Nutrition science was characterized by two major phases in the 20th century. During the first phase, nutrition scientists discovered, characterized, and synthesized the essential nutrients and described their deficiency syndromes in detail. The dietary requirements for these nutrients were estimated and periodically updated as recommended dietary allowances (RDAs). Beginning in 1997, the RDAs were reformulated in a series of volumes containing dietary reference intakes (DRIs); in addition to the recommended intakes judged to be sufficient to meet the nutrient requirements of nearly all healthy individuals, the DRIs include estimates of tolerable upper intake levels—that is, the highest intake levels likely not to pose any adverse health risks.

More fundamentally, the DRIs focus on accumulating evidence related to the relationships of diet and nutritional status to the diseases that plague Western societies, such as coronary heart disease, cancer, diabetes, and the other leading causes of death. DRIs recommend intake levels that not only prevent deficiencies but also may promote long-term health and disease prevention.

Evidence of a Connection between Diet and Disease

It has been estimated that between 300,000 and 800,000 deaths per year could be prevented in the United States if Americans followed evidence-based dietary recommendations. Substantial additional benefits from reduced morbidity and enhanced functional status would also accrue. However, the causal connections between diet and chronic diseases are difficult to tease out of the complex network of other risk factors, including social and behavioral variables, so a wide variety of studies must be relied on to establish these connections with reasonable certainty.

Epidemiologic studies are unable to infer causal relationships and may be confounded by variables that have not been examined. They are also challenged by the difficulty of accurately assessing the diets of free-living individuals.

Animal and in vitro studies can overcome some of these drawbacks but may be confounded by experimental conditions that differ from those encountered by humans. A large number of prospective, randomized human intervention trials have been undertaken to test the effects of dietary change on risk for disease. However, even these trials are not always conclusive because of pitfalls associated with selecting study populations and isolating individual dietary factors.

Taken together, epidemiologic, animal, in vitro, and intervention studies are proving that human dietary habits contribute importantly to the pathogenesis of most of the major causes of death in developed countries.

Diseases Influenced by Nutrition

Table 220-1 lists 8 of the top 15 causes of death in the United States that are influenced by nutrition. Five are strongly linked to dietary habits, and three are associated with alcohol abuse. The table also outlines dietary contributions to obesity, atherosclerosis, osteoporosis, diverticulase disease, and neural tube defects. A meta-analysis indicates that vitamin D supplementation reduces mortality in adults. Table 220-2 summarizes the 2005 Dietary Guidelines for Americans, and Table 220-3 compares dietary recommendations promulgated by professional societies for risk reduction and/or management of the major chronic diseases. The close agreement among these recommendations enhances their credibility.

Coronary Heart Disease

Nutritional influences on the leading cause of death in the United States, coronary heart disease (CHD), have been the subject of a great deal of research. The overall U.S. mortality rate from CHD peaked in the 1960s and, in a trend that has surprised medical science, has declined steadily since then. Changes in lifestyle, including diet, are responsible for a substantial proportion of this decline. Elevated plasma low-density lipoprotein (LDL) cholesterol levels are a major risk factor for CHD and peripheral atherosclerosis, and they correlate strongly with dietary saturated fat intake and less strongly with cholesterol intake. Intake of both these substances in the United States is derived largely from foods of animal origin, such as meats, dairy products, and eggs. Attempts to produce less atherogenic substitutes for some of these foods have not always proved beneficial. For instance, hydrogenation of vegetable oils to create margarine and shortening results in the formation of trans-fatty acids, which affect serum cholesterol levels in a manner similar to—and perhaps even worse than—the saturated fatty acids found in butter and lard. LDL cholesterol levels can be lowered modestly by increasing the intake of soluble fiber from legumes, fruits, vegetables, and flax seed, as well as by consuming proteins and isoflavones from soy foods. LDL must be oxidized before it induces injury to the arterial wall. Although adequate dietary levels of the antioxidant vitamins C and E and β-carotene have been shown to inhibit LDL oxidation, pharmacologic doses of these vitamins have not reduced CHD events when tested in randomized trials. In fact, pharmacologic doses of vitamin E (＞400 IU/day) and other antioxidants have no benefit and may increase all-cause mortality.

Epidemiologic evidence suggests that fish consumption may reduce CHD risk, perhaps through the action of omega-3 fatty acids. Evidence also indicates that moderate consumption of alcohol, especially wine, is associated with a decreased risk for CHD, possibly by increasing high-density lipoprotein (HDL) cholesterol levels, preventing the oxidation of LDL, or both. Traditional Mediterranean lifestyle patterns—with diets high in vegetables, fruits, olive oil, fish, nuts, complex grains and carbohydrates, and red wine, along with physical activity—are associated with reduced risks of cardiovascular disease. A conservative estimate suggests that moderate dietary modification by the U.S. population, consisting mainly of replacing saturated fats with complex carbohydrates, fiber, monounsaturated fats, and fish, could easily lead to a 10% reduction in serum cholesterol levels and a 20% or greater reduction in CHD. The actual risk reduction could be much greater.

Cancer

Nutrients, non-nutritive dietary constituents, and nutritional status can influence the risk for cancer in a variety of ways. Nutrition interacts with each step of carcinogenesis (carcinogen activation and tumor initiation, promotion, and progression). Excess energy intake may favor the generation of free radicals and reduce the body’s ability to detoxify carcinogens. By contrast, antioxidant nutrients scavenge free radicals and other (pre)carcinogens and may thereby inhibit their activation, their ability to initiate mutations, or both. Folic acid may improve a cell’s ability to preserve, repair, and methylate its DNA, either preventing or reversing the tendency toward mutation. Folic acid supplementation, however, may increase the cancer risk in some individuals, so supplementation beyond the levels present in multivitamins is not advised. Obesity has emerged as a major risk factor for many cancers, perhaps by inducing insulin resistance and elevating serum levels of insulin, insulin-like growth factor, and related hormones. Excessive alcohol intake promotes tumor growth.

Lung Cancer

Evidence indicates that the number-one cancer killer, lung cancer (Chapter 197), is influenced by diet. Although the most important causal factor is cigarette smoking, consumption of fruits and vegetables is inversely associated with lung cancer risk in both smokers and nonsmokers. It is probable that both nutrients and the non-nutritive phytochemicals in fruits and vegetables are responsible for the protective effects. However, in view of the disappointing results of randomized trials of supplementation with β-carotene, which increased mortality from lung cancer and other causes, antioxidant supplements should not be relied on to reduce disease risk.

Breast Cancer

The number-two cause of cancer deaths in women, breast cancer (Chapter 204), is positively associated with obesity, especially when excess adiposity is located predominantly in the abdomen, and with physical inactivity. The positive association between obesity and postmenopausal breast cancer has been attributed in part to the synthesis of estrogen (a risk factor for breast
cancer) in adipose tissue. Epidemiologic evidence suggests that alcohol intake may also be a risk factor for this disease, particularly in women with lower intakes of folic acid.

**Colorectal Cancer**
Colorectal cancer (Chapter 199) is the third leading cause of cancer mortality in men and women. The risk for colorectal cancer correlates positively with the intake of red meat (especially when it is overcooked) and dietary fat and with obesity, and the risk correlates inversely with the intake of calcium and folic acid. Evidence regarding the effect of dietary fiber is somewhat equivocal, but the preponderance of evidence points to a protective effect; there is no evidence of harm. Higher physical activity is associated with a 30 to 50% lower risk for colon cancer.

**Summary**
The interaction of all these influences is powerful enough to suggest that diet and physical inactivity contribute to well over 35% of cancer deaths in Western countries. Even though the independent influences of potentially protective nutrients such as carotenoids, vitamins C and E, folic acid, selenium, and fiber are not known with certainty, because they are all present in vegetables and fruits, a liberal intake of fruits and vegetables is strongly recommended. A very large randomized trial indicated that lowering dietary fat intake did not reduce rates of breast cancer or colon cancer, but it is very likely that maintaining an appropriate body weight and being physically active can reduce cancer risks.

**Hypertension**
Elevated blood pressure (Chapter 67) is a major risk factor for stroke, CHD, heart failure, peripheral vascular disease, and renal disease. It is often associated with obesity, especially abdominal obesity, and weight reduction in obese hypertensives generally leads to an improvement in blood pressure. Sodium restriction also usually reduces blood pressure levels. The Dietary Approaches to Stop Hypertension (DASH) diet, which is rich in fruits, vegetables, and low-fat dairy products and advocates a reduced saturated and total fat content, can also decrease blood pressure levels; reducing one’s sodium intake provides an additional benefit when included as part of the DASH diet. Because alcohol intake elevates blood pressure, its use should be limited in hypertensive patients.

**Diabetes Mellitus**
Type 2 diabetes mellitus (Chapter 237) is strongly associated with obesity, especially abdominal obesity. Sugar consumption does not lead to diabetes, except to the extent that it may promote weight gain. The previous recommendation to restrict total carbohydrate intake in diabetics has been abandoned for lack of evidence; 55 to 60% of a diabetic’s energy intake should come from carbohydrates, preferably unrefined carbohydrates that include fiber. Because higher-fat diets tend to promote both obesity and CHD, for which diabetics are at high risk, dietary fat intake should be kept low. Alcohol can cause hypoglycemia, hyperglycemia, and increased triglyceride levels in diabetics, and its use should be limited. In both diabetics and nondiabetics, excess alcohol intake is responsible for many deaths, particularly from accidents and liver disease, and it is a factor in some suicides.

**Osteoporosis**
Osteoporosis (Chapter 251) is influenced by several dietary factors. Inadequate calcium intake during adolescence can result in suboptimal peak bone mass in early adulthood, and during later life it can lead to accelerated bone loss, thereby increasing the risk for osteoporosis. Sodium and protein, which are consumed by Americans in greater quantities than required, may promote excess bone loss. Excessive supplementation with vitamin A reduces bone mass and increases fracture risk. Vitamin D, vitamin K, and magnesium assist in maintaining optimal bone mass.

**Other Conditions**

**Obesity**
The causes and health effects of obesity, the most prevalent nutritional disorder in the United States, are reviewed in Chapter 227. The metabolic syndrome, a constellation that includes obesity with an enlarged waist circumference; increased serum glucose, triglycerides, and blood pressure; and reduced HDL cholesterol, is strikingly prevalent in the United States and is a major risk factor for CHD, cancer, type 2 diabetes, and hypertension (Chapter 67).

**Intestinal Diverticular Disease**
Low dietary fiber intake causes constipation, and it is thought to be a cause of intestinal diverticular disease.
TABLE 220-2  DIETARY GUIDELINES FOR AMERICANS: KEY RECOMMENDATIONS FOR THE GENERAL POPULATION

**Adequate Nutrients Within Calorie Needs**

Consume a variety of nutrient-dense foods and beverages within and among the basic food groups while choosing foods that limit the intake of saturated and trans-fats, cholesterol, added sugars, salt, and alcohol. Meet recommended intakes for energy needs by adopting a balanced eating pattern, such as the U.S. Department of Agriculture (USDA) Food Guide or the Dietary Approaches to Stop Hypertension (DASH) eating plan.

**Weight Management**

To maintain body weight in a healthy range, balance calories consumed from foods and beverages with calories expended.

To prevent gradual weight gain over time, make small decreases in food and beverage calories and increase physical activity.

**Physical Activity**

Engage in regular physical activity and reduce sedentary activities to promote health, psychological well-being, and a healthy body weight.

To reduce the risk for chronic disease in adulthood, engage in at least 30 minutes of moderate-intensity physical activity, above usual activity levels, at work or at home on most days of the week.

For most people, greater health benefits can be obtained by engaging in physical activity of more vigorous intensity or longer duration.

To help manage body weight and prevent gradual, unhealthy body weight gain in adulthood, engage in approximately 60 minutes of moderate- to vigorous-intensity activity on most days of the week while not exceeding caloric intake requirements.

To sustain weight loss in adulthood, participate in at least 60-90 minutes of daily moderate-intensity physical activity while not exceeding caloric intake requirements. Some people may need to consult a health care provider before engaging in this level of activity.

Achieve physical fitness by including cardiovascular conditioning, stretching exercises for flexibility, and resistance exercises or calisthenics for muscle strength and endurance.

**Food Groups to Encourage**

Consume a sufficient amount of fruits and vegetables without exceeding energy needs: 2 cups of fruit and 2 ½ cups of vegetables per day are recommended for a reference 2000-calorie intake, with higher or lower amounts depending on the calorie level.

Choose a variety of fruits and vegetables each day, in particular, select from all five vegetable subgroups (dark green, orange, legumes, starchy vegetables, and other vegetables) several times a week.

Consume 23 ounce-equivalents of whole-grain products/day, with the rest of the recommended grains coming from enriched or whole-grain products. In general, at least half the grains should come from whole grains.

Consume 3 cups/day of fat-free or low-fat milk or equivalent milk products.

**Fats**

Consume <10% of calories from saturated fatty acids and <300 mg/day of cholesterol, and keep trans-fatty acid consumption as low as possible.

Keep total fat intake between 20 and 35% of total calories, with most fats coming from sources of polyunsaturated and monounsaturated fatty acids such as fish, nuts, and vegetable oils.

When selecting and preparing meat, poultry, dry beans, and milk or milk products, choose those that are lean, low fat, or fat free.

Limit intake of fats and oils high in saturated and/or trans-fatty acids, and choose products low in such fats and oils.

**Carbohydrates**

Choose fiber-rich fruits, vegetables, and whole grains often.

Choose and prepare foods and beverages with little added sugar or caloric sweeteners, such as amounts suggested by the USDA Food Guide and the DASH eating plan.

Reduce the incidence of dental caries by practicing good oral hygiene and consuming sugar- and starch-containing foods and beverages less frequently.

**Sodium and Potassium**

Choose and prepare foods with little salt. At the same time, consume potassium-rich foods such as fruits and vegetables.

**Alcoholic Beverages**

Those who choose to drink alcoholic beverages should do so sensibly and in moderation—defined as the consumption of up to 1 drink/day for women and up to 2 drinks/day for men.

Alcoholic beverages should not be consumed by some individuals, including those who cannot restrict their alcohol intake, women of childbearing age who may become pregnant, pregnant and lactating women, children and adolescents, individuals taking medications that can interact with alcohol, and those with specific medical conditions.

Alcoholic beverages should be avoided by individuals engaging in activities that require attention, skill, or coordination, such as driving or operating machinery.

**Food Safety**

To avoid microbial food-borne illnesses, do the following:

- Clean hands, food contact surfaces, and fruits and vegetables. Meat and poultry should not be washed or rinsed.
- Separate raw, cooked, and ready-to-eat foods while shopping, preparing, or storing foods.
- Cook foods to a safe temperature to kill microorganisms.
- Chill (refrigerate) perishable food promptly, and defrost foods properly.
- Avoid raw ( unpasteurized) milk or any products made from unpasteurized milk, raw or partially cooked eggs or foods containing raw eggs, raw or undercooked meat and poultry, unpasteurized juices, and raw sprouts.

**Congenital Neural Tube Defects**

Inadequate maternal folic acid intake has been definitively proved to be a major risk factor for congenital neural tube defects such as spina bifida and myelomeningocele. For this reason, cereal and grain products have been fortified in the United States with folic acid since 1998.

**Translating Evidence into Dietary Change**

Thus, the evidence is strong that dietary habits can influence the incidence and severity of many incapacitating or lethal diseases in the United States. No justification exists for the belief that modification of the “usual” American diet is unnecessary or futile. The only questions are whether change is feasible and what is required to effect it. Various health agencies and the U.S. government have used public education, particularly the publication of dietary goals, as their primary means (see Table 220-3). The Department of Agriculture and the Department of Health and Human Services have developed and periodically revised the Dietary Guidelines for Americans (see Table 220-2) and a food guidance system, now called MyPyramid (Fig. 220-1). Although some have commented that MyPyramid, released in 2005, is complex and overly ambitious, both it and the Dietary Guidelines for Americans are more evidence based than previous versions, and MyPyramid provides detailed recommendations tailored to individual characteristics entered online by the user.

Physicians can influence their patients’ health by encouraging them to optimize their dietary habits and providing them with instructional materials...
### Table 220-3: Dietary Guidelines Promulgated by National Organizations*

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<tbody>
<tr>
<td>General health promotion and disease prevention</td>
<td>Elevated cholesterol, heart disease prevention</td>
<td>Prehypertension and hypertension</td>
<td>Reduced energy intake and modest weight loss can improve glycemia and insulin resistance</td>
<td>Balance calorie intake with physical activity; choose foods and drinks that help achieve and maintain a healthy weight</td>
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<tr>
<td>Total energy</td>
<td>Adequate energy intake to maintain a healthy weight</td>
<td>Reduce energy intake to lose weight if overweight</td>
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<tr>
<td>Fruits/vegetables</td>
<td>2 cups of fruit and 2.5 cups of vegetables/2000 calories/day</td>
<td>8-10 servings/day</td>
<td>≥5 servings/day</td>
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<tr>
<td>Meat</td>
<td>≤6 servings/day</td>
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<td></td>
<td>Limit consumption of processed and red meats</td>
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<tr>
<td>Dairy</td>
<td>2-3 servings/day of low-fat dairy</td>
<td>2-3 servings/day of low-fat dairy</td>
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<tr>
<td>Grains</td>
<td>≥3 ounce-equivalents of whole-grain products</td>
<td>6-8 servings of whole grains and whole-grain products</td>
<td></td>
<td>Choose whole grains over processed (refined) grains</td>
<td></td>
</tr>
<tr>
<td>Fat</td>
<td>20-35% of daily energy intake</td>
<td>25-35% of daily energy intake</td>
<td>&lt;27% of daily energy intake</td>
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<tr>
<td>Saturated fats</td>
<td>&lt;10% of daily energy intake</td>
<td>&lt;7% of daily energy intake</td>
<td>6% of daily energy intake</td>
<td>&lt;10% of daily energy intake; those with LDL cholesterol ≥100 may benefit from lowering saturated fat to &lt;7%</td>
<td></td>
</tr>
<tr>
<td>Polyunsaturated fats</td>
<td>Up to 10% of daily energy intake</td>
<td>Up to 10% of daily energy intake</td>
<td></td>
<td>Up to 10% of daily energy intake</td>
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<tr>
<td>Monounsaturated fats</td>
<td>10-20% of daily energy intake</td>
<td>Up to 20% of daily energy intake</td>
<td>15-20% of daily energy intake; combination of MUFA and carbohydrates should equal 60-70% of total energy intake</td>
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<tr>
<td>Trans-fats</td>
<td>&lt;1% of daily energy intake</td>
<td>Intake should be kept low</td>
<td>Intake should be minimized</td>
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<tr>
<td>Cholesterol</td>
<td>&lt;300 mg/day</td>
<td>&lt;200 mg/day</td>
<td>150 mg/day</td>
<td>&lt;300 mg/day; those with LDL cholesterol ≥100 may benefit from lowering cholesterol intake to 200 mg/day</td>
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<tr>
<td>Carbohydrates</td>
<td>45-65% of daily energy intake</td>
<td>50-60% of daily energy intake</td>
<td>55% of daily energy intake</td>
<td>Total amount of carbohydrate is more important than the source or type</td>
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<tr>
<td>Sugar</td>
<td>Limit added sugars</td>
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<td></td>
<td>Sucrose and sucrose-containing foods do not need to be restricted</td>
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</tr>
<tr>
<td>Protein</td>
<td>Approximately 15% of daily energy intake</td>
<td>18% of daily energy intake</td>
<td>10-20% of daily energy intake if renal function is normal</td>
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<tr>
<td>Alcohol</td>
<td>Up to 2 drinks/day for men and up to 1 drink/day for women; persons in special circumstances (e.g., pregnancy, history of alcoholism) should abstain</td>
<td>&lt;2 drinks/day for men and &lt;1 drink/day for women</td>
<td>If individuals choose to drink, limit to 2 drinks/day for men and 1 drink/day for women</td>
<td>No more than 1 drink/day for women and 2 drinks/day for men</td>
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<tr>
<td>Sodium</td>
<td>Up to 2300 mg/day</td>
<td>&lt;2400 mg/day</td>
<td>&lt;2400 mg/day</td>
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<tr>
<td>Potassium</td>
<td>4700 mg/day</td>
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<tr>
<td>Calcium</td>
<td>1250 mg/day</td>
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<tr>
<td>Magnesium</td>
<td>500 mg/day</td>
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</table>

*For further details, see the websites listed in this chapter.

**LDL** = low-density lipoprotein; **MUFA** = monounsaturated fatty acid.

and assistance from dietitians in making needed changes. A significant barrier to practical nutritional interventions could be removed if health insurers would reimburse dietitians’ services.


SUGGESTED WEBSITES