Analytic Review

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Food Revolution

Abstract: *Recent research has found important links between poor dietary choices, a toxic food environment, and high national and global burdens of chronic diseases. These findings serve as an impetus for a Food Revolution. The Gardner Nutrition Studies Research Group, along with a diverse range of collaborators, has been focusing on solution-oriented research to help find answers to the problems that plague the current food system. Research topics include (1) a recently completed weight loss diet study contrasting Healthy Low-Fat to Healthy Low-Carbohydrate diets among 609 overweight and obese adults; (2) a quasi-experimental study conducted among Stanford undergraduates that examined social and environmental, rather than health-focused, motivations for dietary change; (3) links between dietary fiber, the human microbiome, and immune function; and (4) ongoing collaborations with university chefs to create unapologetically delicious food for campus dining halls that is also healthy and environmentally sustainable. Most of these approaches emphasize plant-based diets. The decreased consumption of animal products has created some concern over the ability of one to obtain adequate protein intake. Evidence is presented that adequate protein is easily obtainable from vegetarian, vegan, and other diets that contain significantly less meat and fewer animal foods than the standard American diet.*

Keywords: food; chefs; stealth nutrition; weight loss; microbiome; protein

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Introduction

Food, health, and lifestyle medicine have garnered significant interest in recent years by researchers and the public. Chefs have become celebrity figures, and food bloggers have become cultural icons.[1] There is an endless stream of media features on food and countless sources of recipes both in print and online.

Part of this is a result of some terrifying urgencies. The US economy is being crippled by health care costs, largely driven by the treatment of lifestyle-related diseases. Unless changes are made quickly, these costs are projected to increase from 17.5% to 20.1% of the GDP by 2025.[2] In fact, poor diet has been identified as the most important risk factor for morbidity and mortality, owing largely to its contributions to heart disease, diabetes, stroke, and some cancers.[3] Obesity has become one of the top public health crises of the current age. The term *adult-onset diabetes* has been replaced by *type 2 diabetes* because more than 200 000 children with obesity in the United States currently have the disease.[4]

The perils of excessive consumption of heavily processed and fast foods are becoming more evident. The Dietary Guidelines Advisory Committee Report identified dietary patterns high in refined grains, saturated fats, added sugars, and sodium as the most problematic.[5] Sugar has been packed into every imaginable processed product, even foods traditionally designated as healthy, such as yogurts, oatmeal, and granola bars. This is because sugar is one of the ingredients that makes foods and beverages hyperpalatable—contributing not only to increased sales for the companies who manufacture them, but also to overconsumption and weight

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gain, among other medical problems.[6,7] Packaged, processed, convenience foods of low nutritional quality have begun to be referred to as “edible, food-like substances” rather than foods.[8] Investigative journalists have published eye-opening explorations of the food industry’s development of ultraprocessed, hyperpalatable foods that manipulate consumers into overeating and, therefore, increase profits.[9,10] Screamin’ Green Go-gurt, a neon-green, sugar-sweetened, tube of yogurt that one squeezes directly into the mouth, is one example that is directly marketed to children.[11]

This dramatic shift in our food culture has led many to question the benefits versus the risks of our current food system. The web of factors that determine what we eat is so intertwined with the way that we live our modern lives that it is too late to try and simply tweak things around the edges. To stop, and reverse, the devastating effects that our national diet is having on our health, happiness, and economic well-being, sweeping changes are needed. It’s time for a Food Revolution!

This review of the keynote presentation that was delivered at the American College of Lifestyle Medicine Annual Meeting in October 2016 highlights a number of studies, projects, and movements under way that are helping to address the challenges facing nutrition in the country and provide innovative solutions that accelerate needed changes to the food system.

State of the Nation’s Health and Food System Contributors

Recent studies published in the *Journal of the American Medical Association* and the *New England Journal of Medicine* helped reinforce what has been known for decades—diet matters.[3,12] In a report on the state of health in the United States, “dietary risks” topped the lists of the 17 leading risk factors for both premature death and Disability Adjusted Life Years (DALYs) in 2010.[3] Four of the other top 8 risk factors on these lists were high blood pressure, high body mass index (BMI), high fasting plasma glucose, and high total cholesterol, all of which are clearly related to diet.[3] In a 2013 publication that summarized the findings of the Global Burden of Disease Study between 1990 and 2010, 8 of the top 25 risk factors for DALYs were diet related, including diets low in fruits, nuts and seeds, whole grains, vegetables, seafood omega-3s, and fiber and diets high in sodium and processed meats.[12]

The American Heart Association has set goals for cardiovascular health promotion and disease prevention for 2020.[13] Therein, the association created a set of 7 health factors for Americans to focus on: smoking, BMI, physical activity, healthy diet score, total cholesterol, blood pressure, and fasting plasma glucose. They collected data on current characteristics of Americans and provided assessments of the proportions of Americans who fall into “ideal,” “intermediate,” and “poor” categories for each of these 7 health factors. Current healthy diet scores were the worst of them all, with 77% and 23% of American adults falling into the poor and intermediate categories, respectively. Less than 1% of Americans managed to make it into the ideal category. The data were even more abysmal for children—nearly all landed in the poor category (91%), with the remaining 9% making it to intermediate. Those in the ideal category were limited to a rounding error (<0.5%).

Explanations for these concerning statistics can be found in recent books addressing the addictions Americans have developed to the ultraprocessed and hyperpalatable foods created by the food industry. Authors Michael Moss (*Salt, Sugar, Fat: How the Food Giants Hooked Us*) and David Kessler (*The End of Overeating*) describe the course of the food industry over the past century as it moved from a goal of simplifying and speeding the process of getting a meal on the table to a focus on hijacking our brain chemistry and stimulating endless appetites through the use of added salt, sugar, and fat.[10,14] The food that is grown, processed, delivered, and consumed has become an important contributor to the crippling epidemic of chronic disease in the United States and beyond. But, food can also be a solution.

DIETFITS Weight Loss Study: Healthy Low Fat Versus Healthy Low Carbohydrate

One area of research that the Nutrition Studies Research Group has been interested in is weight loss.[15] We recently completed a weight loss diet study of 609 women and men with BMIs of 28 to 40 kg/m^2 who were otherwise in general good health. The participants were randomized to either low-fat or low-carbohydrate (low-carb) diets for 12 months. However, this was not a repeat of the dozens of past trials comparing low-fat and low-carb diets. The goal was not to determine if a low-fat or low-carb diet would lead to more weight loss on average over the course of the study. Rather, the aim was to explore the wide range of variability in weight change within each diet group. Like many others, we observed from past trials[16,17] that average differences between study groups tended to be just a few pounds, whereas the ranges of weight change for individuals within the same study groups were 60 pounds or more. We also had preliminary data from our own and other studies[18-21] suggesting that there were likely predisposing, measurable differences at baseline that would predict who would do better on one diet versus another.

Our research questions centered on whether or not we could test factors that helped determine which diet is best for whom. Our primary 2 hypotheses were that degree of insulin resistance and genetic factors may predispose some to lose weight more effectively on one diet versus the other. For insulin resistance, we had hypothesized that those with greater insulin resistance would do better on a low-carb diet, whereas those with greater insulin sensitivity would do better on a low-fat diet.[18,22] In terms of genetic factors, a group of colleagues helped us identify a multilocus genotype pattern, based on 3 single nucleotide polymorphisms, which suggested that there was a genotype that would lose more weight with a low-carb diet (low-carb genotype) and one that would lose more weight with a low-fat diet (low-fat genotype).

Although the main results have yet to be published, we can share some preliminary highlights from the study. Approximately 80% of the 609 enrolled participants completed the 12-month study protocol and collectively lost more than 6500 pounds during the trial. Within both groups, weight change ranged from losing 60 pounds to gaining 20 pounds—an 80-pound range! As predicted, the average weight loss in both diet groups was nearly identical; approximately 13 pounds after 12 months. Next steps include determining if either of our primary hypotheses about insulin resistance or genetic factors were supported by the data and whether any other baseline characteristics predicted differential success on one diet versus the other.

This study—called the DIETFITS (Dietary Intervention Examining The Factors Interacting with Treatment Success) study—involved other, somewhat novel, components that we believe will be of interest to health professionals. These included how we chose to define *low-fat* and *low-carb* as well as our strategy for getting study participants to follow (ie, adhere to) the study diets. Before commencing the DIETFITS Study, a literature review suggested that even though there were dozens of previous low-fat versus low-carb studies, the definitions for these diets were variable and inconsistently followed by study participants.[23-25] Some studies used percentage of Calories from fat and carbohydrates; some used grams. Other studies prescribed energy restriction (eg, 500 kcal deficit per day compared with prestudy intake), whereas some others did not. However, the most problematic issue with past studies was when the investigators designed one of the diets to be much more different from participants' baseline diets than the other(s). This made it more challenging for one group of participants in a study to achieve dietary adherence compared with those assigned to the diet that was more similar to what they were used to eating.

Our goal was to design equally ambitious diets that moved participants as far from their habitual diets as they could while still being able to maintain the assigned diet for the study duration and beyond. The process used to carry out these goals was the following. First, the 2 diet groups were instructed to try to lower their fat or carbohydrate intake to 20 g/d or less for the low-fat and low-carb group respectively. They were asked to try to achieve these levels within the first 8 weeks of the study. After 8 weeks, they were told that they could begin to add small amounts of fat or carbohydrate back into their diets until they achieved the minimum level of fat or carbohydrate intake that they felt they could maintain long term without feeling deprived. In other words, they were asked to reach a point where they were no longer on a temporary weight loss diet, but rather on a new, habitual diet that they could potentially follow for the rest of their lives. No specific energy restriction was prescribed. We explained to participants that if they were truly hungry while trying to follow their study diets, it would be difficult for them to stick to the diet.

Another key component of the design of the study diets was an emphasis on high dietary quality. Building on a prior study conducted by our team,[21] both groups were advised to eat as many vegetables as possible and avoid or eliminate added sugar and refined, white flour products. We defined quality in a number of ways and let participants choose for themselves the best way to achieve a high-quality diet. Examples included the following: eating seasonal foods; cooking as many of one's meals at home as possible; avoiding packaged, processed foods; sitting down to meals with family and friends; and when possible, trying to choose foods that are local, organic, grass fed, pasture raised, and antibiotic and hormone free. We now refer to the DIETFITS study diets not only as low-fat and low-carb, but as healthy low-fat (HLF) and healthy low-carb (HLC). An entire article on this study design has been published and can be referred to for more details.[26]

Preliminary results related to study diet adherence are as follows. Both the HLF and HLC groups made substantial changes to their diets and achieved very different types of diets from each other. The HLF group lowered their percentage of Calories from fat from approximately 35% to 27%, whereas the HLC group increased theirs from 35% to 45%. Similarly, the HLC group lowered their percentage of Calories from carbohydrate from 45% to 30%; the HLF group increased theirs from 45% to 50%. It is important to note that these are averages and that there was a great deal of variability within each group.

Just as there was a remarkable range of weight loss success within each diet group, there was also a remarkable amount of variability in the way participants understood and implemented the diet changes that they were asked to make. Some individuals arrived at polar opposites of the quality spectrum within both the HLF and HLC groups. Nearly 6000 24-hour dietary recalls (ie, an average of about 10 recalls per participant) were collected at the main data collection time points (0, 3, 6, and 12 months) over the course of the study. From these recalls, we observed that many participants worked hard to choose their meals with intention and purpose, whereas other participants appeared to take the shortest and easiest path in trying to adhere to only the low-fat or low-carb portion of the guidelines. This latter group seemed to have missed or disregarded the concept of quality altogether. After publishing the findings of the primary study hypotheses, we plan to use the diet data collected to look deeper into factors pertaining to the understanding and implementation of the diet quality guidelines by individual participants.

Building on this observation, we offer one anecdotal conclusion from the study—a consistent refrain that we heard from the most successful study participants. Those who lost and kept off the most weight said that they "changed their relationship with food." We believe that this has a lot to do with our emphasis on diet quality, but also portions of the study intervention that focused on mindful eating and trouble-shooting tips for real life (eg, tips for eating while traveling, strategies for eating healthy over the holidays, dealing with family members who are not supportive). This qualitative portion of the study is also one that we look forward to analyzing in more detail with a diverse team of colleagues that includes health educators and coaches, behavioral psychologists, registered dietitian nutritionists, nutrition and environmental health researchers, and lifestyle medicine and culinary medicine specialists.

Paradigm Shift: Approach Health Through Stealth

For many decades, the public health and nutrition communities have focused on conducting studies to improve evidence around which foods and nutrients are best for health promotion and disease prevention. That evidence has largely been used to educate the public about the links between diet and health. However, this approach has not accounted for other potential motivators of dietary change. Although health is certainly one motivation for people choosing one food or beverage over another, there are clearly other factors involved—the most obvious being cost, convenience, and taste. The food industry has proven to be incredibly powerful and effective at creating low-cost, convenient, and hedonically pleasing foods that are often unhealthy. In the current food environment, the motivation of health promotion often loses out to these other motivations. As clinicians and public health professionals, we need more tools in our toolkits to address competing motivators. In addition to cost, convenience, and taste, social and environmental causes can be important motivators—especially for young people. Some examples include climate change, global warming, animal rights and welfare, and human labor abuses in the agricultural and fast food industries.

We refer to the focus on social and environmental motivators for dietary change while excluding an explicit focus on health as "stealth health" or "stealth nutrition." To be clear, using the word *stealth* here does not refer to any act of deception. Rather, it is a reframing of issues related to food choice, such that there is acknowledgment of some of the external and social consequences of our individual actions. For the past 8 years at Stanford, we have been teaching an undergraduate class called "Food and Society," which utilizes stealth nutrition. There is no textbook in the class. Instead, reading assignments for the class include popular books such as the *Omnivore's Dilemma* by Michael Pollan, *Fast Food Nation* by Eric Schlosser, *Diet for a Hot Planet* by Anna Lappé, and *Food Politics* by Marion Nestle.[8,27-29] Documentaries—such as *Food Inc.* and *A Place at the Table*[30,31]—and recent op-eds on food-related topics are also assigned.

The class is discussion based, rather than lecture based, and each class discussion is led by 2 students. By design, instructors choose the topics, readings, and video assignments, but the students present, discuss, and wrestle with the complexities of each topic. The grading for the class is not based on traditional quizzes, midterms, and final examinations; rather, the students write an op-ed in the middle of the academic quarter and try to get it published. Quizzes are replaced by class discussions and online blogging. For their final project, they work in small groups to create and post videos to YouTube reflecting creatively on their experience of a topic covered in class.

Consistently, we find that after 10 weeks of these discussions, many students report having made substantial changes in their food choices. In 2010, we published a quasi-experimental study where we compared the students in this class with those in 3 other health-related classes offered at Stanford.[32] Students reported experimenting with a vegan and vegetarian diets; giving up or cutting back on sugar-sweetened beverages; looking for grass-fed, pasture-raised, or antibiotic-free options and cutting back on portion sizes when they choose meat or poultry; selecting organic or non-GMO produce; thinking more about seasonal foods; asking vendors at farmers markets about social justice issues, including fair wages and safe working conditions for farm workers; and more. In comparing these findings with dietary intake, we find that virtually all the changes students reported resulted in their choosing more vegetables, whole grains, and fiber-rich foods and a more plant-based diet in general. They also ate less meat, saturated fat, sodium, and added sugar. In other words, they were making all the changes we would recommend had we focused on dietary changes to improve personal health, but their actual motivations appeared to be external and societal.

Our work in the stealth health arena is still preliminary; to date, it has mostly been done with Stanford undergraduates. This is clearly limited in terms of generalizability to the broader US population. Nonetheless, we are hopeful that this approach to improving diets and health—especially among young people—can spread. To that end, we have recently done some promising pilot work that involved using a stealth health approach at local community college and state university campuses. Other college-level educators have asked for our course materials and are currently trying to implement the class in their universities. Additionally, other researchers are exploring similar ideas and harnessing adolescent values to motivate healthier eating.[33]

Restoring Microbial Diversity: Feed your Friends

Research on the links between diet, the microbiome, and health have grown exponentially in recent years. The human gut—particularly the colon—harbors hundreds of microbial species that create a diverse ecosystem composed of trillions of microbial cells. The millions of genes encoded within the microbiome have important and wide ranging impacts on various aspects of human biology from immune status to metabolic function. Our research group has become involved in this relatively new area via a collaboration with Stanford microbiologists and immunologists, Drs Justin and Erica Sonneburg. This husband and wife team authored the recent book, *The Good Gut*.[34] In the book, the Sonnenburgs make the case that a whole food diet leads to greater microbial diversity, which in turn leads to lower rates of both communicable and noncommunicable diseases. Conversely, the highly processed Western diet, which contains far below the recommended daily allowance of fiber, is leading to a decrease in microbial diversity and may be one unifying factor in explaining the global pandemics of chronic noncommunicable diseases.

Some of the research in this field is epidemiological, contrasting the microbiome and disease rates for some of the few remaining hunter-gatherer societies of the world with populations in more developed regions. To date, most of the interventional and mechanistic research has been done in animal models, specifically gnotobiotic (germ-free) mice. The 2 dietary factors that are most likely to affect the microbiome are prebiotics and probiotics. Prebiotics are the microbiota-accessible carbohydrates (also known as MACs) in the diet that are not absorbed in the small intestine and travel on to the colon. Dietary fibers fall into the prebiotic category. Probiotics are living bacteria that are present in a variety of fermented foods and beverages; commonly consumed examples in the United States include yogurt, sauerkraut, kimchi, kefir, and kombucha. Studies in mice are strongly suggestive of health benefits derived from feeding specific prebiotics and probiotics in specific doses.[35,36] However, since research findings in animal models often do not translate directly to humans, more human research is needed.

To address this gap in the research, we originally collaborated with the Sonnenburgs to conduct a substudy of DIETFITS study participants. Cross-sectional, observational data suggest that overweight adults have a compromised and less-diverse microbiome than lean adults.[37] Therefore, DIETFITS study participants were asked to provide stool samples before and after experiencing weight loss. Participation in this substudy was optional, and follow-up collection was offered to all who provided baseline samples. Given the general aversion to dealing with stool, we were surprised that approximately 80% of applicable participants completed sample collections. Final analyses are not yet complete, but preliminary data suggest that changes in diet and/or changes in weight lead to changes in the microbiome.

The Gardner and Sonnenburg labs have now submitted several grant applications to the National Institutes of Health (NIH) to continue this line of investigation and have obtained other funding to initiate additional pilot studies. Shared objectives include examination of different types and doses of various prebiotics and probiotics in distinct populations (eg, children with allergies, adults who are overweight or obese, and older adults with elevated markers of inflammation) and determination of the parameters of immune function that respond to these manipulations. The treatment protocols in these pilot studies include efforts to maximize either fiber-rich (prebiotic) or fermented (probiotic) foods in the diet. We are also looking at adding additional study arms that would receive prebiotic or probiotic supplements, so that we can study the impacts of food versus supplements on the microbiome and immune function. Taking this a step further, we are also eager to explore the effects of different types of prebiotic (ie, single-fiber types vs mixed fibers) and probiotic (ie, single strains of bacteria vs mixed strains) supplements.

The results of most of these studies will not be available for several years. It will take even longer for enough studies to be published in the scientific literature to allow for a comprehensive review to determine which types and doses of dietary changes and/or supplements are most important for different health outcomes. Even though there are many other researchers currently studying dietary impacts on the microbiome and immune function, the field is still in its infancy. One should be wary of claims for supplements and products that will miraculously heal through their impact on the microbiome; most claims currently go beyond the data available to support them.

Less concerning are fiber-rich and fermented foods, which are generally health-promoting foods, whether or not they change the microbiome. This makes these prebiotic and probiotic foods particularly interesting from a research standpoint—not only because of their healthfulness, but because they also feed into an overall interest in identifying novel motivators for making dietary changes. If the public becomes interested in their microbiomes—and we have seen from the DIETFITS substudy that many are very interested—then, this interest could translate into people consuming more fiber-rich and fermented foods. These changes are well aligned with our other strategies for promoting more plant-based diets rich in whole foods. Recall that the intestinal microbiota work symbiotically with the person harboring them to promote human and microbial health. As the Sonnenburgs tell their daughters at meal times (as they fill their plates with a variety of fiber-rich and fermented foods), "while you are feeding yourself, don't forget to feed your friends."

Chef-Driven: Unapologetic Deliciousness and the Protein Flip

Earlier in this piece, taste was mentioned as one of the obvious motivators for individual food choices. Sadly, public perceptions of taste and health have gone in opposite directions over the past few decades. In other words, when people hear about a new, healthy food option, they are likely to assume that it will taste bad. Sometimes, even those in the public health field are complicit, being almost apologetic that healthy food does not taste as good as unhealthy food. That is a problem.

The solution to this problem is not likely to be found in the offices or on the laptops of nutrition scientists, epidemiologists, or primary care physicians. For an answer to how we get people to eat healthy food, why not turn to those equipped with the skills to make any dish unapologetically delicious? An increasing number of chefs have stepped up to the plate and offered to collaborate with health professionals. Chefs are trained to apply their craft and artistry to create great-tasting food of all kinds.

The Culinary Institute of America (CIA), one of the top culinary schools in the United States, is now collaborating with scientists, health professionals, and food service leaders to create menus that are delicious, healthy, and environmentally sustainable. In 2012, the CIA partnered with the Harvard T. H. Chan School of Public Health to create the industry-changing initiative, Menus of Change: The Business of Healthy, Sustainable, Delicious Food Choices (MOC).[38] The primary target audience is the food industry. An overall mission of the group, as described by Greg Drescher, the Vice President of Strategic Initiatives & Industry Leadership, is to "elevate the unapologetic deliciousness of food."

Early stages of this initiative involved creating the Scientific and Technical Advisory Council and the Sustainable Business Leadership Council to develop their core principles, *Principles of Healthy, Sustainable Menus*.[39] These include 12 operational principles (eg, buy fresh and seasonal, local and global; focus on whole, minimally processed foods) and 12 nutrition principles (eg, serve less red meat, less often; reduce added sugar and cut the salt). These MOC councils also work together each year to publish the *Menus of Change Annual Report*, which "outlines the industry's progress on critical issues at the intersection of public health and nutrition, environmental sustainability, and business."[40] The report also highlights case studies of companies who have successfully combined sustainability and profit. The CIA and their partners are demonstrating a successful strategy for improving the healthfulness of food produced by the food industry—cook healthy, environmentally sustainable food, but lead with a focus on deliciousness.

From the research perspective, Stanford colleagues have partnered with the CIA MOC group in a spin-off called the Menus of Change University Research Collaborative (MC-URC).[41] By the time this organization entered its third year in 2016, more than 25 universities from across the United States had joined. To be included, each university had to agree to open its dining halls to students and faculty to use as living laboratories. This required partnerships with university dining administrators, operations personnel, and chefs.

One theme that the MC-URC has focused on recently is the "protein flip."[42] The general idea behind the protein flip is to move away from plates centered on animal proteins and instead create dishes focused on plant foods; any animal proteins used are for garnishes and side dishes only. When Greg Drescher describes this to food service groups, he explains that rather than offering separate vegetarian and meat-centric menus, why not lead with globally inspired, chef-created, plant-based dishes that include animal foods but in much smaller amounts than are typically served. For those who prefer a meatless meal, just leave the animal foods off completely without diminishing the overall quality of the meal.

The chefs at MC-URC universities are currently designing menus aligned with the protein flip concept and the *Principles of Healthy, Sustainable Menus*. In addition, students, guided by faculty and supported by university dining services, are starting to conduct small, iterative, design-thinking research projects—such as investigating what percentage of a hamburger can be replaced with mushrooms, other vegetables, and whole grains and still achieve equal, or improved, flavor compared with traditional burgers. These gastronomic creations are served in dining halls across the country and evaluated by fellow students.

Beyond the protein flip concept, other target areas for the MC-URC group include food waste reduction, creation of teaching kitchen courses, and metric development in order to accurately assess the changes being tested in the dining halls across the country. As these projects develop and as research is conducted and completed, it is the intention of the MC-URC group to post study designs, research results, and best practices on the website. Both the MOC and the MC-URC websites already contain a significant amount of content that would be of interest to anyone interested in the idea of motivating healthy dietary changes through a focus on elevating the unapologetic deliciousness of food.[38,41]

Protein Myths

The topics discussed up to this point are all important components of the varied, interconnected, and complementary research projects and objectives of the Nutrition Studies Research Group at Stanford.[15] The underlying theme common to all of them is to move individuals to more plant-based diets. A reaction that often follows discussions of plant-based diets—particularly when framed as a protein-flip—is the question, "But, where will you get your protein?" To address this question, an objective discussion of protein quantity, quality, and typical protein intake is needed.

First, Americans eat more meat[43] and more protein[44] than any country in the world. These data do not take into consideration America's obsession with protein bars, shakes, and powders, not to mention the latest, and perhaps craziest, trend of all—bottled protein water.[45,46] Most people can think of at least one friend, family member, colleague, or patient who practices a vegetarian or vegan diet; yet, these individuals do not seem to be suffering from protein malnutrition. Similarly, clinicians and other health professionals would be hard pressed to recall treating any otherwise healthy and well-nourished patient for protein deficiency. So where does this protein obsession come from? The next step in the pursuit of answers is to look into national dietary recommendations.

Daily protein requirements and recommendations were established decades ago and constitute one of the fundamental questions of human nutrition. A 180-page review of the science addressing protein and amino acid requirements was published by the National Academies Press in 2005.[47] Four key points from this review will be covered here and include the following: (1) the estimated average requirement (EAR), (2) the recommended daily allowance (RDA), (3) current estimates of protein intake among Americans, and the most misunderstood of all, (4) the amino acid profiles of animal versus plant foods (ie, the quality of protein).

Starting with the EAR, the published value for this is based on body weight: 0.66 g/kg/d. This would translate to 46 g for an adult weighing 70 kg or approximately 150 pounds. Separate from the EAR, the Institute of Medicine issues RDAs that are determined by adding 2 SDs to the EAR. To explain this in context, if the EAR were the amount recommended to Americans, and if all Americans ate exactly this amount, then by definition 50% of Americans would be deficient. This is because the EAR is the estimated *average* requirement (ie, half of the population has a need below, and half has a need above, the average). By choosing to recommend a value 2 SDs above the EAR, this would mean that if all Americans achieved exactly the RDA, 97.5% would meet or exceed their true requirements and only 2.5% would be deficient. The RDA for protein for Americans is 0.8 g/kg/d. Taking the same example of a 150 pound (70 kg) person, the RDA would translate to 56 g of protein per day.

To compare requirements and recommendations with current intake, another source is needed. Nationally representative food intake data are collected by the Centers for Disease Control and Prevention through the National Center for Health Statistics, which conducts the National Health and Nutrition Examination Survey on an ongoing basis.[48] Several publications[49-52] from those data show that Americans consume an average of 80 to 90 g of protein per day. Furthermore, there is an acknowledged problem with underreporting in NHANES (about 35% for women and 18% for men), which would suggest that actual daily intake of protein may be even higher than published values.[47,51-54] Assuming that it is a reasonable conclusion that Americans consume an average of roughly 90 g of protein per day, then they are consuming nearly double the RDA. Recall that the RDA is already 2 SDs above the estimated average protein requirement. This is probably sufficient to explain why protein deficiency is a condition that is rarely seen clinically in otherwise healthy people in the United States.

The final issue to be addressed has to do with the quality of protein in different foods. There are widely held misconceptions that plant foods have very little protein and that the protein found in plants is missing specific amino acids. There are 20 amino acids that serve as building blocks for the body's organs, skeletal muscle, hair, hormones, and more. Most functional proteins in the body are made up of anywhere from hundreds to thousands of amino acids strung together in very specific sequences that are encoded in human DNA. Virtually every protein in the body contains multiple units of each of the 20 amino acids. In the process of building proteins in the body, if just one of the necessary amino acids is unavailable, protein synthesis stops and will not continue until all needed amino acids are present. Of the 20 amino acids, 9 are considered essential, meaning that they must be obtained from the diet. The other 11 amino acids can be made by the body from other precursors.

A common misperception is that all plant foods are missing one more of the essential amino acids. This is not true. In fact, all plant foods contain all 20 amino acids, including all the essential amino acids. What is potentially challenging for vegans in particular, but not vegetarians (typically lacto-ovo, meaning they consume animal products in the form of dairy and eggs), is that some essential amino acids are proportionally low in plant foods. Examples include methionine, which is proportionally low in beans relative to the body's need for methionine, and lysine, which is proportionally low in grains relative to the body's need for lysine. What this means is that if a person required 40 g of protein per day, and they only ate garbanzo beans, but ate enough garbanzo beans to get exactly 40 g of protein, they would not have met their protein needs because they would not have consumed enough methionine.

There are a couple of solutions to this protein problem. The first is to simply eat even more garbanzo beans. Even though the proportion of methionine is low, it is present, and more garbanzo beans would eventually provide sufficient methionine. At that point there would also be more than enough of every other amino acid needed for the day. The second approach would be to eat something other than garbanzo beans. It turns out that while grains are proportionally low in lysine, they are proportionally high in methionine. The converse is true for beans, which are proportionally low in methionine, but proportionally high in lysine. When consumed in the same day, these proportions complement one another, and the overall amino acid distribution of grains and beans together is more appropriate for humans then either food type alone. One would need to eat 2 cups each of boiled garbanzo beans and brown rice to meet a 40-g/day protein requirement. Although it is certainly not impossible to eat these amounts, they may be more than desirable for some. The good news is that almost every whole plant food contains protein, and this protein adds up as one consumes enough food to meet their daily energy requirement.

The caloric value of protein is 4 Calories/g. Therefore, 40 g of protein add up to 160 Calories (or kcals). The average American woman consumes about 2400 kcals/d, and the average American man consumes about 3100 kcals/d.[47,54] For the sake of this discussion, a conservative energy intake of 2500 kcals/d will be used. So 40 g of protein in a day that included 2500 kcals would equal 6.4% of calories. NHANES data, and many other sources, demonstrate repeatedly that the average American gets 16% or more of their daily calories from protein. That would be 400 kcals or 100 g of protein. At the level of 100 g of protein, the quality of the protein is insignificant because at that point, people are getting far more of every single amino acid than they can possibly use. Although animal food sources tend to have higher amounts of protein than plant food sources, this point becomes moot if an individual requiring 40 to 50 g of protein per day regularly consumes 100 g/day. The bottom line is that there is an unnecessary obsession with achieving adequate protein consumption.

Given that so many Americans exceed their daily requirement for protein, a reasonable follow-up question is, "What happens to the protein consumed in excess of what we need?" The answer is that any amino acids consumed during the day that are not incorporated into some form of functional protein in the body are broken down into their carbon skeletons and nitrogen components. The carbon skeletons are then converted to carbohydrates, if needed, and if carbohydrates are not needed, then they are converted into fat. The nitrogen components are converted into ammonia by the liver before being excreted from the body by the kidneys.

What about athletes who are trying to build muscle and who are breaking down muscle while working out? Do they need a higher percentage of protein in their diets than the average American already eats? Currently, there is not compelling data to support this. Athletes, and others who are participating in levels of physical activity that allow them to build muscle, burn more calories than those who are sedentary. Therefore, they need to eat more calories to support that activity. Elite athletes may consume in excess of 4000 Calories per day. However, without even trying to pick protein-rich foods, or eat more meat, athletes, like the general public, get about 16% or more of their calories from protein. At the 4000 kcal level, that would be 160 g of protein or about 2.1 g/kg/d for a 70-kg (approximately 150 pound) person. This level of protein intake exceeds baseline maintenance requirements. Some of the excess protein goes toward building muscle; however, surprisingly little extra protein is needed for this. Most of the excess protein is converted to carbohydrate, which fuels their high level of activity, and what remains is stored as fat.

The *Clinical Sports Nutrition* textbook recommends that endurance athletes get 1.2 to 1.7 g/kg/d of dietary protein intake, with body builders requiring 1.2 g/kg/d and elite endurance athletes, such as competitive marathon runners, requiring up to 1.7 g/kg/d.[55] However, another study comparing 3 different levels of protein intake (1.0-1.4 vs 1.6-1.8 vs >2.0 g/kg/d) showed no difference in athletic performance between the groups.[56] The most important factors for building muscle are the frequency of workouts that have the intensity and duration to break down existing muscle tissue, appropriate levels and timing of nutrient intake, and the appropriate rest times to build muscle back up, bigger and stronger.[55]

In summary, regarding dietary protein, there is ample room in the American diet to eat less protein overall and, particularly, less animal protein. It is unclear why many Americans have become obsessed with the putative health benefits of eating more protein. The data do not support this.

Summary

There have been frightening developments in the food system that have contributed to, and accelerated, the national and global pandemics of obesity, diabetes, cardiovascular disease, and cancer. The specific nutritional reasons for this are complex, but the general reason is clear: we eat too much and too often, and the foods we eat are too tasty, too convenient, and too inexpensive to resist. Turning this around will require a Food Revolution, and the time is ripe for one. There needs to be a focus on diet quality and less concern with looking for the one best, magical diet. We need to be trying to understand how different diets may be best for different people while keeping in mind that regardless of the type of diet, the benefits will increase if the diet is a high-quality one.

To motivate people to adopt healthier food behaviors, approaches to nutrition education beyond those traditionally focused on health need to be utilized. One potential approach is that of Stealth Nutrition, with its focus on the environmental and societal costs of food choices, such that the healthier food choices end up being those best aligned with personal values. Another solution is to look to microbiologists and immunologists, who can help us recognize the potential health benefits of feeding our friends, or the microbial community that lives in the gut. These microorganisms thrive on a diet rich in plant-based dietary fibers and, possibly, fermented foods. Other partners in this revolution should surely be chefs, who already know how to make food taste great. Because food that is pleasing to all of the senses is still one of the greatest of motivators for choosing what to eat, it is exciting that many chefs and food services organizations are becoming interested in linking great taste to healthfulness and environmental sustainability. Moreover, chefs are responsible for creating new healthy food movements, such as the protein flip, which put more plant-based foods at the center of the plate.

For those who are concerned that some of these changes may compromise one's health in terms of protein adequacy, the data, resources, and references provided here show that the current American obsession with protein is unfounded. The resulting confusion is leading people to eat even more meat and packaged, processed foods with added protein. This is leaving less room for wholesome, delicious, fiber-rich, plant-based foods. The links between many current dietary practices of Americans to chronic, noncommunicable diseases and a lower quality of life can be addressed here and now. Many of the answers are at our fingertips—specifically, the forks in our hands. It is time to be part of the solution. Please join the Revolution.

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Authors' Note

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