

SPECIAL COLLECTOR'S EDITION

# SCIENTIFIC AMERICAN

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THE  
SCIENCE  
OF

# FOOD

INSIDE

Keys to Deliciousness

Healthy Eating  
Made Simple

The Truth  
about GMOs

Future Fruits,  
Veggies, Meats

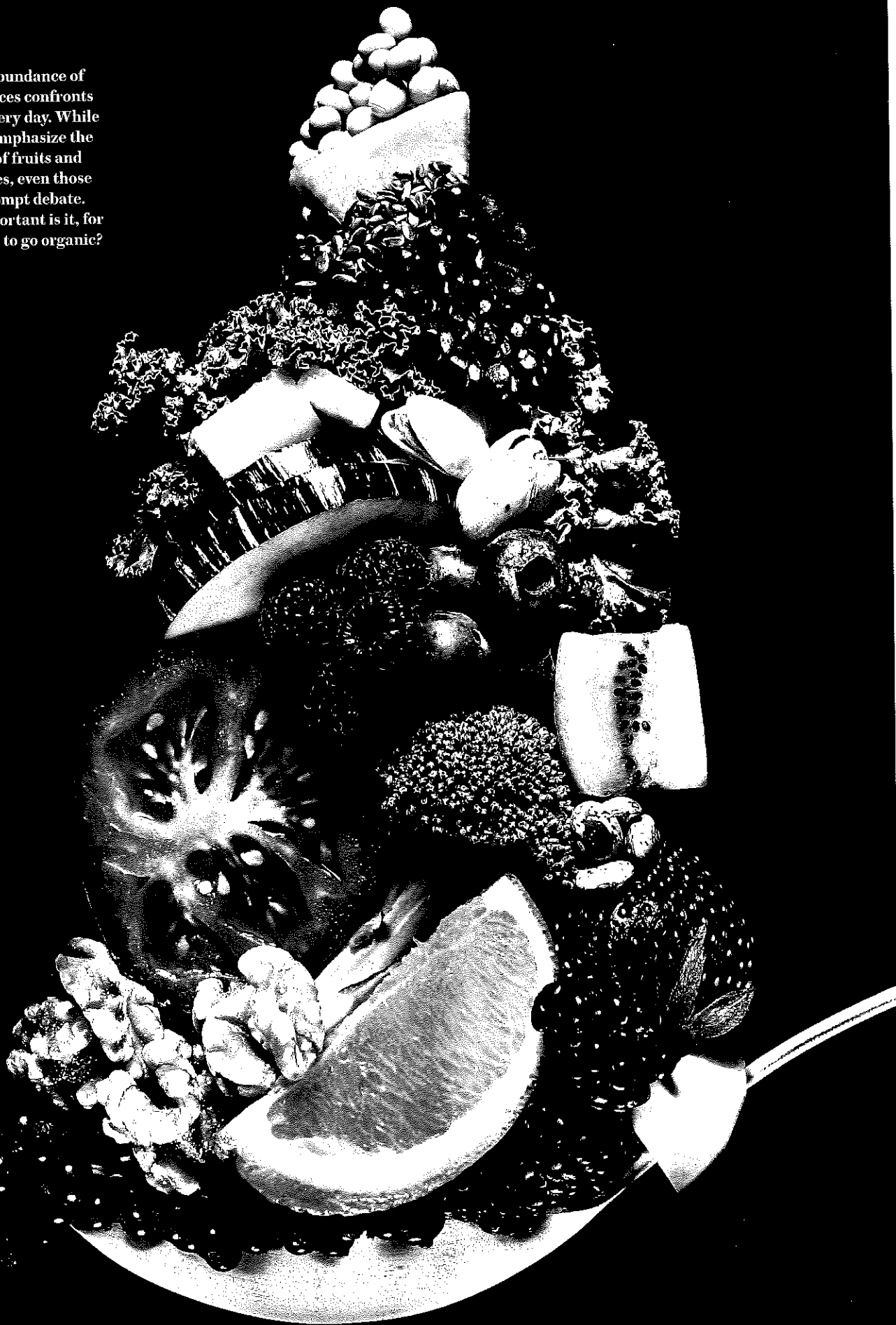
Yes, We Can  
Feed the World



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An overabundance of food choices confronts diners every day. While experts emphasize the benefits of fruits and vegetables, even those foods prompt debate. How important is it, for instance, to go organic?



NUTRITION

# EATING MADE SIMPLE

How do you cope with a mountain  
of conflicting diet advice?

*By Marion Nestle*

**A**S A NUTRITION PROFESSOR, I AM CONSTANTLY ASKED why nutrition advice seems to change so much and why experts so often disagree. Whose information, people ask, can we trust? I'm tempted to say, "Mine, of course," but I understand the problem. Yes, nutrition advice seems endlessly mired in scientific argument, the self-interest of food companies and compromises by government regulators. Nevertheless, basic dietary principles for our weight-conscious society are not in dispute: eat less; move more; eat fruits, vegetables and whole grains; and avoid too much junk food.

"Eat less" means consume fewer calories, which translates into eating smaller portions and steering clear of frequent between-meal snacks. "Move more" refers to the need to balance calorie intake with physical activity. Eating fruits, vegetables and whole grains provides nutrients unavailable from other foods. Avoiding junk food means to shun "foods of minimal nutritional value"—highly processed sweets and snacks laden with salt, sugars and artificial additives. Soft drinks are the prototypical junk food; they contain sweeteners but few or no nutrients.

## IN BRIEF

**Nutrition advice** is confusing. Scientists have difficulty deriving clear guidelines because a study of an individual nutrient fails to produce an understanding of what happens to it when mixed

with other nutrients in the body. **The picture** becomes even more clouded because industry groups constantly press their message to both government agencies and consumers about the benefits of

eating particular food products. **The simplest message** may be the best: do not overeat; exercise more; consume mostly fruits, vegetables and whole grains; and avoid junk food.

MAKSHA V. GALLEY/SHUTTER

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Omega-3 fatty acids, which are thought by some researchers to protect against heart disease, are found in oily fish such as salmon and trout. The scientific committee tasked with proposing changes to the U.S. Dietary Guidelines for 2015 recommended urging American adults to eat a diet rich in seafood.

pared, packaged products and restaurant meals that usually contain more calories than home-cooked meals.

But other social forces also promoted the calorie imbalance. During the Reagan administration, industry deregulation removed controls on agricultural production and encouraged farmers to grow more food. Calories available per capita in the national food supply (that produced by American farmers, plus imports, less exports) rose from 3,500 a day in 1980 to 4,000 a day three decades later [see box on next page].

The early 1980s also marked the advent of the “shareholder-value movement” on Wall Street. Stockholder demands for higher short-term returns on investments forced food companies to expand sales in a marketplace that already contained excessive calories. Food companies responded by seeking new sales and marketing opportunities. They encouraged formerly shunned practices that eventually changed social norms,

such as frequent between-meal snacking, eating in book and clothing stores, and serving larger portions.

Then and now, the industry sponsors organizations and journals that focus on nutrition-related subjects and heavily

#### NUMBERS TO KNOW

### Fast Facts

To lose a pound of fat a week, reduce your daily intake by 500 calories.

Carbohydrates and proteins have about 4 calories per gram. Food fats contain more than twice as much: 9 calories per gram. A teaspoon holds about 5 grams.

Alcohol is metabolized in a way that promotes accumulation of fat in the liver, leading to the proverbial beer belly.

An adult expends roughly 100 calories for every mile run or walked briskly. It takes nearly three miles to burn off the calories in a 20-ounce soft drink.

lobbies government for favorable dietary advice. Food lobbies promote positive interpretations of scientific studies, sponsor research that can be used as a basis for health claims, and attack critics, myself among them, as proponents of “junk science.” If anything, such activities only add to public confusion.

#### SUPERMARKETS AS “GROUND ZERO”

NO MATTER WHOM I speak to, I hear pleas for help in dealing with supermarkets, which shoppers consider “ground zero” for distinguishing health claims from scientific advice. So I spent a year visiting supermarkets to help people think more clearly about food choices. The result was my book *What to Eat*.

Supermarkets provide a vital public service but are not social-services agencies. Their job is to sell as much food as possible. Every aspect of store design—from shelf position to background music—is based on marketing research [see box on page 45]. Because this research shows that the more products customers see, the more they buy, a store’s main objective is to expose shoppers to the maximum number of products they will tolerate viewing.

If consumers are confused about which foods to buy, it is surely because the choices require knowledge of issues that are not easily resolved by science and are strongly swayed by social and economic considerations. Such decisions play out every day in every store aisle.

#### ARE ORGANICS HEALTHIER?

ORGANIC FOODS are the fastest-growing segment of the industry, in part because people are willing to pay more for foods that they believe are healthier and more nutritious. The U.S. Department of Agriculture forbids producers of “Certified Organic” fruits and vegetables from using synthetic pesticides, herbicides, fertilizers, genetically modified seeds, irradiation or fertilizer derived from sewage sludge. It licenses inspectors to ensure that producers follow those rules. Although the USDA is responsible for organics, its principal mandate is to promote conventional agriculture, which explains why the department used to say that it “makes no claims that organically produced food is safer or more nutritious than conventionally produced food.” But the USDA has come a long way on organ-

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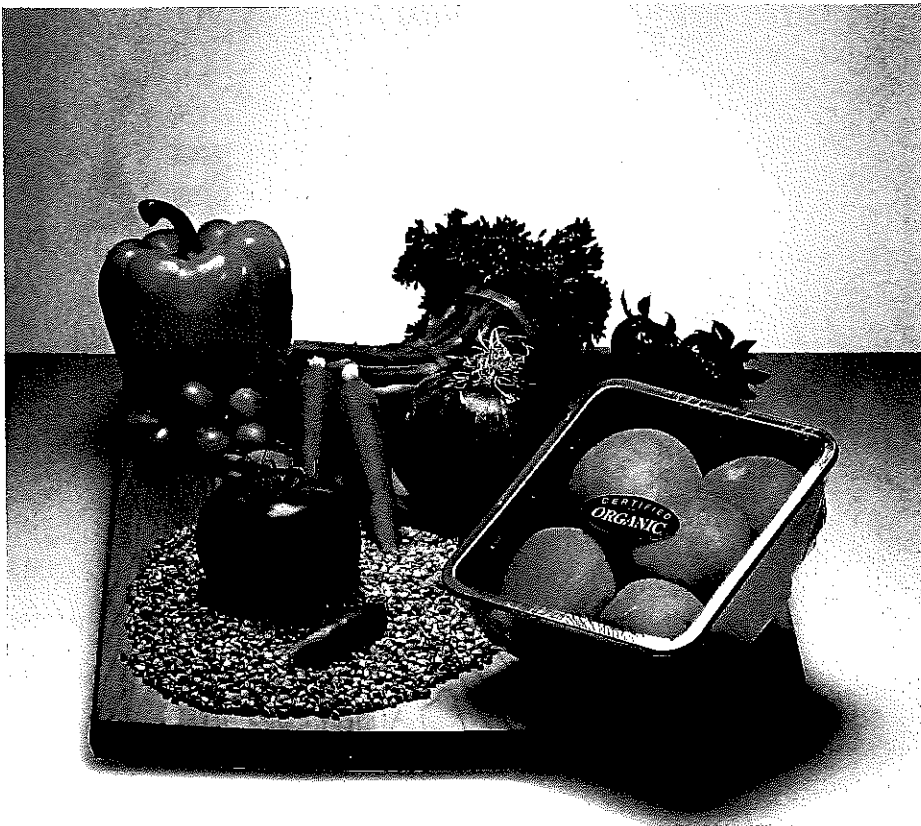
If you follow these precepts, other aspects of the diet matter much less. Ironically, this advice has not changed in years. The noted cardiologist Ancel Keys (who died in 2004 at the age of 100) and his wife, Margaret, suggested similar principles for preventing coronary heart disease over 50 years ago [see box below].

But I can see why dietary advice seems like a moving target. Nutrition research is so difficult to conduct that it seldom produces unambiguous results. Ambiguity requires interpretation. And interpretation is influenced by the individual's point of view, which can become thoroughly entangled with the science.

### CHALLENGES OF NUTRITION SCIENCE

THIS SCIENTIFIC UNCERTAINTY is not overly surprising given that humans eat so many different foods. For any individual, the health effects of diets are modulated by genetics but also by education and income levels, job satisfaction, physical fitness, and the use of cigarettes or alcohol. To simplify this situation, researchers typically examine the effects of single dietary components one by one.

Studies focusing on one nutrient in isolation have worked splendidly to explain symptoms caused by deficiencies of vitamins or minerals. But this approach is less useful for chronic conditions such as coronary heart disease and diabetes that are caused by the interaction of dietary, genetic, behavioral and social factors. If nutrition science seems puzzling, it is because researchers typically examine single nutrients detached from food itself, foods separate from diets, and risk factors apart from other behaviors. This "reductive" kind of research attributes health effects to the consumption of one nutrient or food when it is the overall di-



Organic foods have been shown to leave people who eat them with fewer synthetic pesticides in their bodies than are found in those who consume conventional foods. Proving that organics contain more vitamins or antioxidants is more difficult, but some studies clearly suggest that they do.

etary pattern that really counts most.

For chronic diseases, single nutrients usually alter risk by amounts too small to measure except through large, costly population studies. In many clinical trials of the effects of diet on heart disease, cancer or weight loss, participants were unable to stick with the restrictive dietary protocols. Because humans cannot be caged and fed measured formulas, the

diets of experimental and control study groups tend to converge, making differences indistinguishable over the long run—even with fancy statistics.

### IT'S THE CALORIES

FOOD COMPANIES prefer studies of single nutrients because they can use the results to sell products. Add vitamins to candies, and you can market them as health foods. Health claims on the labels of junk foods distract consumers from their caloric content. This practice matters because when it comes to obesity—which dominates nutrition problems even in some of the poorest countries of the world—it is the calories that count. Obesity arises when people consume significantly more calories than they expend in physical activity.

America's obesity rates began to rise sharply in the early 1980s. Sociologists often attribute the "calories in" side of this trend to the demands of an overworked population for convenience foods—pre-

### THE BASICS

## Old Advice Still Holds True

In 1959 Ancel and Margaret Keys offered the following precepts—now familiar and still useful—regarding nutrition and activity:

- ◆ Do not get fat; if you are fat, reduce.
- ◆ Restrict saturated fats: fats in beef, pork, lamb, sausages, margarine and solid shortenings; fats in dairy products.
- ◆ Prefer vegetable oils to solid fats but keep total fats under 30 percent of your diet calories.
- ◆ Favor fresh vegetables, fruits and nonfat milk products.
- ◆ Avoid heavy use of salt and refined sugar.
- ◆ Good diets do not depend on drugs and fancy preparations.
- ◆ Get plenty of exercise and outdoor recreation.

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ics and now proclaims that it "is committed to helping organic agriculture grow and thrive."

Critics of organic foods view them as an explicit critique of industrial agriculture. They question the reliability of organic certification and the productivity, safety and health benefits of organic production methods. Meanwhile the organic food industry longs for research to address such criticisms, but studies are expensive and difficult to conduct.

Nevertheless, research in this area has established that organic farms are nearly as productive as conventional farms, use less energy and leave soils in better condition. People who eat foods grown without synthetic pesticides ought to have fewer such chemicals in their bodies, and

they do. Because the organic rules require pretreatment of manure and other steps to reduce the amount of pathogens in soil treatments, organic foods should be just as safe as conventional foods.

Similarly, organic foods ought to be at least as nutritious as conventional foods. And proving organics to be more nutritious could help justify their higher prices. For minerals, this task is not difficult. The mineral content of plants depends on the amounts present in the soil in which they are grown. Organic foods are cultivated in richer soils, so their mineral content is higher.

But differences are harder to demonstrate for vitamins or tissue-protecting antioxidants; higher levels of these nutrients relate more to a food plant's ge-

netic strain or protection from unfavorable conditions after harvesting than to production methods. Some studies do show benefits, though, such as that organic peaches and pears do contain greater quantities of vitamins C and E and that organic berries and corn are richer in antioxidants.

Further research will likely confirm that organic foods contain higher levels of some nutrients, but it is unclear whether these additional nutrients lead to measurable improvements in health. All fruits and vegetables contain useful nutrients, albeit in different combinations and concentrations. Eating a variety of food plants is surely more important to health than small differences in the nutrient content of any one food.

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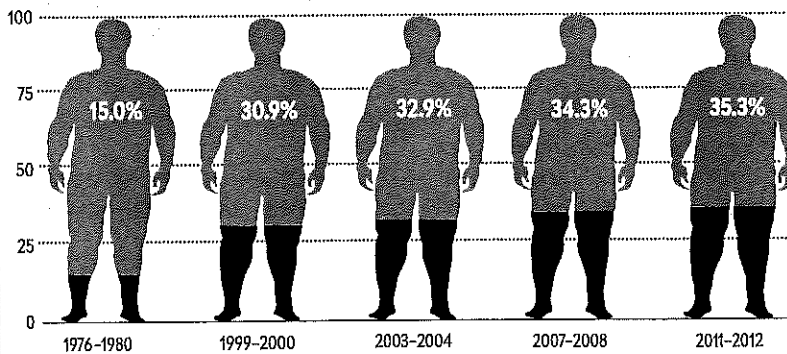
PARALLEL TRENDS

## As Food Calories Swell, So Do Waistlines

The substantial rise in U.S. obesity rates during the 1980s and 1990s paralleled increases in the availability of total calories, caloric sweeteners and sugary soft drinks in the food supply, as well as the increasing introduction of "supersize" portions. The adult obesity rates started to stabilize around 2000 as most of these measures began to decline, probably as a result in part of people substituting water, flavored waters and tea drinks for sugary sodas.

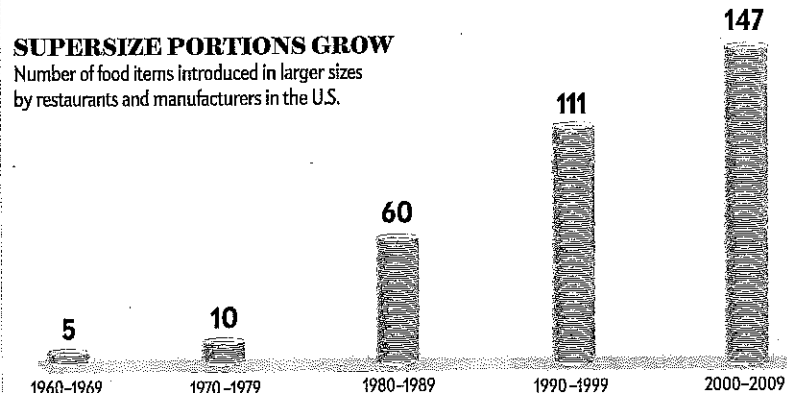
### U.S. OBESITY RATES ON THE RISE

Percent of total population (ages 20-74) classified as obese



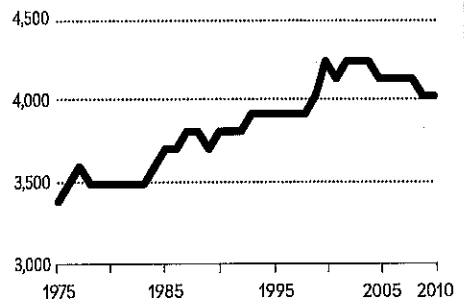
### SUPERSIZE PORTIONS GROW

Number of food items introduced in larger sizes by restaurants and manufacturers in the U.S.



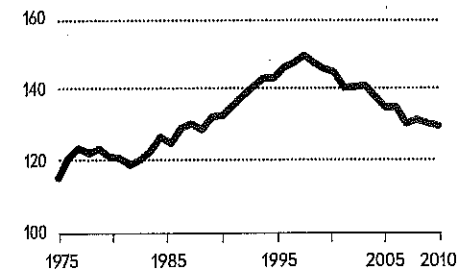
### Calories Available

Per person per day in the U.S. food supply



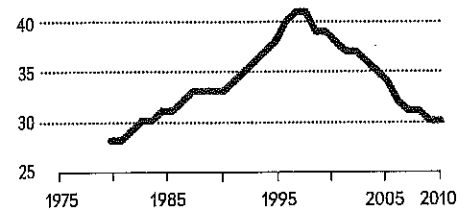
### Caloric Sweeteners Available

Pounds per person in the U.S. food supply



### Sugary Soft Drinks Available

Gallons per person in the U.S. food supply



JEN CHRISTIANSEN (graphics); SOURCES: "PREVALENCE OF OVERWEIGHT, OBESITY, AND EXTREME OBESITY AMONG ADULTS, UNITED STATES, 1965-1962 THROUGH 2011-2012," BY C. D. FRYER, M. D. CARROLL AND C. L. OGDEN, U.S. CENTERS FOR DISEASE CONTROL AND PREVENTION, SEPTEMBER 2014; (obesity rates); "REDUCING PORTION SIZES TO PREVENT OBESITY," BY L. R. YOUNG AND M. NESTLE, IN AMERICAN JOURNAL OF PREVENTIVE MEDICINE, VOL. 48, 2012; (portions); ECONOMIC RESEARCH SERVICE, U.S. DEPARTMENT OF AGRICULTURE (calories, sweeteners); BEVERAGE MARKETING CORPORATION (soft drinks)



Whether or not organics are healthier to eat, they are far less likely to damage the environment, and that is reason enough to choose them at the supermarket.

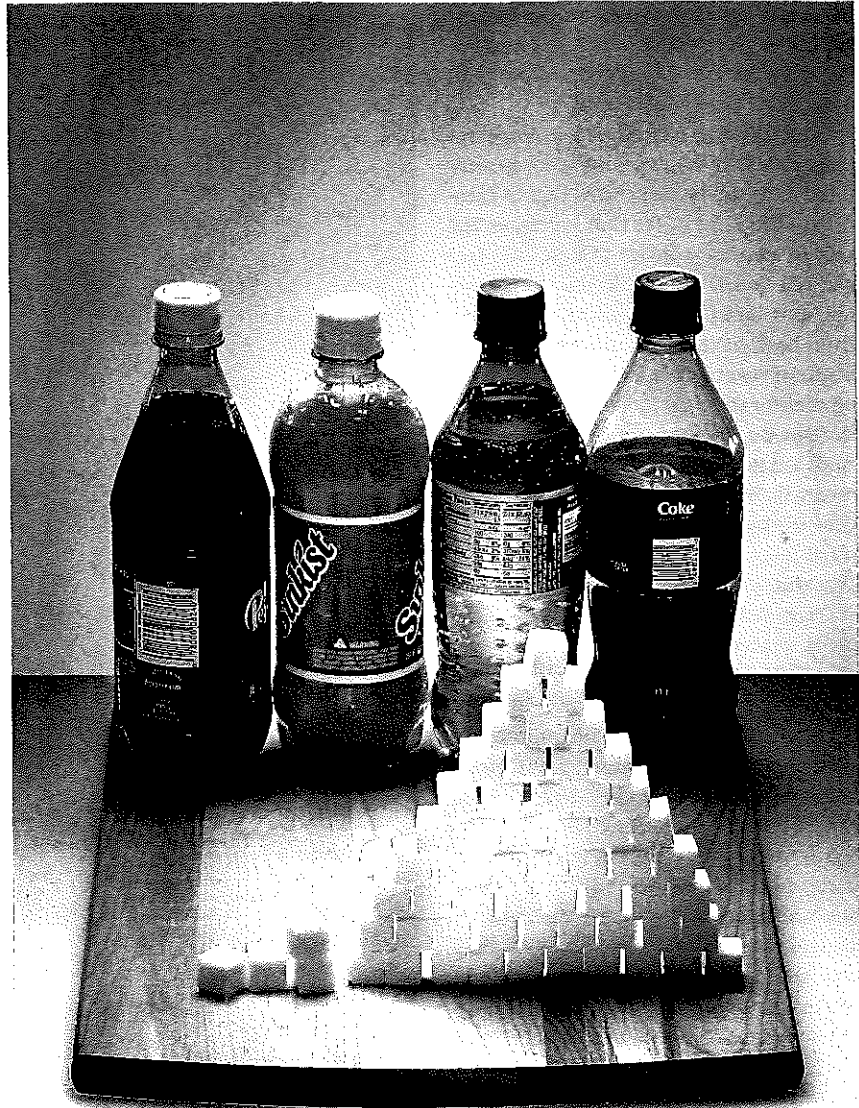
### DAIRY AND CALCIUM

SCIENTISTS CANNOT easily resolve questions about the health effects of dairy foods. Milk has many components, and the health of people who consume milk or dairy foods is influenced by everything else they eat and do. But this area of research is especially controversial because it affects an industry that vigorously promotes dairy products as beneficial and opposes suggestions to the contrary.

Dairy foods contribute about 70 percent of the calcium in American diets. This necessary mineral is a principal constituent of bones, which constantly lose and regain calcium during normal metabolism. Diets must contain enough calcium to replace losses, or else bones become prone to fracture. Experts advise consumption of at least one gram of calcium a day to replace everyday losses. Only dairy foods provide this much calcium without supplementation.

But bones are not made of just calcium; they require the full complement of essential nutrients to maintain strength. Bones are stronger in people who are physically active and who do not smoke cigarettes or drink much alcohol. Studies examining the effects of single nutrients in dairy foods show that some nutritional factors—magnesium, potassium, vitamin D and lactose, for example—promote calcium retention in bones. Others, such as protein, phosphorus and sodium, foster calcium excretion. Therefore, bone strength depends more on overall patterns of diet and behavior than simply on calcium intake.

Populations that do not typically consume dairy products appear to exhibit lower rates of bone fracture despite consuming far less calcium than recommended. The incidence of hip fractures in Singapore, for example, is about one fifth of the rate in the U.S., even though Singaporeans consume only about 75 percent as much calcium as Americans do, on average. Why this is so is unclear. Perhaps their diets contain less protein from meat and dairy foods, less sodium from processed foods and less phosphorus from soft drinks, so they retain calcium more effectively. The fact that calci-



Some obese children in the U.S. consume 1,000 calories a day (equal to about 59 sugar cubes) in sweetened beverages alone. That is equivalent to more than three 20-ounce bottles of soft drinks.

um balance depends on multiple factors could explain why rates of osteoporosis (bone density loss) are highest in countries where people eat the most dairy foods. Further research may clarify such counterintuitive observations.

In the meantime, dairy foods are fine to eat if you like them, but they are not a nutritional requirement. Think of cows: they do not drink milk after weaning, but their bones support bodies weighing 800 pounds or more. Cows feed on grass, and grass contains calcium in small

amounts—but those amounts add up. If you eat plenty of fruits, vegetables and whole grains, you can have healthy bones without having to consume dairy foods.

### A MEATY DEBATE

CRITICS CLAIM THAT eating meat elevates blood cholesterol as well as the risks for heart disease, cancer and other conditions. Meat proponents cite the lack of compelling science to justify such allegations; they emphasize the nutritional benefits of meat protein, vitamins and



minerals. Indeed, studies in low-income countries demonstrate that when growing children eat even small amounts of meat, their health improves.

But because bacteria in a cow's rumen attach hydrogen atoms to unsaturated fatty acids, beef fat is highly saturated—the kind of fat that increases the risk of coronary heart disease. All fats and oils contain some saturated fatty acids, but animal fats, especially those from beef, have more saturated fatty acids than vegetable fats. Nutritionists recommend eating no more than a heaping tablespoon (20 grams) of saturated fatty acids a day. Beef eaters easily meet or exceed this limit. The smallest McDonald's cheeseburger contains six grams of saturated fatty acids, but a Hardee's Monster Thickburger has 45 grams.

Why red and processed meats might boost cancer risks, however, is a matter of speculation. Scientists began to link such meats to cancer in the 1970s, but even after decades of subsequent research they remain unsure if the relevant factor might be fat, saturated fat, protein, carcinogens or something else related to eating these foods. By the late 1990s experts could conclude only that eating beef and processed meat convincingly increases the risk of colon and rectal cancers and possibly enhances the odds of acquiring lung, prostate and perhaps other cancers. Faced with this uncertainty, the American Cancer Society suggests selecting leaner cuts, smaller portions, and alternatives such as chicken, fish or beans—steps consistent with today's basic advice about what to eat.

#### FISH AND HEART DISEASE

FATTY FISH are the most important sources of long-chain omega-3 fatty acids. In the early 1970s Danish investigators observed surprisingly low frequencies of heart disease among indigenous populations in Greenland that typically ate fatty fish, seals and whales. The researchers attributed the protective effect to the foods' content of omega-3 fatty acids. Some subsequent studies—but by no means all—confirm this idea.

Because large, fatty fish are likely to have accumulated methylmercury and other toxins through predation, however, eating them raises questions about the balance between benefits and risks. Understandably, the fish industry is eager to



What to eat: fruits, vegetables and whole grains constitute the main components of a healthy diet.

prove that the health benefits of omega-3s outweigh any risks from eating fish.

Even independent studies on omega-3 fats can be interpreted differently. In 2004 the National Oceanic and Atmospheric Administration—for fish, the agency equivalent to the USDA—asked the Institute of Medicine (IOM) to review studies of the benefits and risks of consuming seafood. The ensuing review of the research on heart disease risk illustrates the challenge such work poses for interpretation.

The IOM's 2006 report concluded that eating seafood reduces the risk of heart disease but judged the studies too inconsistent to decide if omega-3 fats were responsible. In contrast, investiga-

tors from the Harvard School of Public Health published a much more positive report in the *Journal of the American Medical Association* that same year. Even modest consumption of fish omega-3s, they stated, would cut coronary deaths by 36 percent and total mortality by 17 percent, meaning that not eating fish would constitute a health risk.

Differences in interpretation explain how distinguished scientists could arrive at such different conclusions after considering the same studies. The two groups, for example, had conflicting views of work that had recently appeared in the *British Medical Journal*. That study found no overall effect of omega-3s on heart disease risk or mor-



tality, although a subset of the original studies displayed a 14 percent reduction in total mortality that did not reach statistical significance. The IOM team interpreted the “nonsignificant” result as evidence for the need for caution, whereas the Harvard group saw the data as consistent with studies reporting the benefits of omega-3s.

When studies present inconsistent results, both interpretations are plausible. I favor caution in such situations, but not everyone agrees.

Because findings are inconsistent, so is dietary advice about eating fish. The American Heart Association recommends that adults eat fatty fish at least twice a week, but the 2010 U.S. Dietary Guidelines made no specific recommendation about fish and heart disease except that pregnant and breastfeeding women should consume eight to 12 ounces of seafood per week. Of this, only six ounces should come from tuna and none from fish even higher in methylmercury. Whether or not fish uniquely protects against heart disease, seafood is a delicious source of many nutrients, and two small servings per week of the less predatory fish are unlikely to cause harm.

### SODAS AND OBESITY

SUGARS AND CORN SWEETENERS account for a large fraction of the calories in many supermarket foods, and virtually all the calories in drinks—soft, sports and juice—come from added sugars.

In a trend that correlates closely with rising rates of obesity, daily per capita consumption of sweetened beverages grew dramatically during the 1980s and 1990s. Since 1998, U.S. production of sugary sodas has declined, and the obesity rate has stabilized.

Common sense suggests that soda drinking might have something to do with weight gain, but beverage makers argue that studies cannot prove that sugary drinks alone—independent of calories or other foods in the diet—boost the risk of obesity. The evidence, they say correctly, is circumstantial. But pediatricians frequently treat obese children who consume more than 1,000 calories a day from sweetened drinks, and numerous studies indicate that children who habitually consume sugary beverages take in more calories and weigh more than those who do not.

### SAVVY SHOPPING

## Designer Supermarkets

Marketing experts design nearly every feature of food stores—from product placement to mood music—to maximize sales.

When customers enter a grocery store, the first thing they see is typically something colorful, aromatic and enticing—fresh produce, for example.

The long center aisles and aisle-end displays are jam-packed with products, forcing shoppers to pass by many items that they might purchase on impulse.

Food companies pay supermarkets to get their products—salty chips and other junk foods—positioned prominently in huge displays.

Checkout lines are plastered with candy and other junk food items—the last temptation.

Nevertheless, the effects of sweetened drinks on obesity continue to be subject to interpretation. In 2006, for example, a systematic review funded by independent sources found sweetened drinks to promote obesity in both children and adults. But a review that same year sponsored in part by a beverage trade association concluded that soft drinks have no special role in obesity. The industry-funded researchers criticized existing studies as being short-term and inconclusive and pointed to studies finding that people can lose weight even when they substitute sweetened drinks for their usual meals.

These differences imply the need to scrutinize food industry sponsorship of research itself. Although many research-

ers are offended by suggestions that funding support might affect the way they design or interpret studies, systematic analyses say otherwise. In 2007 investigators classified studies of the effects of sweetened and other beverages on health according to who had sponsored them. Industry-supported studies were more likely to yield results favorable to the sponsor than those funded by independent sources. Subsequent studies confirmed this effect of funding source on study outcome. Even though scientists may not be able to prove that sweetened drinks cause obesity, it makes sense for anyone interested in losing weight to consume less of them.

The examples I have discussed illustrate why nutrition science seems so controversial. Without improved methods to ensure compliance with dietary regimens, research debates are likely to rage unabated. Opposing points of view and the focus of studies and food advertising on single nutrients rather than on dietary patterns continue to fuel these disputes. While we wait for investigators to find better ways to study nutrition and health, my approach—eat less, move more, eat a largely plant-based diet, and avoid eating too much junk food—makes sense and leaves you plenty of opportunity to enjoy your dinner. ■

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### MORE TO EXPLORE

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