



Dietary Fat: Friend or Foe?

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For many years, low-fat diets were the cornerstone of public health and clinical guidelines for preventing and treating obesity. The US Senate Select Committee on Nutrition released the first national guidelines in 1977. At that time, *Dietary Goals for the United States* included recommendations to “increase carbohydrate consumption to between 55% and 60% of the energy (caloric) intake” and “reduce fat consumption from over 40% down to 30% of energy intake.” These recommendations were based, in part, on the idea that consuming fat promotes obesity because fat is the most concentrated source of energy in the diet. Despite limited data, the recommendation to reduce dietary fat was underscored in 1984 by an expert panel at the *NIH Consensus Development Conference on Lowering Blood Cholesterol to Prevent Heart Disease*, and again in 1987 by the National Cholesterol Education Program (NCEP). Dietary fat was viewed as a “foe” to good health from 1984 through the 1990s.

Currently, *Dietary Guidelines for Americans 2015–2020* (Eighth Edition) focus on eating patterns, and associated food and nutrient profiles, rather than on nutrient intakes. While there is no explicit limit on total fat intake, the *Guidelines* continue to advocate <10% of calories from saturated fat, consistent with recommendations in developed countries internationally. Interestingly, the daily nutritional goals and healthy eating examples, appended to the *Guidelines*, reflect an upper limit for total fat of 35% of calories, suggesting continued reluctance to promote higher fat consumption.

During the era of low-fat diets, the food industry replaced fat with refined carbohydrate in many products, such that public health messages had unintended consequences. Over the past two decades, the prudence of low-fat diets

has come under intense scrutiny, in light of emerging data from prospective cohort studies and randomized controlled trials showing adverse effects of refined carbohydrate on risk factors (e.g., increased body weight, decreased insulin sensitivity, more atherogenic dyslipidemia [higher triglyceride and lower HDL-cholesterol levels; increased small, dense LDL particles]) and health outcomes (e.g., increased prevalence of obesity, metabolic syndrome, and type 2 diabetes mellitus).

Emerging evidence indicates that low-carbohydrate, high-fat diets may be more effective than low-fat diets for promoting weight loss in patients with obesity. Nevertheless, some nutrition experts continue to advocate low-fat diets, with recommendations to consume vegetables, fruits, whole grains, and nonfat or low-fat milk as sources of carbohydrate (rather than highly processed foods). Others promote low-carbohydrate diets, highlighting beneficial effects on blood glucose and insulin levels, as well as effects on body weight. Those who take a more moderate approach argue against limiting either carbohydrate or fat but instead focus on dietary quality. They emphasize consuming minimally processed sources of carbohydrate and unsaturated fat, and restricting saturated fat. From this perspective, while saturated fat remains a “foe,” unsaturated fat is a “friend” in terms of health benefits. The quest continues to understand the health and metabolic effects of different diets, with some attention to “personalized nutrition,” recognizing that responses to any diet vary widely among individuals.

Here, nutrition experts, who have different perspectives, discuss these complex topics.

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Do you think that previous national and international guidelines, which focused on limiting total dietary fat, contributed to the explosion in obesity, metabolic syndrome, and type 2 diabetes mellitus?



Rafael Perez-Escamilla: Strong and consistent evidence supports a causal link between diets high in sugars and refined carbohydrates and the explosion of the obesity and type 2 diabetes epidemics in the US and globally. Therefore, it is reasonable to conclude that dietary guidelines that have strongly advocated for low-fat diets, and by doing so have nudged the food industry as well as consumers toward a diet low in fat and rich in sugars and other refined carbohydrates, do share responsibility for these epidemics.

by something when it was removed from food products. This something was mostly sugar, a replacement that we know does not benefit health. The unforeseen effect was that consumers often thought low-fat or fat-free also meant low-calorie and they could eat as much as they wanted. It was overly simplistic to think that reducing fat would not have an impact on other aspects of the diet, and thus there is a lesson to be learned from the fat story.



Michelle McKinley: The focus on limiting fat intake has had a few negative effects. A plethora of low-fat foods appeared on the market, and consumers focused so much on fat that they seemed to lose sight of other nutrition messages. Fat contributes to the taste, structure, and texture of food and had to be replaced

by something when it was removed from food products. This something was mostly sugar, a replacement that we know does not benefit health. The unforeseen effect was that consumers often thought low-fat or fat-free also meant low-calorie and they could eat as much as they wanted. It was overly simplistic to think that reducing fat would not have an impact on other aspects of the diet, and thus there is a lesson to be learned from the fat story.



David S. Ludwig: Beginning in the 1970s, Americans were taught that if you don't want fat *on* your body, don't put fat *into* your body. Prominent nutrition experts authoritatively speculated that fats promote overconsumption, whereas carbohydrates—all carbohydrates, including sugar—seemed to pro-

tect against it. The government's *Healthy People 2000* goals called on the food industry to market thousands of processed foods reduced in fat. And the infamous Food Guide Pyramid of 1992 in the US placed a wide variety of processed carbohydrates (6–11 daily servings!) at the base, and all fats at the top. Unfortunately, the obesity epidemic exploded during this time, although the proportion of total calories consumed as fat approached the recommended 30%. These secular trends are probably not coincidental. Multiple recent metaanalyses show that low-fat diets are inferior to all higher fat comparisons—including Mediterranean, low-carbohydrate, and ketogenic diets—for weight loss. Feeding studies of sufficient duration (i.e., at least 3 weeks, to allow for the physiological process of fat adaptation) suggest a unique metabolic benefit of low-carbohydrate diets on energy expenditure. Furthermore, refined grains, potato products, and sugar top the list of dietary variables related to weight gain and diabetes risk in high-quality prospective, observational studies, whereas foods with high energy density, like olive oil, nuts, full-fat dairy, and dark chocolate, appear neutral or protective.



Eric Rimm: The explosion of obesity over the past 50 years, starting in the 1960s in children and adults, is complex and does not have one single cause. Many lifestyle practices gradually changed over this period, but I do believe that the shift in dietary composition was fundamental to the obesity epidemic.

To achieve the target low-fat diet that was recommended by national nutrition experts in the 1970s and 1980s, many people switched to low-fat or nonfat products that were highly refined processed foods, with fat replaced with added sugar, salt, and simple carbohydrates. One could argue that fat was not to blame, but rather the food choices individuals made in replacing fat in their diets. The miracle nonfat cookie or nonfat yogurt likely did a lot more harm than good.

Alice H. Lichtenstein: One single factor is not responsible for the explosion in obesity, metabolic syndrome, and type 2 diabetes mellitus. The current rates of these disorders are more likely due to many diet and lifestyle factors that came together and resulted in the perfect storm. These include ubiquitous availability of super-sized portions of foods and beverages, remote controls obviating the need to get up off the couch, microwave ovens providing instant gratification for food cravings,



e-mail and text messages eliminating the need to stroll over to someone's desk for conversation, and the plethora of fat-free foods that masqueraded as low-calorie. So many times in the field of nutrition we have looked for a simple answer, and each time we have come up short. It's important to re-

member that all the guidelines changed from low-fat to moderate-fat around 2000. These included guidelines issued by the American Heart Association and NCEP, and the 2000 *Dietary Guidelines for Americans*. Although there was inconsistency in how the revised message was first expressed, the intent in all cases was to recognize unanticipated consequences of the low-fat message including reduced consumption of all types of fat (including healthful unsaturated fats) and increased consumption of refined carbohydrate. It is amazing that the low-fat concept is still alive and promoted by some.

How would you classify fat, as “friend” or “foe,” based on chemical structure and food source?

David S. Ludwig: Industrial trans fat, enthusiastically marketed as a healthful replacement for saturated fat in the latter half of the 20th century, is now recognized to be highly unhealthful due to its adverse effects on multiple cardiovascular disease (CVD)⁸ risk factors. In contrast, unsaturated fat lowers CVD risk factors (polyunsaturated fats are also essential nutrients). Saturated fat has a relatively neutral effect on CVD risk compared to the prevailing American diet. And in each of these categories, differences in chain length determine to some degree biological actions. Like carbohydrate, we can't characterize fat as a class as entirely good or bad.

Michelle McKinley: The polyunsaturated fatty acids linoleic acid and α -linolenic acid win the title of “friend” because they are essential fatty acids. The “foe” in fat is industrial trans fat, which is not a natural part of our diet and has only detrimental associations with health outcomes. Beyond this, we know that dietary patterns rich in poly- and monounsaturated fatty acids are positively associated with many aspects of health and should be the predominant fatty acids in the diet. With regard to saturated fat, while regarded as a “foe” for several decades, we now understand more about this fat and that the food

matrix affects the way it behaves. For example, saturated fat within the cheese matrix does not raise cholesterol concentrations.

So the food source needs to be considered; we must not lose sight of the fact that we don't eat nutrients, we eat foods. There are likely to be synergistic and antagonistic effects of nutrients on health depending on food sources and overall dietary patterns. Undoubtedly, what is important is the relative proportion of fatty acids in the diet.

Rafael Perez-Escamilla: Strong epidemiological evidence indicates that diets rich in polyunsaturated (PUFA) and monounsaturated (MUFA) fats have cardioprotective properties. However, it is important to acknowledge that isolating the truly independent effects of healthful oils is difficult given that diets rich in MUFA and PUFA also tend to be high in other cardioprotective food components, including antioxidants and fiber. By contrast, diets in which saturated fat is replaced with sugar or other refined carbohydrates (instead of MUFA, PUFA, and whole grains) increase the risk of CVD. Therefore, when it comes to fat, I associate foods rich in health-promoting oils (PUFA and MUFA), such as fish, eggs, nuts and seeds, and whole-grain products, as “healthy,” with this interpretation also supported by feeding studies with experimental designs. By contrast, the interpretation of whether diets with “excessive” amounts of saturated fat are a “foe” or “friend” is more complicated. Early studies with animal models suggested that saturated fatty acids, particularly shorter chain ones, are more likely to promote changes in lipoprotein metabolism that would favor LDL-cholesterol accumulation in the circulatory system. However, we now know that in humans the impact of saturated fat on cardiometabolic risk strongly depends on other components present or absent in the diet.

The evidence that industrial trans fat increases risk of CVD is well established; therefore, I strongly recommend consumers eliminate trans fat as much as possible from their diets. When it comes to food preparation methods, I recommend cooking with MUFA-rich oils (e.g., canola oil, olive oil) instead of fat products rich in saturated fat such as lard and butter. I also recommend limiting consumption of fried foods no matter which fat or oil is used, given the caloric density of such products and potentially harmful adducts formed during the frying process.

Alice H. Lichtenstein: Nothing in life is black and white. Unsaturated fat, with the exception of trans fat, is “healthy” fat. Some fatty acids are essential and, hence, vital for normal growth, reproduction, and maintenance. Both observational and intervention data indicate that substituting unsaturated fat, particularly PUFA, for sat-

⁸ Nonstandard abbreviations: CVD, cardiovascular disease; PUFA, polyunsaturated fat; MUFA, monounsaturated fat.

urated fat is associated with lower risk of CVD and all-cause mortality, and more favorable plasma lipid profiles. Replacing saturated fat with carbohydrate, particularly refined carbohydrate, does not confer a benefit. It is important not to conflate replacing saturated fat with carbohydrate rather than unsaturated fat, as some have done.

Eric Rimm: Another complexity of food is that few foods only have one type of fat, and types of fat rarely come from only one food. Thus, while we do in general have solid evidence that MUFA and PUFA are “friends” and saturated and trans fats are “foes,” some of the most healthful oils (e.g., olive oil, canola oil, soybean oil) also contain unhealthful saturated fat. We also know that red and processed meats are rich sources of unhealthful saturated fat, but they too are sources of MUFA, typically believed to be a healthful fat. Therefore, I much prefer to think about fats from their food sources with the understanding that we choose those foods that predominantly have the “friendly” fats and also limit consumption of those foods that contain predominantly the unhealthful fats.

What is the effect of increasing dietary fat on blood lipids and other biochemical risk factors for chronic disease? Is there reason for concern when prescribing low-carbohydrate (high-fat) diets?

Alice H. Lichtenstein: The effect of increasing dietary fat on blood lipids and other biochemical risk factors for chronic disease depends on the type of fat rather than the absolute amount of fat, the baseline fat content of the diet, a person’s metabolic status, and what the fat replaces. Increasing dietary fat, from low to moderate or high, by replacing carbohydrate for someone with metabolic syndrome will likely result in improved status: lower triglycerides and higher HDL-cholesterol concentrations. Selectively increasing dietary fat by just adding foods rich in saturated fat will likely raise LDL-cholesterol, and increasing the unsaturated fat will likely lower LDL-cholesterol concentrations if the fat replaces other sources of energy. Just increasing “healthy” fat without cutting down on other sources of energy will result in weight gain and associated adverse effects.

Eric Rimm: This is an area that has a very large body of literature from shorter-term, experimental studies to huge, long-term, longitudinal studies. Some have looked only at LDL-cholesterol and HDL-cholesterol, but others now have looked deeper within these particles to identify subcomponents of LDL-cholesterol, HDL-cholesterol, and triglycerides to highlight differences in lipid levels among diets. Basically, the evidence is really quite strong that PUFA is most beneficial because when

exchanged for equal calories from carbohydrate, it decreases LDL-cholesterol and triglycerides and increases HDL-cholesterol. MUFA is similarly beneficial, although the effects are not as strong. Saturated fat also is beneficial to HDL-cholesterol and triglycerides but also raises LDL-cholesterol, so overall it is detrimental when compared to MUFA and PUFA. Trans fat is the worst because it decreases HDL-cholesterol and increases LDL-cholesterol.

These associations are very important to bear in mind when discussing the importance of n-3 and n-6 PUFA too. Evidence from animal studies and only a few human studies has some scientists concerned over the excess consumption of n-6 compared to n-3 PUFA. I don’t agree because large longitudinal studies and experimental studies clearly show that high intake of n-6 PUFA, up to levels well beyond 10% of energy, show great benefit on lipids and reductions in CVD. Of course, there should always be ample n-3 fatty acids in the diet from marine or vegetable sources, but suggesting that ratios of n-6 to n-3 are important or limiting n-6 fatty acids just does not have an evidence base in humans.

David S. Ludwig: Increasing intake of natural (i.e., non-trans) fat consistently lowers triglycerides and raises HDL-cholesterol, relative to high-glycemic index carbohydrate. Saturated fat also raises LDL-cholesterol, a major CVD factor. However, the increase in LDL-cholesterol produced by saturated fat may be of a relatively less harmful subtype (large, buoyant lipoproteins). In some experimental models, saturated fat promotes chronic inflammation. Importantly, there is considerable individual variation in cardiovascular responses to saturated fat, and different types of saturated fat exert different effects on risk factors. Moreover, weight loss on low-carbohydrate/high-fat diets may exert dominant protective effects. For people aiming to avoid an increase in LDL-cholesterol, the benefits of a high-fat diet can be obtained with an emphasis on unsaturated rather than saturated fat (e.g., more olive oil, less butter).

Michelle McKinley: The effect of increasing dietary fat would depend on the magnitude of increase in fat, what type of fat it was, and what the fat was displacing from the diet. Replacing fat with simple carbohydrate will not improve blood lipid profile. On the other hand, replacing some carbohydrate with MUFA and PUFA may improve CVD risk profile. There is no standardization of what is termed a “low-carbohydrate” diet, making comparisons among studies in the literature difficult. Some people may find it easier to follow a diet that is lower in carbohydrate and higher in fat than current dietary recommendations. As science continues to evolve, we may find that

there is room to consider a range of fat and carbohydrate intakes that is conducive to good long-term health, with an emphasis on nutrient-rich whole foods as sources of this fat and carbohydrate (e.g., whole grains, nuts, oily fish, legumes, and dairy foods).

Very-low-carbohydrate diets, however, are extreme diets that require exclusion of foods and food groups from the diet and hence are severely lacking in fiber and micronutrients, necessitating supplement use to compensate. Such diets should not be advocated by public health or clinical professionals.

Rafael Perez-Escamilla: “Low-carbohydrate diet” is a very general and overly simplistic term that the weight loss industry continues to heavily promote given the revenues it generates. However, this term is quite vague and hence meaningless from a nutritional sciences perspective. As such, we should avoid using it as part of the scientific discourse moving forward. The impact of the carbohydrate/fat ratio of dietary patterns on weight outcomes, blood lipids, and glycemic profiles is, to a large extent, a function of the types of carbohydrate and fat involved, as well as of the presence or absence of other dietary components. For example, a “low-carbohydrate” diet rich in oily fish (e.g., salmon), nonstarchy vegetables, nuts, seeds, legumes, and whole grains, and very limited in added sugars and other refined carbohydrate is very likely to have a beneficial impact on lipid and glycemic profiles. There is also strong and consistent evidence supporting the fact that “very-low-carbohydrate” diets can lead to weight loss and improved cardiometabolic profiles (lower LDL- and higher HDL-cholesterol). However, it is important to note that there is no evidence to support the long-term efficacy, adherence, or safety for obesity management and prevention of these diets. By contrast, a diet that is relatively low in carbohydrate, but with almost all of it coming from added sugars and other refined carbohydrate, and very low in health-promoting MUFA and PUFA may not offer cardioprotective benefits at all. A similar case can be made for “low-fat” diets. A diet low in fats but rich in vegetables, fruits, and whole-grain products is much more likely to have a positive cardioprotective impact than a low-fat diet rich in added sugars and other refined carbohydrates.

Should there be an upper limit on total fat intake as a percentage of calories? If so, what is the limit and why?

Michelle McKinley: Yes, I think there should be an upper limit on total fat intake to achieve a balanced intake of other macro- and micronutrients and to alleviate risk of chronic diseases. What this upper limit should be is still a work in progress. There is some evidence to support a

more moderate upper limit on total fat intake akin to the level of fat consumed in Mediterranean regions (e.g., 40% of total energy intake); however, MUFA and PUFA should predominate.

Eric Rimm: Historically, the upper limit on total fat intake was set at 30% by the American Heart Association and the *Dietary Guidelines for Americans*. Then, in 2005, this limit was pushed up to 35%. Now, no upper limit is given for total fat, but rather for types of fat like trans and saturated fat. As presented quite well in the scientific report that gave rise to the *2015–2020 Dietary Guidelines for Americans*, there is not an evidence base for limiting total fat in the diet.

Rafael Perez-Escamilla: I strongly endorse the recommendation put forth by the 2015 Dietary Guidelines Advisory Committee (of which I was a member) to remove the concept of an upper limit for fat intake as long as individuals stay within their calorie needs. The scientific evidence clearly shows that what matters most for health is the type of fat and not the total amount of fat in the diet. Also, it is very complicated to make public health recommendations based on nutrient amounts or proportions in relation to calories for consumers, as it is confusing for most people.

David S. Ludwig: There is no biological basis for an upper limit on dietary fat. Human populations have lived for long periods eating virtually no carbohydrate, with fat as the primary source of dietary energy (for example, Inuits during winter). Ketogenic diets with up to 80% calories from fat have been prescribed to children for chronic seizure control for decades.

Should there be an upper limit on saturated fat intake as a percentage of calories? If so, what is the limit and why? What about polyunsaturated and monounsaturated fats?

Michelle McKinley: Yes, although the latest metaanalyses don't support an association between saturated fat intake and mortality, coronary heart disease, or type 2 diabetes, this does not mean an increase in saturated fat can be advocated. Most of our calories from fat should come from MUFA and PUFA, although there is a place for some foods that contain saturated fat and also provide many other essential nutrients.

Alice H. Lichtenstein: It would probably be useful to think in terms of the saturated-to-unsaturated fat ratio, possibly parsing it out by MUFA and PUFA, rather than just focusing on saturated fat. That would avoid the contemporary dilemma of the arbitrary replacement of saturated fat with carbohydrate or unsaturated fat.

Eric Rimm: As noted in an earlier discussion, individual fat types rarely are in the food supply by themselves, so I would much rather put a limit on those foods rich in trans or saturated fats to help individuals keep these fat subtypes low. For saturated fat, some have used 10% of total energy intake as the limit, and others have gone even lower, but restricting saturated fat to a very low threshold limits food choices. Therefore, I think that a healthful diet rich in fruits, vegetables, whole grains, and fish will have a saturated fat level in the 8%–10% range and, if prepared correctly, could have MUFA and PUFA combined in the 20%–30% range.

Rafael Perez-Escamilla: I strongly endorse the 2015 Dietary Guidelines Advisory Committee recommendation to base dietary guidance on dietary patterns *vis-à-vis* individual nutrients, foods, or even food groups. The impact of different types of fats in the diet on metabolic and disease outcomes is a function of the presence or absence of other nutrients and phytochemicals in the diet. For example, several Mediterranean diets that have demonstrated cardioprotective properties include meat and other food products rich in saturated fat. Therefore, if a careful analysis confirms that there is a range of saturated fat intakes across healthful diets, some of which may exceed 10% of total daily calories, we should also reconsider recommending upper limits for saturated fat and rather focus on empowering consumers to adopt healthful dietary patterns. Consumers need to know, however, that all types of fat are quite energy dense and that it's very easy to overconsume daily calories if they don't pay attention to the amount of fat and overall amount of food that they consume daily.

The optimal diet for preventing and treating obesity may vary by genotype or phenotype. From a clinical perspective, what is the state-of-the-science regarding “personalized nutrition?”

Eric Rimm: We and many others are starting to explore this area because it is likely that 10–20 years from now we will be able to prescribe diets to those who may be most sensitive to the benefits of lifestyle intervention. I imagine this will be driven in small part by genomics, but also by better understanding the microbiome and the metabolome. Thus far, we have not identified an -omics area that predicts which individuals will or will not respond to a healthful diet, but rather have found some genomic signals for those who have exacerbated effects from eating an unhealthy diet.

David S. Ludwig: The new field of personalized nutrition recognizes that individuals differ in response to macronutrients and other dietary components based on genotype, metabolic phenotype, microbiome, or other

factors. One promising metabolic factor is insulin secretion, which can be simply assessed as insulin level 30 min into a standard oral glucose tolerance test. Animal research, observational studies, behavioral trials, and feeding studies have described a unique phenotype of high insulin secretion, conferring special susceptibility to a high-carbohydrate diet.

Rafael Perez-Escamilla: The optimal diet at the individual level needs to be understood based on numerous complex interactions among the total diet, physical activity and other lifestyle variables (e.g., smoking), surrounding environments (e.g., air quality, violence/stress), the epigenome, the microbiome, and the immune system. These complex interactions manifest themselves collectively in the metabolomic profiles in different tissues and ultimately the individual's health outcomes. Our understanding of the complexity of these interactions and how they relate to health outcomes is still in a very early infancy stage, although the methods to study them are rapidly evolving. Therefore, for the foreseeable future our dietary guidance will need to continue to rely heavily on sound public health approaches grounded in sound epidemiological methods.

Alice H. Lichtenstein: The most efficacious dietary approach to restrict energy intake in an overweight or obese patient is the behavior plan that the individual can successfully adhere to over the long term. Details of the plan will differ among individuals and depend on their food environments (e.g., availability and options); personal, ethnic, and cultural preferences; stress and sleep levels; and the societal context in which they live. Genotype is likely an important factor, but recent data have demonstrated that it is only one factor and can be overridden, to some extent, by diet and lifestyle behaviors. It is important to note, when taking the long-term view, that what works during one period in someone's life may not work during another period. Whether it is called personalized nutrition or a customized approach to reach and maintain a healthy body weight, it is important to remember that midcourse corrections, whether due to biological or environmental changes, will be necessary throughout the lifespan.

What are the most important public health messages for preventing obesity?

David S. Ludwig: The “calorie in, calorie out” approach to weight control, and its low-fat diet, have failed because conventional calorie-restriction elicits predictable physiological responses (rising hunger, slowing metabolism) that predispose people to weight regain. We need more sophisticated approaches that aim to address the biological drivers of excessive weight gain. The carbohydrate-

insulin model provides an intellectual framework for understanding why a higher fat diet would be advantageous for weight control and chronic disease prevention.

Eric Rimm: I believe the *2015–2020 Dietary Guidelines for Americans* are pretty close to right now with a focus on foods and whole dietary patterns instead of nutrients, and a much more careful discussion of replacing unhealthful with healthful foods. We don't give that message strongly enough yet. All nutrition professionals should start the dialogue about health messages with the realization that instructing patients to not eat certain foods does not work well. Instead, the message should be much more clearly provided to try "food x" instead of "food y." Replace a highly processed food with a more healthful whole-grain version. Replace red and processed meat with seafood or poultry. Replace sugar-sweetened beverages with water, tea, coffee, or other noncaloric beverages. Finally, at every meal, fill half your plate or more with fruits and vegetables instead of high-starch foods like corn or potatoes or processed foods like white bread, refined pasta, and sugar-sweetened foods.

Alice H. Lichtenstein: Put a priority on food and nutrition education in schools, as seriously as drug avoidance and smoking cessation. Start early, introduce age-appropriate concepts, and be consistent from kindergarten through grade 12. Children should come out of school with the skills necessary to procure and prepare healthful meals, from shopping to cooking. They should be confident in utilizing available information such as "Nutrient Facts" labels on packaged foods and nutrition information on restaurant websites. They should know how to shop for food, taking advantage of convenience items that are consistent with a healthful dietary pattern and avoiding those that are not. Educational materials, at all grade levels, can be incorporated into multiple disciplines such as science, math, economics, and physical education. Harnessing virtual reality can allow cooking skills to be imparted in creative and cost-effective ways. And importantly, the concept that food should be enjoyed in moderation, rather than feared, should be instilled and reinforced.

Rafael Perez-Escamilla: To curb the obesity epidemic, consumers and policymakers need to be fully aware that the risk of obesity begins very early on in life through epigenetic mechanisms involving powerful genome–environment interactions. Once a young child is on course to becoming obese, it is very hard to reverse it due to powerful epigenetic mechanisms that are set at the beginning of life. In fact, these mechanisms may be set even before the child is conceived, as a result of the body-fat status of the parents. Therefore, it is key that future parents are not overweight or obese by the time they

conceive, the mother doesn't gain excessive weight during pregnancy, the infant is breastfed exclusively for around 6 months, and then introduced to healthful foods at that age while continuing to breastfeed. To prevent excessive weight gain during infancy, a strong risk factor for subsequent childhood obesity, the young child should not be introduced to highly processed foods or beverages as these usually have a very high content of calories, added sugars, unhealthful fats, and sodium. From birth, young children should also be provided ample opportunities for physical activity and healthful sleep patterns as well as a stable and responsive family environment to foster dietary self-regulation and prevent emotional eating. This is crucial as food preferences and eating habits get established very early in life and are likely to remain throughout the life course.

Consumers need to be empowered through proper education and counseling together with sound social protection, economic policies, and public health policies (e.g., user-friendly food labels, healthy lifestyles incentives) to have increased access to vegetables, fruits, nuts, seeds, whole-grain products, as well as animal source foods that have health-promoting fats (e.g., fish). Consumers need to strongly limit their consumption of ultra-processed foods and beverages, especially those that are high in added sugars and refined carbohydrates. Consumers need to be strongly advised to stay within their calorie needs and to replace saturated fat with health-promoting MUFA and PUFA and not with sugars or other refined carbohydrates. Therefore, consumers need nutrition education and counseling that includes food label reading and portion size estimation to be able to limit their daily total intakes of calories and refined carbohydrates, and to increase their intakes of fiber and health-promoting MUFA and PUFA. This guidance needs to be appropriate for diverse literacy levels and cultures.

Michelle McKinley: We live in an environment where the easiest thing to do is to eat a lot and move very little, so preventing obesity needs to address both. For diet, portion size is a critical message—the perception of what a normal portion size is has become distorted over the last few decades. Alongside this, we need to make better choices most of the time, adopt a regular eating schedule, and pay attention to what we are eating. The old messages of balance and variety are still pertinent and can help people visualize what their food intake should look like overall and that there is still a place for our favorite foods.

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