

Diethylhexylphthalate (DEHP)

Plastics that are flexible and stress resistant contain phthalates. These plasticizers are used to produce diverse products, including medical devices and products, flexible tubing, food and beverage packaging materials, electrical conduits, building products, construction materials, wood finishers, lubricants, perfumes, hairsprays, cosmetics, and adhesives. Of the six phthalates in common use I will focus on DEHP because of the strength of evidence demonstrating its testosterone-blocking potential in males.

DEHP is not very soluble in water and has a low vapor pressure. However, rising temperatures in the PVC container will lead to out gassing of the compound and absorbed into the food or water thus raising the risk possibilities to nearby organisms. In addition, DEHP has the ability to leach into a liquid that comes in contact with the plastic and it is known to migrate faster into oils and fats in foods; especially those packed in PVC. In soils, on the other hand, it moves very slowly because of its low solubility in water. So leaching from plastics in landfills is generally low.

The youngest of our species are most susceptible to the effects of phthalates. These, especially DEHP are the compounds used to provide the soft flexibility of many toys and mouthing devices such as teethingers, pacifiers and bottle nipples. Rattles, balls, rings, and sundry toys that can be squeezed are also products that can be harmful. ²²

Medical devices such as flexible tubing contain DEHP; therefore, any solution such as blood serum, glucose drips, or salt solutions being administered to patients through this tubing is also transferring the compound. The American Academy of Pediatrics has advocated against the use of medical devices that can leach DEHP into patients and, instead to resort to DEHP alternatives. In July 2002 the FDA issued a Public Health Notification on DEHP that recommended considering alternatives to their use when high risk procedures need to be performed on male neonates, pregnant women who are carrying male fetuses, and peri-pubertal males. They continue to say that although they have not been notified of adverse effects in humans the large range of adverse effects of DEHP in laboratory animals would indicate a need for caution. The notification stresses that of greatest concern to the FDA is the types of effects on the development of the male reproductive system, and production of normal sperm in young animals.

And well they should be concerned. Not just about development of males but about all individuals. There are far too many observable connections between the abnormalities observed in different animals to continue doubting that any exposure to DEHP can cause the same problems in humans. If low doses of DEHP can be held accountable for male reproductive malformations, sperm damage, asthma and other respiratory diseases, female reproductive tract disease, premature delivery, and thyroid effects in animals both in laboratory and in the wild; it is time to take a stance against the producers of synthetic chemicals.

Conclusion

For decades chemical companies have been elaborating products with little foresight into effects beyond their immediate purpose. As has been shown, many side effects have been very negative for the environment and the creatures of the earth. At present all of the ecosystems of the planet are facing possible destruction because of the wanton procedures by these manufacturers. They are unmoved and indifferent to the

consequences of their irresponsible acts. They argue that there is no proof connecting the visible negative effects to their products. When taken to task they hire unscrupulous lawyers, legislators and scientists to substantiate their claims of innocence. ²³ Governmental agencies designed to protect the citizens are not strong (or willing) enough to impose the laws limiting the right of chemical industries to poison anyone or anything. As things stand, it is the industries that have the right to destroy wantonly while we, the citizens and victims, have the obligation to prove that their products are causing our diseases and illnesses.

It seems the right time to insist that the burden of proof of damages should not rest on the victims. Instead, the burden of proof of safety should rest on the industries. They should be accountable for proving that their products have been tested thoroughly for safety before putting them into the market. Should their products prove to cause unforeseeable negative effects then it should be their obligation to truly take them off the market and not transfer their operations to other countries pretending to benefit them as they have done continuously in the past.

Perhaps naively we have thought that the government of this country - above all others - had the interests of its people at heart. But the evidence is proving otherwise. The governments of dozens of other countries have already taken the proper steps to guarantee the health of their people. Among the countries that have placed PVC childcare restrictions are: Austria, Denmark, Argentina, Greece, Norway, Cyprus, Fiji Islands, Tunisia, the Czech Republic, Japan, and the European Union. They are perfectly aware that the situation is not going to disappear but they are willing to forgo the income generated by industry to provide some security to their people while investigations into the matter go forward.

Throughout the preparation of this paper I have been reminded of a portion of the Popol Vuj, the sacred book of the Mayas. In it the Creators and Molders were displeased with the second set of humans that they had made. These humans, made of wood, had no souls and they did not reason well. Although they could speak their faces were harsh, dry, and expressionless. They did not think of others. They did not think of the Creators and Molders. One day the Creators and Molders became tired of waiting for the humans to develop souls and to reason. But they did not. So, they caused their utensils to rise up against them. Tired of being misused the utensils beat the humans reprimanding them for their thoughtlessness and lack of care. Thus they drove the surviving humans into the jungles where their descendants became the monkeys that now live in the trees.

Lesson Plans

My students are second graders and just beginning to learn about the wonders of the world. I want them to be positive about their surroundings and to develop a harmonious integrative attitude toward nature. But, at the same time there is an urgent need to make them aware of the very real threats to the lives of the earth's fauna, and by association humanity.

One objective included into the second grade science curriculum is to become familiar with the concept of food chains and webs. The idea is to make the students aware of the interconnections that sustain and maintain balance in the natural world and to recognize how the sun's energy flows from plants through the animals that consume them on to the first and second level carnivores. When we present these lessons we often ask student to consider what would happen if a given animal or plant was removed from the chart. All

too often the children chime out "they would die". Now, I realize that some people feel that death is the ultimate threat.

But, starvation, malformation and other impediments can make life pretty grim. I want my students to consider some of the difficulties that some creatures have during their lives. Therefore, I intend to introduce them into the realization of how many of our animals are facing the threat of extinction. Among them I want to discuss: otters, sea gulls, polar bears, blue herons, and alligators.

Just a couple of weeks ago one of my little students was looking at the pictures in a National Geographic Magazine. I saw the look of distressed fascination on her face and walked over to see what she was looking at. It was the picture of a young child whose eyes were fused together. My student wanted to know why that was. I read the caption out loud to her and then had to explain that the birth defect this child had was probably due to some form of poisoning that her mother had undergone while she was being formed. Our discussion attracted the rest of the classmates who wanted to see for themselves what we were talking about.

The discussion gave me the opportunity to point out that some plastics leach their chemicals into the liquids or foods within them. Puritanically I pointed to my glass beaker that I keep with my drinking water and told them that I was wary of the chemicals within, so preferred to use glass. Next morning many brought their drinking water in glass bottles. Will there be accidents? I daresay yes. But they will also learn to be careful.

Lesson I

Such an introduction to plastics was unintentional. However, it is useful and I might replicate the episode for future use. We will discuss the usefulness of plastics, the benefits of having them as well as their chemical compositions and lack of biodegradability. This week long lesson will probably be taught in the spring semester as it is then when the curriculum includes biology (life science).

As the children become aware of the permanence of these synthetic chemicals we will try to follow a molecule through a food web (much as the one that Colborn et al described) and discuss how it is affecting the host biota's ability to reproduce. I believe that making a felt chart simulating a pond or lagoon wild life scene with felt mollusks, crustaceans, small fry, fish, herons, ducks, and perhaps raccoons will help bring the concept to bear.

Because my ultimate goal is for the students to grasp the idea of the dangers posed to the fauna, especially the top predators, I intend to expand the lesson to include a fairly complex mathematical concept: logarithmic increase. My plans for this lesson are to break my students into the pond fauna. The phytoplankton in the pond will bear the number 25. Fauna at the bottom of the pond will be marked with 50X. Those fish that prey upon the bottom feeders will be marked with 800X, the fish that eat those will be marked 2,800X and the top feeders: herons, or raccoons will be marked 25,000X. As predator consumes prey he or she will take on their numbers. The next predator will consume its prey acquiring all the numbers. The top predator will, of course, acquire the greatest number.

Once the top predators have eaten the second level consumers we will take up the numbers and add them up. Then I will begin a discussion about what the numbers represent (concentrations of PCBs) and how it is that the most endangered of the animals are the most affected by the chemicals from plastics. We will look at the polar bear, the dolphin, sea gulls, blue herons, and alligators again and discuss their respective niches.

At this point I would have the students choose one of these top predators and ask them to read some books

(previously collected in the classroom for the purpose) about them. When they have read enough I will have the students draw the ecosystem in which their animal is top predator. As they finish their drawings we will repeat the question above "What will happen to the ecosystem if your animal is gone?"

After a brief discussion I would form groups of three or four students and encourage them to discuss the possible effects of losing top predators. As usual, when they have finished their discussions I will invite the groups to the front of the classroom and have them present their conclusions to the class in general.

To end the sessions on the threat to the balance of ecosystems it follows that we will discuss steps to take in order to reduce the possibility of falling victim of the threat. Among the suggestions will be to use ceramic, glass or steel utensils instead of plastic ones. Another will be to stop buying prepared food products and encouraging their parents to buy and prepare fresh fruit and vegetables for their meals and drinks. Because my students are very young many are becoming siblings to even more vulnerable and defenseless creatures than themselves. It will be very important for them to suggest to their parents to reduce the amount of plastics to which their new babies can be exposed.

Lesson II

Another aspect of the plastics' saga that I intend to cover is the unfortunate Eastern Garbage Patch that collects in the North Pacific gyre. My purpose in introducing this subject is to develop consciousness about the natural world and our obligation to keep it clean and habitable for all the creatures on earth.

In preparation for units such as these the students will have previously learned much about maps: of the world, of the United States, and of course, Texas since that is where we live. Part of that learning includes water features such as rivers, lakes, seas, and oceans. The students have activities that show how rivers empty their water into the oceans along with sediments which will fall into the bottom, forming deltas. As a continuation of these lessons and as a way to introduce the Garbage Patches in the Pacific Ocean we will need to discuss trash and debris as part of the pollutants that are carried to sea.

Before the class I will fill a large transparent container with water (a twenty gallon aquarium will do). When the students are ready for their class I will take them out to pick up as much trash as they can from the school premises. After we have our materials on hand we will begin a discussion about how the rubbish got to the place where they picked it up.

When they have provided enough insight into the ways that garbage gets deposited I will ask them to pretend to be on a picnic near a river when a gust of wind picks up a paper plate and drops it in the water and is carried away by the stream. Some student will drop a paper plate into the water tank and the rest will observe what happens to the paper plate. They will record their findings in their science journals and provide explanations.

Then I will offer another student a plastic plate of the same size and ask the group what they think will happen to the plastic plate. After the student drops the plate into the water we will observe it. After a reasonable amount of time of observation the students will again record their findings along with their explanations. I am certain that there will be a few students who will want to disprove the findings, so I am prepared to allow them to investigate.

The following day we will begin the lesson with a conversation about which items in their garbage bags will float and which ones will sink to the bottom. We will write the opinions on the board and then dump the

collections into the water watch. If everything goes according to plan the plastics will remain afloat while the other debris will eventually sink. After recording their findings and thinking about explanations we will see if their ideas were right.

The third day two students armed with hair dryers will stand on opposite sides of the water tank and, pointing toward the debris still floating will begin to blow air creating a gyre. As the students watch the rubbish float to the center they will be asked to think about the amount of sunlight that would be reaching the fish underneath the accumulated rubbish on the surface. Discuss what the marine fauna might think these floating bits of plastic might be. I will then encourage the students to consider what sea birds flying over head might think some of the floating bits of plastic can be.

I will then show the students pictures of the Pacific Ocean, the Pacific Garbage Patch and a map showing its size relative to the North American continent. These pictures will be followed by a short video from the following website: <http://www.youtube.com>. From it the students will learn what the effects of the plastic debris have on the fauna. The video includes information about bacteria and poisons collecting around the nurdles making them a greater source of poison for the creatures eating them.

After viewing the movie I will have the students collect the floating plastics in the tank and put them out to dry. The next day I will have the students form groups to discuss and plan effective posters to display throughout the school building. The thrust will be to discourage their peers from disposing of their rubbish in careless ways and suggesting effective recycling habits. The students will then begin to make their posters using the collected trash to drive their points across.

Lesson III

By the nature of the Pacific Garbage Patch the unit lessons above will be integrating Social Studies concepts as well as some in Science. The students will have learned about the threat to the health and future of different animals resulting from chemicals migrating out of plastics. They will have learned about air and water currents and their role in the collection of discarded plastics in the Pacific gyre and the threat that it poses to the environment at large.

It will be fitting then, when learning about the three bodies of government, to extend the portion about the legislature to include laws and regulations for the welfare of the people. We will discuss some regulations designed to ensure the health of the general population and the entities assigned to that duty: FDA and EPA. The students will then draw pictures that indicate their understanding of protective agencies. While the students draw I will begin a chart of the three systems which I will mount on the wall. Then I will place the words "Legislative Body" to the left of the large triangle.

The next day the students and I will discuss and review the legislative role in passing laws and regulations. I will then ask them who will validate these laws. I am certain that they will mention the police. Undoubtedly they will have many anecdotes to strengthen their opinions. But, I will ask them if they know what happens after the police "get you". Eventually we will be discussing the judges and their role in the judicial system - or body - of government. The words "Judicial Body" will be placed on another side of the triangle.

Since the purpose of this lesson is to make the students aware of discrepancies between intent and actual procedures I will direct their attention to the FDA' and EPA's roles and ask them into which body they might belong. Then I will place the drawings that the students made on the side of the triangle that they think those entities belong: the Judicial.

After placing the FDA and EPA on the chart the students and I will discuss the benefits that a plastics factory provides for the population: work for people, available money to spend for needs and wants; inexpensive products for the home; etc. The list could go on depending on the students' ideas: ideas that we will incorporate into a brain storming chart.

Then we will revisit the negative effects that those plastics have had on the ecosystem and the health of the wild animals, the laboratory animals and humans. Having added the negative consequences of the chemicals within those plastics on the brain storming chart the students will be asked to evaluate the benefits and the results. This will best be achieved by having them break into discussion groups.

When they have finished discussing their thoughts they will present their conclusions to the rest of the class. Hopefully there will be some question about the efficacy of the FDA and the EPA in preventing, or at least, stopping the promulgation of the noxious chemicals.

Should they not do so I will have to mention it asking them how it came to be that the two groups that were assigned the welfare of the population could have failed so ignominiously. Second graders are very much aware that standards of behavior established by grownups can be systematically broken; especially when the grownups made the rules without really thinking them out or without the desire to enforce them. They will understand how those entities neither implemented nor enforce the regulations and laws.

The following day the students will be asked to offer explanations about what caused the break down in justice. Should I go on to chart the third part of the triangle and speak of the Executive Branch and its influence over the other two? Perhaps I will let it rest until the students are older..... or maybe I will equate government with big business and let the young ones begin to question our entire moral and ethical structure.

While I decide upon this thorny theme I will ask the students to write letters to the members of the Executive branch manifesting their feelings on the subject. When I have collected them and put them into corresponding envelopes the students will put down their pencils and closed their notebooks. Then they will begin to dance around the room chanting the following ditty:

"Children of the Sun

The time has come

To get together

To make the world better"

(Ram Bhagat)

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