THE POWER *of the* PLATE

The Case for Regenerative Organic Agriculture in Improving Human Health

RODALE INSTITUTE™

The Plantrician Project
Planting the seeds of change™

AUTHORED BY:

Jeff Moyer, Scott Stoll, M.D., Zoe Schaeffer, Andrew Smith, Ph.D., Meagan Grega, M.D., Ron Weiss, M.D., Joel Fuhrman, M.D.

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HOPE *for a* HEALTHIER FUTURE

Standing on a hillside at Rodale Institute, overlooking the verdant fields of cover crops and a beautiful organic apple orchard, the two of us found the perfect spot. A location for our future Regenerative Health Institute—a place where farmers, soil scientists, medical professionals and consumers will come together for a common goal: regaining our health and vitality through food.

Although the two of us have built an incredible friendship and working relationship over the past few years—very few doctors and farmers are working together, or are even in the same rooms or conversations. How far we've strayed from the simple adage we knew in grade school: "An apple a day keeps the doctor away."

Rather, what we've found in our respective fields, is the more we specialize, industrialize, monetize, and consolidate agriculture and healthcare—the more we've moved away from our roots. Is the goal of farming not to support human life by giving us the food and nutrients our bodies require? Is the goal of healthcare and doctors not to make us well? Then how did farming become solely about efficiency and yields, and healthcare about managing expensive disease? And what is the path forward?

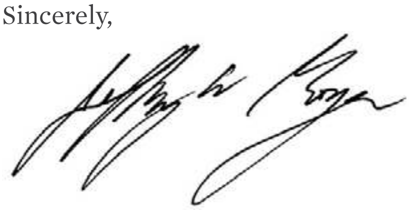
In our in-depth conversations, we've realized many have lost sight of the common ground between these massive industries. At the root is food. Food has the ability to bring us together, over a meal, or at a shared table. And the right food—nutrient-dense food, produced regeneratively, with respect for the environment and with the goal of human health—can fix our broken food and healthcare systems.

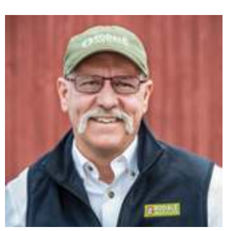
"The Power of the Plate" is the first step in creating that change. This paper takes an in-depth look at the ways farming and health are intertwined, how our systems have deviated from a regenerative path, and why regenerative organic agriculture is the key to improving our human health. And most importantly, the paper lists tangible solutions for the regenerative healthcare of the future.

Our partnership, and this conversation, are signs of a bright new future. Rodale Institute has always been, at its core, a human health organization. Its mission of building healthy soil to grow healthy food, which supports healthy people, has been the foundation of nearly 70 years of research and education in the area of regenerative organic agriculture. The Plantrician Project brings a medical perspective to the impact of food on the body and the benefits of a whole foods, plant-based diet. In this way, our partnership is a first step in the agricultural and medical communities coming together under a shared goal: human health. This white paper is the result of that partnership.

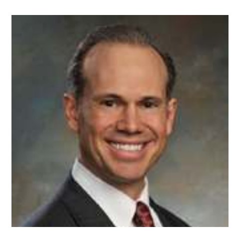
We hope this paper encourages not only consumers but farmers, medical professionals, and policymakers to rethink the stories we've been told about human health and our food system. It is our sincere wish that this report inspires those who read it to seek out regenerative organic growing practices in their food, incorporate more organic whole foods into their diet, and stand up for a system that actively supports the health of people and the planet.

Sincerely,





JEFF MOYER
Chief Executive Officer, Rodale Institute



DR. SCOTT STOLL
CEO & Co-Founder, The Plantrician Project

EXECUTIVE SUMMARY

The world is in desperate need of healing. The increased industrialization of our food system has led to both environmental degradation and epidemic levels of lifestyle-related diseases. Meanwhile our healthcare system continues to prioritize pharmaceutical intervention over lifestyle changes like diet and nutrition.

This white paper offers a holistic analysis of the rise of industrial agriculture, the connection to our poor diets and nutrition, and solutions to move towards regenerative healthcare.

Key Findings

- While many Americans are living longer than their parents, they are not living healthier or happier lives.
- Lifestyle diseases like obesity, diabetes, and heart disease are on the rise as the Standard American Diet has come to consist of mostly processed foods that are high in sugar and fat.
- The rise of this diet can be partly attributed to changing agricultural systems that prioritized yields and shelf life over nutrition.
- Conventional and processed foods lack nutrient density, contributing to "hidden hunger" and the rise of chronic diseases.
- In addition to lacking nutrition, industrial farming directly and indirectly affects human health via exposure to potentially toxic chemicals and environmental pollutants.
- Regenerative organic agriculture grows food without synthetic chemicals or salt-based fertilizers while improving soil health, which can increase the nutrient density of food and help combat environmental issues like climate change.
- Despite a clear link between food and health, the healthcare system underprioritizes nutrition education for medical students and diet-based treatment plans.
- The solution lies in Regenerative Healthcare: adopting regenerative organic farming practices, improving the diet through organic, whole foods, and adopting lifestyle changes that reduce disease.

The Standard American Diet contains a high percentage of processed foods, which are availably cheaply, in part, due to industrial agriculture.

Why It Matters

Our medical system is overburdened attempting to treat chronic diseases with pharmaceutical intervention. At the same time, conventional farming systems rely on toxic inputs that degrade human health and prioritize crops low in nutritional value. With cancer rates and autoimmune diseases on the rise worldwide, and only 60 years of topsoil left due to soil degradation, we need a new path to improving human health.

The Solution

We could increase the availability of nutrient-dense foods and initiate regeneration of the soil by shifting to a regenerative organic farming system that eliminates toxic inputs and focuses on foods optimal for our health. A shift in our medical system to an integrative system founded on lifestyle medicine—supported by regenerative, whole, nutrient-dense foods—could dramatically alter the trajectory of chronic disease and create a healthier future.

Key Recommendations

1. Emphasize education and collaboration between medical professionals, farmers, and consumers to identify the positive impacts of a whole foods, organic diet.
2. Integrate nutritional education into the medical education curriculum.
3. Implement localized, integrated health initiatives that combine medical treatment with access to organic fruits and vegetables and incentivize medical professionals to implement these practices.
4. Fund more research for specialty crops and regenerative organic farming to improve technology & lower costs and incentivize these farming methods.
5. Provide increased financial & institutional support for farmers transitioning to regenerative organic practices.
6. Encourage food companies to support regenerative organic farmers.

THE POWER *of the* PLATE:

The Case for Regenerative Organic Agriculture in Improving Human Health

Jeff Moyer, Scott Stoll, M.D., Zoe Schaeffer, Andrew Smith, Ph.D.,
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"Let thy food be thy medicine and thy medicine be thy food."
– Hippocrates, 400 BC

"The health of soil, plant, animal and man is one and indivisible."
–Sir Albert Howard, 1947

"People are fed by the food industry, which pays no attention to health, and are treated by the health industry, which pays no attention to food."
–Wendell Berry

If you have touched food, you have been touched by soil. Soil is amazingly complex, and yet it's simple. Most soil biota are one-celled creatures—simple—but they are present by the billions in just one teaspoon of topsoil and create complex networks and interactions to support life on earth. Yet with all the power of modern science, we still don't completely understand how soil functions or the depths of its importance to our health and wellbeing.

It doesn't only matter what we eat, but how our food is produced.

We—a group of farmers, soil experts, doctors, and food service providers—have explored the connection from many angles. The scary truth is that we're losing and degrading topsoil rapidly around the world at the same time that chronic disease rates are skyrocketing, and our children are predicted to live shorter lives than their parents. Though the connections between soil and human health are complex and often indirect, the two are linked. It doesn't only matter what we eat, but how our food is produced. We can continue with an industrial food system dependent on toxic chemicals that harms soil and the environment and produces increasingly less nutrient-dense food. Or we can recognize the profound link between food and health, shift to less toxic, more regenerative farming practices, and finally connect our farming, food, and healthcare systems. How we take care of the soil is a reflection of how we take care of ourselves and mankind.

We propose a new vision, called Regenerative Healthcare, in which farming and healthcare work together to inform a prevention-based approach to human and environmental health. Rather than relying on toxic chemicals to solve agricultural issues and pharmaceutical intervention to manage chronic lifestyle-related disease, Regenerative Healthcare aims to prevent disease and regenerate life through an organic, whole-foods, plant-forward diet that begins on farms that work in harmony with nature. Conventional agriculture has been a critical tool in previous decades; however, the consequences of its hyper-focus on yields, the threat it poses to biodiversity, and its reliance on polluting, nonrenewable resources have limited its promises. The solution lies in a new way of farming—regenerative organic agriculture—that addresses the ecological and health challenges we face today, and a new type of healthcare—regenerative healthcare—that harnesses the power of nutritious food and lifestyle to suspend, reverse, and prevent disease.

DEFINING REGENERATIVE HEALTHCARE

A system in which farming and healthcare work together to inform a prevention-based approach to human and environmental health. Rather than relying on toxic chemicals to solve agricultural issues and pharmaceutical intervention to manage disease, Regenerative Healthcare aims to prevent disease through an organic, whole-foods, plant-forward diet that begins on farms that work in harmony with nature.

Our current food system is adept at producing cheap, hyperpalatable, nutrient-poor foods. We're highly efficient at growing, processing, and distributing commodities like wheat, corn and soy, many of which end up as livestock feed, ethanol, and refined, processed foods. Agricultural intensification and consolidation have enabled the mass-scale production of inexpensive animal products through confined animal feeding operations (CAFO). Despite the fact that research overwhelmingly supports the adoption of whole-food diets high in nutrient-dense fruits and vegetables, only **0.9% of adolescents, 2.2% of adult men, and 3.5% of adult women met the daily recommended needs for fruits and vegetables** in 2009.[1] Sonny Ramaswamy, director of the USDA's National Institute for Food and Agriculture from 2012-2018, stated that, **"If Americans were to actually go ahead and jump into consuming the amount of fruits and vegetables recommended, we'd be hard-pressed to meet that demand."**[2]

The US spends approximately 18% of its GDP–$3.6 trillion–on healthcare.

Simply put, our farming systems aren't aligned with what science has identified as the best foods for proper health. By emphasizing a small number of crops for export and animal feed; subsidizing and insuring those crops; and providing only limited research funding and resources to fruit and vegetable production, our current farming system hinders effective dietary change and limits access to health-promoting food. Chemical-intensive, industrial farming has also contributed to declines in nutrient-density and threatens human health through exposure to toxic pollutants.

At the same time, our medical system is overburdened attempting to treat lifestyle-related diseases with pharmaceutical intervention rather than nutritional and lifestyle changes. As a nation, the United States spends approximately 18% of its Gross Domestic Product—$3.6 trillion—on healthcare[3], a number projected to reach nearly $6 trillion by 2027.[4] That's the highest per capita healthcare expenditure of any nation in the world, yet this massive investment hasn't paid off in improved health outcomes or longevity.[5] **The United States ranks near the bottom on many health measures, including life expectancy, obesity, and prevalence of chronic disease** when compared to similar high-income countries that spend significantly less per capita on healthcare services.[6] If current trends continue, the Federal Congressional Budget Office predicts that Medicare and Medicaid alone will devour 20% of GDP by 2050.[7] Although the benefits of nutrition for health and thus reduced healthcare costs are well-established, medical students receive **fewer than 25 hours of nutrition education during their four years of medical school.**[8]

Now is the time for change. **By integrating our food and healthcare systems, emphasizing nutrition and lifestyle choices that prevent, suspend and reverse disease, and transitioning to regenerative organic farming on more cropland, we could radically improve the future of human health.**

THE CURRENT STATE *of* HUMAN HEALTH

Today, six out of ten American adults have a chronic disease, and four of ten have more than one chronic disease.[9] Globally, more than 71% of deaths annually are related to non-communicable, lifestyle-related diseases that include cancer, type 2 diabetes, chronic lung disease and cardiovascular disease.[10] Based on current global trends, 6 of the top 7 causes of death in 2040 (including heart disease, stroke, Alzheimer's and diabetes) will be directly related to our lifestyle choices and diet.[11] **And while total life expectancies have increased since 1950, healthy life expectancies and quality of life have not.**[12] Not only does that mean diminishing quality of life for citizens, it adds to the socioeconomic burden of caring for an ailing, aging population. In communities around the globe, an average of 10 years of total life expectancy are spent in poor health.[13] The top three risk factors globally relating to years of life lost are high body mass index, hypertension and high blood sugar—all conditions related to diet.[14]

In the United States, there are now millions of children that are obese or overweight.

Approximately 92 million Americans are living with coronary artery disease.

Despite greater healthcare access and advanced technology, Americans are not exempt from these statistics. In the United States, the wealthiest country in the world, approximately 92 million Americans are living with coronary artery disease or the consequences of a stroke,[15] illnesses that are largely preventable and reversible with optimal nutrition and healthy lifestyle choices. The prevalence of type 2 diabetes in the United States continues to rise each year.[16] The U.S. adult obesity rate was 42.4% percent of the population in 2017-2018, and worldwide, more than 1.9 billion adults and 340 million children and adolescents are overweight or obese.[17] The result is that our **children are predicted to live shorter and less healthy lives than their parents.**[18]

The good news is that the most prevalent health issues of our time can be prevented by increased consumption of the foods necessary for optimal health, a change that will require modifying our mainstream agricultural model. The aim of modern agriculture should be to maintain and improve the health of the global human population, not simply to produce enough calories to feed the world.

Regenerative organic agriculture supports that goal, with soil and biodiversity at the foundation of a healthy, chemical-free, nutrient-rich diet. The result is a more diverse, nontoxic, regional food supply that mitigates the harmful effects of industrial agriculture on both human health and the planet (see the insert "Impacts of Industrial Agriculture on Human Health" on pg. 12).

The first step in the Regenerative Health model is to **adopt more regenerative organic farming practices** that repair the soil and enhance natural ecosystems, removing toxic chemicals from our food, air and water while ensuring a healthy, secure food supply for generations to come. The second step in Regenerative Health is to **improve diet through greater consumption of nutrient-dense, whole foods**, a shift that will need to be accompanied by increased research and support for the production and distribution of those foods globally. The third step in Regenerative Health includes **lifestyle changes**, like reducing health-threatening habits such as smoking and increasing physical activity levels. Widespread adoption of these changes will result in a radical shift in human health and well-being and a reduction in chronic disease across the globe.

THE STANDARD AMERICAN DIET

Most Americans aren't eating the kinds of foods that promote health. The Standard American Diet is characterized by the excessive consumption of calories from processed and industrialized foods; inadequate consumption of nutrient-dense fruits and vegetables; and excessive intake of sodium and chemical additives. The USDA estimates that the Standard American Diet derives more than half of total calories from highly processed foods.[19] The Standard American Diet is now found far beyond America's borders—22% of deaths worldwide are caused from poor diet; in particular, insufficient intake of unprocessed vegetables, fruits, nuts and seeds, and whole grains.[20]

The Standard American Diet is intertwined with highly industrialized, chemical-intensive farming methods. Changes in farming supported by government policy especially over the last century have incentivized farmers to grow crops that are easy to ship, store, and process—namely cereal grains and sweeteners—ensuring these foods are inexpensive and widely available. These same farming methods rely on a suite of toxic fertilizers and biocides that today have proven to have devastating effects on the environment and hazardous implications for human health.

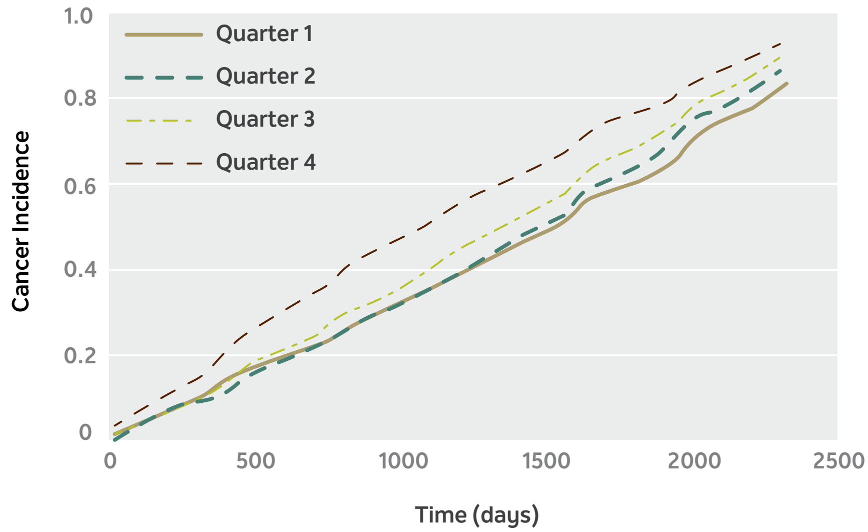

FIGURE 1: Overall cancer risk according to proportion of ultra-processed food in diet based on a study of 105,000 participants in France. *Fiolet Thibault, Srour Bernard, Sellem Laury, Kesse-Guyot Emmanuelle, Allès Benjamin, Méjean Caroline et al. Consumption of ultra-processed foods and cancer risk: results from NutriNet-Santé prospective cohort BMJ 2018; 360 :k322*

> Incentivized by government policy, corn is America's largest crop. Most of our nation's corn is used for animal feed, ethanol or processed foods— contributing to the availability of cheap, highly processed food that makes up the bulk of the Standard American Diet.

THE RISE *of* INDUSTRIAL AGRICULTURE

Beginning in the late 19th century, significant changes took place in American culture and global food and farming technologies.[21] While Americans turned increasingly to convenience foods and meals outside the home (see Figure 2), farming shifted away from small, diversified operations based on feeding a family or community towards a more consolidated approach focused on maximizing yields of a few crops for storage and export.

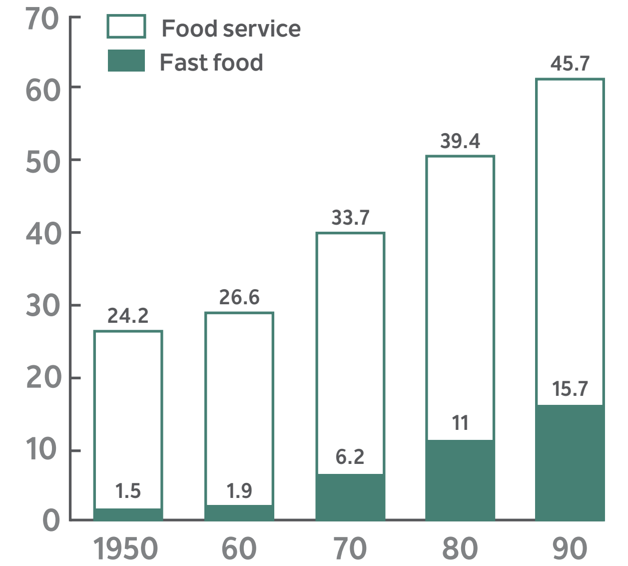

FIGURE 2: From "The Food Marketing Revolution, 1950-90" USDA ERS

Such yield intensification was aided by technological advances leading up to World War II. The Haber-Bosch process, a method of generating nitrogen fertilizer by synthesizing ammonia from hydrogen and nitrogen, was used to create munitions, the large-scale production of which led to surpluses then diverted to agriculture.[22] For the first time, materials formulated to kill people were intentionally used for food production and a massive scaling of chemicals in agriculture was launched.[23]

In the 1960s, the Green Revolution brought new, high-yielding crop varieties that worked in conjunction with the new chemicals and led to an explosion in food production, particularly in developing countries. New machinery combined with new cultivars and chemicals allowed for the increased mechanization of agriculture. Earl Butz, the Secretary of Agriculture under President Nixon, urged farmers to "get big or get out," further driving the consolidation of American agriculture.

Only 8% of farms produce more than four crops.

The result has been an accelerated loss of diversity on American farms, especially in the last 30 years.[24] In previous generations, more farms grew crops and raised livestock simultaneously. The advantage to such a system is a closed-loop nutrient cycle: animals deposit manure, which provides nutrients for crops, reducing or eliminating the need for synthetic fertilizer. Today, 88% of farms specialize in either crops or livestock (a growing percentage of the latter represented by concentrated animal feeding lots), and **only 8% of farms produce more than four crops.**[25] Monocultures, or the growing of a single crop on a large acreage year after year, results in the need for greater chemical inputs. Such lack of diversity and reliance on outside inputs leads to greater risk of pest and disease outbreaks, and degraded soils

Chemicals used in WWII began entering agriculture as pesticides and fertilizers.

keep farmers on a treadmill on which each year more inputs or new technologies are required to maintain production. **The result is a system highly specialized in a few commodities—largely destined for processed food, ethanol, and animal feed—that is dependent on synthetic fertilizers, insecticides, and herbicides.**

> ***We're now much better at growing corn and soybeans than tomatoes and spinach.***

With the rise of industrial agriculture also came an increase in research dollars and resources funneled to commodity cereal crops; the result is that we're now much better at growing corn and soybeans than tomatoes and spinach.

To this day, "specialty crops" including fruits, vegetables, and nuts are grown on just 3% of cropland.[26] In the United States as of 2007, there were 8.5 million acres of specialty crops amongst more than 300 million acres of everything else, and the USDA spends only $400 million studying specialty crops out of a total $3 billion invested in agricultural research.[27] Even less is dedicated to studying organic agriculture, which has only been a formal branch of the USDA since the Organic Program was first conceptualized in 1990. Most recently, the 2018 Farm Bill promised to modestly increase current investments in organic research from $20 million (less than 1% total research budget) to $50 million per year by 2023.[28] Our food system is skewed to support the processed, nutrient-poor foods that are fueling today's epidemics of obesity and chronic disease.

DIFFERENT APPROACHES *to* FOOD *and* FARMING

CONVENTIONAL

Generally, conventional farming relies on the use of chemical intervention—pesticides, herbicides, synthetic fertilizers—and genetically modified organisms (GMOs) to grow crops.

REGENERATIVE

Regenerative farming aims to enrich the soil, but lacks any standards prohibiting the use of conventional pesticides, herbicides, synthetic fertilizers, and GMOs.

COMMON TOOLS

Pesticides and Herbicides

Synthetic Fertilizer

GMOs

ORGANIC

Organic farming does not use chemical intervention or GMOs because it prioritizes building healthy soil. Instead, natural methods such as composting are relied upon, for the growth of healthy food.

REGENERATIVE ORGANIC

Regenerative Organic farming is rooted in organic farming. It abides by a high standard of land management to sequester carbon in the soil, and prioritize welfare of farm animals and fairness for farmers and workers.

COMMON TOOLS

Compost

Crop Rotations

Cover Crops

No GMOs

THE DIRECT IMPACTS *of* INDUSTRIAL AGRICULTURE *on* HUMAN HEALTH

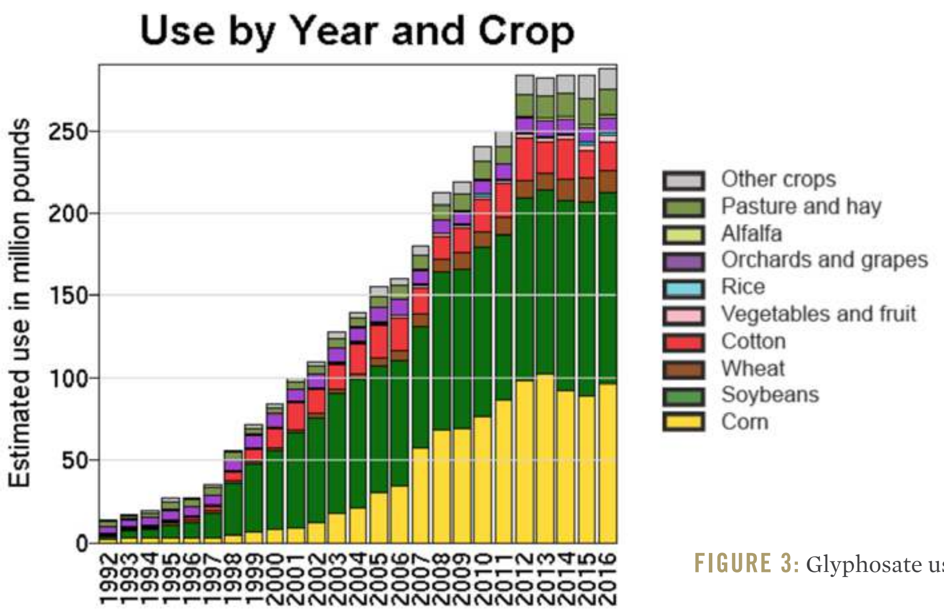

FIGURE 3: Glyphosate use by year and crop, USGS 2016

Toxic exposure from pesticides

- The EPA reports that "More than a billion pounds of pesticides are used in the U.S. each year to control weeds, insects, and other organisms that threaten or undermine human activities.[111] Some of these compounds can be harmful to humans if ingested, inhaled, or otherwise contacted in sufficient quantities."[112]
- Studies show that exposure to pesticides may increase the risk of dementia, Alzheimer's, cancer, and other chronic conditions that are more prevalent today than ever before.[113-119]
- Exposure to glyphosate, the most commonly and intensively used herbicide worldwide and the active ingredient in Bayer's Roundup formulation, has also been hypothesized to contribute to conditions including immune system damage, kidney and liver damage, and Hodgkin's Lymphoma.[120-123]
- Glyphosate was classified by the World Health Organization's International Agency for Research on Cancer as a probable carcinogen in 2015.[124-128]
- More than 250 million pounds of glyphosate are applied on crops each year.[129]
- Glyphosate has become ubiquitous in our food supply; one study found glyphosate residue in 39 out of 44 restaurant food samples.[130]

Air pollution

- Air pollution is a major concern for public health and has been linked to endothelial cell dysfunction, oxidative lung damage, vascular inflammation and exacerbations of asthmatic conditions.[131-133] According to the WHO, worldwide ambient air pollution causes 16% of lung cancer deaths, 25% of COPD deaths, 17% of deaths from ischemic heart disease and stroke, and 26% of respiratory infection deaths.[134]
- Agriculture and factory farming practices are top contributors to global emissions and ambient air pollution: Bauer et al state that "In the past 70 years, global ammonia [nitrate] emissions have more than doubled, from 23 Tg/yr to 60 Tg/yr. This increase is entirely attributed to NH_3 emissions from agriculture, with N fertilizer use contributing 33% and livestock production 66%."[135]

Antibiotic resistance

- The spread of antibiotic resistance through conventional agriculture represents a significant threat to the future of human disease control.
- **Of all antibiotics sold in the United States, 80% are sold for use in animal agriculture.**[143] 58% of those are excreted into the environment and more than half end up in the soil.[144]
- 70% of those drugs are "medically important," meaning they overlap with drug classes important to human medicine.[145]

80% of all antibiotics sold in the U.S. are used for animal agriculture— particularly in feedlots were animals are crowded and disease spreads quickly. This use of antibiotics for animals is contributing to antibiotic resistance in humans.

Water pollution

- Fertilizers, herbicides, insecticides and fungicides pollute waterways when they are washed off fields during rain events or through groundwater leaching.

- In a study of four American agricultural watersheds, the herbicides atrazine and metolachlor were found in every single rainfall sample; dacthal, acetochlor, simazine, alachlor, and pendimethalin were detected in more than 50% of the samples.[136]

- Research from Rodale Institute has shown that conventional farming practices leach atrazine, a known endocrine-disruptor in amphibians, at a rate of nearly 3ppb into the water table (see Figure 4).[137]

- Neonicotinoids, the most widely used insecticides in the world, are commonly found in surface waters across North America; common water treatment processes like chlorination interact with neonicotinoid metabolites, creating potentially even more potent and harmful compounds in drinking water.[138]

- Nitrate pollution in groundwater can cause restriction of oxygen to the bloodstream, leading to methemoglobinemia, or "blue baby" disease.[139] Infants are most vulnerable.

- Chemical nitrogen fertilizers and animal manure are the primary sources of nitrogen and phosphorus pollution of surface and groundwater, according to the EPA.[140-141]

- USGS surveys of surface water, well water, soil, and rain find over 70% of samples are contaminated with glyphosate or its derivative, AMPA.[142]

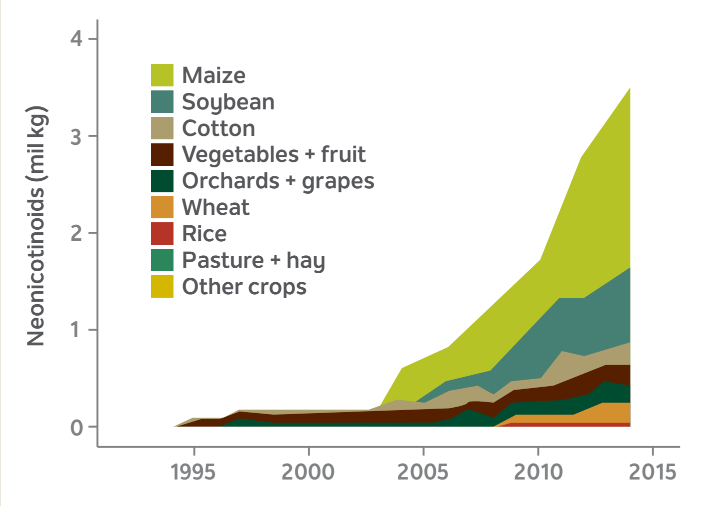

FIGURE 4: Neonicotinoid use by crop from 1992 to 2014. The y-axis represents mass of neonicotinoid active ingredient applied in millions of kg. Tooker, Douglas, Krupke, 2017, doi:10.2134/ael2017.08.0026, CC BY-NC-ND

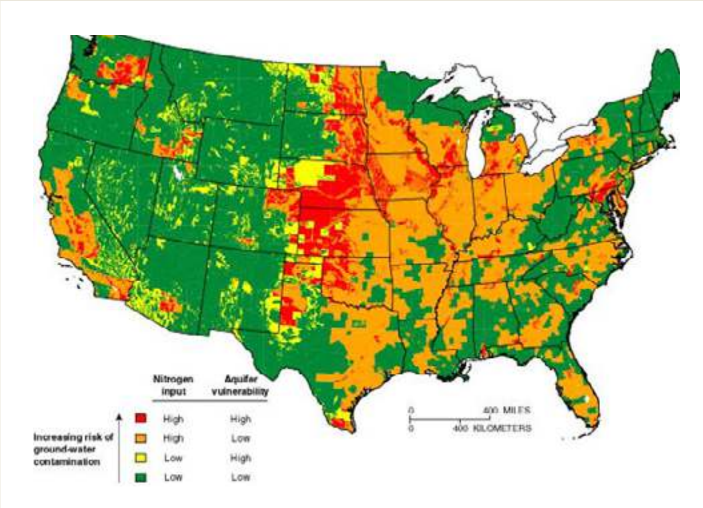

FIGURE 5: Risk of nitrate groundwater pollution. From *USGS Circular 1225, The Quality of Our Nation's Waters.*

Agriculture runoff pollutes waterways, causing Dead Zones, which both kills aquatic life and threatens drinking water.

SECONDARY EFFECTS *of* INDUSTRIAL AGRICULTURE *on* HUMAN HEALTH

The effects of industrial farming on soil

- Conventional practices including monocropping (planting the same crop on the same plot of land year after year), repetitive deep tillage, the application of synthetic fertilizers and pesticides, and the absence of living ground cover or cover crops all contribute to the destruction of biodiversity below ground.
- Fewer microorganisms in the soil compromise nutrient delivery to plants, resulting in weaker plants that are more susceptible to infections and pests, requiring the use of synthetic fertilizers to grow to maturity. The result is increasing dependence on synthetic inputs that require the burning of fossil fuels to create and apply, increased emissions from the soil, reduced soil carbon stores, and the destruction of soil life, leading to reduced soil structure and exacerbating erosion.
- Soluble, salt-based fertilizer use leads to increased soil mineralization and loss of soil carbon over time.[146-148]
- 30% of the world's arable land has become unproductive in the past 40 years due to soil erosion.[149]
- Soil is being lost 10 to 40 times faster than its being replaced.[150]
- By 2050, soil erosion may reduce up to 10% of crop yields, the equivalent of removing millions of hectares of land from production.[151]
- It takes at least 100 years to build an inch of topsoil, and much less time to lose it.[152] Conventional agriculture, on average, erodes soil by about 1 mm/yr, a rate 1.3-1,000x greater than natural erosion under native vegetation, and can erode soil at much faster rates under some conditions.[153]
- Soil is the source of more than 95% of our food[154] and much of our clothing, building material, and antibiotics (about 78% of antibacterial agents and 60% of new cancer drugs approved between 1983 and 1994 had their origins in the soil, as did about 60% of all newly approved drugs between 1989 and 1995).[155]
- Some hypothesize that a decrease in the diversity of microorganisms in the soil driven by industrial farming methods could also contribute to loss of diversity in the human gut microbiome, decreasing immunity and contributing to chronic conditions.[156]

The effects of industrial farming on biodiversity

- The application of biocides can directly deplete populations of beneficial insects, including honeybees—one teaspoon of a neonicotinoid, commonly used in conventional applications, is enough to deliver a lethal dose to 1.25 billion honeybees.[157]
- It is now estimated that 40% of the world's insect species face extinction over the next several decades, and land conversion for the production of food is the single most important driver of biodiversity loss now, presaging mass species extinctions across the world.[158-161]
- Threats to biodiversity are then a threat to the economy, since biodiversity is crucial to the ecosystems on which humans depend, including farming and forestry—the annual economic and environmental benefits of biodiversity in the United States total approximately $300 billion.[162]
- A significant decline in insect populations would severely affect humankind's ability to feed ourselves, as one third of the world's food crops are dependent on insects (and to a lesser extent birds and bats, which are also in decline) for pollination.[163]

Industrial agriculture is hurting pollinators—who are responsible for 1 in 3 bites of food that we eat.

INDUSTRIAL AGRICULTURE *and* NUTRIENT-DENSITY

More than half of the world today suffers from "hidden hunger," a condition defined by a deficiency of micronutrients despite adequate daily caloric intake.[29-31] Such "hidden hunger" may be partly responsible for the rise in chronic diseases in the U.S.,[32] since we rely on the vitamins, minerals, protein, and bioactive compounds in our food—not calories—to prevent disease. Agricultural production goals focused mainly on maximizing crop yields have led to a significant decline in nutrient concentrations over the last 50-70 years.[33-36] An assessment of the nutritional concentrations of 43 crops, mostly fruits and vegetables, from 1950 to 1999 revealed a decline in most nutrients.[37] Six key nutrients—protein, Ca, P, Fe, riboflavin, and vitamin C—significantly declined between 6% to 38%.[38] The same study also revealed higher water and carbohydrate concentrations in our food.

More than half of the world population suffers from undernourishment of nutrients critical for maintaining proper health.

While grain yields have more than doubled in this time period,[39] grain protein concentrations have declined significantly—wheat, rice and barley as much as 30%, 18% and 50% respectively.[40-42] This suggests a "dilution effect," an inverse relationship between yields and a measured nutrient. Such an effect is reason for concern, as more than half of the world population suffers from undernourishment of nutrients critical for maintaining proper health,[43] and grain products constitute a significant portion of many diets.

More recently, climate change—driven, in part, by emissions from the production and use of agricultural fertilizers, herbicides, and pesticides—has been implicated in driving crop nutritional declines.[44] Macrocosm studies that control carbon dioxide levels over rice fields found that increased atmospheric CO_2 levels reduced the concentration of protein, iron, zinc, and B vitamins.[45] Considering the health implications of a continued decline in crop

The food we eat is less nutritious than it was 50-70 years ago, in part, due to industrial agriculture practices.

nutritional density, agricultural production goals will need to shift from a sole emphasis on yield to a more integrated emphasis on crop quality. Regenerative organic agriculture and its emphasis on soil health supports this shift.

This link between soil health and human health is largely unexplored and must be advanced.

Perhaps the greatest factory of bioactive compounds critical for human health lies in the soil and the plants that grow in that soil.[46-47] Soil bacteria and fungi synthesize medically important compounds. Some of these compounds can be extracted from the soil and used directly—78% of antibacterial agents and 60% of new cancer drugs approved between 1983 and 1994 had their origins in the soil, as did about 60% of all newly approved drugs between 1989 and 1995.[48] Some of the compounds synthesized in soil are transported to plants, where they can be consumed by humans—ergothioneine, for example. Other compounds interact with plants in other ways, increasing plant production of bioactive phytochemicals that, when consumed, have been implicated in the prevention and reversal of cancers, diabetes, hypertension, heart disease, neurodegenerative disease.[49-50] These phytochemicals also play a critical role in immune function.[51] Organically managed soils contain higher levels of microbial diversity and organically produced foods possess higher levels of bioactive phytochemicals[53-54] than conventionally managed soils and foods. This link between soil health and human health is largely unexplored and must be advanced.

Two long-term studies that measured bioactive compounds in vegetables grown using organic and conventional management have yielded interesting results. A six-year study at the Teagasc Field Research Center in Dublin, Ireland found higher levels of flavonoids, anthocyanin, and antioxidant activity in two onion varieties grown organically.[55] At the University of California, ten years of comparing organic and conventional systems showed that organic tomatoes had higher anti-cancer flavonoids[56] and immune-boosting alpha-tomatine[57] content than conventional, and these markers tended to increase over time, suggesting that as the soil improved with organic management, bioactive compound levels increased.

At Rodale Institute in Pennsylvania, two long-term trials exist. The Farming Systems Trial, begun in 1981 and active today, is a side-by-side comparison of two organic systems and one conventional system, all growing common cereal crops. Preliminary assessment of the nutrient concentrations in oats grown in the trial have found that 7 of 13 minerals measured were significantly greater in organic legume, no-till systems compared to conventional.[58] The Vegetable Systems Trial, 2017-present, is specifically designed to test nutrient concentrations in leaf, root, and fruit vegetables grown in the different systems for twenty years or more. While there is no refuting that organic foods pose lower human health risks than conventionally grown foods due to reduced pesticide residues, heavy metals, and nitrates,[59-60] more peer-reviewed research is needed to verify and quantify the link between soil health and human health. These trials, along with other controlled field trials, are the starting point to begin discussing how soil health and production methods impact nutrient-density and human health.

In the meantime, there are actions we can take proven to improve health outcomes for both people and the planet.

Rodale Institute's Farming Systems Trial, which has compared organic vs. conventional farming methods since 1981, has found differences in nutrient concentrations, such as minerals, depending on how the crops were produced.

SOLUTION 1: THE POWER *of the* PLATE

The composition of our collective plates matters, and the global crisis of non-communicable, lifestyle-related disease is solvable with the right dietary intervention. Shifting to a predominantly organic, whole foods, plant-based plate can:

1. Provide the body with all necessary vitamins, minerals, fiber, macronutrients and antioxidants to maintain health, build immunity, and prevent, suspend and often reverse lifestyle-related diseases.

2. Reverse the epidemic of chronic, non-communicable disease. Research from the Imperial College of London found that approximately 7.8 million premature deaths around the world could be prevented if people consumed 10 servings of vegetables and fruits every day.[61]

3. Prevent, suspend and potentially reverse cardiovascular disease, the number one cause of death globally. Randomized trials utilizing a whole-food, plant-based lifestyle treatment intervention have demonstrated dramatic 91% reductions in chest pain. Between 82% and 91% of patients showed a trend toward regression in artery narrowing, and reperfusion of heart muscle was seen in three weeks.[62-63] Participants with the greatest adherence saw the greatest degree of improvement; participants who had adherence of 50% or less did not see any significant changes.

4. Prevent, suspend and reverse the epidemic of type 2 diabetes. Type 2 diabetes improves rapidly with diet changes, and in many cases, goes into remission. Studies have demonstrated that in just 4 weeks on a whole food plant-based diet, 44% of patients on insulin and 74% maintained on oral medications were able to discontinue the medications.[64]

5. Powerfully reduce inflammation,[65-66] help heal IBS/IBD, more effectively reduce weight than any other dietary lifestyle,[69-70] improve autoimmune diseases like rheumatoid arthritis,[71] prevent acne,[72] enhance mood,[73-74] reduce and resolve allergies,[75-76] prevent constipation,[77] reduce asthma,[78] improve PCOS,[79] prevent dementia,[80] reduce arthritic pain,[81-82] dramatically improve kidney and chronic kidney disease impairment,[83-84] and significantly reduce the risk of colon and other cancers.[85-88]

6. Cultivate a diverse microbiome. Healthy soil and the human gut are comprised of a diverse population of trillions of bacteria that optimize growth, protection, and health. Diets comprised of a wide variety of organic plants support a healthy microbiome and promote the growth of a variety of microbial species through the digestion of fiber and the unique biomes of fresh fruits and vegetables.[89-90] Optimized populations of bacteria have been shown to prevent weight gain, reduce inflammation, improve gut tight junctions, and reduce the risk of disease.[91] Living in relationship with organic ecosystems enhances microbiome diversity and has been associated with improved immune function.[92-93]

7. Optimize immune function. The Covid-19 pandemic galvanized the need for a healthy immune system. Dietary patterns that are predominantly plant-based have been shown to enhance immune function and lower systemic inflammatory levels.[94] Polyphenols, a group of more than 8,000 bioactive compounds in plants, promote improved immunity to a variety of pathogens and activate important signaling pathways to initiate immune responses. Some polyphenols like curcurmin and EGCG can induce epigenetic changes that enhance immune function.[95] Further, the fiber in plants enhances the growth of synergistic bacterial populations in the microbiome that epigenetically “turn on” key immune cells and “turn off” key inflammatory switches, thus improving the overall health of the immune system.[96-97]

8. Provide the greatest opportunity for rapid change globally. The global population consumes 11.5 million calories per minute.[98] If enough people made a significant shift in their daily purchasing and consumption habits towards a predominantly organic, whole-foods, plant-based plate, we would experience a regenerative revolution of health for the soil, people, and the planet.

SOLUTION 2: REGENERATIVE ORGANIC AGRICULTURE

Regenerative organic agriculture is more than a set of agronomic principles—it is a holistic approach to farming that encourages continuous innovation and improvement of environmental, social, and economic measures. Regenerative organic farming necessarily includes the welfare and health of animals and mankind.

Regenerative organic agriculture aims to improve ecosystem and human health through several basic principles:

1. Eliminate the use of toxic, synthetic inputs like fertilizers and herbicides, thus eliminating the potential harm caused through exposure via diet, air, water, and occupational exposure.

2. Diversify crop rotations, promote on-farm biological diversity, and institute strategies to manage insect, disease, and weed pressures that reduce or eliminate the need for chemical inputs.

3. Maximize soil coverage and biodiversity through cover cropping, permanent perennial agriculture and integrated livestock systems to maintain and improve soil health, thereby ensuring our ability to feed a growing population long into the future.

4. Increase soil organic carbon levels, resulting in greater soil structure and water-holding capacity to maintain crop production during periods of climate uncertainty. Measurements of crop yields and soil/water relationships over more than ten years at the Rodale Institute Farming Systems Trial report between 35% to 96% higher corn and soybean yields in the organic systems than the conventional comparison during periods of drought.[99] This was attributed to greater water capture during rainfall events (less runoff and erosion) and increased soil water holding capacity.

5. Support the growth of diverse microbial populations in the soil through natural soil fertility measures such as compost and green manures, reducing pest pressure and boosting plant bioactive compounds known to provide substantial health benefits and help combat chronic disease.[100-103]

6. Adopt pasture-based farming systems to improve nutrient cycling and allow innate animal behavior and grazing on living grass and forage, leading to less animal stress and more nutritious animal products.[104-107]

7. Use productive farmland to grow food and fiber for people and not for inefficient bio-fuel production, which diverts nutrients into combustible engines and ultimately greenhouse gases.

8. Promote and establish conservation practices to protect vulnerable waterways and the aquatic and terrestrial life that depend on those bodies of water. Regenerative organic agriculture places inherent value on wildlife and habitat management as measures to mitigate pest outbreaks, provide ecosystem services such as carbon storage and air pollution mitigation, and support sources of highly nutritious food.

9. Provide a meaningful source of income for farmers and support rural and urban communities.

HOW TO CREATE *the* CHANGE

It's not enough to consider what we eat—we must also consider how it was produced. The way our food is grown and raised impacts not only our cellular health and immune systems; it has the potential to either harm or regenerate people, families, communities, and entire ecosystems. Regenerative organic farming offers a profound shift in the right direction. Challenges to implementing regenerative organic farming on a significant scale include social barriers, technological barriers, a lack of long-term research studies, and lack of education for the public and medical professionals. But challenges are not insurmountable.

As medical professionals and agricultural experts, we recommend the following actions to create meaningful change in our food and healthcare systems:

1. **Emphasize education and collaboration.** Medical professionals need more education on nutrition and the positive impacts of an organic, whole-foods diet based on human health and regenerative organic farming methods. Farmers need more education on regenerative organic techniques and the potential for the food they grow to contribute to revitalized human health. Consumers need more education on how nutrition impacts their health, how farming practices impact the items most readily available to them, and how their buying habits will influence the quality and availability of future resources. Policy makers need to support governmental programs and policies that encourage positive change instead of subsidizing suboptimal practices. Medical professionals and farmers don't have a collaborative history, but the time is ripe for them to begin a conversation to identify key initiatives and collaborative opportunities. Rodale Institute and the Plantrician Project aim to foster such collaboration and education with the creation of the Regenerative Health Institute, an innovative facility dedicated to cultivating relationships between farmers and doctors and directing new research in soil and human health. Learn more about the initiative at RegenerativeHealthInstitute.org.

2. **Integrate nutritional education into the medical education curriculum** beginning in year one. The University of South Carolina Medical School Greenville incorporated lifestyle medicine and clinical nutrition into their four-year curriculum and are producing skilled physicians that utilize a food- and lifestyle-medicine approach to chronic disease. Provide evidenced-based educational opportunities, like the global suite of Plant Based Nutrition Healthcare Conferences sponsored by The Plantrician Project, for active healthcare providers to learn the science of plant-based nutrition and key implementation strategies and tactics.

3. **Educate consumers** on the comprehensive impact of their food purchases on their health and the health of their loved ones and the stewardship of invaluable, limited resources like soil and water. Encourage consumers to purchase more products from local farms and talk to their healthcare providers about an organic, whole-foods diet as a meaningful prevention of and intervention for lifestyle-related conditions.

4. **Implement more localized, integrative health initiatives**, such as Geisinger's Fresh Food Farmacy, St. Luke's University Health Network Rodale Institute farm partnership, and the M Clinic in Virginia. An increasing number of medical institutions and hospitals are implementing programs that focus on increased patient access to fresh fruits and vegetables as part of improving health measures. Such programs include 1) cash-back rebate programs for fresh fruits and vegetables, 2) fruit and vegetable prescription voucher programs, 3) garden-based programs, 4) subsidized food boxes/community supported agriculture (CSA) programs, 5) home-delivery meal programs for at-risk patients, 6) community gardens at healthcare locations, 7) collaborative food pantry-clinical programs, and 8) hospital meal programs that utilize locally grown food. Programs that provide patients with better access to fruits and vegetables appear promising, with early studies documenting significant improvements in health outcomes and cost savings.[108-110]

5. **Incentivize medical professionals** to implement lifestyle-medicine practices and disincentivize chronic disease management through innovative payment models.

6. **Fund more research for specialty crops and organic farming** to help shift production to a greater emphasis on fruits, vegetables, pulses, and whole grains. Today's food system was significantly shaped by government funding and federal initiatives in the late 19th and throughout the 20th century. More funding for research on organic and specialty crops would incentivize improved technology, lower costs and improve access.

7. **Incentivize organic and regenerative organic methods.** Currently, the federal government subsidizes and insures conventional commodity crops. Instead of incentivizing methods that continue to fail, state and federal programs should instead incentivize resilient agriculture, which is the best insurance. Move federal funding to incentivize farmers to capture carbon and provide other benefits through regenerative organic methods. Additionally, incentivize fruit and vegetable production.

8. **Provide increased financial and institutional support for farmers transitioning to organic and regenerative organic practices.** Examples include paying farmers for ecosystem and carbon sequestration services, providing grants and loans specifically for organic and regenerative organic farmers, building infrastructure like certified organic grain elevators, training more organic inspectors, and providing grant funding for young farmers beginning regenerative organic operations.

9. **Encourage food companies to support regenerative organic farmers**, for example by partially funding certification costs, paying premium rates during the transition period from conventional to organic, providing long-term contracts to farmers, and providing markets & infrastructure for distributing more regenerative organic products.

Now is the time to take action to create a radical shift in the way we grow food and protect human and planetary health. Human health is achieved not with more prescription pills; it's created by harmonizing the system through a healthy diet and lifestyle. **Health begins with food, and healthy food begins in the soil.** Healthy soil is achieved not with expensive synthetic inputs; it's created by harmonizing natural systems.

We are collectively facing an epidemic of diet- and lifestyle-related disease that is eroding individual health and straining the budgets of healthcare systems and businesses around the world. Simultaneously, we are depleting precious, limited resources like soil, water, and the environment to feed a growing population an industrialized diet that will only perpetuate the cycle of global degeneration. The answer is a regenerative vision for the future inspired by collaboration, evidenced-based solutions, and the miraculous interconnectedness of soil, plants, people, and the planet.

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611 Siegfriedale Road, Kutztown, PA 19530
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