PESTICIDE RISKS

FROM OUR FARMS TO OUR HOMES

ENVIRONMENT & HUMAN HEALTH, INC.

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Table of Contents

Part One: Overview 7

1. U.S. and Global Pesticide Use 12
2. Residential Pesticide Use 15
3. Pesticide Manufacturing Is Concentrated in Just a Few Companies 20
4. Pesticide Benefits 21

Part Two: Human Health and the Environment 25

1. Human Exposure to Pesticides 25
2. Residues in Foods 32
3. Benefits of Organic Foods 40
4. Drinking Water Safety 43
5. Health Effects of Pesticides 50

Part Three: Pesticide Law and Regulation 59

1. Laws and Regulations 59
2. Registration and Licensing of Pesticides 61
3. Inert Ingredients 63
4. The FQPA and the Rise of Precautionary Policy 64
5. History of Pesticide Substitutes 66
6. Pesticide Labeling and Warnings 69

Part Four: International Law – Trade Barriers and Pesticide Bans 73

1. Trade and International Law 73
2. Trade and National Sovereignty 74

Part Five: Historical Patterns 80

1. The EPA and Pesticide Regulations 80
2. Pesticide Regulation Flaws 81
3. The EPA's Pesticide Reviewing Process 81
4. Human Health Hazards 83
5. Pesticides in Human Tissues 84
6. Reliance on Animal Testing 85
7. Neglect of Fetal, Infant, and Children's Health 86

Part Six: Conclusion 87

Part Seven: Recommendations 90

1. Recommendations for the Federal Government 90
2. Recommendations for State Governments 92
3. Recommendations for Town Governments 92
4. Recommendations for Individuals 93

Endnotes 94

Table of Figures

Figure 1. U.S. Households Using Pesticides by Type 15

Figure 2. Pesticide Persistence & Exposure Following Single Indoor Application 17

Figure 3. Chronic Daily Exposure Causes Accumulation in Human Tissues.....18

Figure 4. Common Pesticide Active Ingredients, Home and Garden Markets.....19

Figure 5. Number of U.S. Pesticide Producers, Formulators, and Distributors. 21

Figure 6. Human Exposure Pathways: Chemical Release, Transport, and Fate 27

Figure 7. USDA Data from its Pesticide Data Program Sampling Program 36

Figure 8. Percent of Food Samples Testing Positive and Pesticides Detected.....37

Figure 9. Fruits: USDA Single Samples with Multiple Pesticide Residues.....38

Figure 10. Vegetables: USDA Single Samples with Multiple Pesticide Residues 38

Figure 11. USDA Testing Detected Four or More Pesticide Residues on Oranges.....39

Figure 12. California Conventional vs. Organic Food Pesticide Residue Test Results.....41

Figure 13. Organic Food Benefits: Reductions in Human Tissues for Eight Pesticides 43

Figure 14. Top Four Pesticides Commonly Found in Both Agricultural and Urban Waters.....47

Figure 15. Pesticides in Streams & Groundwater: % Samples with Positive Detections 48

Figure 16. Persistent Organochlorine Residues in Fish Tissues and Bottom Sediments.....49

Figure 17. Chemical Company Claims of Costs to Bring New Pesticides to Market 68

Figure 18. Oganophosphate Pesticide Regulatory Status: U.S., EU, Brazil, and China 77

Figure 19. Pesticides Banned in EU that Are Approved in the U.S.....79

Part One: Overview

In 1962, Rachel Carson, a wildlife biologist with the U.S. Fish and Wildlife Service, published her book, Silent Spring, *which attracted worldwide attention. The book warned of pesticides' dangers to human health, risks to the health of many species of animals and plants, and the prospect of rapid loss of biological diversity on a global scale. By that year, the U.S. Department of Agriculture (USDA) had approved nearly 55,000 separate pesticide products, including mixtures of active and inert ingredients.*

- Carson claimed that the government was failing to protect the environment and human health from pesticide exposures because of the freedom granted chemical companies to market their products virtually at will.

- Carson argued that industry's practices threatened the future of ecological and human health, and that the primary source of the threat was industrial, chemical-dependent agriculture that contaminated soils, water, air, food, plants and wildlife, and human tissues.

How have regulations, economic incentives, and education in the U.S. responded to Carson's warnings? Is the world now safer from the perils that she warned us about?

- Carson believed that human dependence on the daily provision of clean water, clean air, and safe food was threatened by the repeated annual release of hundreds of millions of pounds of what were then termed economic poisons.[1]

- What has happened in the 60 years that followed her original research? What are the key benchmarks in understanding the effects of pesticides on the planet and human health? How have regulations, economic incentives, and education in the U.S. responded to Carson's warnings? **Is the world now safer from the perils that she warned us about?**

- Many people worldwide encounter pesticide mixtures every day of their lives, in food, water, air, indoor environments, and often in consumer products.

- Exposures tend to occur without our knowledge, consent, or understanding of potential to harm human health. Pesticides include a large group of chemical mixtures composed of herbi-

cides, insecticides, fungicides, and bactericides. Nearly 17,000 different products marketed in the U.S. are mixtures of the "primary toxins," or *active* ingredients, and *inert* ingredients that constitute the majority of the products.

- Most herbicides and fungicides are released outdoors for agricultural and forestry purposes. By contrast, 50% of insecticides are used in the home and garden sector. Insecticides are used both indoors and outdoors in residential, commercial, recreational, and other environments filled with people. Such uses can produce high human exposures.

- Herbicides are also used to control nuisance insects and for aesthetic purposes, such as killing weeds in lawns and gardens, or clearing vegetation from transit and power line corridors.

- Pesticides are part of a larger class of chemicals known as *biocides,* "bio" meaning organism and "-cide," derived from the Latin word *caedere*, to kill. Biocides include pesticides, preservatives, disinfectants, and other chemical agents intended to kill any harmful or unwanted organisms or cells. Pesticides are prescribed as pharmaceuticals, including the antibiotics tetracycline and streptomycin.

- Biocides are normally unrecognizable hazards, phantoms that escape human senses. We rarely see them applied. They are difficult to smell, or taste, and are difficult and expensive to monitor and track as they move through the global environment.

- Once a new biocide is discovered, it is often added to hundreds of commercial products, adjusted in various concentrations, and mixed with different inert ingredients to increase marketablity and effectiveness. Pesticides can protect human health, but they also have the potential to injure it.

- Pesticides have been purposely designed to injure or kill cells or organisms that can interfere with maximal plant and animal growth. However, some pesticides are a double-edged sword because they also are capable of killing species of insects and microbes that threaten human health.

Pesticides have been purposely designed to injure or kill cells or organisms that can interfere with maximal plant and animal growth.

It's important to use the least amount of pesticides necessary and to apply those with the lowest risks to other species, especially humans. It's also vital to choose products that are the least persistent, mobile, and toxic.

- The core pesticide dilemma is how to obtain their benefits by controlling damaging species without threatening human health, and avoiding injury or death of non-target species.
- Given that they are intentionally toxic substances, the central management challenge is to apply them as specifically as possible to their targets. It's important to use the least amount of pesticides necessary and to apply those with the lowest risks to other species, especially humans. It's also vital to choose products that are the least persistent, mobile, and toxic.
- Cornell Professor David Pimental once wrote that only 1% of the pesticides applied, on average, reach target pests. The remainder miss the pests by being applied during the wrong time, wrong weather conditions, or at the wrong concentration. The result is a waste of chemicals, time, energy, and labor, plus exposure to non-targeted species and environmental contamination.
- Most pesticides have the capacity to trigger many different adverse health effects in humans. They accomplish this by disrupting the normal nervous, reproductive, hormonal, and metabolic systems. The immediate effects can range from nausea, dizziness, loss of cognition, memory, and learning abilities to coma, loss of co-ordination, reproductive failure, and death. More concentrated exposures to pesticides can produce irreversible chronic effects, while milder doses may be unnoticeable or recoverable, depending upon the potency of the chemicals used.
- The adverse effects of biocides and pesticides may be caused by many different chemical, behavioral, environmental, and genetic conditions. This complexity makes it very difficult to prove that they are the cause of illnesses and deaths. The absence of causal certainty, however, does not mean that these purposely toxic substances are safe.
- There is substantial evidence of their potential to cause illness and death from studies of chemical production facilities, farms and greenhouses, as well as workers exposed in enclosed settings.

- Today, nearly 1,500 distinctive pesticide active ingredients are available for agricultural uses. These chemicals are normally mixed with inert ingredients, such as petroleum distillates, which are also toxic substances. This oily solvent binds the pesticides to plants despite rain or irrigation sprays.
- Today's corporate farmers have an enormous variety of chemical combinations available to deploy against species that threaten maximum crop yields.
- Herbicides, insecticides, rodenticides, algicides, and fungicides are exemplary classes of pesticides that include dozens and sometimes hundreds of separately licensed biocidal products. Among all pesticides, herbicides constitute the most sold and applied, followed by insecticides and then fungicides.
- This report examines how society can enjoy the benefits of pesticides, while protecting the planet from serious harm to human and ecological health.

Today's corporate farmers have an enormous variety of chemical combinations available to deploy against species that threaten maximum crop yields.

Surprisingly, 50% of all insecticide use in the nation was in home and garden settings. That is 11% more than was used in the entire agricultural sector of the U.S.

1. U.S. and Global Pesticide Use

- Global pesticide sales now exceed $56 billion, with U.S. sales valued at almost $9 billion.
- Herbicides are the most applied type of pesticide in the nation, followed by insecticides, fungicides, and fumigants.
- Pesticide use is reported by one million U.S. farms, or 77% of the 1.3 million acres of U.S. land cultivated annually. Approximately 400 million acres of land are cultivated in the U.S. each year.
- Nationally, $8.866 billion was spent in 2012, with $5.115 of this total allocated to herbicides.
- U.S. purchases of pesticides constitute 21% of global herbicide sales, 14% of global insecticide sales, 10% of global fungicide sales, and 23% of global fumigants sales.[2]

- Surprisingly, 50% of all insecticide use in the nation was in home and garden settings. That is 11% more than was used in the entire U.S. agricultural sector.
- Insecticides are most often released indoors in enclosed spaces or near residential, commercial, institutional, and recreational sites where people spend the majority of their time.
- Indoor pesticide applications can result in very high exposures due to the fact that people spend so much time indoors.
- As urban areas sprawl into rural environments, pesticide applications to croplands can lead to spray drift and contamination of surface and groundwaters.
- Pesticides are often applied to croplands, pasture lands, forests, and recreational lands, as well as to water bodies such as lakes, rivers, streams, and coastlines.
- Herbicides are commonly applied to highway, power line, and rail corridors to prevent vegetation from interfering with access.
- Pesticides are common additives to building materials, furnishings, plastics, paints, varnishes, and textiles. They are added to prevent bacterial action and insect infestations.
- **Glyphosate** is the world's most widely used herbicide. It is registered for use in 130 different countries and used on 100 different crops. In 2014, nearly 120 pounds of glyphosate were applied to the soybean crop, and 84 million pounds on corn fed to animals.[3] By 2016, nearly 220 million pounds of glyphosate were applied to soybeans and corn.
- **Chlorpyrifos** is an insecticide that is used in agriculture in the U.S. The manufacturers have received U.S. Environmental Protection Agency (EPA) registrations for its use in 800 separate products, mixed with other pesticides and inert ingredients.

Indoor pesticide applications can result in very high exposures due to the fact that people spend so much time indoors.

Atrazine, one of the most commonly used herbicides, is registered for sale and use in 190 separate products, and each is independently labeled and registered. This type of aggressive marketing of a single chemical can result in its residues in many different foods that compose the human diet.

- **Atrazine,** one of the most commonly used herbicides, is registered for sale and use in 190 separate products, and each is independently labeled and registered. This type of aggressive marketing of a single chemical can result in its residues in many different foods that compose the human diet.
- Manufacturers pursue registrations and tolerances that allow their products to be used on the most produced and consumed crops in the world. These crops predominantly include grains, livestock feed, plant species, and livestock products themselves.
- The most sold fruits in the global trade market include bananas, oranges, apples, plantains, pineapples, coconuts, and palm fruits.
- The most sold vegetables in the global trade market include lettuces, spinach, kale, potatoes, cassavas, yams, beets, parsnips, turnips, rutabagas, carrots, yucca, chickpeas, beans, peas, and lentils.

2. Residential Pesticide Use

- The most concentrated source of human exposures to pesticides occurs when they are released indoors to control pest infestations or when using whole-house or apartment sprays, such as flea bombs.
- Most attention to control pesticides has focused on outdoor human exposures, leading to widespread misunderstanding about the serious pesticide exposures that occur indoors. When pesticides are sprayed indoors, surfaces such as rugs, floors, kitchen counters, dinnerware, and bedding can all become residue sinks and sources for continuing human exposures.

Figure 1. U.S. Households Using Pesticides by Type

Pesticide Type	Households
Insecticides	82 million
Fungicides	16 million
Herbicides	52 million
Repellents	57 million
Disinfectants	66 million
Any Pesticide	88 million

Source: EPA estimates based on the 2012 Kline & Company study and 2010 U.S. Census Bureau population estimate

- In 1992, the EPA estimated that Americans held nearly 176 million containers of pesticides in their homes, and that nearly 16 million of them contained chlorpyrifos. At that time, the manufacturer, DowElanco, claimed that chlorpyrifos accounted for roughly 25% of the national market share for residential insecticide use. However, since 2000, chlorpyrifos has been banned for residential uses in the U.S.
- When the EPA began to examine food, water, and residential exposures in 2000, the agency found that the risks faced by infants and children younger than six years were nearly 10 times

When the EPA began to examine food, water, and residential exposures in 2000, the agency found that the risks faced by infants and children younger than six years were nearly 10 times those experienced by adults.

those experienced by adults. This is explained, in part. because small children, whose bodyweights are low, consumed more residue-containing fruit products than adults, when intake is adjusted by bodyweight. Where indoor areas have been treated, young children may also be more exposed than adults.

An EPA study suggests that 80% of most people's exposure to pesticides occurs indoors. Measurable levels of up to a dozen pesticides have been found in the air inside homes.

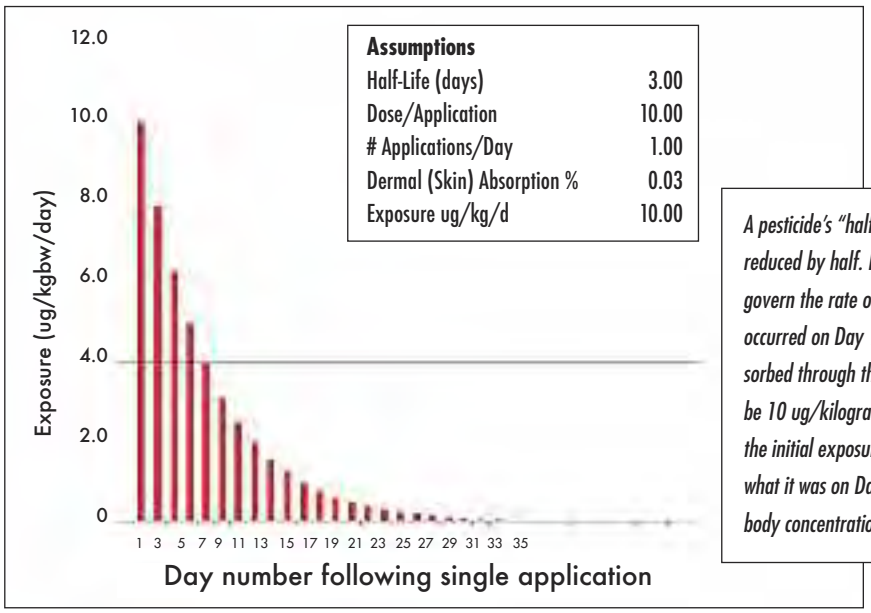
- Children spend much of their time closer to the floor, where pesticide residues settle. Toddlers, in particular, place their fingers and hands in their mouths as often as 15 times an hour.
- When pesticides are released indoors, the exposures to people are greater than when people are exposed outdoors. When pesticides are sprayed inside a home, they land on surfaces such as rugs, floors, and furniture that all continue to add to human exposures.
- Pesticide use indoors is common in the U.S. and can lead to intense and persistent exposures. The EPA estimates that nearly 75% of U.S. households use at least one pesticide product indoors annually. Products used indoors most often are insecticides and disinfectants.
- An EPA study suggests that 80% of most people's exposure to pesticides occurs indoors. Measurable levels of up to a dozen pesticides have been found in the air inside homes.[4]
- The EPA regulates pesticides in foods by setting "tolerances," which are the maximum amounts of a particular pesticide allowed to remain in or on a food.
- Pesticide residues have tended to be highest on certain fruits, vegetables, grains, and animal feeds. Since children have high dietary intake of fruits, and because chlorpyrifos is still allowed for agricultural purposes, their exposure to chlorpyrifos has long been recognized as among the highest of any sub-populations.
- Farmworkers are often the most exposed occupational group. Switching from using pesticides to organic farming substantially reduces pesticide exposures in the human tissues of farmworkers.

In addition, moving residents or workers from indoor treated to untreated buildings similarly reduces human tissue concentrations.

- If building interiors are treated with pesticides via sprays, dusts, smoke bombs, or substances encapsulated in plastic beads, occupant exposures may be higher than outdoor exposures.
- Pesticides applied indoors tend to have longer half-lives, meaning that they persist longer at higher concentrations than outdoor applications that are dispersed by winds, diluted by rains, or broken down by ultraviolet rays in sunlight.
- When residential or office environments are treated, the duration of human exposure is normally higher than would occur outdoors.
- The government's method of analyzing pesticide and chemical exposures to humans has long underestimated the exposures because the government averages exposures among populations.
- This approach masks the presence of higher-risk locations and groups. If regulations are set based upon national averaging without

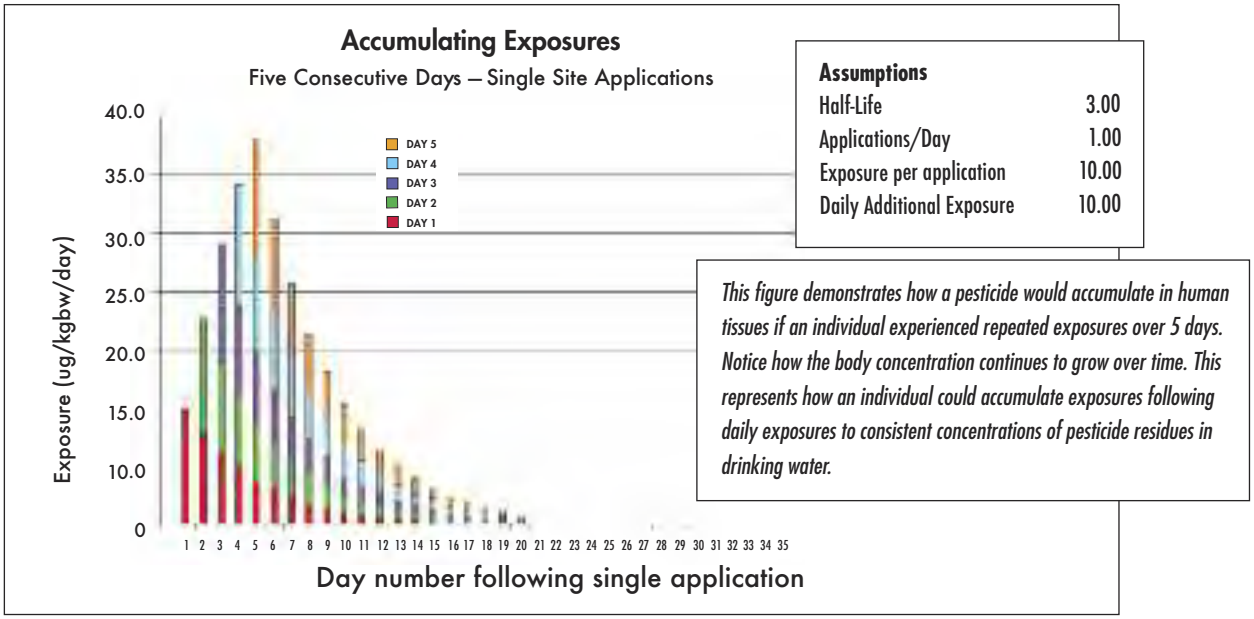
When residential or office environments are treated, the duration of human exposure is normally higher than would occur outdoors.

Figure 2. Pesticide Persistence & Exposure Following Single Indoor Application[5]



A pesticide's "half-life" is the time it takes for its concentration to be reduced by half. In this hypothetical case, a variety of assumptions govern the rate of decline. If one assumes that only 1 application occurred on Day 1, and the half-life is 3 days, only 0.03% is absorbed through the skin; then exposure on Day 1 is estimated to be 10 ug/kilogram of bodyweight per day. Notice that 3 days after the initial exposure, the remaining concentration in the body is half what it was on Day 1. Also, nearly 4 weeks after the application, the body concentration would still be detectable.

Figure 3. Chronic Daily Exposure Causes Accumulation in Human Tissue[6]



Children, for example, eat more food, drink more water, and breathe more air in relation to their bodyweight than adults. This neglect has long left society's youngest more exposed to pesticides, and other chemicals, than adults.

accounting for differences in populations, then exposure predictions are inaccurate. Children, for example, eat more food, drink more water, and breathe more air in relation to their bodyweight than adults. This regulatory neglect has long left society's youngest more exposed than adults to pesticides and other chemicals.

- The high number of allowable pesticide uses and brands creates the likely potential that groups will be exposed to overlapping residues in foods, water, and indoor environments. For example, someone might live in an agricultural area, consume foods with normally detectable residues, drink contaminated water, and spray indoors.

- In addition, restaurants and food service establishments are still permitted to spray chlorpyrifos indoors in the U.S. The EPA has created a separate food tolerance for restaurants and cafeterias that legally permits pesticide residues in the foods they serve.

- Lawn-care products, especially herbicides, are intensively applied in many residential, commercial, recreational, and institutional

environments. People can experience significant exposures to the skin or via air from vapors and spills during pesticide application.

- Many pesticides are water-soluble, meaning that after application, rain or irrigation waters could leach into underlying drinking water wells or into surface waters that supply drinking water. Residential exposures are considerably higher if drinking water is contaminated, since water is the most consumed food, and intake occurs repeatedly day-to-day and many times daily.

- Automatic lawn and garden misters, often placed on fences, are set to timers and spray chemicals into the air. Airborne chemicals can be inhaled by anyone nearby, or contact skin and be absorbed.

- Chemical mixtures are a concern in residential environments, such as applications of herbicides to lawns. Insecticides and fungicides used in gardens can result in human exposures to mixtures of pesticides that have not been regulated or even evaluated for their collective effect. Chemicals applied on one property can drift to adjacent properties and also contaminate neighbors' drinking water wells.

Lawn-care products, especially herbicides, are intensively applied in many residential, commercial, recreational, and institutional environments.

Figure 4. Common Pesticide Active Ingredients, Home and Garden Markets[7]

Active Ingredient	Type	2012	
		Rank	Range
2,4-D	Herbicide	1	7-9
Glyphosate	Herbicide	2	4-6
MCPP	Herbicide	3	2-4
Pendimethalin	Herbicide	4	2-4
Carbaryl	Insecticide	5	2-4
Acephate	Insecticide	6	1-3
Permethrin + Other Pyrethrins	Insecticide	7	1-3
Dicamba	Herbicide	8	1-3
MCPA	Herbicide	9	1-3
Malathion	Insecticide	10	1-3

The top two herbicides on the list above are classified by the World Health Organization as probable human carcinogens. Six are herbicides and three are insecticides that can damage central nervous system function.

3. Pesticide Manufacturing is Concentrated in Just a Few Companies

When Monsanto invested in creating seeds that are genetically modified to tolerate its herbicide glyphosate, the company chose to focus on the world's most produced grain crops—corn, soybeans, cotton, and sorghum.

- Pesticide production is highly concentrated in about 12 major firms that operate in the US, including Corteva Agriscience (formerly DowDupont), Syngenta-ChemChina, Bayer-Monsanto, and BASF.
- Mergers, acquisitions, and partnerships have formed quickly among these giants since 2012 as they vie for larger global market shares. Companies pool expertise in chemical design, expand chemical uses and products, and pair biotechnologies with genetic editing to confer desirable and profitable traits.
- While firms may have their headquarters in one nation,[8] the acquisition of firms, technologies, or products from partners in other nations makes them very agile. They avoid production in nations with the most restrictive environmental and labor regulations. They also tend to produce near growing markets.
- Decisions on future types of products are often targeted to the most broadly planted crop species. For example, when Monsanto invested in creating seeds that are genetically modified to tolerate its herbicide glyphosate, the company chose to focus on the world's most produced grain crops—corn, soybeans, cotton, and sorghum.
- They chose these crops because they understood the growing demand for ethanol, as well as dominance of these crops in providing feed for livestock. In addition, these crops were important for human consumption.
- By genetic editing of these crop species, Monsanto gained the advantage of both selling their proprietary genetically modified (GM) seeds as well as the herbicides and insecticides designed to go with their seeds.

Table 5. Number of U.S. Pesticide Producers, Formulators, and Distributors[9]

Major Pesticide Producers	12
Other Pesticide Producers	100
Major Pesticide Formulators	120-150
Other Pesticide Formulators	1,550
Distributors	24,686
Establishments	42,160

Note: Entities may operate as both a producer and a formulator. This may result in the number of entities being overestimated.

- Formulators purchase pesticide ingredients from manufacturers and mix the active ingredients together in products in various combinations and concentrations. They then obtain EPA registrations for these products and sell them internationally. Nearly 1,700 companies are formulators within the U.S. alone.

4. Pesticide Benefits

- Pesticides provide three major types of benefits to society:
  - Protection of plants and livestock.
  - Prevention of human vector-borne disease infections carried by insects, parasites, bacteria, viruses, and other microbes.
  - Meeting the caloric and nutritional requirements of a growing population.

Plant and Livestock Protection

- Pesticides protect plants and livestock production from disease, immature development, and premature mortality. The United Nations (UN) Food and Agriculture Organization (FAO) estimates that the world loses nearly 24% of food's caloric value each year, despite the use of nearly 10 billion pounds of commercial

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pesticides to control insects, weeds, fungi, algae, marine organisms, and diverse bacteria, parasites, and viruses. If pesticides were not used in global agriculture, the FAO estimates an additional food loss of 25% to 40% would occur.[10]

Despite the chemical war waged on malaria through much of the 20th century, in 2020 nearly 3.2 billion people live in areas where they are at significant risk of infection by mosquitoes carrying malarial parasites.

Pesticides and Vector-Borne Diseases[11]

- Vector-borne illnesses are transmitted by mosquitoes and other vectors that carry viruses, bacteria, and other pathogens.
- The World Health Organization (WHO) estimates that during the 20th century nearly one million people worldwide lost their lives to these illnesses. The total deaths from these diseases is estimated to be more than all those who died as a result of the wars of that century.
- Synthetic insecticides developed a sensational image of sanitation during World War II for their new-found ability to control malaria, yellow fever, dengue fever, and typhus epidemics.
- Pesticides certainly have protected human health from malaria and other vector-borne diseases. Pesticides have been applied to swamps, coastlines, campgrounds, and even immigrant populations seeking refuge. Fumigation of farmworkers, military personnel, and migrants has greatly reduced the incidence of insect-borne illnesses.
- Historically, pesticides have a praiseworthy and proven track record when they have been applied to vector-borne diseases.
- Despite the chemical war waged on malaria through much of the 20th century, in 2020 nearly 3.2 billion people live in areas where they are at significant risk of infection by mosquitoes carrying malarial parasites.[12] This year, nearly 200 million clinical cases of malaria infection are expected to occur worldwide.
- In 2018, WHO estimates that malaria killed 405,000 people, many of them children, particularly in sub-Saharan Africa.[13]

- The application of pesticides effectively diminished the severity of disease, and together with oral rehydration therapies, these interventions have effectively eradicated vector-borne disease-related deaths in most temperate parts of the world.

- Nations lying within semitropical and tropical zones that still harbor endemic disease vectors and pathogens remain highly vulnerable. Intensive chemical control efforts, vector and disease surveillance, and bed nets reduce the prevalence of illnesses and deaths. In the U.S. and Northern Europe, these diseases largely have been eradicated, due predominantly to pesticide applications.

The Population Imperative

- The agricultural and biochemical sectors, and their lobbying arms, such as the American Chemical Society, point out that the world's population will increase by 25-33% by 2050, reaching 9.5 to 10 billion people. This will certainly create further pressure to produce more food, maximize productivity, and avoid both loss and waste.

The world's population will increase by 25-33% by 2050, reaching 9.5 to 10 billion people. This will certainly create further pressure to produce more food, maximize productivity, and avoid both loss and waste.

Over the next 30 years, population growth will occur predominantly in Africa and South Asia, creating a further burden for the nearly 800 million people now living there who are already severely malnourished.

- Pesticides will continue to play a critical role in improving food security for those who are most at risk—the poorest people in the world. Given food insecurity, the risk of disease, and population growth projections, the demand for pesticides will undoubtedly continue to increase throughout the world.

- Over the next 30 years, population growth will occur predominantly in Africa and South Asia, creating a further burden for the nearly 800 million people now living there who are already severely malnourished. These are places where endemic diseases thrive due to water and food contamination, the absence of safe and sufficient water supplies, and limited health care facilities.

- The near certainty that the world's population will grow from 7.5 to 9.5 billion by 2050 has led to calls for less regulation. Farms and corporations want governments and regulators to allow them to use any technologies necessary to meet increasing demand for food.

- Some technologies that could be employed include greater use of pesticides, pharmaceuticals, fertilizers, use of preservatives such as the nitrates and nitrites used in some processed meats, and antibiotic administration to livestock. There could also be genetic designing of new species.

- As per capita income rises, total caloric intake tends to increase, as does demand for livestock products. These patterns are clearly occurring in nations such as China and Indonesia. In India, religious prohibitions on eating cattle, combined with severe poverty, make this same transition happen much more slowly.

- Poorer populations cannot afford to eat meat and dairy products, but instead rely on corn, soybeans, and other grains in their diet. Grains are a critical component of global livestock feeds, especially corn and soybeans, Thus, when countries grow grains to feed their livestock, it increases the price of grains and further disadvantages poor people who rely on those grains for their livelihood.

1. Human Exposure to Pesticides

- During the past century, scientists have often been surprised to discover the persistence and mobility of pesticides. Government scientists had presumed that the compounds might degrade quickly and become non-toxic, or somehow simply disappear. Scientists now understand that this is not the case.

- Many pesticides are detectable far from their sites of application, and long after their release. They can be found in rainwater, oceans, polar ice caps, surface and groundwater, soils, foods, drinking water, indoor environments and, eventually, in human tissues. Pesticide pathways are numerous and overlapping, resulting in broad dispersal and human exposures to ever-changing mixtures.

- To understand what happens to pesticides after their release requires testing for their residues in foods, surface and groundwaters, air, rain and snowfall, soils, and human tissues. The chronic

Many pesticides are detectable far from their sites of application, and long after their release. They can be found in rainwater, oceans, polar ice caps, surface and groundwater, soils, foods, drinking water, indoor environments and, eventually, in human tissues.

failure to test has been used to support claims that residues dissipate completely into non-toxic compounds.

Pesticide residues in water are normally caused by the application of herbicides and insecticides in agricultural areas, especially in the U.S. Midwest. These agricultural pesticide applications often result in pesticide residues being found in drinking water supplies.

- When food residue samples are taken and tested, sample sizes are normally small, and limited to relatively few foods. For example, the USDA's annual food sampling program normally varies the crops tested from year to year, reducing scientists' understanding of trends. Sampling is also limited by geographic region.

- Testing for pesticide residues in the U.S. Midwestern Corn Belt has demonstrated far different patterns of residues than are found in urban areas.

- Pesticide residues in water are normally caused by the application of herbicides and insecticides in agricultural areas, especially in the U.S. Midwest. These agricultural pesticide applications often result in pesticide residues being found in drinking water supplies.

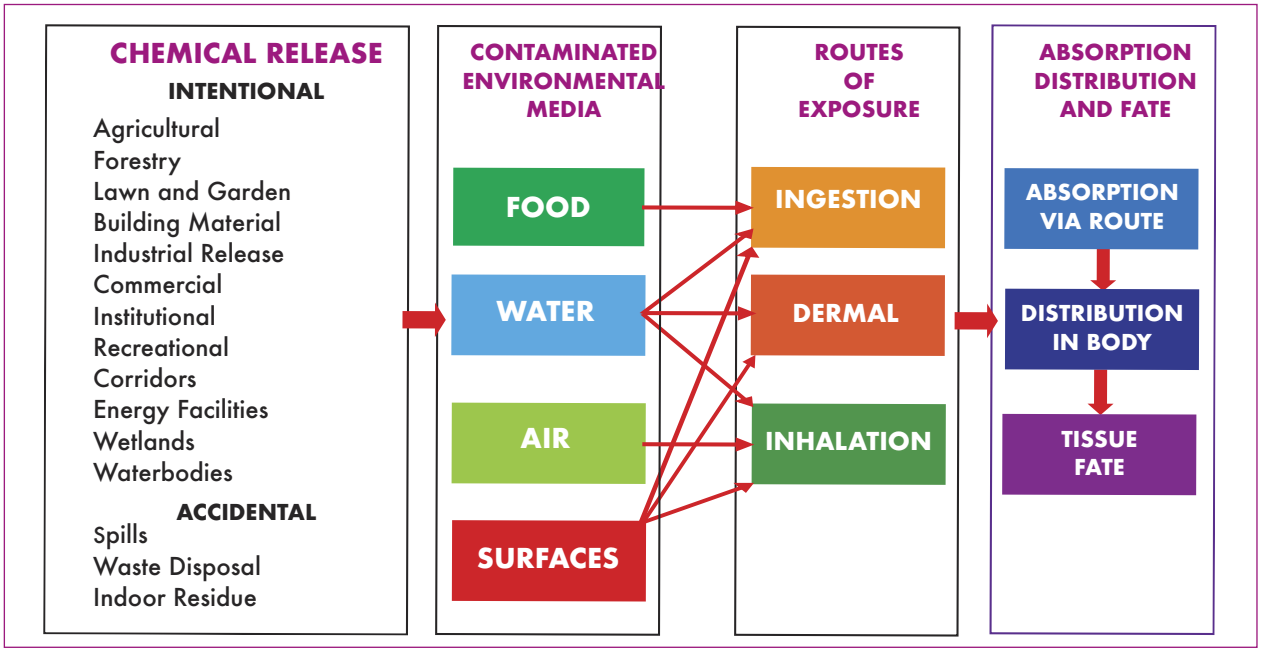
- Many approved pesticides are allowed to be used on 50 or more crops, and individual crops may have as many as 100 different pesticides approved.

- The combinations of possible pesticide residues in a chef's salad made with 10 different ingredients could conceivably include a different pesticide on each one of the ingredients in the salad. This is because the USDA and EPA have set tolerances one at a time, without regard to pesticide mixtures.

- Indoor pesticide applications can result in high levels of human exposure. When infants and small children crawl on floors, even higher levels of exposures can occur.

- Certain pesticides that are prohibited from residential uses are allowed to be used on food crops. Pesticide residue limits for food crops are established on a food-by-food tolerance basis.

Figure 6. Human Exposure Pathways: Chemical Release, Transport, and Fate



- The government's logic for the differences in pesticide regulations is that indoor applications usually result in higher levels of exposure. Indoor pesticide residues are concentrated in less space, and are not dissipated by weather and mixing air. On average, people spend nearly 95% of their lives indoors.
- Figure 6 demonstrates the various pathways that pesticides follow once they are released into the environment. Tracking pathways is expensive, scientifically complex, and difficult to understand for even a single chemical.
- These issues discourage careful research to fully understand chemical releases, environmental movement, and routes of human exposure, as well as chemical absorption and fate within the human body.
- Human tissue studies provide definitive proof of exposures, but do not identify the sources, contaminated media, or routes of exposure, whether via ingestion, inhalation, or dermal absorption.

The government's logic for the differences in pesticide regulations is that indoor applications usually result in higher levels of exposure. Indoor pesticide residues are concentrated in less space, and are not dissipated by weather and mixing air. On average, people spend nearly 95% of their lives indoors.

Significant amounts of pesticides evaporate from agricultural fields, and together with fine sprays, can drift long distances from their target locations. Once airborne, these volatile chemicals flow with the winds before they eventually settle to the earth's surface.

- Some pesticide formulations are sprayed by plane, while others are delivered via irrigation systems. Still others are encapsulated in microscopic plastic balls that break down at varying rates, similar in design to timed-release cold capsules.

- Significant amounts of pesticides evaporate from agricultural fields, and together with fine sprays, can drift long distances from their target locations. Once airborne, these volatile chemicals flow with the winds before they eventually settle to the earth's surface.

- Insects in residential areas have even inspired a new application technique—fence-mounted sprayers wired to timers that trigger the periodic release of pesticides.

- Some chemicals, such as glyphosate and the neonicotinoid insecticides, are systemic, which means that they are absorbed into most or all of a plant's tissues. Other pesticides are superficial,

meaning that they tend to remain on the surface of food or plants until they wash off or evaporate.

- Some chemicals are injected into livestock or added to animal feed in order to promote growth. This produces chronic low-dose exposures to non-target species, including humans.

- Half-life is the amount of time it takes for the concentration of a substance to decrease to half its value. A chemical's half-life strongly influences how long pesticide residues remain present on crops and in the environment.

- The assumption of pesticide disappearance has been a serious, long-standing, and continuing error in judgment made by the EPA, as well as by many other foreign governments.

- The disappearance myth is the underlying pillar of industry's arguments about pesticide safety and environmental protection. It is born from the reluctance of manufacturers and governments to responsibly test both the environment and human tissues for the presence of pesticides, once released.

- This misunderstanding has resulted from inadequate pre-market testing. It has encouraged consumers to buy and apply more of the chemicals, without concern for how they will move through the environment, or where and how they will accumulate.

- The EPA has allowed the pesticide industry to be largely immune from producer responsibility by use of registrations and tolerances that give pesticides a government blessing.

- This even gives pesticides an image of health and safety. From manufacturers' and farmers' perspectives, chemicals have been designed to be persistent, meaning they need to be applied less often, given the longevity of their effectiveness.

The persistence of pesticides is precisely why the insecticide DDT was so effective, and still easily detected in the environment and wildlife nearly 50 years after it was banned in 1972.

The raptors at the top of food chain, such as eagles, hawks, and condors, accumulated the highest concentrations of DDT. The resulting loss of reproductive capacity reduced the number of offspring.

- The persistence of pesticides is precisely why the insecticide DDT was so effective, and still easily detected in the environment and wildlife nearly 50 years after it was banned in the U.S. in 1972. The assumption that pesticides disappear has been disproven over and over again by scientists when they collected and tested samples of food, water, soils, wildlife, and human tissues.[14]

- Chemical persistence has the benefit of prolonging effectiveness after application. The persistence of the insecticide DDT is largely responsible for its use on a global scale between 1950 and 1975.

- During this period, insecticide use in agriculture was detectable in the air above the middle of the Pacific Ocean, even when applied thousands of miles away. The pesticides also concentrated in food chains, moving from small organisms to the larger predators.

- The raptors at the top of food chain, such as eagles, hawks, and condors, accumulated the highest concentrations of DDT. The resulting loss of reproductive capacity reduced the number of offspring.

- Humans lie at the pinnacle of these predatory chains, consuming a wide diversity of plant and animal species. This explains why most people in the world have carried pesticide residues in their fat tissues for decades.

- Although DDT was banned in the U.S. in 1972, it remains one of the most detected pesticides in the U.S. food supply due to its persistence.

- The lessons DDT taught about persistence and the need to understand chemical half-lives have been largely neglected by the public and manufacturers who promote images of immediate product effectiveness and safety.

- Pesticide persistence is well demonstrated by government's failure to identify and contain the risks from those pesticides still intensively used in the U.S., including glyphosate and chlorpyrifos. These pesticides will be discussed in the following pages.
- Toxicity, mobility, and persistence vary considerably among pesticides. This is shown by pesticide residues being found far from their intended targets.
- This issue demonstrates two problems: (1) that the pesticides applied are excessive, mobile, and persistent; and (2) that the most stable chemicals have the capacity to move into global circulation.
- By releasing these substances to the environment, the country has long accepted the fact that excessive applications cause overuse and environmental contamination. Excessive pesticide use damages non-targeted species such as bees, birds and mammals, including humans.

Humans lie at the pinnacle of these predatory chains, consuming a wide diversity of plant and animal species. This explains why most people in the world have carried pesticide residues in their fat tissues for decades.

The Food and Drug Administration (FDA) is responsible for testing foods for pesticide residues.

2. Residues in Foods

- The Food and Drug Administration (FDA) is responsible for testing foods for pesticide residues. The U.S. Department of Agriculture (USDA) tests meat and poultry pesticide residues. This testing becomes the basis for determining if tolerances have been exceeded, and if they are, foods must be impounded and reexamined.

Food testing for pesticide residues

- The USDA conducts annual tests of pesticide residues in U.S. food supplies. Their special focus is on fresh fruits, vegetables, grains, milk, animal feed, and meats. Limited and inconsistent testing supports the USDA's conclusion that the food supply is free from dangerous pesticide residues.

- The USDA is responsible for estimating the benefits of pesticides that are not used in the production of food. The Environmental

Protection Agency (EPA) weighs the benefits of a pesticide against its risks when considering a pesticide's registration. Also, if a pesticide harms an endangered species, the USDA must regulate that pesticide to prevent damage to that species, as well as to its habitats.

Glyphosate and Modified Foods

- All three agencies, FDA, USDA and EPA, decide how best to coordinate the regulation of novel technologies such as genetically modified seeds designed to be resistant to insecticides, herbicides, or fungicides. Products subject to regulation include plants, animals, pesticides, drugs, and chemicals.

- The following questions should be asked: What chemicals have been administered to the food in question, and how persistent are they? Do they bind to water or fat? Are they used on food crops and livestock that are highly consumed as part of the American diet?

- Should raw foods be more sampled than processed foods? Which processed foods should be tested more often: flours, oils, sugars, or fats? Should plants be tested more often than animal products?

- To protect against dangerous exposures in food, the EPA sets maximum contamination limits or tolerances for each crop and its processed food forms. If residues exceed these legal limits, the food may be branded as adulterated and removed from the marketplace.

- Coffee and tea are allowed to be sprayed with glyphosate, and residues of 1 ppm are allowed to remain in products that are traded or sold to consumers. Shellfish may have glyphosate residues three times higher than the 1 ppm limit. Corn and quinoa are permitted to have residues five times higher, peas eight times higher, beet sugar 25 times higher, and vegetable oilseeds 40 times higher.[15]

The USDA conducts annual tests of pesticide residues in U.S. food supplies. Their special focus is on fresh fruits, vegetables, grains, milk, animal feed, and meats. Limited and inconsistent testing supports the USDA's conclusion that the food supply is free from dangerous pesticide residues.

Glyphosate is licensed by the EPA for use on more than 160 different foods, including nearly all of the top 20 most consumed foods in the nation.

- Animal feeds are allowed to have glyphosate residues of 400 ppm, or 400 times higher than the 1 ppm limit. Glyphosate is licensed by the EPA for use on more than 160 different foods, including nearly all of the top 20 most consumed foods in the nation. The EPA, for example, has permitted glyphosate to be used to kill weeds that compete for soil nutrients.[16]

- Receiving EPA approval for the use of a pesticide on crops destined for animal feeds is exceptionally valuable to manufacturers, given the diversity of crops used in feeds. These often include wheat, barley, alfalfa, millet, corn, soy, canola beans, and field hays. Collectively, these crops are planted on hundreds of millions of acres on farms in the U.S.

- The allowance of 400 ppm glyphosate residues in feeds should raise questions about whether these concentrations are passed along to the meats and dairy products eaten by humans.

- Species of sheep are assumed to consume dry feed with 530 ppm, dairy cattle 342 ppm, swine 123 ppm, and poultry 33 ppm. The European Food Safety Agency (EFSA) reports that residues in these meats and their processed products are not expected to exceed 18 ppm, which has become a norm of acceptability. In the U.S., as of the writing of this report, no tests of meat products have been publicly released.[17]

- Why do the allowed residue levels vary so widely for different foods? Some crops may be susceptible to a diversity of pests that demand different intensities of pesticide applications.

- Normally, as the concentration of biocides applied in the field increases, so does the concentration of residues on the food products. Thus, applying a chemical at a concentration that is effective in reducing or eliminating pests is often a more important driver of allowable residue levels than is the consideration of human health risks.

- The residue levels allowed on a particular crop and the residue levels allowed in the processed forms of that same crop are different, and often much higher. This higher residue level has little to do with safe exposure limits, but is still allowed.
- The higher levels could indicate the possibility that concentration during the conversion of the plant to other forms happens during processing. An example of such a conversion is when corn is processed into corn oil.
- The most worrisome scenario is the one in which pesticide residues are high on foods that are heavily consumed by human populations, and the toxic potency of the pesticide is high. This becomes more serious for foods that are consumed by children.
- The EPA's judgment about dangerous levels of food pesticide residues is strongly influenced by the average national intake of a particular food and the average pesticide residue on that food.

The most worrisome scenario is the one in which pesticide residues are high on foods that are heavily consumed by populations, and the toxic potency of the pesticide is high.

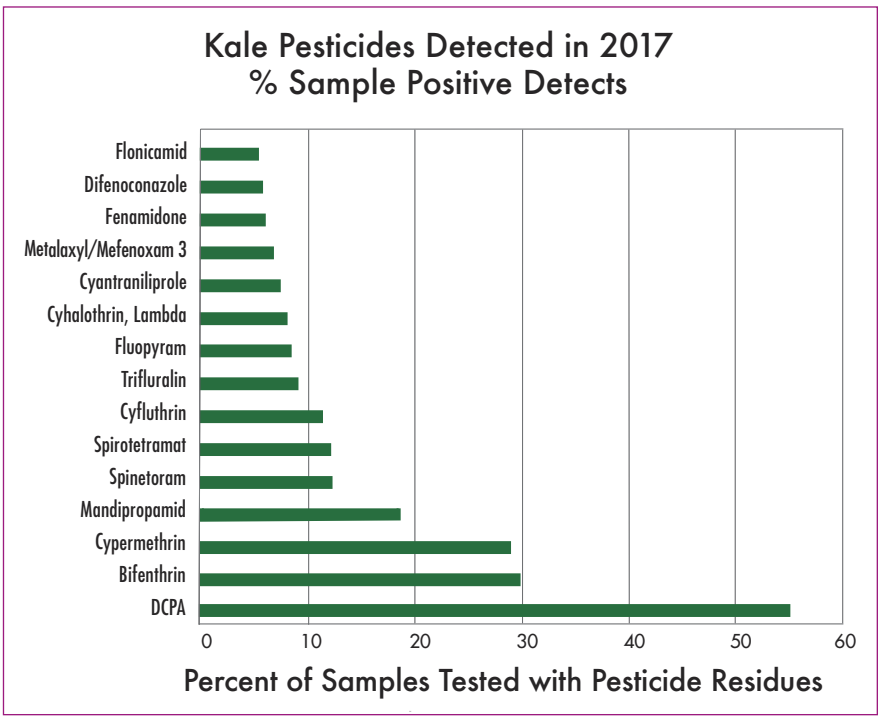
Processed foods are often mixtures of foods from different sources. Oils are a good example. Palm oil is a blend derived from the fruits of many different smallholder producers in Southeast Asia. By the time the palm oil reaches international markets, the mixture can easily have been collected from hundreds of different farms, each having different pesticide practices and uses.

- Residue sampling designs tend to avoid the testing of infrequently consumed foods, with the EPA often allowing higher residues to remain on foods consumed only by a minority of consumers. As an example, when pesticides are found in citrus oil, consumption of citrus oil is so low that exposures would also be low.

- On the other hand, if pesticide residues are found on highly consumed foods, such as milk, orange juice, apples, bananas, and meats, it should follow that allowable residue levels would be more limited.

- Processed foods are often mixtures of foods from different sources. Oils are a good example. Palm oil is a blend derived from the fruits of many different smallholder producers in Southeast Asia. By the time the palm oil reaches international markets, the mixture can easily have been collected from hundreds of different farms, each having different pesticide practices and uses.

Figure 7. USDA Data from its Pesticide Data Program Sampling Program[18]



- Since many pesticides banned in the EU and the U.S. are allowed to be used in other nations, residues in imported foods are a bigger concern for U.S. consumers than those produced domestically.
- Testing showed that kale was found to have the most pesticides detected. Six pesticides were detected in 20+% of samples tested. In total, 30 separate pesticides were found on kale.
- Tracking responsibly produced foods through international markets is both difficult and expensive to accomplish. This is especially important when considering the legitimacy of various food certification programs, especially when the products are derived from many different ingredients and sources.
- It is important for consumers to know that government claims about the absence of residues and the safety of the U.S. food supply can be politically manipulated simply by choosing which foods to test, and which chemicals to search for.

Kale was found to have the most pesticides detected. Six pesticides were detected in 20+% of samples tested. In total, 30 separate pesticides were found on kale.

Figure 8. Percent of Food Samples Testing Positive for Pesticides[19]

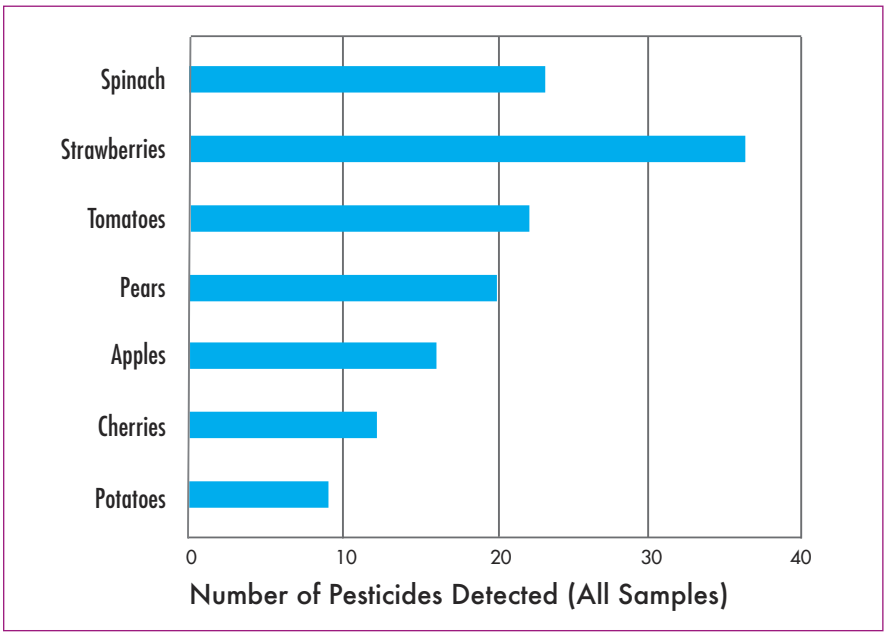
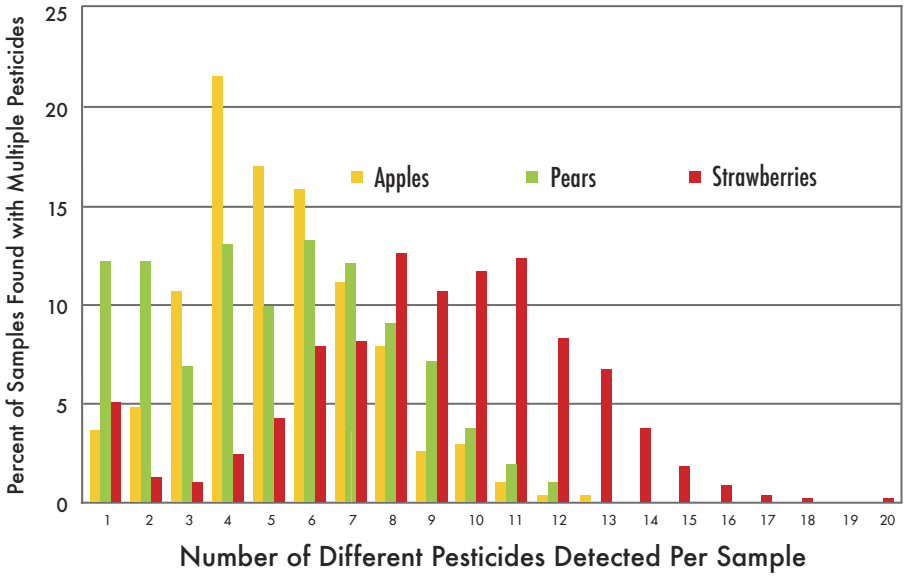


Figure 9. Fruits: USDA Single Samples with Multiple Pesticide Residues

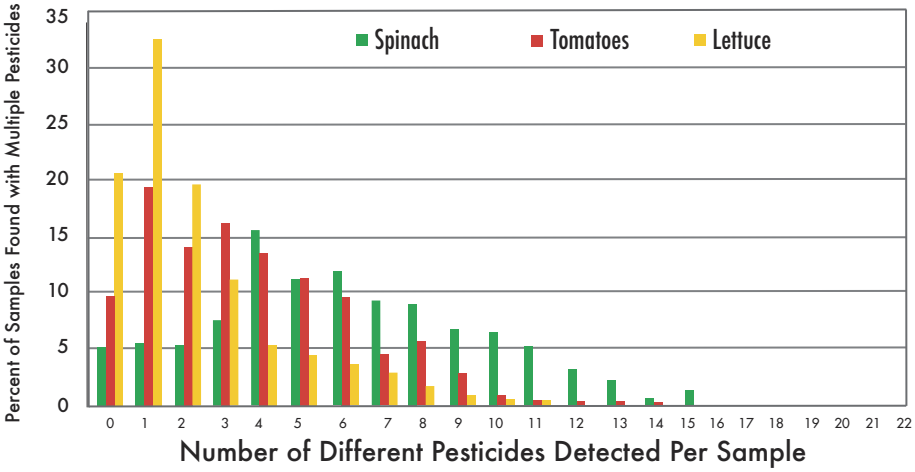


Source: USDA's Pesticide Data Program (2016) demonstrated the presence of numerous pesticides in the same samples of apples, pears, and strawberries.

Strawberries had the largest number of pesticides.

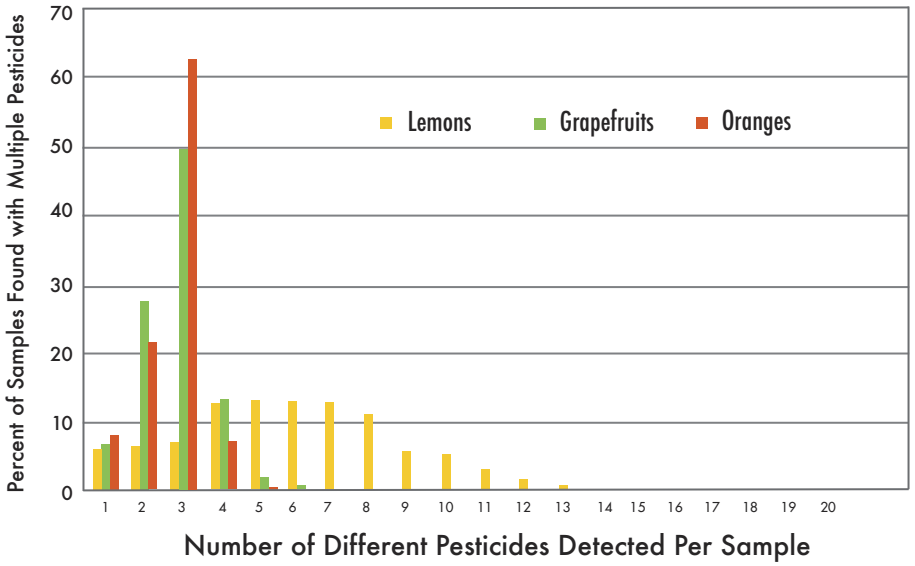
- Figure 9 above shows that many samples contained pesticide residues: 22% of the apples tested contained residues of four different pesticides, and 12% of pears contained residues of seven pesticides. Strawberries had the largest number of pesticides, including one sample that contained residues of 20 different chemicals.

Figure 10. Vegetables: USDA Single Samples with Multiple Pesticide Residues



Source: USDA's Pesticide Data Program (2016) demonstrated the presence of numerous pesticides in the same samples of spinach, tomatoes, and lettuce.

Figure 11. USDA Testing Detected Four or More Pesticide Residues on Oranges



Source: USDA's Pesticide Data Program (2016) demonstrated the presence of numerous pesticides in the same samples of lemons, grapefruits, and oranges.

- When other ingredients are added to glyphosate, the formulations are often more toxic than glyphosate alone. The International Agency for Research on Cancer (IARC) considers the fomulations that add other ingredients to glyphosate to be especially worrisome. The IARC highlighted concerns about formulations that combine glyphosate with other ingredients to enhance their weed-killing effectiveness.

- Monsanto (now Bayer) and its rivals sell hundreds of these products around the world in a market valued at roughly nine billion dollars. The National Toxicology Program (NTP) has shown that glyphosate is more toxic when mixed with other chemicals. The acting chief of the NTP Laboratory noted that glyphosate formulations are much more toxic than glyphosate alone. These chemical formulations are capable of killing cells.[20]

- A 2019 study in the journal *Frontiers in Genetics* reports that glyphosate, when combined with other molecules, resulted in breast cancer development. Although exposing cells to glyphosate

Twenty or more tested foods had one or more pesticide residues over the legal limit. Another 109 contained residues that are illegal to use in the U.S. or above their legal limits. Residues were found on 20+ samples that have no allowable tolerance levels in the U.S. and are therefore prohibited.

The State of California annually tests for pesticide residues in food products, whether grown in the state or imported. In 2016-17, California tested 3,585 samples of food at the California Department of Food and Agriculture (CDFA) Analytical Laboratories.

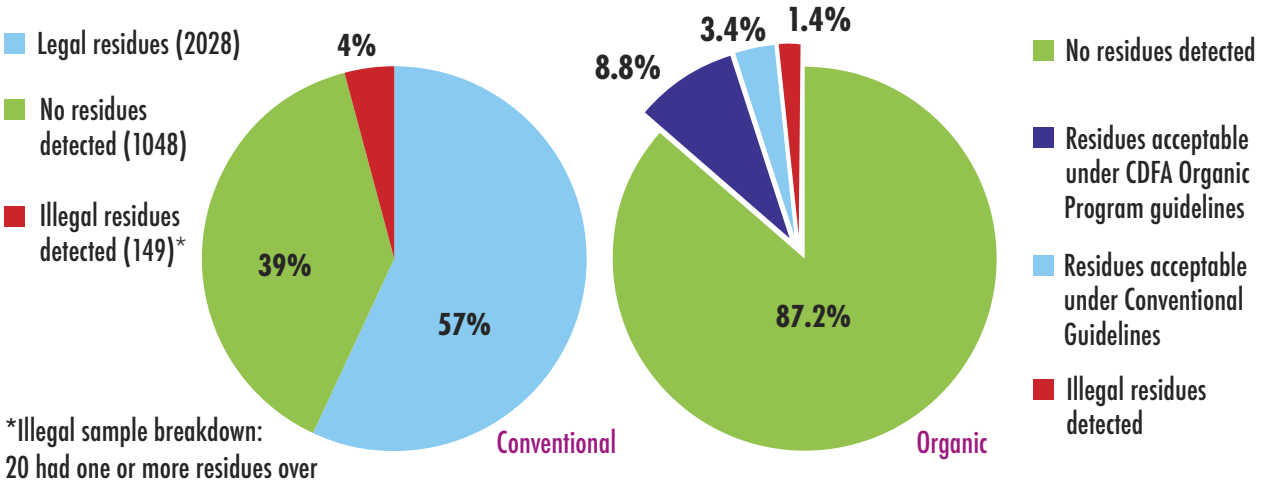
alone did not induce tumor growth, cancerous tumors did develop after glyphosate was combined with molecules that were linked to oxidative stress. Oxidative stress is a chemical reaction that occurs as the result of aging, diet, alcohol consumption, smoking, or other stressors, and it alters the organization and integrity of the genome of the breast, aiding cancer development.[21]

- The study showed that the breast tumor growth wasn't the usual type of breast cancer we see in older women, but was a more aggressive form found in younger women, known as luminal B cancer. This study shows that glyphosate can trigger tumor growth, when combined with other frequently observed risks.[22]

3. Benefits of Organic Foods

- The State of California annually tests for pesticide residues in food products, whether grown in the state or imported. In 2016-17, California tested 3,585 samples of food at the

Figure 12. California Conventional vs. Organic Food Pesticide Residue Test Results, 2016-2017



*Illegal sample breakdown:
20 had one or more residues over legal tolerances (OT); 20 had one or more residues of pesticides that have no legal tolerance (NTE); and 109 had both NTE and OT residues.

Source: California Department of Pesticide Regulation. Pesticide Residues in Fresh Produce, 2016.

California Department of Food and Agriculture (CDFA) Analytical Laboratories.[23]

- Of the 3,585 conventional foods tested, 61% contained pesticide residues. Four percent of the residues were illegal, meaning that concentrations were above the allowable tolerance. No residues were detected on 39% of foods tested, as shown in Figure 12.[24]

- Twenty or more conventional foods tested had one or more pesticide residues over the legal limit. Another 109 contained residues that are illegal to use in the U.S. or above their legal limits. Residues were found on 20+ samples that have no allowable tolerance levels in the U.S. and are therefore prohibited.

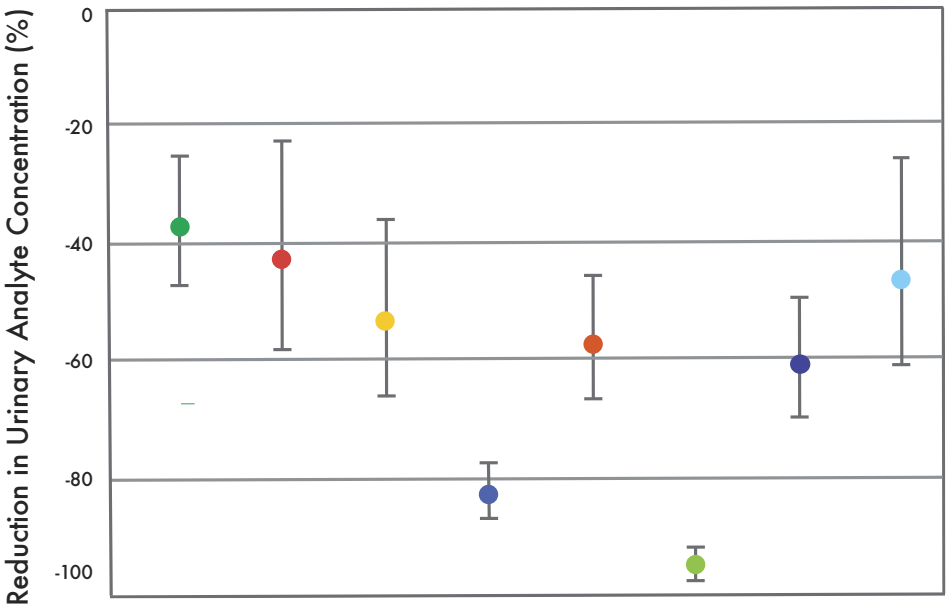
- On the other hand, the finding from the organic produce analyses shows how effective the national and California organic food standards have proven to be. They have now been adopted by the federal government, and further regulated by the State of California.

Of the 3,585 conventional foods tested, 61% contained pesticide residues. Four percent of the residues were illegal, meaning that concentrations were above the allowable tolerance. No residues were detected on 39% of foods tested.

Pesticides acceptable under this organic program are normally natural, and generally pose a far less significant threat to human health, non-target species, and environmental contamination.

- Testing showed that 61% of conventional produce contained pesticide residues. The organic produce tested had \8.8% of legal detectable pesticide residues acceptable under the CDFA Organic Program Guidelines.
- Pesticides acceptable under this organic program are normally natural, and generally pose a far less significant threat to human health, non-target species, and environmental contamination.
- The California Pesticide Residue Testing Program does not test all types of food products. The findings resulted from testing fresh produce. Testing excludes meats, dairy products, and many other processed foods derived from fresh crops, such as oils, sugars, flours, beverages, and an enormous number of ingredient combinations.
- Dietary exposure is the source of many pesticide residues that have been detected in human tissues. A 2018 study of nearly 69,000 participants examined the association between organic food diets and cancer incidence. The authors found that those who consumed the most organic food were 25% less likely to develop cancer during the study period.
- It is possible that people who consumed organic food also avoided intake of other types of foods associated with various cancers, including saturated animal fats, processed meats, and alcohol, further reducing their risk factors.
- A 2019 study that tested human urinary concentrations of pesticide residues from dietary sources showed that the residues declined when the study group switched from a conventionally produced diet to an organic diet.
- Residues of organophosphate (OP), neonicotinoid, and pyrethroid insecticides, as well as the herbicide 2,4-D, were reduced when the study paricipants changed from a conventional

Figure 13. Organic Food Benefits: Reductions in Human Tissues for Eight Pesticides



to organic diet. As shown above in Figure 13, the median percent reductions ranged from 37% to 95%.[25]

- An earlier study of chlorpyrifos supported this finding by showing that residues declined by four times when children switched from eating a conventional diet to consuming organic food.[26]

A 2019 study that tested human urinary concentrations of pesticide residues from dietary sources showed that the residues declined when the study group switched from a conventionally produced diet to an organic diet.

4. Drinking Water Safety

The Safe Drinking Water Act

- The Safe Drinking Water Act (SDWA) was passed in 1974. It is the principal federal law in the United States whose purpose is to ensure safe drinking water for the public.

- The SDWA does not apply to bottled water. Bottled water is regulated by the Food and Drug Administration (FDA), under the Federal Food, Drug, and Cosmetic Act.

The SDWA applies to every public water system in the United States. There are currently more than 170,000 public water systems providing water to almost all Americans at some time in their lives. However, the most direct oversight of water systems is conducted by state drinking water programs.

- The SDWA was amended in 1986 and 1996 and requires many actions to protect drinking water and its sources—rivers, lakes, reservoirs, springs, and groundwater wells. The SDWA does not regulate private wells that serve fewer than 25 individuals.
- The SDWA applies to every public water system in the United States. There are currently more than 170,000 public water systems providing water to almost all Americans at some time in their lives. However, the most direct oversight of water systems is conducted by state drinking water programs.

Pesticides in Drinking Water

- Water is the most consumed food in the human diet, and it is intrinsic to all foods. Even beef consists of 70-80% water, depending on the cut and proportion of fat.
- Poultry and fish are often pressure-infused with a salt water solution to increase purchase weight and enhance the flavor.

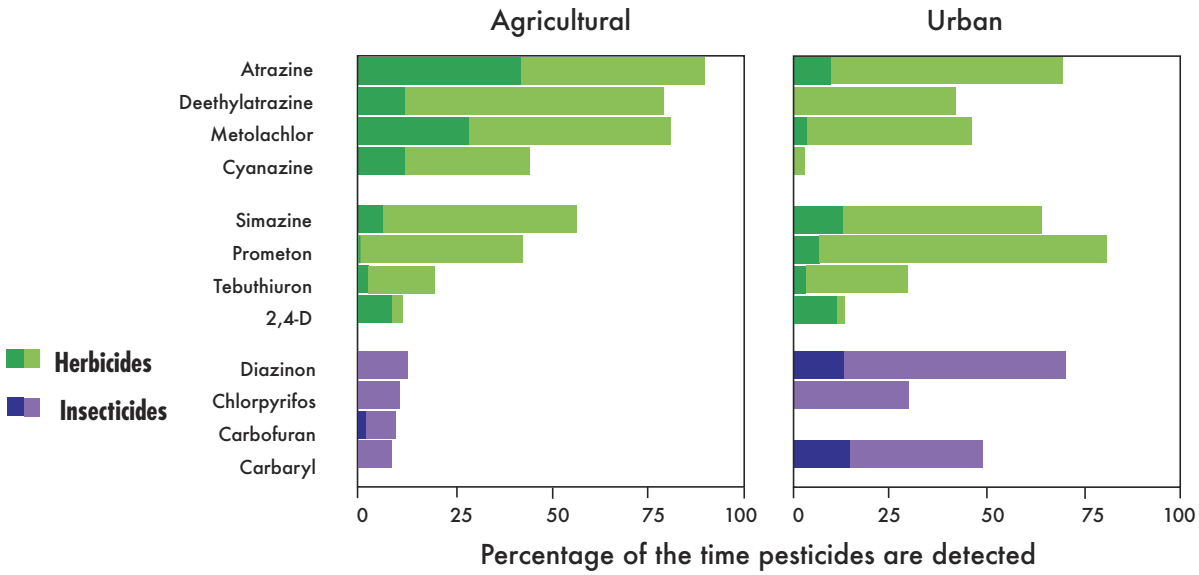
- Water is commonly added to foods during processing and meal preparation, besides being consumed as a beverage.
- Water is vulnerable to contamination by pesticides and other industrial chemicals. Microbes that contaminate water produce more than 38 million cases of food poisoning each year.[27]
- Four problems contribute to the nation's continuing pesticide contamination:
  - Few pesticides are monitored;
  - Sample sizes and frequencies are insufficient to understand dangers to health with reasonable accuracy;
  - Many public and private water suppliers are exempted from testing requirements based upon past results; and
  - Monitoring failures cripple any possibility of effective protection against water-borne hazards to human health.
- Because many pesticides volatilize, they end up in rainwater, snow, and ice, and they move long distances before returning to the earth's terrestrial and aquatic environments.
- The increased use and intensity of pesticides in American agriculture has caused pesticides to reach underground aquifers.
- The USDA estimated nearly two decades ago that nearly 50 million people living in the U.S. were at risk from pesticide residues. Groundwater drinking supplies are often contaminated not only with pesticides, but also with other agricultural chemicals.[28]
- Pesticide residues have been detected in the drinking water of most nations that have tested for them. More than 17,000 scientific articles report the presence of hundreds of different pesticides in drinking water.[29]
- These findings demonstrate the absence of forethought about managing the lifecycle of the billions of pounds of pesticides applied each year.

Water is vulnerable to contamination by pesticides and other industrial chemicals. Microbes that contaminate water produce more than 38 million cases of acute food poisoning each year.

Farmers have long assumed that government licenses and label requirements demonstrate the safety of the pesticides that they use. However, regulators rely on the pesticide manufacturers' own data, and assurances from the manufacturers that the pesticide residues will be minimal.

- The widespread presence of herbicide contaminants in the world's water supplies also reflect governments' neglect of basic chemical ingredients that could have predicted contamination of soils, water, foods, rain, and air.
- These ingredients include the chemicals' ability to be soluble in fats and water, to be mobile, to cause adverse effects on non-target species, and and to cause human toxicity.
- All these effects should have been fully examined before the U.S. and over 100 other governments provided corporations with licenses to sell and use pesticides in their nations.
- Farmers have long assumed that government licenses and label requirements demonstrate the safety of the pesticides that they use. However, regulators rely on the pesticide manufacturers' own data, and assurances from the manufacturers that the pesticide residues will be minimal.

Figure 14. Top Pesticides Commonly Found in Both Agricultural and Urban Water[30]



(Note: The full length bar includes all detections, while the darker segments reflect detections that are ≥0.1 µg/L.)

- The pesticides most commonly detected as residues in surface, ground, and well water are shown in Figure 14 above. Although the U.S. Geological Survey (USGS) has known about these findings since 2007, few consumers realize that residues are present in drinking water, or that they may pose health hazards.[31]

- Figure 14 shows the pesticides most often found in both agricultural and urban water. The pesticides predominantly used are herbicides. Atrazine, a herbicide, has been detected in 80% of the water samples tested in agricultural areas.

- The insecticides most often detected, chlorpyrifos and diazinon, are well-recognized neurotoxins. Although banned in the E.U. and many other nations, the U.S. still allows their use in agriculture.

- The absence of glyphosate from the list of detected pesticides does not imply its absence. Instead, it reflects government testing avoidance.

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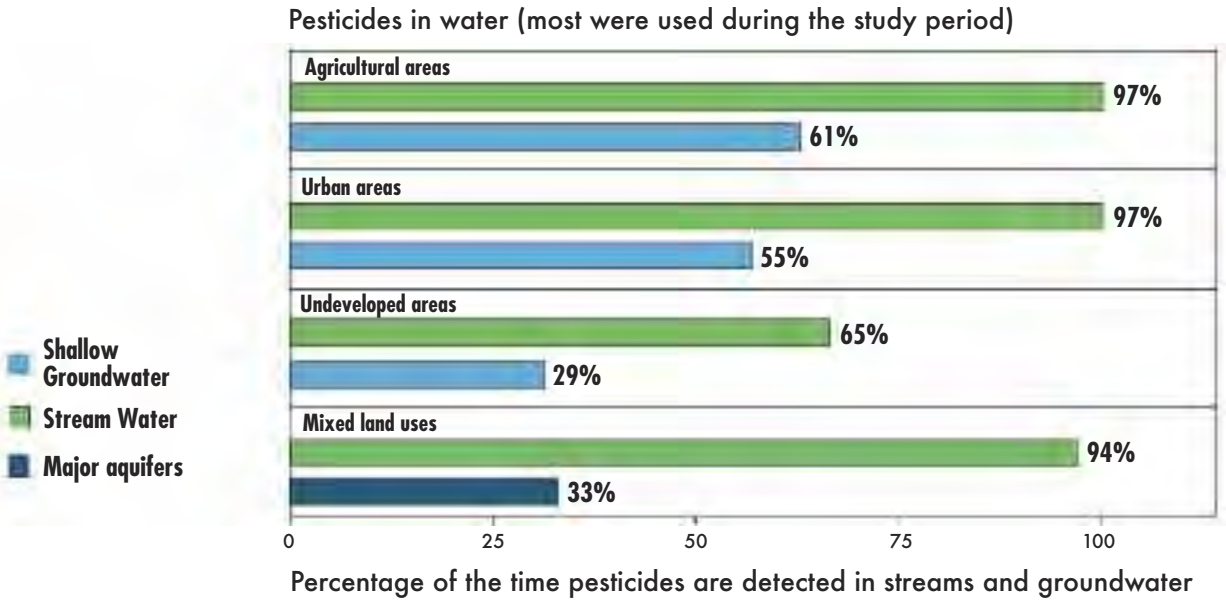
Figure 15. Pesticides in Streams & Groundwater: Percent Samples with Positive Detections[32]



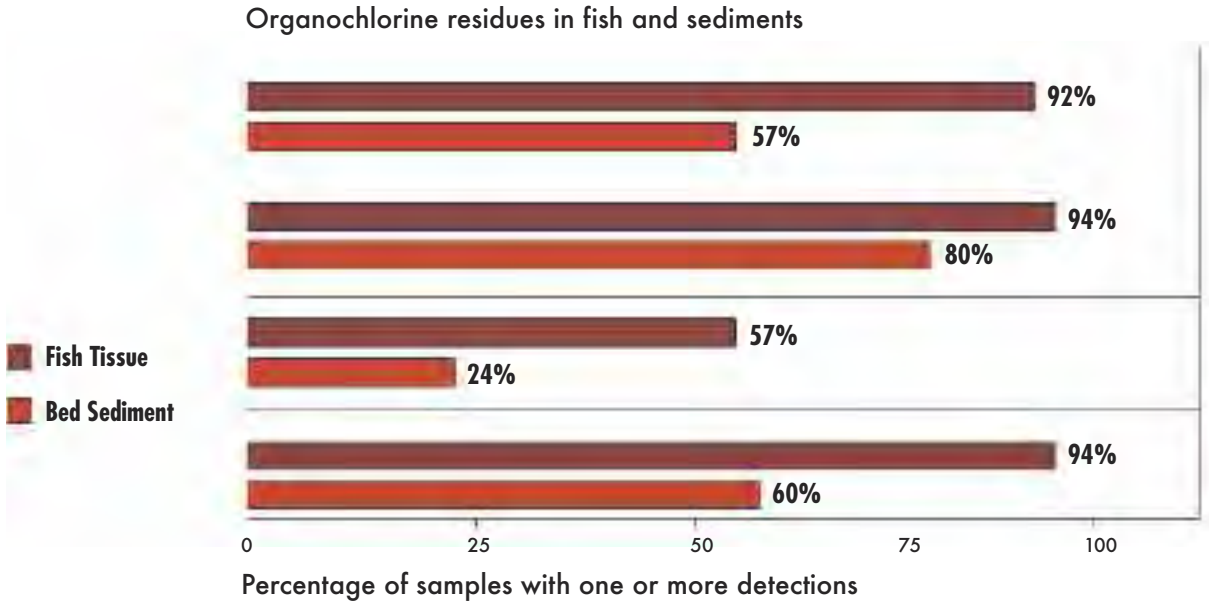
Pesticides were detected in 97% of the stream waters in both agricultural and urban areas that were tested. Surprisingly, these chemicals were also commonly found in surface and groundwaters in all types of land use.

- The U.S. Food and Drug Administration (FDA) has similarly avoided testing for glyphosate residues. The presence of residues in water means that exposures are occurring from both food and water sources. When Canada tested foods for glyphosate residues, manufacturers pressured the government not to release the details to the public, including both sampling protocols and detected concentrations.

- As shown in Figure 15, pesticides were detected in 97% of the stream waters in both agricultural and urban areas that were tested. Surprisingly, these chemicals were also commonly found in surface and groundwaters in all types of land use.

- Even in undeveloped areas, pesticides were detected in 65% of the stream waters and 29% of the shallow groundwater tested. This shows that the pesticides used were persistent and mobile. Pesticides were more likely to be found in stream waters than in shallow groundwater and major aquifers.

Figure 16. Persistent Organochlorine Residues in Fish Tissues and Bottom Sediments[33]



- Organochlorine pesticides include DDT, dieldrin, lindane, heptachlor, chlordane, endosulfan and dicofol. The use of these pesticides was widespread from the 1940s through the 1970s and 1980s. Because of the toxicity and the persistence of this class of pesticides, most of them were finally restricted or banned by the 1980s.

- Organochlorine pesticides are extremely persistent in the environment. They break down slowly and accumulate in the fatty tissues of animals. They stay in the environment and food chain long after they had been applied.

- The presence of organochlorine residues in fish and sediments shows the chemicals' persistence and their ability to magnify in concentration as they move up the food chain.

- The organochlorine pesticides' ability to kill many different and non-targeted species, as well as to accumulate in the environment and in human tissues, were all discovered well after the chemicals

Persistent pesticides in the sediments of rivers, streams, and lake beds can be mobilized by floods and storms, making them available for absorption by plants and aquatic life.

had become staples in global agriculture, forestry, vector-borne disease control, and residential uses.

Relying on stream and river water for irrigation when it contains multiple pesticide residues can cause the chemicals to be spread over fields and crops. There is little understanding of the long-term effects of such practices on pesticide exposures from the food crops.

- Persistent pesticides in the sediments of rivers, streams, and lake beds can be mobilized by floods and storms, making them available for absorption by plants and aquatic life.
- The U.S. Geological Survey (USGS) study of 1992-2001 showed that pesticides were more commonly found in stream water than in groundwater. Pesticide compounds were detected throughout most of the year in water from streams with agricultural (97%), urban (97%), or mixed-land-use watersheds (94%).[34]
- The USGS study concluded that pesticides usually are found in mixtures, leading to questions of additive toxicity and synergistic health risks. For example, chlorpyrifos and diazinon are both organophosphate compounds that attack the nervous system. What is their effect when used together? They are not tested for their safety when used in combinations.
- The National Academy of Sciences concluded in 1993 that when two chemicals are found together, the risks of the combination should be tested. Although this regimen has been accepted when judging unacceptable concentrations of chemical mixtures in foods, it has not been applied during risk assessments of pesticides in drinking water within the U.S.[35]
- Finally, relying on stream and river water for irrigation when it contains multiple pesticide residues can cause the chemicals to be spread over fields and crops. There is little understanding of the long-term effect of such practices on pesticide exposures from the food crops.

5. Health Effects of Pesticides

- Pesticides are designed to injure cells, cause disease, and induce death in many species. The single greatest error in governments'

collective judgment about their reflexive licensing of ever more pesticides is the simplistic assumption that humans would somehow be immune to their damage.

- Pesticides have been proven to cause many different human illnesses, including neurological disorders, cancers, cardiovascular events, reproductive impairment, immune system abnormalities, and disruption of normal hormonal actions. A single chemical may create many of these effects at the same time.
- This report focuses on many pesticides recognized as neurotoxins and hormone disruptors. The toxic effects of many of these pesticides are repeated across generations, meaning they can get passed on to future generations.
- It is important to consider how scientists reach conclusions concerning pesticides' ability to damage health. Traditionally, experts have relied upon clinical evidence of disease associated with populations or individuals with known exposures.
- For example, farmworkers who enter fields that have been sprayed recently may suddenly and collectively experience dizziness, nausea, and skin rashes. Accidental poisonings also provide important understanding about human illnesses following intensive pesticide exposures. This evidence is invaluable, though less frequently available.
- An alternative way to better understand causation is pursued by epidemiologists who examine disease trends among large populations. Groups experiencing the same illnesses are then studied to search for patterns in pesticide exposure over long periods of time.
- These longitudinal studies are time-consuming and expensive, often including thousands of individuals, making possible comparison of illness rates among those exposed to pesticides compared to those unexposed.

Farmworkers who enter fields that have been sprayed recently may suddenly and collectively experience dizziness, nausea, and skin rashes. Accidental poisonings also provide important understanding about human illnesses following intensive pesticide exposures.

Regulators are routinely confounded by research-related problems, such as inconsistencies in findings among different studies, and the absence of clear standards to discern the degree of danger associated with common uses and typical exposures.

Difficulties in Determining Health Effects

- It is difficult to control for the influence of many other potential causes of disease, since we all are exposed to carcinogens, neurotoxins, and endocrine disruptors in our daily lives that are not pesticides.
- Given these inherent problems in the availability of human evidence of toxicity, scientists turn to testing different animal species by exposing them to different concentrations of single chemicals and then examining them to understand any changes in physiology, growth and development, lifespan, and the onset of different abnormalities such as cancer, neurological deficits, reproductive failure, endocrine system disruption, and immunological impairments.
- Estimating human health risks by extrapolating them from animal evidence is fraught with uncertainties. This is because there are differences in lifespan, organ systems, functions from conception to maturity, and the ability to metabolize tested chemicals, often transforming them into non-toxic substances. The high doses that test animals receive compared to the exposures that humans are likely to experience are often very different.
- Most air, water, food, and consumer protection laws are designed to limit chemical releases. The goal is to ensure that human exposures remain below benchmark thresholds that would otherwise produce adverse effects.
- These laws assume a precision in scientists' abilities to identify a threshold of dangerous health-threatening exposures that is rarely justified by available evidence.
- Regulators are routinely confounded by research-related problems, such as inconsistencies in findings among different studies, and the absence of clear standards to discern the degree of danger associated with common uses and typical exposures.

- The study of chemicals that disrupt normal endocrine system action and outcomes has turned the presumption of dose-response upside down. One property of many endocrine-disrupting chemicals is their larger effects at smaller, rather than larger, doses.

- The exceptionally low doses necessary for hormones to trigger cellular responses leads endocrinologists to conclude that no safe doses can be identified.

- These compounds bind to a variety of hormone receptor sites, and can have the harmful effect of landing on a receptor site that blocks other natural or synthetic molecules from having a normal effect.

- Because it is clear that some pesticides have harmful effects at low doses, this finding has very significant implications for regulations. The legal tradition sets residue limits based on high dose responses in air, water, food, and consumer products, and is therefore a hopeless strategy for creating health protective regulations.

- Nearly 9,600 legal limits for pesticide residues in food have been set one by one, all with the public expectation that allowable doses are health protective.

- The presence of pesticide residues in food, water, and air all demonstrate that pesticide residues surround us daily in a complex and ever-changing mixture of exposures. Given the absence of health effect testing of pesticide combinations, any public belief in the health protective nature of U.S. or international law is unfounded.[36]

- Individual pesticides may cause many different types of health effects. Many of the pesticides intensively applied to food crops in the U.S. have been shown to be capable of affecting a number of different organ systems and functions that threaten human illness.

- While individual pesticides may cause many different types of health effects, mixtures are a particular concern. The world's legal

The presence of pesticide residues in food, water, and air all demonstrate that pesticide residues surround us in a daily complex and ever-changing mixture of exposures. Given the absence of health effect testing of pesticide combinations, any public belief in the health protective nature of U.S. or international law is unfounded.

architecture examines chemical risks one by one, and sets residue limits one pesticide at a time, all while humans are exposed every day to ever-changing mixtures.

Human prenatal exposures to synthetic pyrethroids have been associated with reduced motor function, social adaptation, and intelligence among infants.

Neurological Hazards of Pesticides[37]

- Pesticide researchers will hopefully guide their search for new types of pesticides using principles that extend well beyond achieving pest-control functionality. These principals should include concerns for persistence, mobility, toxicity, reactivity, solubility, and degradability into stable, non-toxic molecules.
- Oganochlorines are still in use today, but their neurotoxicity, discovered long after their use, motivated the search for a new class of pesticides to replace them in the 1980s.
- The harmful characteristics of organochlorines led to the design of two new classes of pesticides: (1) the *organophosphates,* including chlorpyrifos, diazinon, parathion, malathion, and 60 other variants; and (2) the *carbamates,* including aldicarb and carbofuran.
- Synthetic *pyrethroids* mimic the molecular structure of six natural pyrethrins esters derived from chrysanthemum flowers. After these synthetic pesticides became popular as replacements for organophosphates, they were discovered to have neurological effects, especially following gestational exposures and in very young animals.
- These pesticides are able to cross the blood-brain barrier, and can lead to changes in the blood vessels in the brain, causing deficiencies in coordination, learning, and memory among exposed animals.
- Fortunately, the synthetic pyrethroids tend to break down quickly, so they do not accumulate in the environment. Examples of the pyrethroids include allethrin, cyhalothrin, cypermethrin, deltamethrin, fenpropathrin, fenvalerate, permethrin, resmethrin, and tralomethrin.

- Human prenatal exposures to synthetic pyrethroids have been associated with reduced motor function, social adaptation, and intelligence among infants.[38]

- A new class of pesticides was developed in the 1990s in response to the resistance of some pests to other insecticides. This class of insecticides is known as *neonicotinoids* because they are chemically related to nicotine, and like nicotine they act on certain receptors in the nervous system.[39]

- This class of insecticides includes imidacloprid, clothianidin, athiamethoxam, acetamiprid, nitenpyram, nithiazine, thiacloprid, and thiamethoxam. Even though this class of pesticides is relatively new, it is now the most widely used insecticide in the world.[40]

- During the 2000s, the neonicotinoids clothianidin and thiamethoxam entered the marketplace and quickly became heavily used on corn and soybean crops. As of 2013, most corn planted in the U.S. was treated with one of these pesticides, and by 2014 almost one third of soybean crops were planted with neonicotinoid-treated seeds.

- Neonicotinoids have a common mode of action that affects the nervous system of insects, causing paralysis and death. These pesticides are persistent in the environment, and when used to treat seeds they become part of the pollen and nectar of the resulting plants. This effect has proven dangerous to both bees and birds.[41]

- Neonicotinoids are systemic when applied to crops. This means that the insecticide enters the entire plant, the leaves, the nectar and the pollen. Washing the affected plant will not rid it of the pesticide.

- Neonicotinoids are used in over 120 countries. There is some controversy over how much neonicotinoids are actually causing bird populations to decline and honey-bee colonies to collapse.

Neonicotinoids have a common mode of action that affects the nervous system of insects, causing paralysis and death.

Bumblebees are more sensitive than honey bees to neonicotinoid insecticides. Researchers have been sounding the alarm for years about the declining numbers of bee populations, and they continue to do so.

There is more agreement on their negative impact on bumblebees, as bumblebees are more sensitive than honey bees to neonicotinoid insecticides. Researchers have been sounding the alarm for years about the declining numbers of bee populations, and they continue to do so.[42]

- In 2013, the European Union restricted the use of certain neonicotinoids, and in 2018 the EU banned the three main neonicotinoids, clothianidin, imidacloprid, and thiamethoxam, for all outdoor uses.[43] The Canadian federal government is taking steps to phase out the use of neonicotinoid-based pesticides starting in 2021.[44]

- In summary, each generation of insecticides has spread quickly in international markets before independent tests to predict their neurotoxic risks have been fully conducted.

- Avoiding the late-recognized neurological hazards of former generations has normally occurred without sufficient environmental and health testing to understand and predict hazards for future generations.

- *This cycle of regret for past ignorance and faith in the safety of unproven replacements has occurred roughly every 25 years.* It is curious that the patent life for new generations of pesticides is 20 years, after which generic brands may be produced, and profitability declines for original patent holders.

- The neurotoxicity of organophosphate pesticides is a special case. They were introduced in the U.S. in the 1940s to 1960s, before there were any significant government pesticide regulations.

- In 1947, the USDA became responsible for pesticide registration, but that agency had little, if any, expertise in neurotoxicity.

- The expectation then was that serious health loss could be avoided simply by reducing human exposures during chemical mixing and application.

- The neurotoxity of organophosphate pesticides works by causing the enzyme that regulates the central nervous system to malfunction. In humans, organophosphates inhibit the production of the enzyme acetylcholinesterase that breaks down acetylcholine, a key neurotransmitter in nerve synapses.
- Tests for various types of developmental neurotoxicity should go beyond cholinesterase inhibition. Effects on the human central nervous system (CNS) range from confusion, dizziness, and convulsions to coma and death.
- Government regulators know that avoiding acute effects is important, but they also need to know and pay attention to the chronic health effects of pesticides, especially when exposures occur during fetal development and early childhood.
- During the 1990s, the organophosphate pesticides were discovered to be capable of disrupting the normal neurological development of fetuses, infants, and young children when they were exposed.
- Brain cell replication is reduced in relation to the intensity of pregnant women's and children's exposures, resulting in altered cognitive, memory, and learning capacity.
- Governments have long over-simplified health threats associated with pesticide exposures during the different stages of the human lifecycle. Now it is well understood that windows of vulnerability open and shut for exposures to cause various harmful health effects.
- Most human epidemiological studies on threats from pesticide exposures have focused on the period of gestation. A study by Whyatt et al. in 2004 and 2005 found that as organophosphate exposures increased, birth weight and body length among minority children declined.[45]
- These physiological metrics led to the discovery that the same cohort of children, especially those that were more heavily exposed

Government regulators know that avoiding acute effects is important, but they also need to know and pay attention to the chronic health effects of pesticides, especially when exposures occur during fetal development and early childhood.

The failure of governments to recognize the vulnerability of fetuses and children is difficult to understand given physicians' historical hesitancy to prescribe pharmaceuticals to pregnant women precisely because of concerns over susceptibility during gestation and early childhood.

to oganophosphates, experienced some attention deficits and motor skill deficiencies that were dependent on neurological functions.

- The most important implication of these findings is that government regulation focused on cholinesterase inhibition, only one neurological effect among many, and even then only in adults.
- Given the high level of pesticide exposures necessary to produce adverse effects, pesticide residues on food were permitted to be high for decades.
- Government studies found that nearly everyone examined carried residues of organophosphate metabolites in their urine at levels capable of inducing the developmental effects that government had long neglected.
- For nearly 50 years, the USDA and EPA failed to test for other health effects, such as issues of memory, learning, motor skills connected to brain functions, and attention deficits, among those exposed to residue levels commonly found in the U.S. food supply.
- The failure of governments to recognize the vulnerability of fetuses and children is difficult to understand, given physicians' historical hesitancy to prescribe pharmaceuticals to pregnant women precisely because of concerns over susceptibility during gestation and early childhood.
- Since many of the firms producing pesticides also manufacture drugs, this neglect seems more deliberate than just an oversight.
- The neurological risks to children have diminished somewhat, due to the EU and U.S. cancellations of several dozen organophosphate insecticides. However, the U.S. government has responded slowly to the serious threat to children's health posed by a large group of remaining neurotoxic pesticides. The European Union, by contrast, has moved with much greater speed to ban most of these chemicals.

Part Three: Pesticide Law and Regulation

1. Laws and Regulations

- Legal control over pesticides in the U.S. is predominantly the responsibility of the federal government. However states have the legal authority to set standards that are more rigorous than federal requirements, as California has done. Before the U.S. Environmental Protection Agency was created in 1969, the Department of Agriculture was primarily responsible for pesticide licensing.
- The USDA was created to help nurture the agricultural sector in the U.S., including providing a diversity of technologies to help protect crop and livestock production and profitability. Half a century later, the USDA's institutional support for agribusiness and pesticides is as strong as it has ever been.
- Many of the same chemicals that the USDA approved in the 1950s and 1960s are still in the marketplace, such as chlorpyrifos, 2,4-D, alachlor, atrazine, dicamba, and parathion.

The USDA was created to help nurture the agricultural sector in the U.S., including providing a diversity of technologies to help protect crop and livestock production and profitability. Half a century later, the USDA's institutional support for agribusiness and pesticides is as strong as it has ever been.

Manufacturers' data for these compounds supported corporate claims of effectiveness in managing pests, yet in most cases, the data were either nonexistent, or poor in quality.

- The USDA did not require scientific analyses of a pesticide's environmental fate or effects, nor did they consider the pesticide's potential for human exposure and health loss.
- Nearly all of the data regarding chemical safety were provided to the federal government by manufacturers seeking licenses. No independent testing was required, so chemical companies argued repeatedly that no evidence of chemical persistence, mobility, exposures, or significant risk existed.
- T*his claim was interpreted by government regulators to mean that the absence of evidence of chemical danger is evidence of its safety.*
- This distorted logic led the USDA to issue more than 50,000 pesticide product registrations by 1960, and nearly 10,000 separate tolerances, or legal limits, for separate chemical residues to exist in our nation's food supply, approved by the FDA and the EPA.
- Manufacturers' data for these compounds supported corporate claims of effectiveness in managing pests, yet in most cases, the data were either nonexistent, or poor in quality.
- Thus, the EPA has spent much of its 50-year life reevaluating the hazards of previously approved chemicals and products. Normally, as pesticides are more carefully studied, scientists generally discover that their dangers are more extreme than previously believed.
- *Complete bans have been rare events in the history of U.S. pesticide regulation.* More likely than bans are regulations that restrict certain uses of a particular pesticide that has been shown to have harmful effects.
- Federal regulators complain that their limited budgets slow their pace of chemical-by-chemical reviews. The reregistration process has rarely occurred in less than a decade following original licensing.

- EPA officials in the 1990s quipped that the agency's decision-making delays were akin to putting the pesticides in a regulatory parking lot, often due to manufacturers' objections to tighter regulations.

- Manufacturers understand that delays in the reregistration process can extend the market lives of their products to get beyond the 20-year proprietary patent life that prevents the introduction of generic brands by competitors.

- By contrast, manufacturers are anxious to bring new chemicals to market quickly to recover their research, development, and regulatory compliance costs.

- These findings should require immediate adjustments in allowable uses of pre-approved products, more cautionary labels, restricted application methods, or worker training requirements. Instead, original uses have normally continued for decades before the EPA has taken more rigorous regulatory action.

- The laws and regulations that pertain to pesticide residues in foods are even more complicated because they are spread across three federal agencies: the EPA, the FDA, and the USDA. This division of authority impedes effective regulations since these agencies do not easily share data, expertise, budgets, or legal authority.

- The EPA, FDA, and USDA have very different missions and political will, when it comes to pesticide uses and the protection of human health from pesticide exposures.

EPA officials in the 1990s quipped that the agency's decision-making delays were akin to putting the pesticides in a regulatory parking lot, often due to manufacturers' objections to tighter regulations.

2. Registration and Licensing of Pesticides

- Although the Federal Insecticide, Fungicide, and Rodenticide Act of 1947 (FIFRA) still provides the backbone of U.S. laws governing pesticides, it is now the EPA that registers products containing pesticides.[46]

The USDA did not have the scientific expertise to demand or review technical studies relevant to judge human health threats, nor did they monitor environmental contamination.

- To reach the decision to register a pesticide, the EPA must find that the pesticide in question will not cause any *unreasonable adverse effects on the environment.*[47]
- The phrase cited above requires consideration of the *economic, social, and environmental costs and benefits.* Importantly, it provides the ethical framework that has long guided pesticide licensing.
- Prior to the establishment of the EPA in 1970, the USDA registered pesticides. Yet the USDA did not have the scientific expertise to demand or review technical studies relevant to judge human health threats, nor did they monitor environmental contamination.
- FIFRA was unclear about whether "social costs" included human health. By 1960, the USDA had granted manufacturers 10,000 different food and animal feed tolerances, and nearly 50,000 pesticide product registrations.[48]

- The USDA balanced benefits against risks when evaluating pesticides. Once the certainty of pesticides' effectiveness in increasing productivity exceeded the certainty of damage to the environment, the USDA routinely granted registrations and tolerances.

- The sheer number of different pesticide licenses guaranteed that these chemicals could be designed, sold, and used with little government oversight or interference.

- Rachel Carson's landmark book, *Silent Spring,* captured international attention and raised public concern about the environmental effects of pesticides.[49]

- Conservationists, environmentalists, and health advocates pressured Congress to pass the Federal Environmental Pesticide Control Act of 1972. The law gave the EPA broad authority to demand stronger evidence about the environmental and health effects of chemicals proposed for registration and tolerances.

- In addition, the law authorized the review of previously registered pesticides to examine the hazards they posed, using recent evidence, to ban chemicals, and to cancel or adjust food tolerances.[50]

- The EPA spent much of its first three decades reassessing the risks associated with the chemicals already approved by the USDA. Often, the EPA spent 10 or more years reviewing single chemicals, while relying on manufacturers to report the chemicals' persistence, mobility, toxicity, and health and environmental risks.

Pesticides are composed of active ingredients and inert ingredients. Some inert ingredients may be more toxic than active ingredients and can comprise 90% to 95% of the product.

3. Inert Ingredients

- Pesticides are composed of active ingredients and inert ingredients. Some inert ingredients may be more toxic than active ingredients and can comprise 90% to 95% of the product.[51]

- Some inert ingredients are suspected carcinogens. Other inerts have been linked to central nervous system disorders, liver and

kidney damage, birth defects, some short-term health effects, and a range of adverse health effects.[52]

- For much of the past half century, the EPA has permitted more than 1,000 chemicals to be classified as inert ingredients. These are often additives, such as petroleum distillates or other solvents.
- Inert ingredients commonly make up the majority of what is released to the environment, yet neither Congress nor any regulatory agency has required chemical testing to understand the toxicity or environmental fate of these chemicals.
- Nearly 394 inert chemicals in some products are classified as active pesticide ingredients in other products. In addition, nearly 200 have been listed as hazardous wastes or pollutants under U.S. environmental laws.[53]
- The EPA's inability to effectively review these active ingredients in a timely manner at least partly explains the neglect by the agency to address the problem of inert ingredients.[54]
- *The list of trade name inert ingredients now includes 2,632 products, registered or permitted by EPA.*[55]
- These products are often complex mixtures of chemicals that have not been tested to learn their collective toxicity. Despite this lack of testing, these chemicals are permitted to be released in agricultural, residential, commercial, educational, and recreational environments.

In 1996, the Food Quality Protection Act (FQPA) became federal law. Congress passed the most important statutory change in 50 years in response to a 1993 National Academy of Sciences study that found that children's health was at special risk from dangerous pesticide exposures.

4. The FQPA and the Rise of Precautionary Policy

- In 1996, the Food Quality Protection Act (FQPA) became federal law. Congress passed the most important statutory change in 50 years in response to a 1993 National Academy of Sciences study that found that children's health was at special risk from dangerous pesticide exposures.[56]

- The National Academy of Sciences panel concluded that the maximum residue levels then in force were not protective of prenatal, neonatal, and young children's health.[57]
- Another key finding was that variations in diet could lead to differences in pesticide exposure, and this knowledge raised special concern over residues in the diets of children.
- Children are more likely than adults to be harmed by pesticides, due to their immature organs and their bodies' rapid growth rate.
- Children are typically more exposed than adults to environmental chemicals due to their higher dietary intake when adjusted by their lower bodyweight, higher inhalation rate, and higher skin permeability.
- The FQPA of 1996 requires that the EPA must apply an additional tenfold margin of safety for pesticide chemical residue and

Children are typically more exposed than adults to environmental chemicals due to their higher dietary intake when adjusted by their lower bodyweight, higher inhalation rate, and higher skin permeability.

other sources of exposure for infants and children, in order to protect against underestimates and danger. The law also requires that the EPA consider how risks accumulate from exposure to other chemicals that can produce similar damaging health effects, such as cancer, neurotoxicity, or endocrine disruption.[58]

- The FQPA has now been in effect for 24 years. It was adopted by Congress three years after the National Academy of Sciences warned that children were unprotected from dangerous pesticide exposures.

Organochlorine pesticides were believed to be less toxic than metals, and highly effective in killing thousands of different insect species. Their danger grew from their persistence and tendency to bioaccumulate along food chains, eventually concentrating in human fat tissues.

5. History of Pesticide Substitutes[59]

- Historically, the harmful effects of different pesticides were only understood decades after their international acceptance and use. Most pesticides were later found to have unanticipated environmental and/or human health effects.

- Innovation in the chemical industry has created a number of groups of similar pesticides that include minor molecular variants. Starting in the 1940s, organochlorine pesticides replaced heavy metals and rapidly gained market share because of their ability to control a wide diversity of pests. Their unanticipated environmental persistence and toxicity led to their gradual phaseout as chemical companies introduced substitutes.

- Organochlorine pesticides were believed to be less toxic than metals, and highly effective in killing thousands of different insect species. Their danger grew from their persistence and tendency to bioaccumulate along food chains, eventually concentrating in human fat tissues.

- Long after the organochlorines were approved by governments, they were discovered in the tissues of most humans tested, as the result of their heavy usage on food supplies, and other applications.

- Both metals and the organochlorine pesticides have similar characteristics. Although highly effective at eradicating a broad spectrum of species, they are highly persistent and they tend to be highly toxic. Together, these traits create the potential for harmful human exposures.

- The obvious lessons government should have learned from the 1950s and '60s was to phase out the most toxic and persistent pesticides. Governments' failure to do so has been repeated for decades and continues today.

- Given the chemical-by-chemical regulatory process, and the tens of thousands of pesticide products exchanged in international markets, the substitution of one entire class of chemicals for another has been gradually accomplished by private innovation in the chemical industry decisions, rather than by any rational plan by the EPA, USDA, or FDA.

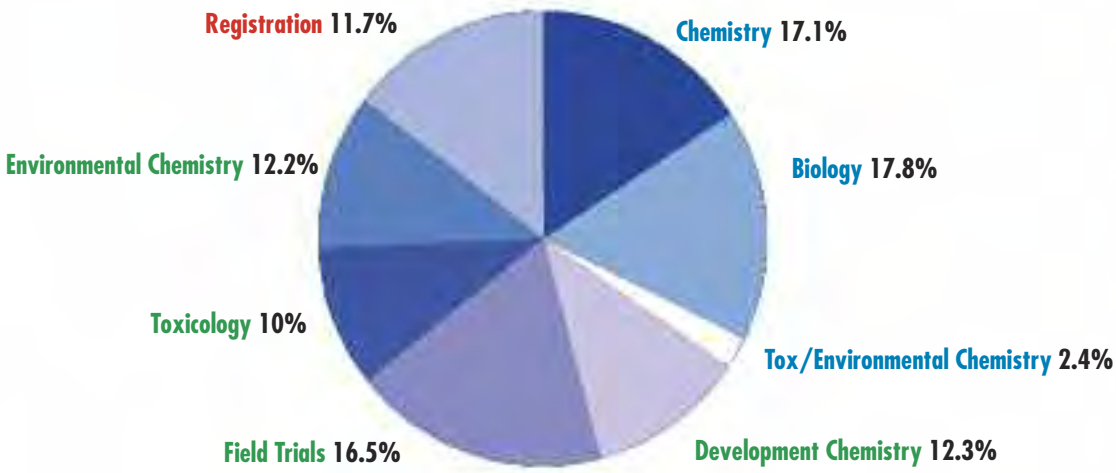
- Independently funded scientific testing prior to governmental approval of pesticides is the only reliable antidote to the regrettable substitution syndrome:
  - **1870s:** metals - arsenic, lead, chromium, cadmium
  - **1940s:** chlorinated organics - DDT, aldrin, chlordane
  - **1950s:** organophosphates and carbamates
  - **1960s:** triazine herbicides
  - **1980s:** pyrethrins and pyrethroids
  - **1990s:** pesticides sold with genetically modified seeds designed to be uniquely resistant
  - **2000s:** neonicotinoids

- The slow pace of new pesticide design, testing, and registration limits the capacity of government to trade older, riskier pesticides for newer, safer ones. Safer pesticides might be as effective as older ones, but they may be less persistent and less toxic.

- A serious impediment to speeding the design and approval of less risky pesticide products is the cost to discover, produce, and register new products. CropLife America, the trade organization

The slow pace of new pesticide design, testing, and registration limits the capacity of government to trade older, riskier pesticides for newer, safer ones. Safer pesticides might be as effective as older ones, but they could be less persistent and less toxic.

Figure 17. Chemical Company Claims of Costs to Bring New Pesticides to Market 2010-2014[60]



Each pesticide may require hundreds of separate product registrations to permit its use in agriculture, livestock rearing, forestry, and residential, commercial, industrial, and consumer product applications, such as additives to textiles, plastics, or preserved wood.

that represents the pesticide industry, recently published the results of a survey among the world's largest pesticide manufacturers. They reported on what the average cost would be of bringing a single new pesticide to the global marketplace.[61] That cost included basic research that totaled $100 million; product development that totaled $146 million; and regulatory approvals requiring an additional $33 million, for a total average cost of $279 million per pesticide (Figure 17).

- Each pesticide may require hundreds of separate product registrations to permit its use in agriculture, livestock rearing, forestry, and residential, commercial, industrial, and consumer product applications, such as additives to textiles, plastics, or preserved wood.

- As costs of chemical design or discovery, testing, and gaining government licenses to market new products increase, the rate of discovery and introduction of safer chemicals has declined. The largest biochemical companies now claim that new chemical introduction

costs are nearing $300 million dollars annually, with regulatory compliance and licensing costs accounting for 11.7% of the total.

- The pesticide industry normally looks to get approvals from as many foreign nations as possible. Glyphosate, for example, is registered for use in 160 nations. The average time from chemical design to government approval is 11 years.
- In addition, developing a pesticide is so costly that it incentivizes agrochemical-biotechnology companies to find as many applications as possible. Chlorpyrifos, for example, produced initially by Dow AgroSciences, was granted 800 separate product registrations. The company also received approval for more than 100 separate agricultural crop uses, and associated tolerance limits.
- Pesticide companies are under enormous pressure to recover their research and development costs as quickly as possible within the 20-year international patent life that precludes government licensing of competitive generic brands.
- Monsanto, now part of Bayer, found a lucrative solution to extend their market domination by selling glyphosate in tandem with their corn, soybean, cotton, and other seeds that had been genetically edited to resist the damaging effects of the herbicide.
- This genetic innovation became the vehicle to carry Monsanto's profitability beyond the patent life of their pesticides. Monsanto paired their herbicide with modified grain seeds, which covered the most extensive acreage in the U.S. and many other parts of the world.

Federal law to control pesticide risks relies heavily on labeling to provide consumers with information on product ingredients, directions for safe use, specific health and environmental warnings, and acceptable methods of disposal.

6. Pesticide Labeling and Warnings[62]

- The oldest, and still the most common, approach to pesticide risk management has been to issue consumer and user warnings about health and environmental hazards, including safe use instructions via product labels.

There are many reasons that explain why labels are ineffective in managing highly toxic substances contained within over-the-counter products.

- Federal law to control pesticide risks relies heavily on labeling to provide consumers with information on product ingredients, directions for safe use, specific health and environmental warnings, and acceptable methods of disposal. Pesticide packaging and labeling remain the excusive authority of the federal government.

- Pesticides that are sold over the counter must contain a label that has been approved by the EPA, and which contains appropriate directions for use to prevent loss of health or environmental quality. The principle of prior warning underlies most consumer protection law. Prescription drugs, in contrast to pesticides, are more stringently regulated and need approval from physicians, pharmacists, and licensed dispensaries.

- Each separate product is given a distinctive label with a registration number that permits rapid identification in cases of accidental exposures or environmental releases. The majority of the chemical mixture in the container is not the pesticide, but rather inert ingredients that may add up to 99% of the net weight sold.

- There are many reasons that explain why labels are ineffective in managing highly toxic substances contained within over-the-counter products. These include the following:

  - Illiteracy makes it impossible for many consumers to understand warning labels.
  - Consumers, if informed, are unlikely to accurately convey warnings to those exposed.
  - Warnings are normally required only for proven adverse effects.
  - Consumers expect product safety due to EPA approval on the label.
  - Consumers also assume product safety, due to wide unregulated retail availability.
  - Consumers expect product effectiveness, with no demonstration required by governments.

- Information about adverse effects may have been withheld by manufacturers.
- Warning language is seldom updated, only following EPA reviews, and commonly after a decade delay.
- Warnings do not explain hazards and ingredients in non-technical language.
- Untrained consumers may make mistakes in mixing and applying pesticides.
- Licensed applicators may delegate authority to untrained workers.
- Residues normally persist longer than users and government regulators realize.
- Pesticides are not tested in mixtures, but they are sold and applied as mixtures.
- Pesticide packaging normally emphasizes product benefits and effectivenesss.

Government-required warning labels are often placed on the backs of packaging or in booklets printed in type so small that many people find them unreadable.

- Government-required warning labels are often placed on the backs of packaging or in booklets printed in type so small that many people find them unreadable. Label instructions are expressed in scientific and technical language that is often unintelligible to untrained individuals. Products are and wrapped inside packaging that is impossible for consumers to read prior to purchase.

- Warning language is normally in English, though many farm-workers in the U.S. are immigrants for whom English is not their first language.

- Finally, pesticides produced in one nation are often exported without translation to importing nations' languages, even when the producers' countries have banned the chemicals.[63]

- Producers, formulators, and retail owners have stopped referring to chemicals as pesticides or toxins, but instead call them crop

protection products, designed to promote the health of plants and livestock.

The dangers of pesticides are deliberately disguised in consumer products with packaging photographs that portray their benefits, such as waving fields of corn, or children playing on perfect lawns.

- The dangers of pesticides are deliberately disguised in consumer products with packaging photographs that portray their benefits, such as waving fields of corn, or children playing on perfect lawns.
- Labels, warnings, and advertising fail to deliver clarity about the risks posed by pesticides. The decreasing transparency of the EPA since 2016 has reduced access to crucial data the public needs to understand the risks to themselves and their environments.
- The agency's refusal to disclose information aboout residue, exposure, and/or toxicity data prevents independent hazard assessments.

7. Fractured Regulatory Authority

- Legal authority to manage pesticides is divided among the EPA, FDA, and USDA. This impedes effective regulation since these agencies do not easily share data, expertise, budgets, legal authority, or political will to protect human health or environmental quality from pesticides. They also have widely differing institutional norms and mission priorities.
- The EPA is responsible for pesticide registration and tolerance setting for both food and water, under authority granted by three main statutes. The EPA is also required to evaluate pesticides' environmental fate and effects, patterns of human exposure, and chemical toxicity.
- Today, nearly 17,000 pesticides are registered, and nearly 9,000 maximum allowable residue levels are set as tolerances that provide legal limits for pesticide residues, chemical by chemical and food by food.[64]

Part Four: International Law – Trade Barriers and Pesticide Bans

1. Trade and International Law

- Free trade among nations has long been a valued goal to increase food security and producer profits. The UN created the General Agreement on Tariffs and Trade (GATT) at the end of World War II to resolve disputes among nations about restrictions on imports adopted to protect domestic products. GATT evolved into the World Trade Organization (WTO) in 1995.[65]

- One of the WTO's primary purposes is to resolve disputes among nations about differences in allowable residue limits in food products. Exporting nations with less restrictive contamination standards are normally upset by stricter regulations in foreign nations that prevent their products from being imported.

- The stricter regulations are viewed as trade barriers adopted by exporting nations due to their exclusion from valuable markets. WTO's fundamental purpose is to encourage dispute resolution to avoid trade barriers, retaliatory tariffs, and physical conflicts.

Exporting nations with less restrictive contamination standards are normally upset by stricter regulations in foreign nations that prevent their products from being imported.

Historically, U.S. statutory law has charged government with the burden of demonstrating these dangers, and the costs of doing so often preclude careful investigations into these dangers.

- Willingness to accept risks of environmental damage and human health loss varies considerably among and within nations. The U.S. accepts substantially higher risks from food and water-borne pesticide residues than Europeans allow.
- These differences often interfere with free trade in food products between the U.S. and the European Union (EU). The U.S. has been quite accepting of chemical additives, including pesticides, pharmaceuticals, and genetically modified species.
- Historically, U.S. statutory law has charged government with the burden of demonstrating these dangers, and the costs of doing so often preclude careful investigations into these dangers.
- The European Parliament, by contrast, has adopted directives that rely on the precautionary principle, meaning that the safety of food contaminants and additives lies with the producers of the products.
- U.S. firms must comply with European Food Safety Agency standards when exporting their products to the EU. By contrast, EU nations normally expect their products to be accepted in the U.S.
- International debates about the legitimacy of health regulations as they pertain to food normally focus on the degree of certainty regarding the hazards in question. Those countries with stricter regulations find evidence of danger sufficient, while those countries that have lax regulations normally argue that the evidence of risk is highly uncertain.

2. Trade and National Sovereignty

- This precautionary principle often conflicts with the longer-standing principle of international free trade. When the U.S. wishes to sell food products in Europe that contain chemicals or other ingredients that are not permitted, or have significantly higher maximum allowable residue levels, EU law normally pro-

vides governments with the authority to reject these shipments. Tens of billions of dollars in trade can be affected annually among these trading partners.

- Chemicals have rarely been banned on a global scale. Instead, bans most often occur within nations, or among clusters of some nations. Often the agreements are not flat-out prohibitions, but rather restrictions on production and exports.

- Limitations on chemicals in international commerce have historically been accomplished by way of voluntary treaties. The Rotterdam[66] and Stockholm[67] Conventions, and the Montreal Protocol[68] are international agreements that identify lists of hazardous chemicals that various nations have agreed not to exchange in international commerce without notifying nations of the hazards of their shipments.

- These lists include 33 pesticides. Signatory nations that wish to export these chemicals must provide importing countries with notification of shipment content and hazards. In turn, these nations must acknowledge and accept the shipments.

- This *Prior Informed Consent* requirement is designed to warn importers, but it clearly fails to transfer this knowledge of danger along supply chains to end users, such as rural farmworkers.[69] Many nations, including the United States, have failed to ratify these treaties due to differing perceptions of the degree of danger these treaties might allow, or the manageability of risks they present.

- Many nations believe that the concept of national sovereignty should include the freedom to accept chemical hazards, given that their **national priority of economic development might be more important to them than environmental protections.**

- Many of the world's poorest nations, for example, were willing to accept DDT imports, despite its ban in production and trade by many of the wealthiest countries. DDT has long been the

Many nations believe that the concept of national sovereignty should include the freedom to accept chemical hazards, given that their national priority of economic development might be more important to them than environmental protections.

The World Health Organization (WHO) maintains a list of extremely hazardous and highly hazardous chemicals, including pesticides.

least expensive pesticide capable of killing mosquitoes known to transmit malaria, yellow fever, dengue fever, and other vector-borne diseases that threaten populations. DDT risks seemed miniscule compared to the loss of life historically experienced in regions suffering from these endemic diseases.[70]

- The World Health Organization (WHO) maintains a list of extremely hazardous and highly hazardous chemicals, including pesticides. This list includes chemicals that are found to be carcinogenic, mutagenic, reproductive toxins, or listed as toxic under the Rotterdam and Stockholm Conventions and the Montreal Protocol.

- The Pesticide Action Network (PAN), an international NGO, maintains its own list of highly hazardous pesticides that includes 310 active ingredients among nearly 1,000 that are produced in the world. They have expanded the FAO list and those of the conventions mentioned above to include endocrine disruptors. These chemicals are also on the lists of the Rotterdam and Stockholm Conventions and the Montreal Protocol.

- An additional criterion for pesticides being included as highly hazardous includes pesticides that have shown a high incidence of severe or irreversible adverse effects on human health.[71] Among the extremely hazardous or highly hazardous pesticides listed are 35 organophosphate pesticides.[72]

- Figure 18 shows the differences in the regulatory conclusions reached by the U.S., EU, Brazil, and China in licensing the use of organophosphate pesticides. What is significant is that the U.S. has not banned any of these organophosphate chemicals.

- The chart demonstrates the problem with the current legal approach to protecting human health. Many of the chemicals listed in this chart are among the most intensively applied to food crops in the U.S.

Figure 18. Oganophosphate Pesticide Regulatory Status in the U.S., EU, Brazil, and China (2018)[73]

Pesticide Name	USA	EU	BRAZIL	CHINA
Dicrotophos	3	1	1	0
Disulfoton	4	1	3	4
Terbufos	3	1	3	1
Oxydemeton-methyl	4	1	0	4
Mevinphos	4	1	3	0
Methidathion	4	1	3	2
Phorate	3	1	1	2
Dimethoate	3	3	3	3
Methyl-Parathion	4	1	1	1
Acephate	3	1	3	3
Chlorethoxyfos	3	4	0	0
Fenamiphos	4	3	3	1
Ethoprop	3	3	3	2
Azinphos-methyl	4	1	0	4
Naled	3	1	3	3
Chlorpyrifos	3	3	3	3
Phosmet	3	3	3	3
Diazinon	3	1	3	3
Tribufos	3	1	1	0
Phosalone	4	1	3	3

0 = Not in database/unknown
1 = Banned
2 = In process of phaseout
3 = Approved
4 = Not approved/voluntarily withdrawn

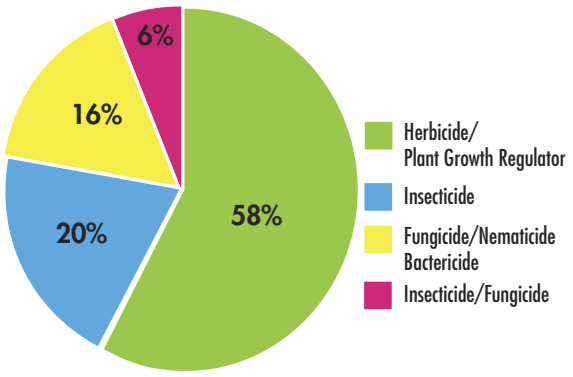
This chart shows the problem with the current legal approach to protecting human health. Many of the chemicals listed in this chart are among the most intensively applied to food crops in the U.S. The chart clearly shows how lax the pesticide regulations are in the U.S.

Numerous pesticides are listed as probable or possible carcinogens. Many are recognized or suspected endocrine disruptors, while others are linked to neurological and kidney damage, as well as to effects on the immune system.

- In addition to the organophosphates, other pesticides continue to be used in the U.S. that are banned in the EU, Brazil, or China as of 2018. Among these, nearly 60% are herbicides, 20% are insecticides, and 16% are fungicides.
- Several pesticides were withdrawn from the market by the manufacturers when the EPA demanded additional testing and data to update risk estimates for the chemicals.
- Numerous pesticides are listed as probable or possible carcinogens. Many are recognized or suspected endocrine disruptors, while others are linked to neurological and kidney damage, as well as to effects on the immune system.
- In 1993, the U.S. National Academy of Sciences Committee recommended strict regulation of the organophosphates. As of 2020, the EPA is still permitting the use of eight organophosphate pesticides banned by the EU. These include acephate, chlorethoxyfos, diazinon, dicrotophos, naled, phorate, terbufos, and tribufos.
- By 2001, presidential enthusiasm for regulation was diminishing significantly under the George W. Bush administration. Only one of the targeted pesticides, the insecticide parathion, was banned or cancelled during Bush's second term. Parathion was a well-known cause of farmworker poisoning.
- In contrast, by 2018 the EU had banned 26 of the 33 organophosphate pesticides that had previously been allowed. Not so in the U.S. Herbicides that are applied to crops in the U.S. are usually used in combinations, such as glyphosate and atrazine, or glyphosate and acetochlor, or glyphosate and 2,4-D. For example, herbicides and herbicide combinations are applied to 97% of the corn acreage in the U.S.
- Repeated applications of herbicide mixtures has left a signature of chemical residues in U.S. surface and groundwater. The EPA has adopted the *de facto* policy that herbicide residues in the nation's

Figure 19. Pesticides Banned in EU that Are Approved in the U.S. (2018)[74]

Pesticide Name	USA	EU	BRAZIL	CHINA
2,4-D	3	3	1	1
Bensulide	3	1	1	0
Chloropicrin	3	1	0	2
Dichlobenil	3	1	1	4
Dicrotophos	3	1	1	0
EPTC	3	1	1	0
Norflurazon	3	1	1	0
Oxytetracycline	3	1	1	4
Paraquat	3	1	2	1
Phorate	3	1	1	2
Streptomycin	3	1	1	3
Terbufos	3	1	3	1
Tribufos	3	1	1	0



0 = Not in database/unknown
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This chart above clearly shows that herbicides constitute the majority of pesticides banned in the E.U., yet allowed in the U.S.

water supplies are acceptable, despite growing scientific evidence of the health hazards these chemicals pose.

- The scale of contamination results from the intensity of annual herbicide applications over nearly 300 million acres of land, often twice a year. Herbicides including atrazine, simazine, 2,4-D, alachlor, metolachlor, and glyphosate have been detected in surface and groundwater.[75]
- Herbicides constitute the majority of pesticides that have been banned in China, Brazil, and the EU but still allowed in the U.S. This demonstrates a pattern on the part of the U.S. of accepting higher health risks from herbicides than they do from other types of pesticides.
- It also demonstrates the willingness of U.S. regulators to accept increasing volume of herbicide applications, and increasing presence of herbicides detected in foods, ground, surface, and drinking water supplies.

The EPA has adopted the de facto *policy that herbicide residues in the nation's water supplies are acceptable, despite growing scientific evidence of the health hazards these chemicals pose.*

Part Five: Historical Patterns

The EPA let pesticide regulation reviews spiral into a never-ending set of technical, evidence-demanding questions.

1. The EPA and Pesticide Regulations

- Since the EPA's founding 70 years ago, it has become clear that the agency has been overwhelmed with producing the science and controlling the political pressures from industry to adopt and enforce effective protective pesticide regulations.

- The EPA let pesticide regulation reviews spiral into a never-ending set of technical, evidence-demanding questions. The agency allowed the search for evidence to draw them into endless debates about the quality of evidence and the appropriateness of analytical techniques. This made it very difficult for NGOs and the public to participate effectively in regulatory decisions.

- In addition to the problems above, the EPA's top-level administrators and their deputies are political appointees. This fact creates very serious impediments to attaining protective human health and environmentally protective standards for pesticides.

- The EPA failed to recognize that it was basically approving 99% percent of the pesticide manufacturers' requests. The EPA's approvals rarely required such things as minor adjustments to conditions of use, chemical concentrations, labeling; and application methods. In addition, monitoring, enforcement, and bans were rare.

2. Pesticide Regulation Flaws

- The assumption that the EPA, USDA, FDA or USGS have the financial resources to monitor pesticide concentrations to ensure that they do not exceed safe thresholds has proven to be foolish.
  - The fundamental flaw with U.S. pesticide law is its premise that mixtures of their residues are acceptable in our environments and our bodies.
  - Nearly 10,000 separate limits have been set with the intent to restrict lingering pesticide residues in food, water, and air. Additional limits are set for indoor environments and commercial products.
  - If residues are not monitored, then legal limits are not enforceable.
  - The government has allowed hundreds of millions of pounds of pesticides to be released into the environment, both indoors and outdoors, without any hope of ensuring environmental or public health protections.
- The government needs to set pesticide residue limits that are backed by monitoring and vigorous enforcement policies and actions.

3. The EPA's Pesticide Reviewing Process

- The EPA has approved nearly 2,500 chemicals for use in pesticide products, and these are mixed together with "inactive" or inert ingredients and sold in nearly 20,000 separate products.

The fundamental flaw with U.S. pesticide law is its premise that mixtures of their residues are acceptable in our environments and our bodies.

A single chemical may have several hundred tolerances, permitting the presence of pesticide residues in hundreds of different raw and processed foods.

- The EPA has been reviewing nearly 5,000 pesticide registration proposals for new uses of existing pesticides and changes in pesticide labeling, as well as new chemicals.
- The EPA has rarely tested for the presence or toxicity of pesticide combinations. This process has created the potential for human exposure to hundreds of thousands of chemical mixtures.
- A single chemical may have several hundred tolerances, permitting the presence of pesticide residues in hundreds of different raw and processed foods.
- Each tolerance requires a separate risk assessment, and regulation is delayed while EPA and manufacturers reach a negotiated agreement regarding the outcome. The average time to complete a risk assessment for all of the uses of a single chemical has typically taken 10-15 years.
- Collectively for all pesticides, EPA must make nearly 200,000 decisions regarding necessary data, quality of data, necessary testing of residues, exposures, and toxicity.
- The evidence collected has never been sufficient to permit the EPA to project future patterns of contamination or unintended health and environmental damages.
- The current legal and regulatory structure has failed to accomplish the statutory requirements to protect both human health and environmental quality. It is time for a complete replacement of the current legal structure for regulating pesticides.
- The EPA should deny licenses for pesticides that have proven to be persistent, mobile, and hazardous to human health and other non-target species. When the government fails to do this, it leads to pesticide residue mixtures being detected far beyond their originally intended targets.

4. Human Health Hazards

- The EPA is required by law to reach a conclusion regarding the severity of nearly 30 different adverse human health effects. These effects include cancer, genotoxicity, mutagenicity, reproductive failure, neurotoxicity, endocrine disruption, immune toxicity, and neurodevelopmental disorders, among others. Each of these categories contains a variety of disorders.

- For example, neurodevelopmental disorders include abnormal rates of central nervous system maturation; learning, memory, and cognition impairment; lack of physical coordination; and vision disorders. It is easy to see how each of these effects would be incredibly difficult to understand and prove, even for a single pesticide. Therefore, determining pesticide safety can easily take decades before a licensing decision is reached.

- The state of knowledge in each of the human health categories above is highly variable. With such incomplete understanding, it is hard to protect against widespread pesticide residue contamination of the environment. Young children are especially vulnerable to pesticide residues that can cause adverse neurological effects, such as those that have been clearly associated with children's organophosphate exposures.

- The EPA's understanding of health hazards is usually highly uncertain, and in many cases, such as neurodevelopmental and endocrine system effects, EPA has simply avoided testing.

- Pesticide risk analysis and associated regulatory decisions for a single pesticide are splintered chemical-by-chemical, product by product, and use by use, leading to hundreds of thousands of decisions that need to be made if we are to have any hope that regulation will prevent risky exposures.

- All pesticide testing prior to government approval is conducted one-chemical at a time, while humans are exposed routinely to pesticide

Young children are especially vulnerable to pesticide residues that can cause adverse neurological effects, such as those clearly associated with children's organophosphate exposures.

mixtures in foods and water, creating very significant uncertainty about the magnitude of health risk posed by dietary intake.

- *Given this fragmented decision process, it is clear that the EPA has been and will continue to be overwhelmed.* Yet the agency continues to review and approve new chemicals, and allow new uses of existing chemicals. The global marketing and use of pesticides today ensures the global distribution of their residues, since regulation of international trade in pesticides is very difficult to achieve.

Foods that are derived in batches from varying sources are especially difficult to protect from pesticide residues. Examples of this issue are oils, processed meats, dairy products, beverages, coffee beans, and fish.

- Surprisingly, pesticides banned in one nation may be legally permitted to be produced and exported to other nations. This creates a nearly impossible challenge for nations that import food to ensure that products carrying banned pesticide residues are identified and impounded at ports of entry.

- Because pesticides banned in one nation may be legally permitted to be used on exported foods, and as foods become mixed in global commerce, exposures to banned pesticides occur. No international surveillance system is in place to track either pesticide residues or products that contain these chemicals.

- Foods that are derived in batches from varying sources are especially difficult to protect from pesticide residues. Examples of this issue are oils, processed meats, dairy products, beverages, coffee beans, and fish.

- The costs of creating a monitoring and enforcement network preclude any reasonable expectation that this international exchange could be effectively regulated.

5. Pesticides in Human Tissues

- Human studies demonstrate the presence of residue mixtures in human tissues. The problem has been well understood in the U.S. since the discovery of DDT nearly 70 years ago in breast milk fats.

- The government has understood how food contamination can cause pesticide concentration to build up over time in human tissues. The USDA, EPA, and FDA have collectively failed to prevent human accumulation of pesticide residues. These agencies have allowed food and water contamination to become acceptable as a cost of pesticide's benefits.

- This failure has resulted in a massive experiment affecting human health and the planet's biological diversity. The experiment has long been global in scale and has created an unbearable burden on national governments trying to be health-protective for their citizens.

6. Reliance on Animal Testing

- Rather than human epidemiological studies, pesticide researchers predominately rely on animal testing. Cancer risk assessment routinely involves tests of genotoxicity and mutagenicity, as well as studies of animals exposed to residues at low, medium, and high doses, along with a control group that remains unexposed. These studies routinely continue for two years to determine if any incidence of tumors is dose-dependent.

- Human epidemiological studies normally evaluate disease incidence in pesticide-exposed and unexposed populations. However, these human studies are often challenged on the basis of understanding the subjects' exposure to pesticides of interest, claiming that other chemicals might have contributed to the identified illness. Far more frequently, *in vivo* or *in vitro* toxicological studies, along with genotoxicity and mutagenicity studies, are used to judge carcinogenicity.

- The Agricultural Health Study, a prospective human cohort study, found some evidence of elevated risks among farmworkers for multiple myeloma, leukemia, bladder, pancreas, colon, lung, and prostate cancer.[76] This was surprising, because some of the pesticides causing farmworkers' exposures had demonstrated negative effects in animal and *in vitro* studies.

This failure has resulted in a massive experiment affecting human health and the planet's biological diversity. The experiment has long been global in scale and has created an unbearable burden on national governments trying to be health-protective for their citizens.

7. Neglect of Fetal, Infant and Children's Health

The EPA neither asked nor tested whether pesticides interfered with the development of fetal, infant, or children's nervous systems. Pesticides pose a special threat to the youngest members of society.

- The U.S. National Academy of Sciences warned in 1993 that pesticides were especially dangerous to children. The Academy also said children are often more exposed to pesticides than adults.
- Twenty-five years after the EPA was created, the agency had not asked whether different pesticide registrations or tolerances should be set to protect children's developing body organs and tissues. The EPA also failed to asked what concentrations of pesticides might circulate between a pregnant mother and her fetus.
- Until 1996, the EPA neither asked nor tested whether pesticides interfered with the development of fetal, infant, or children's nervous systems. Since then, an exceptionally large body of research has clearly demonstrated that pesticides pose a special threat to the youngest members of society.
- It is now well-established that pesticide residues easily cross the placenta to developing human embryos and fetuses. They also cross the blood-brain barrier, giving additional evidence that pesticides freely circulate throughout human tissues.
- When the EPA reviewed organophosphate insecticides for their potential harm to children, the agency approved continued use of many of these chemicals, including chlorpyrifos.[77]
- Chlorpyrifos is recognized to slow brain development among children, and EPA removed the safety factor that would have reduced allowable residues in children's diets.
- In 2017, the EPA again decided against banning chlorpyrifos uses in agriculture, although it has not been allowed for residential uses since 2000.

Part Six: Conclusion

- Our 20th century attempts to restrict pesticides via government regulation of residue limits in air, water, soils, foods, indoor environments, and human tissues has largely failed. Governments do not have the funding or ability to test pesticides to know their environmental fate, or the specific dangers they pose to human health. Even more importantly, they often do not have the political will.

- The entire global system of regulations and trade agreements rests on pesticide manufacturers' largely unproven claims of product effectiveness and pesticide safety. The EPA is plainly guilty of neglect, failure to demand independent and complete testing prior to pesticide approval, and of bowing to corporate and political pressure when evidence of significant risk to human health is clear.

- Quantitative risk assessments are extremely technical, expensive, and time-consuming even for a single pesticide, and yet we are daily exposed to many pesticides at a time in our food and water. Simpler criteria should be adopted to judge chemical safety. The current

The entire global system of regulations and trade agreements rests on pesticide manufacturers' largely unproven claims of product effectiveness and chemical safety.

Government errors in forecasting the safety of pesticides are clear for every class of pesticide used during the past half century: metals, chlorinated hydrocarbons, organophosphates, carbamates, pyrethroids, neonicotinoids, and growth-regulating herbicides.

regulatory regime for pesticides in the U.S. is highly exclusionary because unless one possesses high-level quantitative and scientific knowledge, influencing the decision process is impossible. Since this expertise is highly centralized among the chemical-biotechnology sector, their experts effectively control the pesticide regulatory process.

- The EPA has suffered from the statutory demands for separate evaluations and decisions it must make on even a single pesticide, yet the number of pesticides to be evaluated is about 200,000, with nearly 2,500 pesticide ingredients. This has overwhelmed the analytic capacity of the agency.

- The FDA similarly has been overwhelmed by its statutory demand to test for pesticide residues in marketplace foods. The EPA and FDA together have been derelict, given their neglect of testing drinking water for pesticide residues.

- The problems include the small number of samples tested, the EPA's search for only several dozen agricultural pesticides among the several thousands of pesticides applied, and the EPA's pattern of exempting communities and municipalities from annual testing.

- The claim that global pesticide contamination of ecosystems and human tissues is harmless is logically impossible, given the inadequacies of independent scientific testing. Careful analyses of the evidence demonstrate that chemical manufacturers, product formulators, and government regulators have little understanding of the short- or long-term effects that pesticide exposures have on human health that have been well documented.

- Government errors in forecasting the safety of pesticides are clear for every class of pesticides used during the past half century. All have proven to have serious health risks. They include metals (cadmium, mercury, lead), arsenic, chlorinated hydrocarbons,

organophosphates, carbamates, pyrethroids, neonicotinoids, and growth-regulating herbicides.

- Even though U.S. law was changed in 1996 to require human health protection for the most vulnerable in the population, exposures and health risks have continued and are increasing with growing intensity of pesticide use. Each class of pesticides was introduced with manufacturers' promises of inconsequential persistence, mobility, and toxicity. However, later independent studies demonstrated that regulators misinterpreted the data and risks remained.

- The repetitive pesticide license-granting behavior of the U.S. government has changed the chemistry of the entire planet as well as the human body. We are all led to believe that carrying an ever-changing mixture of pesticides in our bodies is normal and harmless.

- There are reasons to be optimistic. One is that our population is increasingly literate and health conscious. A second is a growing willingness to pay for products that do not contain pesticide residues.

- The Organic Food Protection Act prohibits any synthetic pesticide products from being used on organically certified food. This approach avoids all of the residue, exposure, contamination, health, and ecological hazards described above. The simplicity and brilliance of the organic movement is undermined by the U.S. tradition of subsidizing the largest food crops that are synthetic pesticide dependent.

- These are the crops that should be taxed for creating the problems identified in this report, treating our food, water, air, soils, and bodies as free repositories for their hazardous chemical wastes. The subsidies should be switched to support the organic sector due to its proven potential, its protective effect on humans and ecosystems.

Even though U.S. law was changed in 1996 to demand human health protection for the most vulnerable, exposures and health risks have continued and are increasing with growing intensity of pesticide use.

Part Seven: Recommendations

The EPA needs to test for the toxicity of pesticide combinations. This failure has created the potential for human exposure to hundreds of thousands of chemical mixtures that people are exposed to every day.

1. Recommendations for the Federal Government

- The EPA should deny licenses for pesticides that have proven to be persistent, mobile, and hazardous to human health and other non-target species. When the government fails to do this, it leads to pesticide residue mixtures being detected far beyond their originally intended targets.
- The EPA needs to set pesticide residue limits that are backed by monitoring and vigorous enforcement policies and action.
- The EPA needs to test for the toxicity of pesticide combinations. Their failure to do so has created the potential for human exposure to hundreds of thousands of chemical mixtures that people are exposed to every day.
- The EPA needs to release testing information about potentially harmful compounds listed as inert ingredients in pesticides.

- The EPA needs to test whether pesticides interfere with the development of fetal, infant, and children's nervous systems.
- The EPA needs to demand independent and complete testing prior to a pesticide's approval when evidence of significant risk to human health is questioned.
- The EPA relies on the labeling of pesticide packaging as its way to protect human health. Therefore, the labeling on pesticide packaging should be in type no smaller than 16 point.
- The EPA should require that pesticide package labeling be in English and in Spanish, as many applicators are Spanish-speaking.
- Pesticide package labeling should include chronic health effects, such as cancer and neurotoxicity—not just the acute health effects, as are now listed on the label.
- Pesticide labels should list the inert ingredients and their health effects, as well as what pesticides are included in the package.
- Lawn-care pesticides sold to the public should be required to be in packaging that prevents pesticide vapors from escaping. Stores that carry these products are filled with the outgassing from these pesticide products.
- When lawn-care products are advertised, health risks to people should be required to be listed, just as they are required for drug advertising.
- The federal government should ban all uses of chlorpyrifos.
- Glyphosate should be put on a pesticide restricted list.
- Pesticide risk assessments are extremely technical, so simpler criteria should be adopted to judge chemical safety so that the public can influence decisions about a pesticide's safety.

The EPA needs to demand independent and complete testing prior to a pesticide's approval when evidence of significant risk to human health is questioned.

Pesticide misters are a new and dangerous product and should be banned by all states to protect children and pets.

- Federal subsidies should be given to support the organic sector due to its proven potential and protective effect on humans and ecosystems.
- Perhaps it is time for a complete replacement of the current legal structure for regulating pesticides.

2. Recommendations for State Governments

- States should enact a pesticide registry that allows neighbors to be alerted 24 hours before their neighbors' properties are sprayed with pesticides.
- States should amend their pesticide laws so that local governments can have stricter laws than the state government.
- States should enact laws that ban pesticides on school grounds and on elementary and middle school playing fields.
- Pesticides should be disposed of as hazardous waste, not as household waste.
- States should ban the use of chlorpyrifos for all uses.
- States should put glysophate on a pesticide restricted list.
- States should enact neonicotinoid pesticide restrictions to protect their bee populations.
- Lawn-care pesticides should not be sold indoors or near food. Their porous packaging allows pesticide vapors to accumulate indoors.
- Pesticide misters are a new and dangerous product and should be banned by all states to protect children and pets.

3. Recommendations for Town Governments

- Towns should use only organic materials on their town property grounds, including libraries, town halls, and parks. This will set an example for the whole town and show that the town is using

sustainable practices. In addition, organic practices in town parks will protect children's health.

- Towns should help educate residents about reducing their uses of lawn-care pesticides for cosmetic reasons, especially those who live on land with private drinking water wells.
- Towns should lobby their state legislatures to enact laws that will allow the towns to have stricter pesticide regulations than the state has. This is even more important if the towns have critical aquifers to protect against pesticide contamination.
- On their website, towns should put information about good and healthy lawn-care practices. It should include how to protect residents' private wells from pesticide contamination. Local health departments should post the same information on their websites.

3. Recommendations for Individuals

- If you are pregnant, avoid using pesticides—many of them have birth and reproductive health effects.
- Use organic lawn care practices on your property. This will protect your children and your pets.
- Indoor pesticide use causes far more toxic exposures than outdoor use, so you should use as little pesticide as possible indoors.
- Only use pesticides when absolutely necessary.
- Ant cups and similar cups for insect infestations are preferable to spraying pesticides.
- If you have pesticides in your home, make sure they are stored securely and safely, away from pets and children.
- If your state does not have a pesticide registry for you to learn when your neighbors are going to have their properties sprayed with pesticides, lobby your state to enact legislation to alert you.

Use organic lawn care practices on your property. This will protect your children, your pets, and yourself.

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