Part I

Food

1

Food Constituents

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Animals, including man, consume food to obtain the nutrients they need. Throughout the world there are differences in food consumption related to socioeconomic conditions, food availability, and cultural dictates. If a variety of fresh and cooked foods is consumed in sufficient quantities to meet the energy needs of the consumer, then the needs for protein and the micronutrients should be met. Having this in mind, it is surprising to learn that some people are poorly nourished, and indeed may develop one or more nutrition-related diseases. The early years of nutrition research focused on diseases related to inadequate vitamin and mineral intake. An important component of this research was the determination of the vitamin and mineral content of a vast variety of foods. The composition of these foods has been compiled by the USDA, and Table 1.1 provides web addresses to access these data sets. Several data sets that may not be available on the web can be found in this section. Table 1.2 provides the sugar content of selected foods in 100 g portions. This may be a very large serving size or a very small one, depending on the food in question. However, using a standard portion allows one to compare the sugar content of a variety of foods. Those that are very rich sources, i.e., honey or table sugar (sucrose), of course will have a very high value, yet one would not consume this much in a single food under most circumstances. Usually, one would select a portion size compatible with the need for sweetness in the particular food product. For example, one might add a teaspoon of table sugar to a cup of coffee. That teaspoon of sugar might weigh 8 grams.Table 1.3 provides information on the tagatose content of food. Tagatose is a new food additive used to reduce the amount of sugar in a food. It has a sweet taste, yet does not have the same energy value as sucrose. Other sugar substitutes are also used in the preparation of reduced-energy foods; however, data on their quantitative occurrence is not as readily available because of the proprietary interests of food producers. A list of sweeteners added to foods is provided in Table 1.5. Following this table is a list of the types of food additives that change the properties of food (Table 1.6). This table describes compounds that increase the shelf life of a class of foods, or additives that change the texture of a food. The specific attributes of individual food additives are described in Table 1.7. This table provides information on how these additives function in particular food products. Table 1.8 is a list of mycotoxins and bacterial toxins that can occur in food. The reader should also review Section 52 for an extensive description of foodborne illness. Table 1.9 provides a list of antinutrients sometimes found in food, and Table 1.10 is a list of toxic substances that can be present in food. Some of these toxic substances are added inadvertently by the food processing methods, but some occur naturally. If consumed in minute quantities, some of these toxic materials are without significant effect, yet other compounds (e.g., arsenic), even in minute amounts, could accumulate and become lethal.

Tables 1.11, 1.12, and 1.14 overlap to some extent. All contain information about plants. Some of these plants can have both a food and a non-food use. Non-food use is defined as a use that may have a real or imagined pharmacologic (drug/herbal) effect. The reader should use this information with considerable caution. Plants can differ from variety to variety, and indeed from one growing condition to another in the content of certain of their herbal or nutritive ingredients. Over-the-counter herbal preparations can also vary. There is little regulation of these preparations and few safeguards exist to protect the consumer with respect to biopotency. Furthermore, the consumer should be aware of the fact that some of these herbal remedies may interact with prescribed drugs, either nullifying the drug effect or, worse, interacting to cause an unwarranted or even lethal effect. Consumers of plants used for herbal remedies should consult their pharmacists and physicians about these potentially dangerous uses.

The next six tables provide information about the micronutrients. Table 1.14 gives vitamin terminology. Table 1.15 is a list of compounds that have vitamin A activity. Table 1.16 gives the structures and characteristics of the vitamins. The use of vitamin supplements as well as descriptions of vitamin deficiency is covered in Sections 43, 61, and 62. Table 1.17 summarizes vitamin deficiencies and needs. Table 1.18 summarizes the essential minerals and their functions. A more detailed description of the minerals is provided in Section 57. Table 1.19 lists the essential fatty acids, and Table 1.20 gives the common and technical names for fatty acids. It should be noted that felines require arachidonic acid as well as linoleic and linolenic acid in their diets. Other mammals only require linoleic and linolenic acids.

TABLE 1.1

Web Addresses for Information on the Composition of Food

Data Set	Web Address
Composition of foods, raw, processed, prepared; 6200 foods, 82 nutrients	http://www.nal.usda.gov/fnic/foodcomp/Data/
Daidzein, genisten, glycitein, isoflavone content of 128 foods	Use above address, click on this file to open
Carotenoid content of 215 foods	Use above address, click on this file to open
Trans fatty acid content of 214 foods	Use above address, click on this file to open
Sugar content of 500+ foods	Use above address, click on this file to open
Nutritive value of food in common household units; more than 900 items are in this list	Use above address, click on Nutritive Value of Foods (HG-72) to open
Vitamin K	Use above address, click on vitamin K to open
List of key foods (foods that contribute up to 75% of any one nutrient)	Use above address, click on Key Foods to open
Nutrient retention factors: calculations of retention of specific micronutrients	Use above address, click on Nutrient Retention Factors, Release 4 (1998)
Primary nutrient datasets (results of USDA surveys)	Use above address, click on Primary Nutrient for USDA Nationwide Food Surveys Dataset
Selenium and vitamin D (provisional values)	Use above address, click on selenium and vitamin D to open
Food composition (foods from India)	www.unu.edu/unupress/unupbooks/80633e/80633Eoi.htm
European foods	Cost99/EUROFOODS:Inventory of European Food Composition food.ethz.ch/cost99db-inventory.htm
Foods in developing countries	www.fao.org/DOCREP/W0073e/woo73eO6.htm
Other food data	www.arborcom.com/frame/foodc.htm
Soy foods (beneficial compounds)	See above, isoflavone, etc.
Individual amino acids and fatty acids	http://www.infinite faculty.org/sci/cr/crs/1994

Note: Most of these databases can be accessed as subdirectories of: http://www.Nal.USDA.gov/foodcomp/data/. A printed format can be obtained from the Superintendent of Documents, U.S. Printing Office, Washington D.C. 20402. Request USDA Handbooks 8 through 16. A CD-ROM can also be obtained. None of these are free.

TABLE 1.2

Sugar Content of Selected Foods, 100 Grams, Edible Portion[1]

Food Item	Moisture (%)	Monosaccharides (in grams)			Disaccharides (in grams)			Other Sugars	Total Sugars
		Galactose	Glucose	Fructose	Lactose	Sucrose	Maltose		
Dairy Products									
Cheese									
Brie	47.7	—	1.0	0.3	0.2	0.1	TR	—	1.6
Edam	41.1	—	0.1	—	—	0.1	—	—	0.2
Mozzarella	47.0	—	1.1	—	TR	—	—	—	1.1
Ice cream									
Chocolate	53.7	—	—	—	3.7	14.9	TR	—	18.6
Strawberry	56.9	—	1.5	0.8	4.1	8.5	TR	—	14.9
Vanilla	60.5	—	—	—	5.1	8.9	TR	—	14.0
Ice milk, vanilla	59.3	—	1.6	0.8	5.8	6.5	TR	—	14.7
Yogurt									
Plain	86.0	—	0.3	—	3.0	—	—	—	3.3
Strawberry	72.5	—	2.3	2.1	3.2	7.3	—	—	14.9

TABLE 1.2 *(Continued)*

Sugar Content of Selected Foods, 100 Grams, Edible Portion[1]

Food Item	Moisture (%)	Monosaccharides (in grams)			Disaccharides (in grams)			Other Sugars	Total Sugars
		Galactose	Glucose	Fructose	Lactose	Sucrose	Maltose		
Grains and Baked Products									
Bread									
Banana	32.9	—	TR	0.1	—	25.8	—	—	25.9
Hamburger buns	34.7	—	1.7	1.3	0.2	—	0.2	—	3.4
Pita	20.5	—	0.1	0.2	—	—	1.0	—	1.3
Pumpernickel	37.1	—	0.6	0.1	—	—	1.0	—	1.7
Raisin	31.5	—	7.3	6.6	—	TR	TR	—	13.9
Rye	36.5	—	0.6	0.4	—	0.6	—	—	1.6
White	36.3	—	1.8	1.2	—	0.4	0.2	—	3.6
Whole wheat	39.3	—	0.7	0.6	—	—	0.6	—	1.9
Cake									
Angel food	34.8	—	—	—	—	33.7	—	—	33.7
Sponge	21.1	—	TR	—	—	23.6	—	—	23.6
Yellow	33.9	—	TR	—	—	25.8	—	—	25.8
Cheesecake, plain	38.2	—	TR	—	0.1	7.0	—	—	7.1
Chocolate chip cookies	3.7	—	TR	TR	—	18.7	—	—	18.7
Corn flakes	1.7	—	2.2	2.1	—	2.9	—	—	7.2
Crude wheat germ	9.6	—	0.9	TR	—	6.9	—	—	7.8
Donuts									
Cake type	20.8	—	0.9	0.1	TR	8.6	TR	—	9.6
Yeast type	26.3	—	1.4	1.4	1.0	—	1.4	—	5.2
Flour									
Rye	11.0	—	0.2	0.1	—	0.6	—	—	0.9
White	10.5	—	TR	TR	—	0.1	TR	—	0.1
Whole wheat	9.3	—	TR	TR	—	0.4	—	—	0.4
Graham crackers	5.6	—	1.9	1.2	—	12.6	—	—	5.7
Pasta									
Egg noodles, raw	8.8	—	—	—	—	0.1	0.8	—	0.9
Egg noodles, cooked	67.0	—	0.1	—	—	TR	0.2	—	0.3
Spaghetti, raw	9.8	—	TR	—	—	0.1	0.4	—	0.5
Spaghetti, cooked	62.7	—	0.1	—	—	—	0.2	—	0.3
Rice									
Parboiled, raw	9.8	—	TR	—	—	0.1	—	—	0.1
Parboiled, cooked	72.8	—	0.1	TR	—	0.1	—	—	0.2
Tortillas									
Flour	18.5	—	—	TR	—	0.1	0.5	—	0.6
Corn	49.6	—	—	TR	—	0.5	—	—	0.5
Fruits and Fruit Juices									
Apples									
Delicious, golden	84.5	—	1.8	6.4	—	1.8	—	—	10.0

TABLE 1.2 *(Continued)*

Sugar Content of Selected Foods, 100 Grams, Edible Portion[1]

Food Item	Moisture (%)	Monosaccharides (in grams)			Disaccharides (in grams)			Other Sugars	Total Sugars
		Galactose	Glucose	Fructose	Lactose	Sucrose	Maltose		
Delicious, red	84.9	—	2.4	6.2	—	2.0	—	—	10.6
Winesap	84.7	—	3.5	6.7	—	3.6	—	—	13.8
Apricot nectar	84.6	—	6.3	4.6	—	2.0	—	—	12.9
Cantaloupe	90.0	—	1.1	1.3	—	5.9	—	—	8.3
Dried apricots	26.5	—	13.1	7.6	—	5.8	—	—	26.5
Dried peaches	22.6	—	9.9	11.4	—	17.6	—	—	38.9
Dried pears	33.1	—	8.9	23.0	—	—	—	—	31.9
Dried prunes	3.8	—	19.5	10.6	—	—	—	—	30.1
Grapes, Thompson, seedless	74.9	—	7.9	7.8	—	1.1	—	—	16.8
Grapefruit, white, seedless	87.7	—	2.0	1.9	—	2.5	—	—	6.4
Kiwi	83.1	—	3.5	3.9	—	0.9	—	—	8.3
Orange juice, canned	87.7	—	2.4	2.6	—	2.8	—	—	7.8
Peaches	87.5	—	0.9	0.9	—	—	—	—	1.8
Pears, Bartlett	83.6	—	4.4	6.7	—	0.9	—	—	12.0
Persimmon	78.9	—	5.4	5.6	—	1.5	—	—	12.5
Plums	89.1	—	3.1	2.6	—	2.7	—	—	8.4
Strawberries									
Fresh, raw	91.7	—	1.6	1.8	—	0.2	—	—	3.6
Frozen with sugar added	71.2	—	5.8	5.1	—	16.3	—	—	27.2
Frozen without sugar added	90.4	—	1.9	1.8	—	—	—	—	3.7
Tangelos	86.5	—	1.5	1.6	—	4.0	—	—	7.1
Tangerines	82.3	—	2.2	2.6	—	6.7	—	—	11.5
Watermelon	91.1	—	1.6	3.4	—	3.7	—	—	8.7
Vegetable Products									
Broccoli									
Raw	90.9	—	0.4	0.4	—	0.1	—	—	0.9
Cooked	90.7	—	0.4	0.3	—	0.1	—	—	0.8
Cabbage									
Raw	92.7	—	1.5	1.1	—	TR	TR	—	2.6
Cooked	93.8	—	1.0	0.7	—	0.1	—	—	1.8
Carrots									
Raw	88.3	—	0.6	0.5	—	3.1	—	—	4.2
Cooked	90.1	—	0.3	0.3	—	1.6	—	—	2.2
Mushrooms, raw	93.2	—	2.6	TR	—	—	—	—	2.6
Spinach									
Raw	93.5	—	0.1	TR	—	TR	—	—	0.1
Cooked	93.2	—	0.1	TR	—	TR	—	—	0.1
Sprouts									
Alfalfa, raw	92.3	—	0.1	0.1	—	TR	—	—	0.2
Mung bean, raw	91.0	—	1.0	0.5	—	0.2	—	—	1.7
Sweet potatoes									
Raw	73.4	—	0.9	0.7	—	3.5	—	—	5.1
Cooked	82.1	—	0.7	0.8	—	2.4	2.6	—	6.5

TABLE 1.2 *(Continued)*

Sugar Content of Selected Foods, 100 Grams, Edible Portion[1]

Food Item	Moisture (%)	Monosaccharides (in grams)			Disaccharides (in grams)			Other Sugars	Total Sugars
		Galactose	Glucose	Fructose	Lactose	Sucrose	Maltose		
Beverages									
Beer									
Light	97.9	—	TR	TR	—	—	TR	—	TR
Regular	96.1	—	TR	—	—	—	—	—	TR
Sherry									
Dry	72.2	—	0.6	0.5	—	TR	TR	—	1.1
Medium	71.7	—	1.6	1.3	—	—	—	—	2.9
Sweet	70.8	—	0.9	5.2	—	—	—	—	6.1
Wine									
Port, dessert	69.0	—	4.3	5.1	—	TR	—	—	9.4
Red, dry	85.1	—	0.4	0.3	—	0.1	—	—	0.8
Rose, dry	84.2	—	1.4	1.4	—	—	—	—	2.8
White, dry	86.5	—	0.6	0.6	—	—	0.1	—	1.3
Vermouth, dry	72.8	—	0.6	0.5	—	—	—	—	1.1
Sweets									
Honey	7.8	—	38.7	45.2	—	TR	TR	—	83.9
Maple syrup	32.7	—	TR	TR	—	55.4	—	—	55.4
Milk chocolate, plain	1.4	—	—	—	6.6	46.4	—	—	53.0
Molasses	17.4	—	15.7	14.8	—	24.5	—	—	55.9
Molasses, blackstrap	23.0	—	—	9.8	—	42.5	—	—	52.3
Nuts and Seeds									
Coconut, dried, sweetened	10.6	—	0.4	0.2	—	3.9	—	—	4.5
Sesame seeds									
Dehulled	4.1	—	0.1	—	—	0.1	—	—	0.2
Whole	5.4	—	TR	—	—	0.3	—	—	0.3
Sunflower nuts, dried roasted	1.4	—	1.5	—	—	1.5	—	—	3.0
Legumes									
Baked beans									
In tomato sauce	73.8	—	0.6	0.5	—	4.2	—	0.3	5.6
With pork	69.0	—	1.4	1.0	—	4.2	—	0.3	6.9
Black-eyed peas	75.9	—	—	0.2	—	0.3	—	—	0.5
Chickpeas	65.0	—	—	0.2	—	0.2	—	—	0.4

Note: Dash denotes lack of data for sugar that may be present; (0.0) denotes lack of data for sugar thought not to be present; TR denotes trace.

[1] See also http://www.nal.usda./goo/fnic/foodcomp/data/sugar.

TABLE 1.3

Tocopherols and Tocotrienols in Selected Food Products (mg/100 g)

Product	α-T	α-T3	β-T	β-T3	γ-T	γ-T3	δ-T	δ-T3	Total	α Tocopherol Equivalents
Breakfast Cereals										
Fortified										
Total	104.50				ND		ND		104.50	104.50
King Vitamin	35.10				ND		ND		35.10	35.10
Non-Fortified										
Post Natural Raisin Bran	1.50				ND		ND		1.50	1.50
Kellogg's	1.30				ND		ND		1.30	1.30
Cheese										
American										
Low fat Weight Watchers	1.50				ND		ND		1.50	1.50
Borden Lite Line	0.10				ND		ND		0.10	0.10
Processed										
Kraft	0.40				ND		ND		0.40	0.40
American processed										
Kroger	0.40				ND		ND		0.40	0.40
Cheddar										
Kraft	0.30				ND		ND		0.30	0.30
Kroger	0.20				ND		ND		0.20	0.20
Munster										
Sargento	0.50				ND		ND		0.50	0.50
Kroger	0.30				ND		ND		0.30	0.30
Swiss										
Kraft	0.60				ND		ND		0.60	0.60
Beatrice City Line Old World	0.40				ND		ND		0.40	0.40
Chips										
Potato										
Lay's	1.30				4.60		1.30		7.20	1.80
Wise	7.40				1.20		0.10		8.70	7.52
Tortilla										
Tostitos	1.10				2.40		0.50		4.00	1.36
Tostados	1.50				1.00		0.30		2.80	1.61
										0.00

TABLE 1.3 *(Continued)*

Tocopherols and Tocotrienols in Selected Food Products (mg/100 g)

Product	α-T	α-T3	β-T	β-T3	γ-T	γ-T3	δ-T	δ-T3	Total	α Tocopherol Equivalents
Fish										
Salmon, waterpack										
Chicken of the Sea	0.70				ND		ND		0.70	0.70
Black Top	0.60				ND		ND		0.60	0.60
Sardines, in tomato sauce										
Spirit of Norway	3.60				0.20		0.10		3.90	3.62
Orleans	3.90				ND		0.10		4.00	3.90
Tuna, canned in oil										0.00
Starkist	1.00				4.80		1.90		7.70	1.54
Chicken of the Sea	0.98				2.60		1.10		4.68	1.27
Fruits and Fruit Juices										
Grape juice, bottled										
Welch's	ND				ND		ND		0.00	0.00
Seneca	ND				ND		ND		0.00	0.00
Orange juice										
Fresh Tropicana	0.20				ND		ND		0.20	0.20
Frozen Minute Maid	0.20				0.10		ND		0.30	0.21
Plums										0.00
Variety 1	0.70				0.10		ND		0.80	0.71
Variety 2	0.50				0.04		ND		0.54	0.50
Milk chocolate, plain	0.50				2.00		ND		2.50	0.70
Nuts										
Brazil nuts										
Health food store	6.60				2.10		1.60		10.30	6.86
Dekalb Farmers Market	11.00				5.10		2.60		18.70	11.59
English walnuts										
Diamond	1.40				9.20		0.60		11.20	2.34
Kroger					6.70		0.50		7.20	0.69
Hazelnuts										
Health food store	21.50				0.10		0.01		21.61	21.51
Dekalb Farmers Market	16.80				0.70		ND		17.50	16.87

Oils					
Margarine, stick					
Mazzola	8.40	24.40	0.40	33.20	10.85
Fleischman	7.90	23.10	0.60	31.60	10.23
Mayonnaise					
Kraft	1.30	6.60	1.00	8.90	1.99
Hellman	1.60	9.80	1.90	13.30	2.64
Shortenings, Crisco	5.60	25.20	5.40	36.20	8.28
Vegetable oil					0.00
Crisco	2.90	33.30	7.00	43.20	6.44
Wesson	2.80	18.30	3.00	24.10	4.72
Protein Diet Powder					
Slimfast	26.50	ND	ND	26.50	26.50
Herbalife	24.60	ND	ND	24.60	24.60
Salad Dressings					
Bleu Cheese					
Marie's	4.70	57.50	25.40	87.60	11.21
Kraft	2.80	49.00	14.40	66.20	8.13
French					
Wishbone	3.00	66.90	27.70	97.60	10.52
Kraft	3.10	61.90	18.20	83.20	9.84
Italian					
Wishbone	4.40	60.60	30.00	95.00	11.36
Kraft	4.00	62.70	17.80	84.50	10.80
Tea					
Tea leaves from tea bags					
Tetley	2.40	0.60	ND	3.00	2.46
Lipton	12.30	3.20	ND	15.50	12.62
Tea brewed from tea bags					
Tetley	ND	ND	ND	0.00	0.00
Lipton	ND	ND	ND	0.00	0.00
Tomato Products					
Barbecue sauce					
Kraft	1.00	0.80	0.10	1.90	1.08

TABLE 1.3 *(Continued)*

Tocopherols and Tocotrienols in Selected Food Products (mg/100 g)

Product	α-T	α-T3	β-T	β-T3	γ-T	γ-T3	δ-T	δ-T3	Total	α Tocopherol Equivalents
Heinz	1.10				0.40		0.10		1.60	1.14
Catsup										
Heinz	1.10				0.10		ND		1.20	1.11
Hunt's	1.80				0.20		ND		2.00	1.82
Tomato chili sauce										
Del Monte	2.70				0.20		ND		2.90	2.72
Heinz	3.20				0.30		ND		3.50	3.23
Tomato paste										
Hunt's	4.10				0.30		ND		4.40	4.13
Contadina	4.50				0.70		ND		5.20	4.57
Tomato sauce										
Hunt's	1.40				0.10		ND		1.50	1.41
Progresso	1.50				0.20		ND		1.70	1.52
Tomato soup										
Campbell's	0.70				0.30		0.10		1.10	0.73
Kroger	0.60				0.10		ND		0.70	0.61
Tomatoes, stewed										
Del Monte	0.90				0.20		ND		1.10	0.92
Stokely's	0.70				0.20		ND		0.90	0.72
Vegetables										
Asparagus										
Sample 1	1.00				0.10		ND		1.10	1.01
Sample 2	1.30				0.10		ND		1.40	1.31
Cabbage										
Sample 1	0.12				ND		ND		0.12	0.12
Sample 2	0.09				ND		ND		0.09	0.09
Cucumbers										
Sample 1	0.04				0.02		ND		0.06	0.04
Sample 2	0.09				0.02		ND		0.11	0.09
Turnip greens										
Sample 1	2.90				0.10		ND		3.00	2.91
Sample 2	2.80				0.20		ND		3.00	2.82

Note: ND, not detectable.

TABLE 1.4

Occurrence of D-Tagatose in Foods[1]

Food	Result (mg/kg)	Sample Preparation	Apparatus
Sterilized cow's milk	2 to 3000	Extracted with methanol; prepared trimethylsilyl (TMS) derivatives	Gas chromatography (GC), fused silica capillary column (18m × 0.22mm) coated with AT-1000; carrier gas-N_2; flame ionization detector (FID)
Hot cocoa (processed with alkali) prepared with milk	140	Extracted with deionized (DI) water	High performance liquid chromatography (HPLC); used Bio-Rad Aminex® HPX-87C column (300 mm × 7.8 mm) heated to 85° C; mobile phase-DI water; flow rate-0.6 mL/min; refractive index (RI) detector
Hot cocoa prepared with milk	190	Extracted with DI water	HPLC; Bio-Rad Aminex® HPX-87C column heated to 85°C; mobile phase-DI water; flow rate-0.6 mL/min; RI detector
Powdered cow's milk	800	Extracted three times with distilled water for 3h at 60°C; column chromatography to remove organic acids and bases; fractionation by partition chromatography	Paper partition chromatography, descending method on Whatman no.1 paper; used three solvent systems
Similac® infant formula	4	Extracted with 90% ethanol; prepared TMS derivatives	GC; DB-5 fused-silica capillary column (15 m × 0.53 mm, 1.5 µm film thickness); carrier gas-He; FID detector
Enfamil® infant formula	23	Extracted with 90% aqueous ethanol; prepared TMS derivatives	GC; DB-17 fused-silica capillary column (15 m × 0.53 mm,1 µm film thickness); carrier gas-He; FID detector
Parmesan cheese	10	Extracted with 80% aqueous methanol; prepared TMS derivatives	GC; DB-5 fused silica capillary column (30 m, 0.25 µm film thickness); carrier gas-He; FID detector
Gjetost cheese	15	Extracted with 80% aqueous methanol; prepared TMS derivatives	GC; DB-5 fused silica capillary column (30 m, 0.25 µm film thickness); carrier gas-He; FID detector
Cheddar cheese	2	Extracted with 80% aqueous methanol; prepared TMS derivatives	GC; DB-5 fused silica capillary column (30 m, 0.25 µm film thickness); carrier gas-He; FID detector
Roquefort cheese	20	Extracted with 80% aqueous methanol; prepared TMS derivatives	GC; DB-5 fused silica capillary column (30 m, 0.25 µm film thickness); carrier gas-He; FID detector
Feta cheese	17	Extracted with 80% aqueous methanol; prepared TMS derivatives	GC; DB-5 fused silica capillary column (30 m, 0.25 µm film thickness); carrier gas-He; FID detector

TABLE 1.4 *(Continued)*

Occurrence of D-Tagatose in Foods[1]

Food	Result (mg/kg)	Sample Preparation	Apparatus
Ultra high temperature milk	~5	Dried under vacuum; water was added, then volatile derivatives extracted with isooctane	GC; Rescom type OV1 capillary column (25 m × 0.25 mm, 0.1 or 0.25 μm film thickness); carrier gas-H 2; FID detector
BA Nature® Yogurt	29	Extracted with DI water; passed through a strong cation exchange column followed by an amine column	HPLC; Bio-Rad Aminex® HPX-87C column heated to 85ºC; mobile phase-DI water; flow rate-0.6 mL/min; RI detector
Cephulac®, an orally-ingested medication for treatment of portal-systemic encephalopathy	6500	Deionized with Amberlite IR-120 (H) and Duolite A-561 (free base); diluted to 20 mg/mL with a 50:50 mixture of acetonitrile and water	HPLC; Waters Carbohydrate Analysis Column (300 mm × 3.9 mm); mobile phase-water: acetonitrile, 77:23 (w/w); flow rate-2 mL/min; RI detector
Chronulac®, an orally ingested laxative	6500	Deionized with Amberlite IR-120 (H) and Duolite A-561 (free base); diluted to 20 mg/mL with a 50:50 mixture of acetonitrile and water	HPLC; Waters Carbohydrate Analysis Column (300 mm × 3.9 mm); mobile phase-water: acetonitrile, 77:23 (w/w); flow rate-2 mL/min; RI detector

[1] This table was prepared by Lee Zehner, Beltsville, MD.

TABLE 1.5

Sweetening Agents, Sugar Substitutes

Name	Sweetness	Classification	Uses	Comments
Acesulfame-K (sold under brand Sunette)	130	Nonnutritive; artificial	Tabletop sweetener, chewing gum, dry beverage mixes, puddings	This is actually the potassium salt of the 6-methyl derivative of a group of chemicals called oxathiazinone dioxides; approved by the FDA in 1988
Aspartame	180	Nutritive; artificial	In most diet sodas; also used in cold cereals, drink mixes, gelatin, puddings, toppings, dairy products, and at the table by the consumer; not used in cooking due to lack of stability when heated	Composed of the two naturally occurring amino acids, aspartic acid and phenylalanine; sweeter than sugar, therefore less required, hence fewer calories
Cyclamate	30	Nonnutritive; artificial	Tabletop sweetener and in drugs in Canada and 40 other countries	Discovered in 1937; FDA banned all cyclamate-containing beverages in 1969 and all cyclamate-containing foods in 1970 Cyclamate safety is now being reevaluated by the FDA
Dulcin (4-ethoxy-phenyl-urea)	250	Nonnutritive; artificial	None	Not approved for food use in the U.S.; used in some European countries; also called Sucrol and Valzin
Fructose (levulose)	1.7	Nutritive; natural	Beverages, baking, canned goods; anywhere invert sugar or honey may be used	A carbohydrate; a monosaccharide; naturally occurs in fruits; makes up about 50% of the sugar in honey; commercially found in high-fructose syrups and invert sugars; contributes sweetness and prevents crystallization
Glucose (dextrose)	0.7	Nutritive; natural	Primarily in the confection, wine, and canning industries; and in intravenous solutions	Acts synergistically with other sweeteners
Glycine	0.8	Nutritive; natural	Permissible to use to modify taste of some foods	A sweet-tasting amino acid; tryptophan is also a sweet-tasting amino acid
Mannitol	0.7	Nutritive; natural	Candies, chewing gums, confections, and baked goods; dietetic foods	A sugar alcohol or polyhydric alcohol (polyol); occurs naturally in pineapples, olives, asparagus, and carrots; commercially prepared by the hydrogenation of mannose or glucose; slowly and incompletely absorbed from the intestines; only slightly metabolized, most excreted unchanged in the urine; may cause diarrhea

TABLE 1.5 *(Continued)*

Sweetening Agents, Sugar Substitutes

Name	Sweetness[1]	Classification	Uses	Comments
Miraculin	—	Nutritive; natural	None	Actually a taste-modifying protein rather than a sweetener; after exposing tongue to miraculin, sour lemon tastes like sweetened lemon; responsible for the taste-changing properties of mircale fruit, red berries of *Synsepalum dulcificum,* a native plant of West Africa; first described in 1852; one attempt made to commercialize by a U.S. firm but FDA denied approval and marketing was stopped
Monellin	3000	Nutritive; natural	None; only a potential low-calorie sweetener	Extract of the pulp of the light red berries of the tropical plant *Dioscoreophyllum cumminsii;* also called Serendipity Berry; first protein found to elicit a sweet taste in man; first extracted in 1969; potential use limited by lack of stability; taste sensation is slow and lingering; everything tastes sweet after monellin.
Neohesperidin dihydrochalone (Neo DHC, NDHC)	1250	Nonnutritive; artificial	None approved; potential for chewing gum, mouthwash, and toothpaste	Formed from naringen isolated from citrus fruit; slow to elicit the taste sensation; lingering licorice-like aftertaste; animal studies indicate not toxic
P-4000 (5-nitro-2-propoxyaniline)	4100	Nonnutritive; artificial	None approved	Derivative of nitroaniline; used as a sweetener in some European countries but banned in the U.S. due to toxic effects on rats; no bitter aftertaste; major drawback of P-4000 is powerful local anesthetic effect on the tongue and mouth; used in the Netherlands during German occupation and Berlin blockade
Phyllodulcin	250	Natural	None approved	Isolated from *Hydrangea macrophylla Seringe* in 1916; displays a lagging onset of sweetness with licorice aftertaste; not well studied; possible market for hard candies, chewing gums, and oral hygiene products
Saccharin (0 benzosulfimide)	500	Nonnutritive; artificial	Used in beverages, as a tabletop sweetener, and in cosmetics, toothpaste, and cough syrup; used as a sweetener by diabetics	Both sodium and calcium salts of saccharin used; passes through body unchanged; excreted in urine; originally a generally recognized as safe (GRAS) additive Subsequently, saccharin was classed as a carcinogen based on experiments with rats; however, recent experiments indicate that saccharin causes cancer in rats, but not in mice and people

Sorbitol	0.6	Nutritive; natural	Chewing gum, dairy products, meat products, icing, toppings, and beverages	A sugar alcohol or polyhydric alcohol (polyol); occurs naturally in many fruits commercially prepared by the hydrogenation of glucose; many unique properties besides sweetness; on the FDA list of GRAS food additives; the most widely used sugar alcohol; slow intestinal absorption; consumption of large amounts may cause diarrhea
SRI Oxime V (Perilla sugar)	450	Nonnutritive; artificial	None approved	Derived from extract of Perilla namkinensis; clean taste; needs research; used as sweetening agent in Japan
Stevioside	300	Nutritive; natural	None approved	Isolated from the leaves of the wild shrub *Stevia rebaudiana Bertoni;* used by the people of Paraguay to sweeten drinks; limited evidence suggests nontoxic to humans Rebaudioside A is isolated from the same plant and is said to taste superior to stevioside; its chemical structure is very similar to stevioside and it is 190 times sweeter than sugar
Sucrose (brown sugar, liquid sugar, sugar, table sugar, white sugar	1.0	Nutritive; natural	Many beverages and processed foods; home use in a wide variety of foods	The chemical combination of the sugars fructose and glucose; one of the oldest sweetening agents; most popular and most available sweetening agent; occurs naturally in many fruits; commercially extracted from sugar cane and sugar beets
Thaumatins	1600	Nutritive; natural	None	Source of sweetness of the tropical fruit from the plant *Thaumatococcus daniellii*; enjoyed by inhabitants of western Africa; doubtful commercial applications
Xylitol (Also see XYLITOL)	0.8	Nutritive; natural	Chewing gums and dietetic foods	A sugar alcohol or polyhydric alcohol (polyol); occurs naturally in some fruits and vegetables; produced in the body; commercial production from plant parts (oat hulls, corncobs, and birch wood chips) containing xylans — long chains of the sugar xylose; possible diarrhea; one British study suggests xylitol causes cancer in animals

Adapted from Ensminger et al. *Foods and Nutrition Encyclopedia,* 2nd ed., CRC Press, Boca Raton, 1994, pp. 2082–2087.

TABLE 1.6

Terms used to Describe the Functions of Food Additives

Term	Function
Anticaking agents and free-flow agents	Substances added to finely powdered or crystalline food products to prevent caking
Antimicrobial agents	Substances used to preserve food by preventing growth of microorganisms and subsequent spoilage, including fungicides, mold and yeast inhibitors, and bacteriocides
Antioxidants	Substances used to preserve food by retarding deterioration, rancidity, or discoloration due to oxidation
Colors and coloring adjuncts	Substances used to impart, preserve, or enhance the color or shading of a food, including color stabilizers, color fixatives, color-retention agents
Curing and pickling agents	Substances imparting a unique flavor and/or color to a food, usually producing an increase in shelf life stability
Dough strengtheners	Substances used to modify starch and gluten, thereby producing a more stable dough
Drying agents	Substances with moisture-absorbing ability, used to maintain an environment of low moisture
Emulsifiers and emulsifier salts	Substances which modify surface tension of two (or more) immiscible solutions to establish a uniform dispersion of components; called an emulsion
Enzymes	Substances used to improve food processing and the quality of the finished food
Firming agents	Substances added to precipitate residual pectin, thus strengthening the supporting tissue and preventing its collapse during processing
Flavor enhancers	Substances added to supplement, enhance, or modify the original taste and/or aroma of a food without imparting a characteristic taste or aroma of its own
Flavoring agents and adjuvants	Substances added to impart or help impart a taste or aroma in food
Flour treating agents	Substances added to milled flour, at the mill, to improve its color and/or baking qualities, including bleaching and maturing agents
Formulation aids	Substances used to promote or produce a desired physical state or texture in food, including carriers, binders, fillers, plasticizers, film-formers, and tableting aids
Fumigants	Volatile substances used for controlling insects or pests
Humectants	Hygroscopic substances incorporated in food to promote retention of moisture, including moisture-retention agents and antidusting agents
Leavening agents	Substances used to produce or stimulate production of carbon dioxide in baked goods to impart a light texture, including yeast, yeast foods, and calcium salts
Lubricants and release agents	Substances added to food contact surfaces to prevent ingredients and finished products from sticking to them
Nonnutritive sweeteners	Substances having less than 2% of the caloric value of sucrose per equivalent unit of sweetening capacity
Nutrient supplements	Substances which are necessary for the body's nutritional and metabolic processes
Nutritive sweeteners	Substances having greater than 2% equivalent unit of sweetening capacity
Oxidizing and reducing agents	Substances which chemically oxidize or reduce another food ingredient, thereby producing a more stable product
pH control agents	Substances added to change or maintain active acidity or alkalinity, including buffers, acids, alkalis, and neutralizing agents
Processing aids	Substances used as manufacturing aids to enhance the appeal or utility of a food or food component, including clarifying agents, clouding agents, catalysts, flocculents, filter aids, and crystallization inhibitors

TABLE 1.6 *(Continued)*

Terms used to Describe the Functions of Food Additives

Term	Function
Propellants, aerating agents, and gases	Gases used to supply force to expel a product, or used to reduce the amount of oxygen in contact with the food in packaging
Sequestrants	Substances which combine with polyvalent metal ions to form a soluble metal complex, to improve the quality and stability of products
Solvents and vehicles	Substances used to extract or dissolve another substance
Stabilizers and thickeners	Substances used to produce viscous solutions or dispersions, to impart body, improve consistency, or stabilize emulsions, including suspending and bodying agents, setting agents, gelling agents, and bulking agents
Surface-active agents	Substances used to modify surface properties of liquid food components for a variety of effects, other than emulsifiers but including solubilizing agents, dispersants, detergents, wetting agents, rehydration enhancers, whipping agents, foaming agents, and defoaming agents
Surface-finishing agents	Substances used to increase palatability, preserve gloss, and inhibit discoloration of foods, including glazes, polishes, waxes, and protective coatings
Synergists	Substances used to act or react with another food ingredient to produce a total effect different or greater than the sum of the effects produced by the individual ingredients
Texturizers	Substances which affect the appearance or feel of the food

Taken from Ensminger, et al. *Foods and Nutrition Encyclopedia*, 2nd ed., CRC Press, Boca Raton, 1994, p. 11.

TABLE 1.7

Specific Food Additives and Their Functions

Name	Function[1]	Food Use and Comments[2]
Acetic acid	pH control, preservative	Acid of vinegar is acetic acid; miscellaneous and/or general purposes; many food uses; GRAS additive
Adipic acid	pH control	Buffer and neutralizing agent; use in confectionery; GRAS additive
Ammonium alginate	Stabilizer and thickener, texturizer	Extracted from seaweed; widespread food use; GRAS additive
Annatto	Color	Extracted from seeds of *Bixa crellana*; butter, cheese, margarine, shortening, and sausage casings; coloring foods in general
Arabinogalactan	Stabilizer and thickener, texturizer	Extracted from Western larch; widespread food use; bodying agent in essential oils, nonnutritive sweeteners, flavor bases, nonstandardized dressings, and pudding mixes
Ascorbic acid (Vitamin C)	Nutrient, antioxidant, preservative	Widespread use in foods to prevent rancidity, browning; used in meat curing; GRAS additive
Aspartame	Sweetener; sugar substitute	Soft drinks, chewing gum, powdered beverages, whipped toppings, puddings, gelatin; tabletop sweetener
Azodicarbonamide	Flour treating agent	Aging and bleaching ingredient in cereal flour
Benzoic acid	Preservative	Occurs in nature in free and combined forms; widespread food use; GRAS additive
Benzoyl peroxide	Flour treating agent	Bleaching agent in flour; may be used in some cheeses
Beta-apo-8′ carotenal	Color	Natural food color; general use not to exceed 30 mg/lb or pt of food

TABLE 1.7 *(Continued)*

Specific Food Additives and Their Functions

Name	Function[1]	Food Use and Comments[2]
BHA (butylated hydroxyanisole)	Antioxidant, preservative	Fats, oils, dry yeast, beverages, breakfast cereals, dry mixes, shortening, potato flakes, chewing gum, sausage; often used in combination with BHT; GRAS additive
BHT (butylated hydroxytoluene)	Antioxidant, preservative	Rice, fats, oils, potato granules, breakfast cereals, potato flakes, shortening, chewing gum, sausage; often used in combination with BHA; GRAS additive
Biotin	Nutrient	Rich natural sources are liver, kidney, pancreas, yeast, milk; vitamin supplement; GRAS additive
Calcium alginate	Stabilizer and thickener, texturizer	Extracted from seaweed; widespread food use; GRAS additive
Calcium carbonate	Nutrient	Mineral supplement; general purpose additive; GRAS additive
Calcium lactate	Preservative	General purpose and/or miscellaneous use; GRAS additive
Calcium phosphate	Leavening agent, sequestrant, nutrient	General purpose and/or miscellaneous use; mineral supplement; GRAS additive
Calcium propionate	Preservative	Bakery products, alone or with sodium propionate; inhibits mold and other microorganisms; GRAS additive
Calcium silicate	Anticaking agent	Used in baking powder and salt; GRAS additive
Canthaxanthin	Color	Widely distributed in nature; color for foods; more red than carotene
Caramel	Color	Miscellaneous and/or general purpose use in foods for color; GRAS additive
Carob bean gum	Stabilizer and thickener	Extracted from bean of carob tree (Locust bean); numerous foods, e.g., confections, syrups, cheese spreads, frozen desserts, and salad dressings; GRAS additive
Carrageenan	Emulsifier, stabilizer, and thickener	Extracted from seaweed; a variety of foods, primarily those with a water or milk base
Cellulose	Emulsifier, stabilizer, and thickener	Component of all plants; inert bulking agent in foods; may be used to reduce energy content of food; used in foods which are liquid and foam systems
Citric acid	Preservative, antioxidant, pH control agent, sequestrant	Widely distributed in nature in both plants and animals; miscellaneous and/or general purpose food use; used in lard, shortening, sausage, margarine, chili con carne, cured meats, and freeze-dried meats; GRAS additive
Citrus Red No. 2	Color	Coloring skins of oranges
Cochineal	Color	Derived from the dried female insect, *Coccus cacti*; raised in West Indies, Canary Islands, southern Spain, and Algiers; 70,000 insects to 1 lb.; provides red color for meat products and beverages
Corn endosperm oil	Color	Source of xanthophyll for yellow color; used in chicken feed to color yolks of eggs and chicken skin
Cornstarch	Anticaking agent, drying agent, formulation aid, processing aid, surface-finishing agent	Digestible polysaccharide used in many foods, often in a modified form; these include baking powder, baby foods, soups, sauces, pie fillings, imitation jellies, custards, and candies
Corn syrup	Flavoring agent, humectant, nutritive sweetener, preservative	Derived from hydrolysis of cornstarch; employed in numerous foods, e.g., baby foods, bakery products, toppings, meat products, beverages, condiments, and confections; GRAS additive

TABLE 1.7 *(Continued)*

Specific Food Additives and Their Functions

Name	Function[1]	Food Use and Comments[2]
Dextrose (glucose)	Flavoring agent, humectant, nutritive sweetener, synergist	Derived from cornstarch; major users of dextrose are confection, wine, and canning industries; used to flavor meat products; used in production of caramel; variety of other uses
Diglycerides	Emulsifiers	Uses include frozen desserts, lard, shortening, and margarine; GRAS additive
Dioctyl sodium sulfosuccinate	Emulsifier, processing aid, surface active agent	Employed in gelatin dessert, dry beverages, fruit juice drinks, and noncarbonated beverages with cocoa fat; used in production of cane sugar and in canning
Disodium guanylate	Flavor enhancer	Derived from dried fish or seaweed
Disodium inosinate	Flavor adjuvant	Derived from seaweed or dried fish; sodium guanylate is a byproduct
EDTA (ethylenediamine-tetraacetic acid)	Antioxidant, sequestrant	Calcium disodium and disodium salt of EDTA employed in a variety of foods including soft drinks, alcoholic beverages, dressings, canned vegetables, margarine, pickles, sandwich spreads, and sausage
FD&C colors: Blue No. 1 Red No. 40 Yellow No. 5	Color	Coloring foods in general, including dietary supplements
Gelatin	Stabilizer and thickener, texturizer	Derived from collagen by boiling skin, tendons, ligaments, bones, etc. with water; employed in many foods including confectionery, jellies, and ice cream; GRAS additive
Glycerine (glycerol)	Humectant	Miscellaneous and general purpose additive; GRAS additive
Grape skin extract	Color	Colorings for carbonated drinks, beverage bases, and alcoholic beverages
Guar gum	Stabilizer and thickener, texturizer	Extracted from seeds of the guar plant of India and Pakistan; employed in such foods as cheese, salad dressings, ice cream, and soups
Gum arabic	Stabilizer and thickener, texturizer	Gummy exudate of Acacia plants; used in variety of foods; GRAS additive
Gum ghatti	Stabilizer and thickener, texturizer	Gummy exudate of plant growing in India and Ceylon; a variety of food uses; GRAS additive
Hydrogen peroxide	Bleaching agent	Modification of starch and bleaching tripe; GRAS bleaching agent
Hydrolyzed vegetable (plant) protein	Flavor enhancer	Used to flavor various meat products
Invert sugar	Humectant, nutritive sweetener	Main use in confectionery and brewing industry
Iron	Nutrient	Dietary supplements and food; GRAS additive
Iron-Ammonium citrate	Anticaking agent	Used in salt
Karraya gum	Stabilizer and thickener	Derived from dried extract of *Sterculia urens* found primarily in India; variety of food uses; a substitute for tragacanth gum; GRAS additive
Lactic acid	Preservative, pH control	Normal product of human metabolism; numerous uses in foods and beverages; a miscellaneous general purpose additive; GRAS additive
Lecithin (phosphatidyl-choline)	Emulsifier, surface active agent	Normal tissue component of the body; edible and digestible additive naturally occurring in eggs; commercially derived from soybeans; margarine, chocolate, and wide variety of other food uses; GRAS additive

TABLE 1.7 *(Continued)*

Specific Food Additives and Their Functions

Name	Function[1]	Food Use and Comments[2]
Mannitol	Anticaking, nutritive sweetener, stabilizer and thickener, texturizer	Special dietary foods; GRAS additive; supplies 1/2 the energy of glucose; classified as a sugar alcohol or polyol
Methylparaben	Preservative	Food and beverages; GRAS additive
Modified food starch	Drying agent, formulation aid, processing aid, surface finishing agent	Digestible polysaccharide used in many foods and stages of food processing; examples include baking powder, puddings, pie fillings, baby foods, soups, sauces, candies, etc.
Monoglycerides	Emulsifiers	Widely used in foods such as frozen desserts, lard, shortening, and margarine; GRAS additive
MSG (monosodium glutamate)	Flavor enhancer	Enhances the flavor of a variety of foods including various meat products; possible association with the Chinese restaurant syndrome
Papain	Texturizer	Miscellaneous and/or general purpose additive; GRAS additive; achieves results through enzymatic action; used as meat tenderizer
Paprika	Color, flavoring agent	Provides coloring and/or flavor to foods; GRAS additive
Pectin	Stabilizer and thickener, texturizer	Richest source of pectin is lemon and orange rind; present in cell walls of all plant tissues; used to prepare jellies and jams; GRAS additive
Phosphoric acid	pH control	Miscellaneous and/or general purpose additive; used to increase effectiveness of antioxidants in lard and shortening; GRAS additive
Polyphosphates	Nutrient, flavor improver, sequestrant, pH control	Numerous food uses; most polyphosphates and their sodium, calcium, potassium, and ammonium salts; GRAS additive
Polysorbates	Emulsifiers, surface active agent	Polysorbates designated by numbers such as 60, 65, and 80; variety of food uses including baking mixes, frozen custards, pickles, sherbets, ice creams, and shortenings
Potassium alginate	Stabilizer and thickener, texturizer	Extracted from seaweed; wide usage; GRAS additive
Potassium bromate	Flour treating agent	Employed in flour, whole wheat flour, fermented malt beverages, and to treat malt
Potassium iodide	Nutrient	Added to table salt or used in mineral preparations as a source of dietary iodine
Potassium nitrite	Curing and pickling agent	To fix color in cured products such as meats
Potassium sorbate	Preservative	Inhibits mold and yeast growth in foods such as wines, sausage casings, and margarine; GRAS additive
Propionic acid	Preservative	Mold inhibitor in breads and general fungicide; GRAS additive; used in manufacture of fruit flavors
Propyl gallate	Antioxidant, preservative	Used in products containing oil or fat; employed in chewing gum; used to retard rancidity in frozen fresh pork sausage
Propylene glycol	Emulsifier, humectant, stabilizer and thickener, texturizer	Miscellaneous and/or general purpose additive; uses include salad dressings, ice cream, ice milk, custards, and a variety of other foods; GRAS additive
Propylparaben	Preservative	Fungicide; controls mold in sausage casings; GRAS additive
Saccharin	Nonnutritive sweetener	Special dietary foods and a variety of beverages; baked products; tabletop sweeteners
Saffron	Color, flavoring agent	Derived from plant of western Asia and southern Europe; all foods except those where standards forbid; to color sausage casings, margarine, or product branding inks

TABLE 1.7 *(Continued)*

Specific Food Additives and Their Functions

Name	Function[1]	Food Use and Comments[2]
Silicon dioxide	Anticaking agent	Used in feed or feed components, beer production, production of special dietary foods, and ink diluent for marking fruits and vegetables
Sodium acetate	pH control, preservative	Miscellaneous and/or general purpose use; meat preservation; GRAS additive
Sodium alginate	Stabilizer and thickener, texturizer	Extracted from seaweed; widespread food use; GRAS additive
Sodium aluminum sulfate	Leavening agent	Baking powders, confectionery; sugar refining
Sodium benzoate	Preservative	Variety of food products; margarine to retard flavor reversion; GRAS additive
Sodium bicarbonate	Leavening agent, pH control	Miscellaneous and/or general purpose uses; separation of fatty acids and glycerol in rendered fats; neutralize excess and clean vegetables in rendered fats, soups, and curing pickles; GRAS additive
Sodium chloride (salt)	Flavor enhancer, formulation acid, preservation	Used widely in many foods; GRAS additive
Sodium citrate	pH control, curing and pickling agent, sequestrant	Evaporated milk; miscellaneous and/or general purpose food use; accelerate color fixing in cured meats; GRAS additive
Sodium diacetate	Preservative, sequestrant	An inhibitor of molds and rope-forming bacteria in baked products; GRAS additive
Sodium nitrate (Chile saltpeter)	Curing and pickling agent, preservative	Used with or without sodium nitrite in smoked, cured fish, cured meat products
Sodium nitrite	Curing and pickling agent, preservative	May be used with sodium nitrate in smoked or cured fish, cured meat products, and pet foods
Sodium propionate	Preservative	A fungicide and mold preventative in bakery products; GRAS additive
Sorbic acid	Preservative	Fungistatic agent for foods, especially cheeses; other uses include baked goods, beverages, dried fruits, fish, jams, jellies, meats, pickled products, and wines; GRAS additive
Sorbitan monostearate	Emulsifier, stabilizer and thickener	Widespread food usage such as whipped toppings, cakes, cake mixes, confectionery, icings, and shortenings; also many nonfood uses
Sorbitol	Humectant, nutritive sweetener, stabilizer and thickener, sequestrant	A sugar alcohol or polyol; used in chewing gum, meat products, icings, dairy products, beverages, and pet foods
Sucrose	Nutritive sweetener, preservative	The most widely used additive; used in beverages, baked goods, candies, jams and jellies, and other processed foods
Tagetes (Aztec marigold)	Color	Source is flower petals of Aztec marigold; used to enhance yellow color of chicken skin and eggs, incorporated in chicken feed
Tartaric acid	pH control	Occurs free in many fruits, free or combined with calcium, magnesium, or potassium; used in the soft drink industry, confectionery products, bakery products, and gelatin desserts
Titanium dioxide	Color	For coloring foods generally, except standardized foods; used for coloring ingested and applied drugs
Tocopherols (vitamin E)	Antioxidant, nutrient	To retard rancidity in foods containing fat; used in dietary supplements; GRAS additive
Tragacanth gum	Stabilizer and thickener, texturizer	Derived from the plant *Astragalus gummifier* or other Asiatic species of *Astragalus*; general purpose additive

TABLE 1.7 *(Continued)*

Specific Food Additives and Their Functions

Name	Function[1]	Food Use and Comments[2]
Turmeric	Color	Derived from rhizome of *Curcuma longa*; used to color sausage casings, margarine or shortening, and ink for branding or marking products
Vanilla	Flavoring agent	Used in various bakery products, confectionery, and beverages; natural flavoring extracted from cured, full grown unripe fruit of *Vanilla panifolia;* GRAS additive
Vanillin	Flavoring agent and adjuvant	Widespread confectionery, beverage and food use; synthetic form of vanilla; GRAS additive
Yellow prussiate of soda	Anticaking agent	Employed in salt

[1] Function refers to those defined in Table 1.3.

[2] Adapted from Ensinger et al., *Food and Nutrition Encyclopedia,* 2nd ed., CRC Press, Boca Raton, 1994, pp. 13-18.

TABLE 1.8

Mycotoxins/Bacterial Toxins in Foods

Toxins from Bacteria	
Staphylococcus aureus:	α exotoxin (lethal, dermonecrotic, hemolytic, leucolytic) β exotoxin (hemolytic) γ exotoxin (hemolytic) δ exotoxin (dermonecrotic, hemolytic) leucocidin (leucolytic) exfoliative toxin enterotoxin
Clostridium botulinum (four strains): Toxins are lettered as A,B, Cα (1,2,D), Cβ, D(C_1 and D), E, F, G. All of the toxics are proteolytic and produce NH_3, H_2S, CO_2, and volatile amines. The toxins are hemolytic and neurotoxic	
Escherichi coli (several serotypes): Induce diarrhea, vomiting; produce toxins that are heat labile	
Bacillus cereus (several types): Produces heat labile enterotoxins that induce vomiting and diarrhea	
Mycotoxins Produced by Fungi	
Aspergillus flavis *Claviceps purpura* *Fusarium graminearum* *Aspergillus ochraceus* *Aspergillus parasiticus* *Penicillium viridicatum*	

TABLE 1.9

Antinutrients in Food

Type of Factor(s)	Effect of Factor(s)	Legumes Containing the Factor(s)
Antivitamin factors	Interfere with the actions of certain vitamins	
Antivitamin A	Lipoxidase oxidizes and destroys carotene (provitamin A)	Soybeans
Antivitamin B_{12}	Increases requirement for Vitamin B_{12}	Soybeans
Antivitamin D	Causes rickets unless extra vitamin D is provided	Soybeans
Antivitamin E	Damage to the liver and muscles	Alfalfa, Common beans (*Phaseolus vulgaris*), Peas (*Pisum sativum*)

TABLE 1.9 *(Continued)*

Antinutrients in Food

Type of Factor(s)	Effect of Factor(s)	Legumes Containing the Factor(s)
Cyanide-releasing glucosides	Releases hydrocyanic acid. The poison may also be released by an enzyme in *E. coli*, a normal inhabitant of the human intestine	All legumes contain at least small amounts of these factors; however, certain varieties of lima beans (*Phaseolus lunatus*) may contain much larger amounts
Favism factor	Causes the breakdown of red blood cells in susceptible individuals	Fava beans (*Vicia faba*)
Gas-generating carbohydrates	Certain indigestible carbohydrates are acted upon by gas-producing bacteria in the lower intestine	Many species of mature dry legume seeds, but not peanuts; the immature (green) seeds contain much lower amounts
Goitrogens	Interfere with the utilization of iodine by the thyroid gland	Peanuts and soybeans
Inhibitors of trypsin	The inhibitor(s) binds with the digestive enzyme trypsin	All legumes contain trypsin inhibitors; these inhibitors are destroyed by heat
Lathyrogenic neurotoxins	Consumption of large quantities of lathyrogenic legumes for long periods (several months) results in severe neurological disorders	Lathyrus pea (*L. sativus*) which is grown mainly in India Common vetch (*Vicia sativa*) may also be lathyrogenic
Metal binders	Bind copper, iron, manganese, and zinc	Soybeans, Peas (*Pisum sativum*)
Red blood cell clumping agents (hemagglutinins)	The agents cause the red blood cells to clump together	Occurs in all legumes to some extent

Adapted from Ensminger et al., *Food and Nutrition Encyclopedia,* 2nd ed., CRC Press, Boca Raton, 1994, pp. 1284–1285.

Type A antinutritives. Substances primarily interfering with the digestion of proteins or the absorption and utilization of amino acids. Also known as antiproteins. People depending on vegetables for their protein supply, as in less developed countries, are in danger of impairment by this type of antinutritives. The most important type A antinutritives are protease inhibitors and lectins.

Protease inhibitors, occurring in many plant and animal tissues, are proteins which inhibit proteolytic enzymes by binding to the active sites of the enzymes. Proteolytic enzyme inhibitors were first found in avian eggs around the turn of the century. They were later identified as ovomucoid and ovoinhibitor, both of which inactivate trypsin. Chymotrypsin inhibitors also are found in avian egg whites. Other sources of trypsin and/or chymotrypsin inhibitors are soybeans and other legumes and pulses, vegetables, milk and colostrum, wheat and other cereal grains, guar gum, and white and sweet potatoes. The protease inhibitors of kidney beans, soybeans, and potatoes can additionally inhibit elastase, a pancreatic enzyme acting on elastin, an insoluble protein in meat. Animals given food containing active inhibitors show growth depression. This appears to be due to interference in trypsin and chymotrypsin activities and to excessive stimulation of the secretory exocrine pancreatic cells, which become hypertrophic. Valuable proteins may be lost to the feces in this case. *In vitro* experiments with human proteolytic enzymes have been shown that trypsin inhibitors from bovine colostrum, lima beans, soybeans, kidney beans, and quail ovomucoid were active against human trypsin, whereas trypsin inhibitors originating from bovine and porcine pancrease, potatoes, chicken ovomucoid, and chicken ovoinhibitor were not. The soybean and lima bean trypsin inhibitors are also active against human chymotrypsin. Many protease inhibitors are heat labile, especially with moist heat.

Relatively heat resistant protease inhibitors include the antitryptic factor in milk, the alcohol-precipitable and nondialyzable trypsin inhibitor in alfalfa, the chymotrypsin inhibitor in potato, the kidney bean inhibitor, and the trypsin inhibitor in lima beans.

Lectin is the general term for plant proteins that have highly specific binding sites for carbohydrates. They are widely distributed among various sources such as soybeans, peanuts, jack beans, mung beans, lima beans, kidney beans, fava beans, vetch, yellow wax beans, hyacinth beans, lentils, peas, potatoes, bananas, mangoes and wheat germ. Most plant lectins are glycoproteins, except concanavalin A from jack beans, which is carbohydrate-free. The most toxic lectins in food include ricin in castor bean (oral toxic dose in man: 150-200 mg; intravenous toxic dose: 20 mg), and the lectins of kidney bean and hyacinth bean. The mode of action of lectins may be related to their ability to bind to specific cell receptors in a way comparable to that of antibodies. Because they are able to agglutinate red blood cells, they are also known as hemaglutinins. The binding of bean lectin on rat intestinal mucosal cells has been demonstrated *in vitro*, and it has been suggested that this action is responsible for the oral toxicity of the lectins. Such bindings may disturb the intestines' absorptive capacity for nutrients and other essential compounds. The lectins, being proteins, can easily be inactivated by moist heat. Germination decreases the hemaglutinating activity in varieties of peas and species of beans.

Type B antinutritives. Substances interfering with the absorption or metabolic utilization of minerals are also known as antiminerals. Although they are toxic per se, the amounts present in foods seldom cause acute intoxication under normal food consumption. However, they may harm the organism under suboptimum nutriture. The most important type B antinutritives are phytic acid, oxalates, and glucosinolates.

Phytic acid, or myoinositol hexaphosphate, is a naturally occurring strong acid which binds to many types of bivalent and trivalent heavy metal ions, forming insoluble salts. Consequently, phytic acid reduces the availability of many minerals and essential trace elements. The degree of insolubility of these salts appears to depend on the nature of the metal, the pH of the solution, and for certain metals, on the presence of another metal. Synergism between two metallic ions in the formation of phytate complexes has also been observed. For instance, zinc-calcium phytate precipitates maximally at pH 6, which is also the pH of the duodenum, where mainly calcium and trace metals are absorbed. Phytates occur in a wide variety of foods, such as cereals (e.g. wheat, rye, maize, rice, barley), legumes and vegetables (e.g. bean, soybean, lentil, pea, vetch); nuts and seeds (e.g. walnut, hazelnut, almond, peanut, cocoa bean), and spices and flavoring agents (e.g. caraway, coriander, cumin, mustard, nutmeg). From several experiments in animals and man it has been observed that phytates exert negative effects on the availability of calcium, iron, magnesium, zinc, and other trace essential elements. These effects may be minimized considerably, if not eliminated, by increased intake of essential minerals. In the case of calcium, intake of cholecalciferol must also be adequate, since the activity of phytates on calcium absorption is enhanced when this vitamin is inadequate or limiting. In many foodstuffs the phytic acid level can be reduced by phytase, an enzyme occurring in plants, that catalyzes the dephosphorylation of phytic acid.

Oxalic acid is a strong acid which forms water soluble Na^+ and K^+ salts, but less soluble salts with alkaline earth and other bivalent metals. Calcium oxalate is particularly insoluble at neutral or alkaline pH, whereas it readily dissolves in acid medium. Oxalates mainly exert effects on the absorption of calcium. These effects must be considered in terms of the oxalate/calcium ratio (in milliequivalent/milliequivalent): foods having a ratio greater than 1 may have negative effects on calcium availability, whereas foods with a ratio of 1 or below do not. Examples of foodstuffs having a ratio greater than 1 are: rhubarb (8.5), spinach (4.3), beet (2.5 to 5.1), cocoa (2.6), coffee (3.9), tea (1.1), and potato (1.6). Harmful oxalates in food may be removed by soaking in water. Consumption of

calcium-rich foods (e.g. dairy products and seafood), as well as augmented cholecalciferol intake, are recommended when large amounts of high oxalate food are consumed.

A variety of plants contain a third group of type B antinutritives, the glucosinolates, also known as thioglucosides. Many glucosinolates are goitrogenic. They have a general structure, and yield on hydrolysis the active or actual goitrogens, such as thiocyanates, isothiocyanates, cyclic sulfur compounds, and nitriles. Three types of goiter can be identified: 1) cabbage goiter, 2) brassica seed goiter, and 3) legume goiter. Cabbage goiter, also known as struma, is induced by excessive consumption of cabbage. It seems that cabbage goitrogens inhibit iodine uptake by directly affecting the thyroid gland. Cabbage goiter can be treated by iodine supplementation. Brassica seed goiter can result from the consumption of the seeds of Brassica plants (e.g. rutabaga, turnip, cabbage, rape) which contain goitrogens that prevent thyroxine synthesis. This type of goiter can only be treated by administration of the thyroid hormone. Legume goiter is induced by goitrogens in legumes like soybeans and peanuts. It differs from cabbage goiter in that the thyroid gland does not lose its activity for iodine. Inhibition of the intestinal absorption of iodine or the reabsorption of thyroxine has been shown in this case. Legume goiter can be treated by iodine therapy. Glucosinolates which have been shown to induce goiter, at least in experimental animals, are found in several foods and feedstuffs: broccoli (buds), brussels sprouts (head), cabbage (head), cauliflower (buds), garden cress (leaves), horseradish (roots), kale (leaves), kohlrabi (head), black and white mustard (seed), radish (root), rape (seed), rutabaga (root), and turnips (root and seed). One of the most potent glucosinolates is progoitrin from the seeds of Brassica plants and the roots of rutabaga. Hydrolysis of this compound yields 1-cyano-2-hydroxy-3-butene, 1-cyano-2-hydroxy-3,4-butylepisulfide, 2-hydroxy-3,4-butenylisothiocyanate, and (*S*)-5-vinyl-oxazolidone-2-thione, also known as goitrin. The latter product interferes, together with its R-enantiomer, in the iodination of thyroxine precursors, so that the resulting goiter cannot be treated by iodine therapy.

Type C antinutritives. Naturally occurring substances which can decompose vitamins, form unabsorbable complexes with them, or interfere with their digestive or metabolic utilization. Also known as antivitamins. The most important type C antinutritives are ascorbic acid oxidase, antithiamine factors, and antipyridoxine factors.

Ascorbic acid oxidase is a copper-containing enzyme that catalyzes the oxidation of free ascorbic acid to diketogluconic acid, oxalic acid, and other oxidation products. It has been reported to occur in many fruits (e.g. peaches, bananas) and vegetables (e.g. cucumbers, pumpkins, lettuce, cress, cauliflowers, spinach, green beans, green peas, carrots, potatoes, tomatoes, beets, kohlrabi). The enzyme is active between pH 4 and 7 (optimum pH 5.6 to 6.0); its optimum temperature is 38°C. The enzyme is released when plant cells are broken. Therefore, if fruits and vegetables are cut, the vitamin C content decreases gradually. Ascorbic acid oxidase can be inhibited effectively at pH 2 or by blanching at around 100°C. Ascorbic acid can also be protected against ascorbic acid oxidase by substances of plant origin. Flavonoids, such as the flavonoles quercetin and kempferol, present in fruits and vegetables, strongly inhibit the enzyme.

A second group of type C antinutritives are the antithiamine factors, which interact with thiamine, also known as vitamin B_1. Antithiamine factors can be grouped as thiaminases, catechols, and tannins. Thiaminases, which are enzymes that split thiamine at the methylene linkage, are found in many freshwater and saltwater fish species, and in certain species of crab and clam. They contain a nonprotein coenzyme structurally related to hemin. This coenzyme is the actual antithiamine factor. Thiaminases in fish and other sources can be destroyed by cooking. Antithiamine factors of plant origin include catechols and tannins. The most well known ortho-catechol is found in bracken fern. In fact, there are two types of heat-stable antithiamine factors in this fern, one of which has been identified as caffeic acid, which can also by hydrolyzed from chlorogenic acid (found in

green coffee beans) by intestinal bacteria. Other ortho-catechols, such as methylsinapate occurring in mustard seed and rapeseed, also have antithiamine activity. The mechanism of thiamine inactivation by these compounds requires oxygen and is dependent on temperature and pH. The reaction appears to proceed in two phases: a rapid initial phase, which is reversible by addition of reducing agents (e.g. ascorbic acid), and a slower subsequent phase, which is irreversible. Tannins, occurring in a variety of plants, including tea, similarly possess antithiamine activity. Thiamine is one of the vitamins likely to be deficient in the diet. Thus, persistent consumption of antithiamine factors and the possible presence of thiaminase-producing bacteria in the gastrointestinal tract may compromise the already marginal thiamine intake.

A variety of plants and mushrooms contain pyridoxine (a form of vitamin B_6) antagonists. These antipyridoxine factors have been identified as hydrazine derivatives. Linseed contains the water-soluble and heat-labile antipyridoxine factor linatine (γ-glutamyl-1-amino-D-proline). Hydrolysis of linatine yields the actual antipyridoxine factor 1-amino-proline. Antipyridoxine factors have also been found in wild mushrooms, the common commercial edible mushroom, and the Japanese mushroom shiitake. Commercial and shiitake mushrooms contain agaritine. Hydrolysis of agaritine by γ-glutamyl transferase, which is endogenous to the mushroom, yields the active agent 4-hydroxymethylphenylhydrazine. Disruption of the cells of the mushroom can accelerate hydrolysis; careful handling of the mushrooms and immediate blanching after cleaning and cutting can prevent hydrolysis. The mechanism underlying the antipyridoxine activity is believed to be condensation of the hydrazines with the carbonyl compounds pyridoxal and pyridoxal phosphate (the active form of the vitamin), resulting in the formation of inactive hydrazones.

TABLE 1.10

Toxic Substances in Food (Toxic if Consumed in Excess)

Poison (Toxin)	Source	Symptoms and Signs	Distribution; Magnitude	Prevention; Treatment	Remarks
Aflatoxins (See Table 1.8).					
Aluminum (Al)	Food additives, mainly presented in such items as baking powder, pickles, and processed cheeses. Aluminum-containing antacids.	Abnormally large intakes of aluminum irritate the digestive tract. Also, unusual conditions have sometimes resulted in the absorption of sufficient aluminum from antacids to cause brain damage. Aluminum may form non-absorbable complexes with essential trace elements, thereby creating deficiencies of these elements.	**Distribution**: Aluminum is widely used throughout the world. **Magnitude**: The U.S. uses more aluminum than any other mineral except iron. However, known cases of aluminum toxicity are rare.	**Prevention**: Based on the evidence presented, no preventative measures are recommended.	Aluminum toxicity has been reported in patients receiving renal dialysis.
Arsenic (As)	Consuming contaminated foods and beverages. Arsenical insecticides used in vineyards exposing the workers (1) when spraying or (2) by inhaling contaminated dusts and plant debris. Arsenic in the air from three major sources; smelting of metals, burning of coal, and use of arsenical pesticides.	Burning pains in the throat or stomach, cardiac abnormalities, and the odor of garlic on the breath. Other symptoms may be diarrhea and extreme thirst along with a choking sensation. Small doses of arsenic taken into the body over a long period of time may produce hyperkeratosis (irregularities in pigmentation, especially on the trunk); arterial insufficiency; and cancer. There is strong evidence that inorganic arsenic is a skin and lung carcinogen in man.	**Distribution**: Arsenic is widely distributed, but the amount of the element consumed by man in food and water, or breathed, is very small and not harmful. **Magnitude**: Cases of arsenic toxicity in man are infrequent. Two noteworthy episodes occurred in Japan in 1955. One involved tainted powdered milk; the other contaminated soy sauce. The toxic milk caused 12,131 cases of infant poisoning, with 130 deaths. The soy sauce poisoned 220 people.	**Treatment**: Induce vomiting, followed by an antidote of egg whites in water or milk. Afterward, give strong coffee or tea, followed by Epsom salts in water or castor oil.	Arsenic is known to partially protect against selenium poisoning. The highest residues of arsenic are generally in the hair and nails. Arsenic in soils may sharply decrease crop growth and yields, but it is not a hazard to people or livestock that eat plants grown in these fields.

TABLE 1.10 *(Continued)*

Toxic Substances in Food (Toxic if Consumed in Excess)

Poison (Toxin)	Source	Symptoms and Signs	Distribution; Magnitude	Prevention; Treatment	Remarks
Chromium (Cr)	Food, water, and air contaminated by chromium compounds in industrialized areas.	Inorganic chromium salt reduces the absorption of zinc; hence, zinc deficiency symptoms may become evident in chronic chromium toxicity.	**Distribution**: Chromium toxicity is not common. **Magnitude**: Chromium toxicity is not very common.	**Prevention**: It is unlikely that people will get too much chromium because (1) only minute amounts of the element are present in most foods, (2) the body utilizes chromium poorly, and (3) the toxic dose is about 10,000 times the lowest effective medical dose.	
Copper (Cu)	Diets with excess copper, but low in other minerals that counteract its effects. Acid foods or beverages (vinegar, carbonated beverages, or citrus juices) that have been in prolonged contact with copper metal may cause acute gastrointestinal disturbances.	**Acute copper toxicity**: Characterized by headache, dizziness, metallic taste, excessive salivation, nausea, vomiting, stomachache, diarrhea, and weakness. If the disease is allowed to get worse, there may also be racing of the heart, high blood pressure, jaundice, hemolytic anemia, dark-pigmented urine, kidney disorders, and even death. **Chronic copper toxicity**: May be contributory to iron-deficiency anemia, mental illness following childbirth (postpartum psychosis), certain types of schizophrenia, and perhaps heart attacks.	**Distribution**: Copper toxicity may occur wherever there is excess copper intake, especially when accompanied by low iron, molybdenum, sulfur, zinc, and vitamin C. **Magnitude**: The incidence of copper toxicity is extremely rare in man. Its occurrence in significant form is almost always limited to (1) suicide attempted by ingesting large quantities of copper salt, or (2) a genetic defect in copper metabolism inherited as an autosomal recessive, known as Wilson's disease.	**Prevention**: Avoid foods and beverages that have been in prolonged contact with copper metal. Administration of copper chelating agents to remove excess copper.	Copper is essential to human life and health, but like all heavy metals, it may be toxic in excess.

Ergot	Rye, wheat, barley, oats and triticale carry this mycotoxin. Ergot replaces the seed in the heads of cereal grains, in which it appears as a purplish-black, hard, banana-shaped, dense mass from 1/4-3/4 in. (6-9 mm) long.	When a large amount of ergot is consumed in a short period, convulsive ergotism is observed. The symptoms include itching, numbness, severe muscle cramps, sustained spasms and convulsions, and extreme pain. When smaller amounts of ergot are consumed over an extended period, ergotism is characterized by gangrene of the fingertips and toes, caused by blood vessel and muscle contraction stopping blood circulation in the extremities. These symptoms include cramps, swelling, inflammation, alternating burning and freezing sensations ("St. Anthony's fire") and numbness; eventually the hands and feet may turn black, shrink, and fall off. Ergotism is a cumulative poison, depending on the amount of ergot eaten and the length of time over which it is eaten.	**Distribution**: Ergot is found throughout the world wherever rye, wheat, barley, oats, or triticale are grown. **Magnitude**: There is considerable ergot, especially in rye. But, normally, screening grains before processing alleviates ergotism in people.	**Prevention**: Consists of an ergot-free diet. Ergot in food and feed grains may be removed by screening the grains before processing. In the U.S., wheat and rye containing more than 0.3% ergot are classed as "ergoty." In Canada, government regulations prohibit more than 0.1% ergot in feeds. **Treatment**: An ergot-free diet; good nursing; treatment by a doctor.	Six different alkaloids are involved in ergot poisoning. Ergot is used to aid the uterus to contract after childbirth, to prevent loss of blood. Also, another ergot drug (ergotamine) is widely used in the treatment of migraine headaches.

TABLE 1.10 *(Continued)*

Toxic Substances in Food (Toxic if Consumed in Excess)

Poison (Toxin)	Source	Symptoms and Signs	Distribution; Magnitude	Prevention; Treatment	Remarks
Fluorine (F) (fluorosis)	Ingesting excessive quantities of fluorine through either the food or water, or a combination of these. Except in certain industrial exposures, the intake of fluoride inhaled from the air is only a small fraction of the total fluoride intake in man. Pesticides containing fluorides, including those used to control insects, weeds, and rodents. Although water is the principal source of fluoride in an average human diet in the U.S., fluoride is frequently contained in toothpaste, tooth powder, chewing gums, mouthwashes, vitamin supplements, and mineral supplements.	**Acute fluoride poisoning**: Abdominal pain, diarrhea, vomiting, excessive salivation, thirst, perspiration, and painful spasms of the limbs. **Chronic fluoride poisoning**: Abnormal teeth (especially mottled enamel) during the first 8 years of life; brittle bones. Other effects, predicted from animal studies, may include loss of body weight and altered structure and function of the thyroid gland and kidneys. Water containing 3-10 ppm of fluoride may cause mottling of the teeth. An average daily intake of 20-80 mg of fluoride over a period of 10-20 years will result in crippling fluorosis.	**Distribution**: The water in parts of Arkansas, California, South Carolina, and Texas contains excess fluorine. Occasionally, throughout the U.S., high-fluorine phosphates are used in mineral mixtures. **Magnitude**: Generally speaking, fluorosis is limited to high-fluorine areas. Only a few instances of health effects in man have been attributed to airborne fluoride, and they occurred in persons living in the vicinity of fluoride-emitting industries.	**Prevention**: Avoid the use of food and water containing excessive fluorine. **Treatment**: Any damage may be permanent, but people who have not developed severe symptoms may be helped to some extent if the source of excess fluorine is eliminated. High dietary levels of calcium and magnesium may reduce the absorption and utilization of fluoride.	Fluorine is a cumulative poison. The total fluoride in the human body averages 2.57 g. Susceptibility to fluoride toxicity is increased by deficiencies of calcium, vitamin C, and protein. Virtually all foods contain trace amounts of fluoride.

Lead (Pb)	Consuming food or medicinal products (including health food products) contaminated with lead. Inhaling the poison as a dust by workers in such industries as painting, lead mining, and refining. Inhaling airborne lead discharged into the air from auto exhaust fumes. Consuming food crops contaminated by lead being deposited on the leaves and other edible portions of the plant by direct fallout. Consuming food or water contaminated by contact with lead pipes or utensils. Old houses in which the interiors were painted with leaded paints prior to 1945, with the chipped wall paint eaten by children. Such miscellaneous sources as illicitly distilled whiskey, improperly lead-glazed earthenware, old battery casings used as fuel, and toys containing lead.	Symptoms develop rapidly in young children, but slowly in mature people. **Acute lead poisoning**: Colic, cramps, diarrhea or constipation, leg cramps, and drowsiness. The most severe form of lead poisoning, encountered in infants and in heavy drinkers of illicitly distilled whiskey, is characterized by profound disturbances of the central nervous system and permanent damage to the brain; damage to the kidneys; and shortened life span of the erthrocytes. **Chronic lead poisoning**: Colic, constipation, lead palsy especially in the forearm and fingers, the symptoms of chronic nephritis, and sometimes mental depression, convulsions, and a blue line at the edge of the gums.	**Distribution**: Predominantly among children who may eat chips of lead-containing paints, peeled off from painted wood. **Magnitude**: The Centers for Disease Control, Atlanta, GA, estimates that (1) lead poisoning claims the lives of 200 children each year, and (2) 400,000-600,000 children have elevated lead levels in the blood. Lead poisoning has been reduced significantly with the use of lead-free paint.	**Prevention**: Avoid inhaling or consuming lead. **Treatment**: **Acute lead poisoning**: An emetic (induce vomiting), followed by drinking plenty of milk and 1/2 oz (14 g) of Epsom salts in 1/2 glass of water. **Chronic lead poisoning**: Remove the source of lead. Sometimes treated by administration of magnesium or lead sulphate solution as a laxative and antidote on the lead in the digestive system, followed by potassium iodide which cleanses the tracts. Currently, treatment of lead poisoning makes use of chemicals that bind the metal in the body and help in its removal.	Lead is a cumulative poison. When incorporated in the soil, nearly all the lead is converted into forms that are not available to plants. Any lead taken up by plant roots tends to stay in the roots, rather than move up to the top of the plant. Lead poisoning can be diagnosed positively by analyzing the blood tissue for lead content; clinical signs of lead poisoning usually are manifested at blood lead concentrations above 80 µg/100 grams.

TABLE 1.10 *(Continued)*

Toxic Substances in Food (Toxic if Consumed in Excess)

Poison (Toxin)	Source	Symptoms and Signs	Distribution; Magnitude	Prevention; Treatment	Remarks
Mercury (Hg)	Mercury is discharged into air and water from industrial operations and is used in herbicide and fungicide treatments. Mercury poisoning has occurred where mercury from industrial plants has been discharged into water, then accumulated as methylmercury in fish and shellfish. Accidental consumption of seed grains treated with fungicides that contain mercury, used for the control of fungus diseases of oats, wheat, barley, and flax.	The toxic effects of organic and inorganic compounds of mercury are dissimilar. The organic compounds of mercury, such as the various fungicides (1) affect the central nervous system, and (2) are not corrosive. The inorganic compounds of mercury include mainly mercuric chloride, a disinfectant; mercurous chloride (calomel), a cathartic; and elemental mercury. Commonly the toxic symptoms are corrosive gastrointestinal effects, such as vomiting, bloody diarrhea, and necrosis of the alimentary mucosa.	**Distribution**: Wherever mercury is produced in industrial operations or used in herbicide or fungicide treatments. **Magnitude**: Limited. But about 1200 cases of mercury poisoning identified in Japan in the 1950s were traced to the consumption of fish and shellfish from Japan's Minamata Bay contaminated with methylmercury. Some of the offspring of exposed mothers were born with birth defects, and many victims suffered central nervous system damage. Another outbreak of mercury toxicity occurred in Iraq, where more than 6000 people were hospitalized after eating bread made from wheat that had been treated with methylmercury.	Control mercury pollution from industrial operations.	Mercury is a cumulative poison. FDA prohibits use of mercury-treated grain for food or feed. Grain crops produced from mercury-treated seed and crops produced on soils treated with mercury herbicides have not been found to contain harmful concentrations of this element.

Polychlorinated biphenyls (PCBs), industrial chemicals; chlorinated hydrocarbons which may cause cancer when taken into the food supply.

Sources of contamination to man include:

1. Contaminated foods
2. Mammals or birds that have fed on contaminated foods of fish.
3. Residues on foods that have been wrapped in papers and plastics containing PCBs.
4. Milk from cows that have been fed silage from silos coated with PCB-containing paint; and eggs from layers fed feeds contaminated with PCBs.

Clinical effects on people are: an eruption of the skin resembling acne, visual disturbances, jaundice, numbness, and spasms. Newborn infants from mothers who have been poisoned show discoloration of the skin which regresses after 2-5 months. PCBs are fat soluble.

Distribution: PCBs are widespread. Their use by industry is declining.

Although the production of PCBs was halted in 1977 and the importing of PCBs was banned January 1, 1979, the chemicals had been widely used for 40 years, and they are exceptionally long-lived.

PCBs have been widely used in dielectric fluids in capacitors and transformers, hydraulic fluids, and heat transfer fluids. Also, they have more than 50 minor uses including plasticizers and solvents in adhesives, printing ink, sealants, moisture retardants, paints, and pesticide carriers.

PCB will cause cancer in laboratory animals (rats, mice, and rhesus monkeys). It is not known if it will cause cancer in humans. More study is needed to gauge its effects on the ecological food chain and on human health. When fed Coho salmon from Lake Michigan with 10-15 ppm PCB, mink in Wisconsin stopped reproducing or their kits died.

TABLE 1.10 *(Continued)*

Toxic Substances in Food (Toxic if Consumed in Excess)

Poison (Toxin)	Source	Symptoms and Signs	Distribution; Magnitude	Prevention; Treatment	Remarks
Salt (NaCl-sodium chloride) poisoning	Consumption of high-salt food and beverages.	Salt may be toxic (1) when it is fed to infants or others whose kidneys cannot excrete the excess in the urine, or (2) when the body is adapted to a chronic low-salt diet.	**Distribution**: Salt is used all over the world. Hence, the potential for salt poisoning exists everywhere. **Magnitude**: Salt poisoning is relatively rare.	**Treatment**: Drink large quantities of fresh water.	Even normal salt concentration may be toxic if water intake is low.
Selenium (Se)	Consumption of high levels in food or drinking water. Presence of malnutrition, parasitic infestation, or other factors which make people highly susceptible to selenium toxicity.	Abnormalities in the hair, nails, and skin. Children in a high-selenium area of Venezuela showed loss of hair, discolored skin, and chronic digestive disturbances. Normally, people who have consumed large excesses of selenium excrete it as trimethyl selenide in the urine, and/or as dimethyl selenide on the breath. The latter substance has an odor resembling garlic.	**Distribution**: In certain regions of western U.S., especially in South Dakota, Montana, Wyoming, Nebraska, Kansas, and perhaps areas in other states in the Great Plains and Rocky Mountains. Also, in Canada. **Magnitude**: Selenium toxicity in people is relatively rare.	**Treatment**: Selenium toxicity may be counteracted by arsenic or copper, but such treatment should be carefully monitored.	Confirmed cases of selenium poisoning in people are rare because (1) only traces are present in most foods, (2) foods generally come from a wide area, and (3) the metabolic processes normally convert excess selenium into harmless substances which are excreted in the urine or breath.
Tin (Sn)	From acid fruits and vegetables canned in tin cans. The acids in such foods as citrus fruits and tomato products can leach tin from the inside of the can. Then the tin is ingested with the canned food. In the digestive tract tin goes through a methylation process in which nontoxic tin is converted to methylated tin, which is toxic.	Methylated tin is a neurotoxin — a toxin that attacks the central nervous system, the symptoms of which are numbness of the fingers and lips followed by a loss of speech and hearing. Eventually, the afflicted person becomes spastic, then coma and death follow.	**Distribution**: Worldwide. **Magnitude**: The use of tin in advanced industrial societies has increased 14-fold over the last 10 years.	**Prevention**: Tin cans are rare. Many tin cans are coated on the inside with enamel or other materials. Most cans are steel.	Currently, not much is known about the amount of tin in the human diet.

Adapted from Ensminger et al. *Foods & Nutrition Encyclopedia,* 2nd ed., CRC Press, Boca Raton, 1994, pp. 1790-1803.

TABLE 1.11

Edible Weeds

Common Name	Scientific Name	Use
Maple tree	*Acer* (many varieties)	Sap can be collected and reduced by evaporation into syrup.
Sweetflag	*Acorus calamus*	Rootstocks or stems are edible with a sweet taste. Young shoots can be used as salad.
Quackgrass	*Agropyron repens* L. (has many other names)	Rootstocks can be chewed or scorched to use as coffee substitute; seeds can be used for breadstuffs and for beer.
Waterplantain	*Alisma* spp.	Root is starchy and edible; should be dried to reduce acrid taste. Three varieties of this plant can be toxic.
Garlic mustard	*Alliaria petiolata*	Leaf, stem, flower, and fruit are spicy and hot. If cooked, some of this spiciness is lost. Several plants that resemble this one are not edible.
Wild garlic	*Allium vineale* L.	Used as an herbal seasoning; there are similar plants that are not garlic in aroma; they can be toxic.
Pigweed	*Amaranthus* spp.	Leaves from a young plant can be eaten raw as salad or boiled like spinach.
Serviceberry	*Amelanchier* spp.	Berries are rich and sweet; pits and leaves contain cyanide; also called shadbush or juneberry.
Hog peanut	*Amphicarpaea bracteata*	Fleshy seedpods found underground are edible.
Ground nut	*Apios americana Medik*	Root can be eaten raw or cooked. Seeds can also be used. Europeans use the term ground nut to refer to peanuts. This is not the same plant.
Common burdock	*Arctium minus*	Young leaves can be eaten as salad; roots are carrot-like in shape and can be cooked (boiled) and eaten. A little baking soda added to the cooking water improves tenderness and flavor. Scorched roots can be used as a coffee substitute.
Giant reed	*Arundo donax* L.	Young shoots and rootstalks are sometimes sweet enough to be used as a substitute for sugar cane. Infusions of the root stocks can have some herbal properties; local weak anesthetic and in some instances either a hypotensive agent or hypertensive agent (depends on dose).
Milkweed	*Asclepias syriaca* L.	Young shoots, flower buds boiled with at least two changes of water. The plant contains cardiac glycosides and can be toxic.
Pawpaw	*Asimina triloba* L.	The aromatic fruits are quite tasty. Seeds and bark have pesticide properties and should be handled with caution.
Wild oat	*Avena Fatua* L.	Seeds are similar to cultivated oats. Useful when dried and ground as a cereal. Seeds can be scorched and used as a coffee substitute.
Wintercress/Yellow rocket	*Barbarea* spp. (*B. vcma; B. vulgaris*)	Young leaves and stems can be used as a salad.
Birches	*Betula* spp. (*Betulacea*)	Spring sap can be reduced to a syrup; bark can be boiled for tea.
Mustard; black or yellow	*Brassica nigra*	Seeds used to prepare mustard; leaves can be boiled for consumption, as can young stalks.
Bromegrass	*Bromus japonicus*	Seeds can be dried, ground, and used as cereal.
Shepherd's purse	*Capsella bursa-pastoris*	Seeds are used as a spicy pot herb. Tender young shoots can be eaten raw. Has a peppery taste.
Bittercress	*Cardamme bulbosa*	Roots can be ground for a horseradish substitute; leaves and stems can be added to salad. The roots of some species (*C. bulbosa*) can be toxic.

TABLE 1.11 *(Continued)*

Edible Weeds

Common Name	Scientific Name	Use
Hornbeam	*Carpus caroliniana*	Nuts are edible.
Hickory	*Carya* spp.	Nuts are edible.
Chestnut	*Castanea* spp.	Nuts are edible but are covered by a prickly coat. Roasting improves flavor and texture.
Sandbur	*Cenchrus* spp.	Seeds and burrs can be used as cereal grains.
Lambsquarter	*Chenopodium album* L.	Leaves can be eaten raw or cooked as spinach. The Mexican version (*Mexicantea, C. ambrosioides*) is toxic.
Oxeye daisy	*Chrysanthemum leucanthemum*	Leaves and flowers can be eaten raw or cooked.
Chicory	*Cichorium intybus* L.	Leaves are good salad ingredients.
Thistles	*Cirsium* spp.	The taproot is chewy but tasty.
Wandering jew	*Commelina communis*	Leaves can be used as potherbs; flowering shoots can be eaten raw.
Hawthorn	*Crataegus* spp.	Berries are edible, thorns can be a problem when gathering the berries. Some species contain heart stimulants.
Wild chervil	*Cryototaenia canadensis*	Roots can be boiled, with a taste like parsnips; young leaves and stems can be eaten as salad; has an herb use in stews and soups.
Nutgrass	*Cyperus* spp.	Tubers can be eaten or ground up to make a beverage called "chufa" or "horchata."
Queen Anne's lace, also called wild carrot	*Daucus carota* L.	Root can be eaten after boiling; however, because it looks like poisonous hemlock, one should be cautious.
Crabgrass	*Digitaria snaguinalis* L.	Seeds can be dried and ground for use as a cereal.
Persimmon	*Diospyros virginiana* L.	Fruits when ripe are very sweet.
Barnyard grass	*Echinochloa crusgalli* L.	Seeds can be dried and used as cereal.
Russian olive	*Elaegnus angustifolia* L.	Fruits are edible though astringent.
American burnweed	*Erechtites hieracifolia*	Leaves can be eaten raw as salad or cooked.
Redstem filaree	*Erodium cicutarium*	Tender leaves are eaten as salad; can also be used as potherb.
Wild strawberry	*Fragaria virginiana*	Fruits are small but delicious.
Catchweed bedstraw	*Galium aparine*	Young shoots are good potherbs; leaves and stems can be steamed and eaten as vegetable.
Wintergreen	*Gaultheria procumbens* L.	Berries, foliage, and bark can be used to make tea. Berries can be eaten raw.
Huckleberry	*Gaylussacia baccata*	Berries can be eaten raw or cooked.
Honey locust	*Gleditsia triacanthos*	The pulp around the seeds can be used as a sweetener. (Tender green pods can also be cooked and eaten as a vegetable.) The tree is similar in appearance to the Kentucky coffee tree, and the pods of this tree cannot be eaten.
Jerusalem artichoke	*Helianthus tuberosus*	The tubers are crisp and can be used in place of chinese chestnuts in salads; can also be cooked and mashed.
Daylily	*Hemerocallis fulva* L.	Flower buds can be used in salads. Tubers can be cooked and eaten. Can cause diarrhea in sensitive people.
Foxtail barley	*Hordeum jubatum*	Seeds can be dried and used as cereal.
Touch-me-not	*Impatients* spp.	Leaves can be used for an herbal tea; leaves can be eaten as salad; pods are also edible.
Burning bush	*Kochia scoparia*	Young shoots can be used as a potherb; seeds can be dried and used as cereal.
Prickly lettuce	*Lactuca scariola* L.	Young leaves can be used as salad, however may have a bitter taste.

TABLE 1.11 *(Continued)*

Edible Weeds

Common Name	Scientific Name	Use
Virginia peppergrass	*Lepidium virginicum*	Has a pungent mustard-like taste; used as a potherb.
Bugleweed	*Lycorise* spp.	Roots can be eaten raw or cooked.
Common mallow	*Malva neglecta*	Boiled leaves have a slimy consistency much like okra. Flower buds can be pickled; leaves can be used as a thickener for soup.
Black medic	*Medicago lupulina*	Sprouts can be added to salads for texture; leaves can be used as a potherb.
Mulberry	*Mortis* spp.	Berries can be eaten out of hand.
Watercress	*Nasturtium officinale* R.	Leaves can be eaten raw or used as a potherb.
American lotus	*Nelumbo lutea*	Entire plant is edible.
Yellow water lily	*Nuphar luteum* L.	Tubers when cooked are a starch substitute.
Fragrant water lily	*Nymphaea odorata*	Flower buds and young leaves can be boiled and eaten; seeds can be dried and used as cereal.
Evening primrose	*Oenothera biennis* L.	Seeds are a source of γ linolenic acid; tap roots can be eaten raw or cooked.
Wood sorrel	*Oxalis* spp.	Leaves can be eaten cooked or raw; seed pods can also be eaten.
Perilla mint	*Perilla frutescens* L.	Leaves can be eaten cooked or raw.
Common reed	*Phragmites communis*	Young shoots are edible. Plant is similar to the poisonous Arundo, so the forager should be very careful to correctly identify the plant.
Ground cherry (Chinese lanterns)	*Physalis heterophylla*	Berries can be eaten cooked or raw.
Pokeweed	*Phytolacca americana* L.	Young shoots can be used as a potherb; berries and roots may be poisonous.
Plantain	*Plantago major* L.	Leaves can be used in salads.
Mayapple	*Podophyllum peltatum*	Fruits are edible raw or cooked, rest of the plant may be poisonous.
Japanese knotweed	*Polygonum cuspidatum*	Young sprouts can be cooked and eaten like asparagus.
Purslane	*Portulaca oleracea* L.	Young leaves can be used as a potherb or salad ingredient.
Healall	*Prunella vulgaris* L.	Boiled and used as a potherb.
Wild cherry	*Prunus serotina*	Fruits are edible.
Kudzu	*Pueraria lobata*	Roots and leaves are edible.
Rock chestnut oak	*Quercus prinus* L.	Nuts (acorns) are edible.
Sumac	*Rhus glabra* L.	Berries are edible as are the roots; however, some people are allergic to all parts of the plant and will develop skin rash.
Multiflora rose	*Rosa multifora*	The hips are edible in small quantities.
Raspberry, blackberry	*Rubus* spp.	Fruits are eaten raw or used to make juice or jam.
Red sorrel	*Rumex acetosella* L.	Leaves can be eaten as salad or cooked in water. The leaves contain a lot of oxalic acid, so small quantities would be preferred.
Arrowhead	*Sagittaria latifolia Willd*	Roots can be eaten raw or cooked. Plants resemble the poisonous Jack-in-the-pulpit plant so gatherers should beware.
Elderberry	*Sambucus canadensis*	Fruits can be eaten raw or cooked.
Hardstem bulrush	*Scrpus acutus Muhl*	Roots can be boiled and eaten.
Foxtail grass	*Setaria* spp.	Seed grains can be dried and used as cereal.
Tumble mustard	*Sisymbrium altissimum* L.	All parts of the plant are edible but have a strong mustard flavor; better used as a potherb.
Roundleaf cabriar	*Smilax rotundiflora* L.	Young tender shoots can be eaten raw. Young leaves can be eaten as salad; roots can be used for tea.

TABLE 1.11 *(Continued)*

Edible Weeds

Common Name	Scientific Name	Use
Sowthistle	*Sonchus oleraceus* L.	Leaves are prickly and bitter but can be used as a potherb.
Johnson grass	*Sorghum halepense* L.	Young shoots can be eaten raw; seeds can be dried and used as cereal; mature stalks can be ground and the liquid extracted for use as syrup.
Chickweed	*Stellaria media* L.	Leaves can be eaten raw or cooked.
Dandelion	*Taraxacum officinale*	All parts of the plant are edible.
Stinkweed	*Thlaspi arvense* L.	All parts of the plant are edible after cooking.
Westem salsify	*Tragopogon dubius Scopoli*	Roots can be eaten after boiling; leaves, flowers, and stems can be eaten raw.
Red clover	*Trifolium pratense* L.	Flowers can be boiled to make a broth; powdered leaves and flowers can be used as seasoning.
Coltsfoot	*Tussilago farfara* L.	Can be used as a potherb in small amounts.
Cattail	*Typha* spp.	Roots, stalks, and spears are edible.
Stinging nettle	*Urtica dioica* L.	Can be eaten cooked or used as a potherb.
Bellwort	*Uvularia perfoliata* L.	Young shoots can be cooked and eaten; leaves are bitter.
Blueberry, gooseberry	*Vaccinium, stamineun*	Berries can be eaten raw or used to make juice, jam, or jelly.
Violet	*Viola papilionacea Purish*	Flowers are edible.
Wild grapes	*Vitis* spp.	Fruits can be eaten raw or cooked.
Spanish bayonnet	*Yucca filimentosa* L.	Flower buds can be eaten raw.

[1] Persons using this list should be aware that individuals may differ in their responses to these plants. For some consumers allergic reactions may be elicited. For others, there may be chemicals in the plants that elicit an undesirable physiological effect. Still other plants, especially the water plants, may harbor parasites that may be injurious. The serious forager should consult a plant taxonomist to be sure that the plant gathered is an edible plant. There are may similar plants that may in fact be poisonous, while others are safe to consume.

[2] Weeds are plants that grow in places where we humans do not want them to grow. As such, we may not recognize them as food. The above plants contain edible portions. Not all parts of these plants may be useful as human food. Some varieties, in fact, may contain toxic chemicals that if consumed in large quantities may cause problems. A number of the plants have been identified based on their use by native Americans. These plants can have many different names as common names. This list is an abstract provided by James A. Duke in *Handbook of Edible Weeds,* CRC Press, Boca Raton, 1992, 246 pages.

TABLE 1.12

Toxic Plants

Common and Scientific Name	Description; Toxic Parts	Geographical Distribution	Poisoning; Symptoms	Remarks
Baneberry *Actaea* sp.	**Description**: Perennial growing to 3 ft (1 m) tall from a thick root; compound leaves; small, white flowers; white or red berries with several seeds borne in short, terminal clusters. **Toxic parts**: All parts, but primarily roots and berries.	Native woodlands of North America from Canada south to Georgia, Alabama, Louisiana, Oklahoma, and the northern Rockies; red-fruited western baneberry from Alaska to central California, Arizona, Montana, and South Dakota.	**Poisoning**: Attributed to a glycoside or essential oil which causes severe inflammation of the digestive tract. **Symptoms**: Acute stomach cramps, headache, increased pulse, vomiting, delirium, dizziness, and circulatory failure.	As few as 6 berries can cause symptoms persisting for hours. Treatment may be a gastric lavage or vomiting. Bright red berries attract children.
Buckeye; Horsechestnut *Aesculus* sp.	**Description**: Shrub or tree; deciduous, opposite, palmately, divided leaves with 5-9 leaflets on a long stalk; red, yellow, or white flowers; 2- to 3-valved, capsule fruit; with thick, leathery husk enclosing 1-6 brown shiny seeds. **Toxic parts**: Leaves, twigs, flowers, and seeds.	Various species throughout the United States and Canada; some cultivated as ornamentals, others growing wild.	**Poisoning**: Toxic parts contain the glycoside, esculin. **Symptoms**: Nervous twitching of muscles, weakness, lack of coordination, dilated pupils, nausea, vomiting, diarrhea, depression, paralysis, and stupor.	By making a "tea" from the leaves and twigs or by eating the seeds, children have been poisoned. Honey collected from the buckeye flower may also cause poisoning. Roots, branches, and fruits have been used to stupefy fish in ponds. Treatment usually is a gastric lavage or vomiting.
Buttercup *Ranunculus* sp.	**Description**: Annual or perennial herb growing to 16–32 in. (41–81 cm) high; leaves alternate entire to compound, and largely basal; yellow flowers borne singly or in clusters on ends of seed stalks; small fruits, 1-seeded pods. **Toxic parts**: Entire plant.	Widely distributed in woods, meadows, pastures, and along streams throughout temperate and cold locations.	**Poisoning**: The alkaloid protoanemonin, which can injure the digestive system and ulcerate the skin. **Symptoms**: Burning sensation of the mouth, nervousness, nausea, vomiting, low blood pressure, weak pulse, depression, and convulsions.	Sap and leaves may cause dermatitis. Cows poisoned by buttercups produce bitter milk or milk with a reddish color.

TABLE 1.12 *(Continued)*

Toxic Plants

Common and Scientific Name	Description; Toxic Parts	Geographical Distribution	Poisoning; Symptoms	Remarks
Castor bean *Ricinus communis*	**Description**: Shrublike herb 4-12 ft. (1.2-3.7 m) tall; simple, alternate, long-stalked leaves with 5 to 11 long lobes which are toothed on margins; fruits oval, green, or red, and covered with spines; 3 elliptical, glossy, black, white, or mottled seeds per capsule. **Toxic parts**: Entire plant, especially the seeds.	Cultivated as an ornamental or oilseed crop primarily in the southern part of the United States and Hawaii.	**Poisoning**: Seeds, pressed cake, and leaves poisonous when chewed; contain the phytotoxin, ricin. **Symptoms**: Burning of the mouth and throat, nausea, vomiting, severe stomach pains, bloody diarrhea, excessive thirst, prostration, dullness of vision, and convulsions; kidney failure and death 1–12 days later.	Fatal dose for a child is 1-3 seeds, and for an adult 2-8 seeds. The oil extracted from the seeds is an important commercial product. It is not poisonous and it is used as a medicine (castor oil), for soap, and as a lubricant.
Chinaberry *Melia azedarach*	**Description**: Deciduous tree 20–40 ft (6–12 m) tall; twice, pinnately divided leaves and toothed or lobed leaflets, purple flowers borne in clusters; yellow, wrinkled, rounded berries which persist throughout the winter. **Toxic parts**: Berries, bark, flowers, and leaves.	A native of Asia introduced as an ornamental in the United States; common in the southern United States and lower altitudes in Hawaii; has become naturalized in old fields, pastures, around buildings, and along fence rows.	**Poisoning**: Most result from eating pulp of berries; toxic principle is a resinoid with narcotic effects. **Symptoms**: Nausea, vomiting, diarrhea, irregular breathing, and respiratory distress.	Six to eight berries can cause the death of a child. The berries have been used to make insecticide and flea powder.
Death camas *Zigadenus paniculatus*	**Description**: Perennial herb resembling wild onions but the onion odor lacking; long, slender leaves with parallel veins; pale yellow to pink flowers in clusters on slender seedstalks; fruit a 3-celled capsule. **Toxic parts**: Entire plant, especially the bulb.	Various species occur throughout the United States and Canada; all are more or less poisonous.	**Poisoning**: Due to the alkaloids zygadenine, veratrine, and others. **Symptoms**: Excessive salivation, muscular weakness, slow heart rate, low blood pressure, subnormal temperature, nausea, vomiting, diarrhea, prostration, coma, and sometimes death.	The members of Lewis and Clark Expedition made flour from the bulbs and suffered the symptoms of poisoning. Later some pioneers were killed when they mistook death camas for wild onions or garlic.

Dogbane (Indian hemp) *Apocynum cannabinum*	**Description**: Perennial herbs with milky juice and somewhat woody stems; simple, smooth, and oppositely paired leaves; bell-shaped, small, white to pink flowers borne in clusters at ends of axillary stems; paired, long, slender seed pods. **Toxic parts**: Entire plant.	Various species growing throughout North America in fields and forests, and along streams and roadsides.	**Poisoning**: Only suspect since it contains the toxic glycoside, cymarin and is poisonous to animals. **Symptoms**: In animals, increased temperature and pulse, cold extremities, dilation of the pupils, discoloration of the mouth and nose, sore mouth, sweating, loss of appetite, and death.	Compounds extracted from roots of dogbane have been used to make a heart stimulant.
Foxglove *Digitalis purpurea*	**Description**: Biennial herb with alternate, simple, toothed leaves; terminal, showy raceme of flowers, purple, pink, rose, yellow, or white; dry capsule fruit. **Toxic parts**: Entire plant, especially leaves, flowers, and seeds.	Native of Europe commonly planted in gardens of the United States; naturalized and abundant in some parts of the western United States.	**Poisoning**: Due to digitalis component. **Symptoms**: Nausea, vomiting, dizziness, irregular heartbeat, tremors, convulsions, and possibly death.	Foxglove has long been known as a source of digitalis and steroid glycosides. It is an important medicinal plant when used correctly.
Henbane *Hyoscyamus niger*	**Description**: Erect annual or biennial herb with coarse, hairy stems 1–5 ft (30–152 cm) high; simple, oblong, alternate leaves with a few, coarse teeth, not stalked; greenish-yellow or yellowish with purple vein flowers; fruit a rounded capsule. **Toxic parts**: Entire plant.	Along roads, in waste places across southern Canada and northern United States, particularly common in the Rocky Mountains.	**Poisoning**: Caused by the alkaloids, hyoscyamine hyoscine, and atropine. **Symptoms**: Increased salivation, headache, nausea, rapid pulse, convulsions, coma, and death.	A gastric lavage of 4% tannic acid solution may be used to treat the poisoning.
Iris (Rock Mountain Iris) *Iris missouriensis*	**Description**: Lilylike perennial plants often in dense patches; long, narrow leaves; flowers blue-purple; fruit a 3-celled capsule. **Toxic parts**: Leaves, but especially the root stalk.	Wet land of meadows, marshes, and along streams from North Dakota to British Columbia, Canada; south to New Mexico, Arizona, and California; scattered over entire Rocky Mountain area; cultivated species also common.	**Poisoning**: An irritating resinous substance, irisin. **Symptoms**: Burning, congestion, and severe pain in the digestive tract; nausea and diarrhea.	Rootstalks have such an acrid taste that they are unlikely to be eaten.

TABLE 1.12 *(Continued)*

Toxic Plants

Common and Scientific Name	Description; Toxic Parts	Geographical Distribution	Poisoning; Symptoms	Remarks
Jasmine *Geisemium sempervirens*	**Description**: A woody, trailing, or climbing evergreen vine; opposite, simple, lance-shaped, glossy leaves; fragrant, yellow flowers; flattened 2-celled, beaked capsule fruits. **Toxic parts**: Entire plant, but especially the root and flowers.	Native to the southeastern United States; commonly grown in the Southwest as an ornamental.	**Poisoning**: Alkaloids, geisemine, gelseminine, and gelsemoidine found throughout the plant. **Symptoms**: Profuse sweating, muscular weakness, convulsions, respiratory depression, paralysis, and death possible.	Jasmine has been used as a medicinal herb, but overdoses are dangerous. Children have been poisoned by chewing on the leaves.
Jimmyweed (Rayless goldenrod) *Haplopappus heterophyllus*	**Description**: Small, bushy, half-shrub with erect stems arising from the woody crown to a height of 2–4 ft (61–122 cm); narrow, alternate, sticky leaves; clusters of small, yellow flower heads at tips of stems. **Toxic parts**: Entire plant.	Common in fields or ranges around watering sites and along streams from Kansas, Oklahoma, and Texas to Colorado, New Mexico, and Arizona.	**Poisoning**: Contains the higher alcohol, tremetol, which accumulates in the milk of cows and causes human poisoning known as "milk sickness."	Other species of Haplopappus probably are equally dangerous. White snakeroot also contains tremetol, and causes "milk sickness."
Jimsonwood (Thornapple) *Datura stramonium*	**Description**: Coarse, weedy plant with stout stems and foul-smelling foliage; large, oval leaves with wavy margins; fragrant, large, tubular, white to purple flowers; round, nodding or erect prickly capsule. **Toxic parts**: Entire plant, particularly the seeds and leaves.	Naturalized throughout North America; common weed of fields, gardens, roadsides, and pastures.	**Poisoning**: Due to the alkaloids hyoscyamine, atropine, and hyoscine (scopolamine). **Symptoms**: Dry mouth, thirst, red skin, disturbed vision, pupil dilation, nausea, vomiting, headache, hallucination, rapid pulse, delirium, incoherent speech, convulsion, high blood pressure, coma, and possibly death.	Sleeping near the fragrant flowers can cause headache, nausea, dizziness, and weakness. Children pretending the flowers were trumpets have been poisoned.

Lantana (Red Sage) *Lantana camara*	**Description**: Perennial shrub with square twigs and a few spines; simple, opposite or whorled oval-shaped leaves with tooth margins; white, yellow, orange, red, or blue flowers occurring in flat-topped clusters; berry-like fruit with a hard, blue-black seed. **Toxic parts**: All parts, especially the green berries.	Native of the dry woods in the southeastern United States; cultivated as an ornamental shrub in pots in the northern United States and Canada; or a lawn shrub in the southeastern coastal plains, Texas, California, and Hawaii.	**Poisoning**: Fruit contains high levels of an alkaloid, lantanin or lantadene A. **Symptoms**: Stomach and intestinal irritation, vomiting, bloody diarrhea, muscular weakness, jaundice, and circulatory collapse; death possible but not common.	In Florida, these plants are considered a major cause of human poisoning. The foliage of lantana may also cause dermatitis.
Larkspur *Delphinium* sp.	**Description**: Annual or perennial herb 2–4 ft (61–122 cm) high; finely, palmately divided leaves on long stalks; white, pink, rose, blue, or purple flowers each with a spur; fruit a many-seeded, 3-celled capsule. **Toxic parts**: Entire plant.	Native of rich or dry forest and meadows throughout the United States but common in the West; frequently cultivated in flower gardens.	**Poisoning**: Contains the alkaloids delphinine, delphineidine, ajacine, and others. **Symptoms**: Burning sensation in the mouth and skin, low blood pressure, nervousness, weakness, prickling of the skin, nausea, vomiting, depression, convulsions, and death within 6 hours if eaten in large quantities.	Poisoning potential of larkspur decreases as it ages, but alkaloids still concentrated in the seeds. Seeds are used in some commercial lice remedies.
Laurel (Mountain laurel) *Kalmia latifolia*	**Description**: Large evergreen shrubs growing to 35 ft (11 m) tall; alternate leaves dark green on top and bright green underneath; white to rose flowers in terminal clusters; fruit in a dry capsule. **Toxic parts**: Leaves, twigs, flowers, and pollen grains.	Found in moist woods and along streams in eastern Canada southward in the Appalachian Mountains and Piedmont, and sometimes in the eastern coastal plain.	**Poisoning**: Contains the toxic resinoid, andromedotoxin. **Symptoms**: Increased salivation, watering of eyes and nose, loss of energy, slow pulse, vomiting, low blood pressure, lack of coordination, convulsions, and progressive paralysis until eventual death.	The Mountain laurel is the state flower of Connecticut and Pennsylvania. By making "tea" from the leaves or by sucking on the flowers, children have been poisoned.

TABLE 1.12 *(Continued)*

Toxic Plants

Common and Scientific Name	Description; Toxic Parts	Geographical Distribution	Poisoning; Symptoms	Remarks
Locoweed (Crazyweed) *Oxtropis* sp.	**Description:** Perennial herb with erect or spreading stems; pealike flowers and stems — only smaller.	Common throughout the southwestern United States.	**Poisoning**: Contains alkaloidlike substances — a serious threat to livestock. **Symptoms**: In animals, loss of weight, irregular gait, loss of sense of direction, nervousness, weakness, and loss of muscular control.	Locoweeds are seldom eaten by humans, hence they are not a serious problem. There are more than 100 species of locoweeds.
Lupine (Bluebonnet) *Lupinus* sp.	**Description**: Annual or perennial herbs; digitately divided, alternate leaves; pear-shaped blue, white, red, or yellow flowers borne in clusters at ends of stems; seeds in flattened pods. **Toxic parts**: Entire plant, particularly the seeds.	Wide distribution but most common in western North America; many cultivated as ornamentals.	**Poisoning**: Contains lupinine and related toxic alkaloids. **Symptoms**: Weak pulse, slowed respiration, convulsions, and paralysis.	Rarely have cultivated varieties poisoned children. Not all lupines are poisonous.
Marijuana (hashish, Mary Jane, pot, grass)	**Description**: A tall coarse, annual herb; palmately divided and long stalked leaves; small, green flowers clustered in the leaf axils. **Toxic parts**: Entire plant, especially the leaves, flowers, sap and resinous secretions.	Widely naturalized weed in temperate North America; cultivated in warmer areas.	**Poisoning**: Various narcotic resins but mainly tetrahydrocannabinol (THC) and related compounds. **Symptoms**: Exhilaration, hallucinations, delusions, mental confusion, dilated pupils, blurred vision, poor coordination, weakness, and stupor; coma and death in large doses.	Poisoning results form drinking the extract, chewing the plant parts, or smoking a so-called "reefer" (joint). The hallucinogenic and narcotic effects of marijuana have been known for more than 2000 years. Laws in the United States and Canada restrict the possession of living or dried parts of marijuana.

Mescal bean (Frijolito) *Sophora secundiflora*	**Description**: Evergreen shrub or small tree growing to 40 ft (12 m) tall; stalked, alternate leaves 4–6 in. (10–15 cm) long, which are pinnately divided and shiny, yellow-green above and silky below when young; violet-blue, pealike flowers; bright red seeds. **Toxic parts**: Entire plant, particularly the seed.	Native to southwestern Texas and southern New Mexico; cultivated as ornamentals in the southwestern United States.	**Poisoning**: Contains cytisine and other poisonous alkaloids. **Symptoms**: Nausea, vomiting, diarrhea, excitement, delirium, hallucinations, coma, and death; deep sleep lasting 2–3 days in nonlethal doses.	One seed, if sufficiently chewed, is enough to cause the death of a young child. The Indians of Mexico and the Southwest have used the seeds in medicine as a narcotic and as a hallucinatory drug. Necklaces have been made from the seeds.
Mistletoe *Phoradendron serotinum*	**Description**: Parasitic evergreen plants that grow on trees and shrubs; oblong, simple, opposite leaves, which are leathery; small, white berries. **Toxic parts**: All parts, especially the berries.	Common on the branches of various trees from New Jersey and southern Indiana southward to Florida and Texas; other species throughout North America.	**Poisoning**: Contains the toxic amines, beta-phenylethylamine and tyrosamine. **Symptoms**: Gastrointestinal pain, diarrhea, slow pulse, and collapse; possibly nausea, vomiting, nervousness, difficult breathing, delirium, pupil dilation, and abortion; in sufficient amounts, death within a few hours.	Mistletoe is a favorite Christmas decoration. It is the state flower of Oklahoma. Poisonings have occurred when people eat the berries or make "tea" from the berries. Indians chewed the leaves to relieve toothache.
Monkshood (Wolfsbane) *Aconitum columbianum*	**Description**: Perennial herb about 2–5 ft (61–152 cm) high; alternate, petioled leaves which are palmately divided into segments with pointed tips; generally dark blue flowers with a prominent hood; seed in a short-beaked capsule. **Toxic parts**: Entire plant, especially roots and seeds.	Rich, moist soil in meadows and along streams from western Canada south to California and New Mexico.	**Poisoning**: Due to several alkaloids, including aconine and aconitine. **Symptoms**: Burning sensation of the mouth and skin; nausea, vomiting, diarrhea, muscular weakness, and spasms, weak, irregular pulse, paralysis of respiration, dimmed vision, convulsions, and death within a few hours.	Small amounts can be lethal. Death in humans reported from eating the plant or extracts made from it. It has been mistaken for horseradish.

TABLE 1.12 *(Continued)*

Toxic Plants

Common and Scientific Name	Description; Toxic Parts	Geographical Distribution	Poisoning; Symptoms	Remarks
Mushrooms (toadstools) *Amanita muscaria, Amantia verna, Chlorophyllum molybdites*	**Description**: Common types with central stalk, and cap; flat plates (gills) underneath cap; some with deeply ridged, cylindrical top rather than cap. **Toxic parts**: Entire fungus.	Various types throughout North America.	**Poisoning**: Depending on type of mushroom; complex polypeptides such as amanitin and possibly phalloidin; a toxic protein in some; the poisons ibotenic acid, muscimol, and related compounds in others. **Symptoms**: Vary with type of mushroom but include deathlike sleep, manic behavior, delirium, seeing colored visions, feeling of elation, explosive diarrhea, vomiting, severe headache, loss of muscular coordination, abdominal cramps, and coma and death from some types; permanent liver, kidney, and heart damage from other types.	Wild mushrooms are extremely difficult to identify and are best avoided. There is no simple rule of thumb for distinguishing between poisonous and nonpoisonous mushrooms — only myths and nonsense. Only one or two bites are necessary for death from some species. During the month of December 1981, three people were killed, and two hospitalized in California after eating poisonous mushrooms.
Nightshade *Solanum nigrum, Solanum eleagnifolium*	**Description**: Annual herbs or shrublike plants with simple alternate leaves; small, white, blue or violet flowers; black berries or yellow to yellow-orange berries depending on species. **Toxic parts**: Prinarily the unripe berries.	Throughout the United States and southern Canada in waste places, old fields, ditches, roadsides, fence rows, or edges of woods.	**Poisoning**: Contains the alkaloid solanine; possibly saponin, atropine, and perhaps high levels of nitrate. **Symptoms**: Headache, stomach pain, vomiting, diarrhea, dilated pupils, subnormal temperature, shock, circulatory and respiratory depression, possible death.	Some individuals use the completely ripe berries in pies and jellies. Young shoots and leaves of the plant have been cooked and eaten like spinach.

Oleander *Nerium oleander*	**Description**: An evergreen shrub or small tree growing to 25 ft (8 m) tall; short-stalked, narrow, leathery leaves, opposite or in whorls of 3; white to pink to red flowers at tips of twigs. **Toxic parts**: Entire plant, especially the leaves.	A native of southern Europe but commonly cultivated in the southern United States and California.	**Poisoning**: Contains the poisonous glycosides oleandrin and nerioside, which act similar to digitalis. **Symptoms**: Nausea, severe vomiting, stomach pain, bloody diarrhea, cold feet and hands, irregular heartbeat, dilation of pupils, drowsiness, unconsciousness, paralysis of respiration, convulsions, coma, death within a day.	One leaf of an oleander is said to contain enough poison to kill an adult. In Florida, severe poisoning resulted when oleander branches were used as skewers. Honey made from oleander flower nectar is poisonous.
Peyote (Mescal buttons) *Lophophora williamsii*	**Description**: Hemispherical, spineless member of the cactus family growing from carrot-shaped roots; low, rounded sections with a tuft of yellow-white hairs on top; flower from the center of the plant, white to rose-pink; pink berry when ripe; black seeds. **Toxic parts**: Entire plant, especially the buttons.	Native to southern Texas and northern Mexico; cultivated in other areas.	**Poisoning**: Contains mescaline, lophophorine and other alkaloids. **Symptoms**: Illusions and hallucinations with vivid color, anxiety, muscular tremors and twitching, vomiting, diarrhea, blurred vision, wakefulness, forgetfulness, muscular relaxation, dizziness.	The effects of chewing fresh or dried "buttons" of peyote are similar to those produced by LSD, only milder. In some states, peyote is recognized as a drug. Peyote has long been used by the Indians and Mexicans in religious ceremonies.
Poison hemlock (poison parsley) *Conium maculatum*	**Description**: Biennial herb with a hairless purple-spotted or lined, hollow stem growing up to 8 ft (2.4 m) tall; turniplike, long, solid taproot; large, alternate, pinnately divided leaves; small, white flowers in umbrella-shaped clusters, dry; ribbed, 2-part capsule fruit. **Toxic parts**: Entire plant, primarily seeds and root.	A native of Eurasia, now a weed in meadows, and along roads and ditches throughout the United States and southern Canada where moisture is sufficient.	**Poisoning**: The poisonous alkaloid coniine and other related alkaloids. **Symptoms**: Burning sensation in the mouth and throat, nervousness, dyscoordination, dilated pupils, muscular weakness, weakened and slowed heartbeat, convulsions, coma, death.	Poisoning occurs when the leaves are mistaken for parsley, the roots for turnips, or the seeds for anise. Toxic quantities seldom consumed because the plant has such an unpleasant odor and taste. Assumed by some to be the poison drunk by Socrates.

TABLE 1.12 *(Continued)*

Toxic Plants

Common and Scientific Name	Description; Toxic Parts	Geographical Distribution	Poisoning; Symptoms	Remarks
Poison ivy (poison oak) *Toxicondendron radicans*	**Description**: A trailing or climbing vine, shrub, or small tree; alternate leaves with 3 leaflets; flowers and fruits hanging in clusters; white to yellowish fruit (drupes). **Toxic parts**: Roots, stems, leaves, pollen, flowers, and fruits.	An extremely variable native weed throughout southern Canada and the United States with the exception of the west coast; found on flood plains, along lake shores, edges of woods, stream banks, fences, and around buildings.	**Poisoning**: Skin irritation due to an oil-resin containing urushiol. **Symptoms**: Contact with skin causes itching, burning, redness, and small blisters; severe gastric disturbance and even death by eating leaves or fruit.	Almost half of all persons are allergic to poison ivy. Skin irritation may also result from indirect contact such as animals (including dogs and cats), clothing, tools, or sports equipment.
Pokeweed (Pokeberry) *Phytolacca americana*	**Description**: Shrublike herb with a large fleshy taproot; large, entire, oblong leaves which are pointed; white to purplish flowers in clusters at ends of branches; mature fruit a dark purple berry with red juice. **Toxic parts**: Rootstalk, leaves, and stems.	Native to the eastern United States and southeastern Canada.	**Poisoning**: Highest concentration of poison mainly in roots; contains the bitter glycoside, saponin and glycoprotein. **Symptoms**: Burning and bitter taste in mouth, stomach cramps, nausea, vomiting, diarrhea, drowsiness, slowed breathing, weakness, tremors, convulsions, spasms, coma and death if eaten in large amounts.	Young tender leaves and stems of pokeweed are often cooked as greens. Cooked berries are used for pies without harm. It is one of the most dangerous poisonous plants because people prepare it improperly.
Poppy (common poppy) *Papaver somniferum*	**Description**: An erect annual herb with milky juice, simple, coarsely toothed, or lobed leaves; showy red, white, pink, or purple flowers; fruit an oval, crowned capsule; tiny seeds in capsule. **Toxic parts**: Unripe fruits or their juice.	Introduced from Eurasia and widely grown in the United States until cultivation without a license became unlawful.	**Poisoning**: Crude resin from unripe seed capsule source of narcotic opium alkaloids. **Symptoms**: From unripe fruit, stupor, coma, shallow and slow breathing, depression of the central nervous system; possibly nausea and severe retching (straining to vomit).	The use of poppy extracts is a double edged sword — addictive narcotics and valuable medicines. Poppy seeds used as toppings on breads are harmless.

Rhododendron, azaleas *Rhododendron sp.*	**Description**: Usually evergreen shrubs; mostly entire, simple, leathery leaves in whorls or alternate; snowy white to pink flowers in terminal clusters; fruit a wood capsule. **Toxic part**: Entire plant.	Throughout the temperate parts of the United States as a native and as an introduced ornamental.	**Poisoning**: Contains the toxic resinoid, andromedotoxin. **Symptoms**: Watering eyes and mouth, nasal discharge, nausea, severe abdominal pain, vomiting, convulsions, lowered blood pressure, lack of coordination and loss of energy; progressive paralysis of arms and legs until death, in severe cases.	Cases of poisoning are rare in this country but rhododentrons should be suspected of possible danger.
Rosary pea (precatory pea) *Abrus precatorius*	**Description**: A twining, more or less woody perennial vine; alternate and divided leaves with small leaflets; red to purple or white flowers; fruit a short pod containing ovoid seeds which are glossy, bright scarlet over 3/4 of their surface, and jet black over the remaining 1/4. **Toxic parts**: Seeds.	Native to the tropics, but naturalized in Florida and the Keys.	**Poisoning**: Contains the phytotoxin abrin and tetanic glycoside, abric acid. **Symptoms**: Severe stomach pain, in 1-3 days, nausea, vomiting, severe diarrhea, weakness, cold sweat, drowsiness, weak, fast pulse, coma, circulatory collapse, death.	The beans are made into rosaries, necklaces, bracelets, leis, and various toys which receive wide distribution. Seeds must be chewed and swallowed to cause poisoning. Whole seeds pass through the digestive tract without causing symptoms. One thoroughly chewed seed is said to be potent enough to kill an adult or child.
Snow-on-the-mountain *Euphorbia marginata*	**Description**: A tall annual herb, browing up to 4 ft (122 cm) high; smooth, lance-shaped leaves with conspicuously white margins; whorls of white petal-like leaves border flowers; fruit a 3-celled, 3-lobed capsule. **Toxic parts**: Leaves, stems, milky sap.	Native to the western, dry plains and valleys from Montana to Mexico; sometimes escapes in the eastern United States.	**Poisoning**: Toxins causing dermatitis and severe irritation of the digestive tract. **Symptoms**: Blistering of the skin, nausea, abdominal pain, fainting, diarrhea, possibly death in severe cases.	Milky juice of this plant is very caustic. Outwardly resembles a poinsettia.

TABLE 1.12 *(Continued)*

Toxic Plants

Common and Scientific Name	Description; Toxic Parts	Geographical Distribution	Poisoning; Symptoms	Remarks
Skunkcabbage *Veratrum californicum*	**Description**: Tall, broadleaved herbs of the lily family, growing to 6 ft (183 cm) high; large, alternate pleated, clasping, and parallel-veined leaves; numerous whitish to greenish flowers in large terminal clusters; 3-lobed, capsule fruit. **Toxic parts**: Entire plant.	Various species throughout North America in wet meadows, forests, and along streams.	**Poisoning**: Contains such alkaloids as veradridene and veratrine. **Symptoms**: Nausea, vomiting, diarrhea, stomach pains, lowered blood pressure, slow pulse, reduced body temperature, shallow breathing, salivation, weakness, nervousness, convulsions, paralysis, possibly death.	These plants have been used for centuries as a source of drugs and as a source of insecticide. Since the leaves resemble cabbage, they are often collected as an edible wild plant, but with unpleasant results.
Tansy *Tanacetum vulgare*	**Description**: Tall, aromatic herb with simple stems to 3 ft (91 cm) high; alternate, pinnately divided, narrow leaves, flower heads in flat-topped clusters with numerous small, yellow flowers. **Toxic parts**: Leaves, stems, and flowers.	Introduced from Eurasia; widely naturalized in North America; sometimes found escarped along roadsides, in pastures, or other wet places; grown for medicinal purposes.	**Poisoning**: Contains an oil, tanacetin, or oil of tansy. **Symptoms**: Nausea, vomiting, diarrhea, convulsions, violent spasms, dilated pupils, rapid and feeble pulse, possibly death.	Tanys and oil of tansy are employed as an herbal remedy for nervousness, intestinal worms, to promote menstruation, and to induce abortion. Some poisonings have resulted from the use of tansy as a home remedy.

Waterhemlock *Cicuta sp.*	**Description**: A perennial with parsleylike leaves; hollow, jointed stems and hollow, pithy roots; flowers in umbrella clusters; stems streaked with purple ridges; 2-6 ft (61-183 cm) high. **Toxic parts**: Entire plant, primarily the roots and young growth.	Wet meadows, pastures, and flood plains of western and eastern United States, generally absent in the plains states.	**Poisoning**: Contains the toxic resinlike higher alcohol, cicutoxin. **Symptoms**: Frothing at the mouth, spasms, dilated pupils, diarrhea, convulsions, vomiting, delirium, respiratory failure, paralysis, and death.	One mouthful of the waterhemlock root is reported to contain sufficient poison to kill a man. Children making whistles and peashooters from the hollow stems have been poisoned. The waterhemlock is often mistaken for the edible wild artichoke or parsnip. However, it is considered to be one of the poisonous plants of the North Temperate Zone.
White snakeroot *Eupatorium rogosum*	Description: Erect perrenial with stems 1-5 ft (30-152 cm) tall; opposite oval leaves with pointed tips and sharply toothed edges, and dull on the upper surface but shiny on the lower surface; showy, snow white flowers in terminal clusters. Toxic parts: Entire plant.	From eastern Canada to Saskatchewan and south to Texas, Louisiana, Georgia, and Virginia.	Poisoning: Contains the higher alcohol, tremetol and some glycosides. Symptoms: Weakness, nausea, loss of appetite, vomiting, tremors, labored breathing, constipation, dizziness, delirium, convulsions, coma, and death.	Recovery from a nonlethal dose is a slow process, due to liver and kidney damage. Poison may be in the milk of cows that have eaten white snakeroot — "milk sickness."

Taken from Ensminger et al., *Foods and Nutrition Encyclopedia,* 2nd ed., CRC Press, Boca Raton, 1994, pp. 1776-1785.

TABLE 1.13

Plants Used as Herbal Remedies[1]

Common and Scientific Name	Description	Production	Part(s) of Plant Used	Reported Uses
Agrimony *Agrimonia gryposepala*	Small yellow flowers on a long spike; leaves hairy and at least 5 in. (13 cm) long, narrow and pointed; leaf edges toothed; a perennial.	Needs good soil and sunshine; grows in New England and Middle Atlantic states.	Whole plant including roots	A tonic, alterative, diuretic, and astringent; infusions from the leaves for sore throats; treatment of kidney and bladder stones; root for jaundice.
Aletris root (whitetube stargrass) *Aletris farinosa*	Grasslike leaves in a flat rosette around a spike-like stem; white to yellow tubular flowers along stem.	Moist locations in woods, meadows, or bogs; New England to Michigan and Wisconsin; south to Florida and west to Texas.	Leaves, roots	Poultice of leaves for sore breast; liquid from boiled roots for stomach pains, tonic, sedative, and diuretic.
Alfalfa *Medicago sativa*	Very leafy plant growing 1–2 ft (30–61 cm) high; small green leaves; bluish-purple flowers; deep roots.	A legume cultivated widely in the United States.	Leaves	Powdered and mixed with cider vinegar as a tonic; infusions for a tasty drink; leaves may also be used green.
Aloe vera *Aloe barbadensis*	A succulent plant with leathery sword-shaped leaves, 6–24 in. (15–61 cm) long.	A semidesert plant which grows in Mexico and Hawaii; temperature must remain above 50°F (10°C); can be a house plant.	Mucilaginous juice of the leaves	Effective on small cuts and sunburn; speeds healing; manufactured product for variety of cosmetic purposes.
Angelica *Angelica atropurpurea*	Shrub growing to 8 ft (2.4 m) high; stem purplish with 3 toothed leaflets at tip of each leaf stem; white or greenish flowers in clusters at end of each stalk.	Grows in rich low soil near streams and swamps and in gardens; from New England west to Ohio, Indiana, Illinois, and Wisconsin; south to Delaware, Maryland, West Virginia, and Kentucky.	Roots, seeds	Small amount of dried root or seeds for relief of flatulence; roots for the induction of vomiting and perspiration; roots for treatment of toothache, bronchitis, rheumatism, gout, fever, and to increase menstrual flow.
Anise (Anise seed) *Pimpinella anisum*	Annual plant, 1–2 ft (30–61 cm) high; belongs to carrot family; small white flowers on long hairy stalk; lower leaves egg-shaped; upper leaves feathery.	Grown all over the world; grows wild in countries around the Mediterranean; much is imported to United States.	Seed	As a hot tea to relieve flatulence or for colic.

TABLE 1.13 *(Continued)*

Plants Used as Herbal Remedies[1]

Common and Scientific Name	Description	Production	Part(s) of Plant Used	Reported Uses
Asafetida *Ferula* sp.	A coarse plant growing to 7 ft (2.1 m) high with numerous stem leaves; pale green-yellow flowers; flowers and seeds borne in clusters on stalks; large fleshly root; tenacious odor.	Indigenous to Afghanistan, but some species grow in other Asiatic countries.	Gummy resin from the root	As an antispasmodic; to ward off colds and flu by wearing in a bag around the neck.
Bayberry (Southern wax myrtle) *Myrica cerifera*	Perennial shrub growing to 30 ft (9.2 m) high; waxy branchlets; narrow evergreen leaves tapering at both ends; yellowish flowers; fruits are grayish berries.	Grows in coastal regions from New Jersey, Delaware and Maryland to Florida, Alabama, Mississippi, and Arkansas.	Root bark, leaves, stems	Decoction of root bark to treat uterine hemorrhage, jaundice, dysentery, and cankers; leaves and stems boiled and used to treat fevers; decoction of boiled leaves for intestinal worms.
Bearberry *Arctostaphylos uva-ursi*	Creeping evergreen shrub with stems up to 6 in. (15 cm) high; reddish bark; bright green leaves, 1 in. (3 cm) long; white flowers with red markings, in clusters; smooth red fruits.	Grows in well-drained soils at higher altitudes; from Oregon, Washington, and California, to Colorado and New Mexico.	Leaves	As a diuretic; also boiled infusions used as a drink to treat sprains, stomach pains, and urinary problems; poison oak inflammations treated with leaf decoction by pioneers.
Blackberry (brambleberry, dewberry, raspberry) *Rubus*	Shrubby or viny thorny perennial; numerous species; large white flowers; red or black fruit.	Grows wild or in gardens throughout the United States; wild in old fields, waste areas, forest borders, and pastures.	Roots, root bark, leaves, fruit	Infusion made from roots used to dry up runny noses; infusion from root bark to treat dysentery; fruit used to treat dysentery in children; leaves also used in similar manner.
Black cohosh *Cimicifuga racemosa*	Perennial shrub growing to 9 ft (2.7 m) or more in height; leaf has 2 to 5 leaflets; plant topped with spike of slender candlelike, white or yellowish flowers; rhizome gnarled and twisted.	Grows throughout eastern United States; commercial supply from Blue Ridge Mountains.	Rhizomes, roots	Infusion and decoctions used to treat sore throat, rheumatism, kidney trouble, and general malaise; also used for "women's ailments" and malaria.

TABLE 1.13 *(Continued)*

Plants Used as Herbal Remedies[1]

Common and Scientific Name	Description	Production	Part(s) of Plant Used	Reported Uses
Black Walnut *Juglans nigra*	A tree growing up to 120 ft (36.6 m) high; leaflets alternate 12–23 per stem, finely toothed and about 3–3.5 in. (8–9 cm) long; nut occurs singly or in clusters with fleshy, aromatic husk.	Native to a large section of the rich woods of eastern and midwestern United States.	Bark, nut husk, leaves	Inner bark used as mild laxative; husk of nut used for treating intestinal worms, ulcers, syphilis, and fungus infections; leaf infusion for bedbugs.
Blessed thistle *Cnicus benedictus*	Annual plant growing to 2 ft (61 cm) high; spiny tooth, lobed leaves; many flowered yellow heads.	Grows along roadsides and in waste places in eastern and parts of southwestern United States.	Leaves and flowering tops in full bloom, seeds	Infusions from leaves and tops for cancer treatment, to induce sweating, as a diuretic, to reduce fever, and for inflammations of the respiratory system; infusion of tops as Indian contraceptive; seeds induce vomiting.
Boneset *Eupatorium perfoliatum*	Perennial bush growing to 5 ft (1.5 m) in height; heavy stems with leaves opposite; purplish to white flowers borne in flat heads.	Commonly found in wet areas such as swamps, rich woods, marshes, and pastures; grows from Canada to Florida and west to Texas and Nebraska.	Leaves, flowering tops	Infusions made from leaves used for laxative and treatment of coughs and chest illnesses — a cold remedy; Negro slaves and Indians used it to treat malaria.
Borage *Borago officinalis*	Entire plant not over 1 ft (30 cm) high; nodding heads of starlike flowers grow from clusters of hairy obovate leaves.	Introduced in United States from Europe; occasionally grows in waste areas in northern states; cultivated widely in gardens.	Leaves	Most often used as an infusion to increase sweating, as a diuretic, or to soothe intestinal tract; can be applied to swellings and inflamed areas for relief.
Buchu *Rutaceae*	Low shrubs with angular branches and small leaves growing in opposition; flowers from white to pink.	Grown in rich soil in warm climate of South Africa.	Dried leaves	Prepared as tincture or infusion; used for genito-urinary diseases, indigestion, edema, and early stages of diabetes.
Buckthorn *Rhamnus purshiana*	Deciduous tree growing to 25 ft (7.6 m) high; leaves 2–6 in. (5–15 cm) long; flowers small greenish yellow; fruit globular and black, about 1/4 in. (6 mm) across.	Grows usually with conifers along canyon walls, rich bottom lands, and mountain ridges in western United States.	Bark, fruit	Bark used as a laxative and tonic; fruit (berries) used as a laxative.

TABLE 1.13 *(Continued)*

Plants Used as Herbal Remedies[1]

Common and Scientific Name	Description	Production	Part(s) of Plant Used	Reported Uses
Burdock *Arctium minus*	Biennial or perennial growing 5–8 ft (1.5–2.4 m) high; large leaves resembling rhubarb; tube-shaped white and pink to purple flowers in heads; brown bristled burrs contain seeds.	Grows in wastelands, fields, and pastures throughout the United States.	Root	Infusion of roots for coughs, asthma, and to stimulate menstruation; tincture of root for rheumatism and stomachache.
Calamus (Sweet flag) *Acorus calamus*	Perennial growing 3–5 ft (1.0–1.5 m) high; long narrow leaves with sharp edges; aromatic leaves; flower stalk 2–3 in. (3–8 cm) long and clublike; greenish-yellow flowers.	Grows in swamps, edges of streams and ponds from New England west to Oregon and Montana, and from Texas east to Florida and north.	Rhizomes	Root chewed to clear phlegm (mucous) and ease stomach gas; infusions to treat stomach distress; considered useful as tonic and stimulant.
Catnip *Nepeta cataria*	Perennial growing to 3 ft (1 m) in height; stem downy and whitish; leaves heart-shaped opposite coarsely toothed and 2–3 in. (3–8 cm) long; tubular whitish with purplish marked flowers in compact spikes.	Grows wild along fences, roadsides, waste places, and streams in Virginia, Tennessee, West Virginia, Georgia, New England, Illinois, Indiana, Ohio, New Mexico, Colorado, Arizona, Utah, and California; readily cultivated in gardens.	Entire plant	Infusions for treating colds, nervous disorders, stomach ailments, infant colic, and hives; smoke relieves respiratory ailments; poultice to reduce swellings.
Celery *Apium graveolens*	A biennial producing flower stalk second year; terminal leaflet at end of stem; fruit brown and round.	Cultivated in California, Florida, Michigan, New York, and Washington.	Seeds	As an infusion to relieve rheumatism and flatulence (gas); to act as a diuretic; to act as a tonic and stimulant; oil from seeds used similarly.

TABLE 1.13 *(Continued)*

Plants Used as Herbal Remedies[1]

Common and Scientific Name	Description	Production	Part(s) of Plant Used	Reported Uses
Chamomile *Anthemis nobilis*	Low growing, pleasantly strong-scented, downy, and matlike perennial; daisylike flowers with white petals and yellow center.	Cultivated in gardens; some wild growing which escaped from gardens.	Leaves, flowers	Powdered and mixed with boiling water to stimulate stomach, to remedy nervousness in women, and stimulate menstrual flow, also a tonic; flowers for poultice to relieve pain; chamomile tea known as soothing, sedative, completely harmless.
Chaparral *Croton corynbulosus*	Shrubby perennial plant of the Spurge family.	Grows in dry rock areas from Texas west.	Flowering tips	Infusions act as laxative; some claims as cancer treatment.
Chickweed *Stellaria media*	Annual growing 12–15 in. (30–38 cm) high; stems matted to somewhat upright; upper leaves vary but lower leaves ovate; white, small individual flowers.	Grows in shaded areas, meadows, wasteland, cultivated land, thickets, gardens, and damp woods in Virginia to South Carolina and southeast.	Entire plant in full bloom	Poultice made to treat sores, ulcers, infections, and hemorrhoids.
Chicory *Cichorium intybus*	Easily confused with its close relative the dandelion; in bloom bears blue or soft pink blooms not resembling dandelion.	Introduced from Europe, now common wild plant in United States; some grown in gardens.	Roots, leaves	No great medicinal value; some mention of diuretic, laxative, and tonic use; mainly added to give coffee distinctive flavor.
Cinnamon *Cinnamomum zeylanicum*	An evergreen bush or tree growing to 30 ft (9 m) high.	A native plant of Sri Lanka, India, and Malaysia; tree kept pruned to a shrub; bark of lower branches peeled and dried.	Bark	Treatment for flatulence, diarrhea, vomiting, and nausea.
Cleaver's herb (Catchweed bedstraw) *Galium aparine*	Annual plant; weak reclining bristled stem with hairy joints; leaves in whorls of 8; white flowers in broad, flat cluster; bristled fruit.	Grows in rich woods, thickets, seashores, waste areas, and shady areas from Canada to Florida and west to Texas.	Entire plant during flowering	To increase urine formation; to stimulate appetite; to reduce fever; to remedy vitamin C deficiency.

TABLE 1.13 *(Continued)*

Plants Used as Herbal Remedies[1]

Common and Scientific Name	Description	Production	Part(s) of Plant Used	Reported Uses
Cloves *Syzygium aromaticum*	Dried flower bud of a tropical tree which is a 30-ft (9 m) high red flowered evergreen.	Tree native to Molucca, but widely cultivated in tropics; flower bud picked before flower opens and dried.	Flower bud	To promote salivation and gastric secretion; to relieve pain in stomach and intestines; applied externally to relieve rheumatism, lumbago, toothache, muscle cramps, and neuralgia; clove oil used, too; infusions with clove powder relieves nausea and vomiting.
Colt's foot (Canada wild ginger) *Asarum canadense*	Low growing stemless perennial; heart-shaped leaves; flowers near root are brown and bell-shaped.	Found in moist woods from Maine to Georgia and west to Ohio.	Roots, leaves	Infusion of root to relieve flatulence; powdered root to relieve flatulence; induce sweating, and to relieve aching head and eyes; leaves substitute for ginger.
Comfrey *Symphytum officinale*	A perennial which reaches about 2 ft (61 cm) in height; leaves are large and broad at base but lancelike at terminal; fine hair on leaves; tail-shaped head of white to purple flowers at terminal.	Prefers a moist environment; a European plant now naturalized in the United States.	Roots, leaves	Numerous uses including treatments for pneumonia, coughs, diarrhea, calcium deficiency, colds, sores, ulcers, arthritis, gallstones, tonsils, cuts and wounds, headaches, hemorrhoids, gout, burns, kidney stones, anemia, and tuberculosis; used as a poultice, infusion, powder, or in capsule form.
Dandelion *Taraxacum officinale*	Biennial growing 2–12 in. (5–30 cm) high; leaves deeply serrated forming a basal rosette in spring; yellow flower but turns to gray upon maturing.	Weed throughout the United States; the bane of lawns.	Flowers, roots, green leaves	Root uses include diuretic, laxative, tonic, and to stimulate appetite; infusion from flower for heart troubles; paste of green leaves for bruises.
Echinacea (Purple echinacea) *Echinacea purpurea*	Perennial from 2–5 ft (0.6–1.5 m) high; alternate lance-shaped leaves; leaf margins toothed; top leaves lack stems; purple to white flower.	Grows wild on road banks, prairies, and dry, open woods in Ohio to Iowa, south to Oklahoma, Georgia, and Alabama.	Roots	Treatment of ulcers and boils, syphilis, snakebites, skin diseases, and blood poisoning; used as powder and in capsules.

TABLE 1.13 *(Continued)*

Plants Used as Herbal Remedies[1]

Common and Scientific Name	Description	Production	Part(s) of Plant Used	Reported Uses
Eucalyptus *Eucalyptus globulus*	Tall, fragrant tree growing up to 300 ft (92 m) high; reddish-brown stringy bark.	Native to Australia but grown in other semitropical and warm temperate regions.	Leaves and oil distilled from leaves	Antiseptic value; inhaled freely for sore throat; asthma relief; local application to ulcers; used on open wounds.
Eyebright (Indian tobacco) *Lobelia inflata*	Branching annual growing to 3 ft (1 m) high with leaves 1–3 in. (3–8 cm) long; small violet to pinkish-white flowers in axils of leaves; seed capsules at base of flower containing many tiny brown seeds.	Roadside weed of eastern United States, west to Kansas.	Entire plant in full bloom or when seeds are formed	Treatment of whooping cough, asthma, epilepsy, pneumonia, hysteria, and convulsion; alkaloid extracted for use in antismoking preparations.
Fenugreek *Trigonella foenum-graceum*	Annual plant similar to clover in size.	Native to the Mediterranean regions and northern India; widely cultivated; easily grown in home gardens.	Seed	Poultice for wounds; gargle for sore throat.
Flax (Linseed) *Linum usitatissimum*	Herbaceous annual; slender upright plant with narrow leaves and blue flowers; grows to about 2 ft (61 cm) high.	Originated in Mediterranean region; cultivated widely for fiber and oil.	Seed	Ground flaxseed mixed with boiling water for poultice on burns, boils, carbuncles, and sores; internally as a laxative.
Garlic *Allium sativum*	Annual plant growing to 12 in. (30 cm) high; long, linear, narrow leaves; bulb composed of several bulblets.	Throughout the United States under cultivation; some wild.	Entire plant when in bloom; bulbs	Fresh poultice of the mashed plant for treating snake bite, hornet stings, and scorpion stings; eaten to expel worms, treat colds, coughs, hoarseness, and asthma; bulb expressed against the gum for toothache.
Gentian (Sampson snakeroot) *Gentiana villosa*	Perennial with stems growing 8–10 in. (20–25 cm) high; opposite ovate, lance-shaped leaves; pale blue flowers.	Grows wild in swampy areas Florida west to Louisiana, north to New Jersey, Pennsylvania, Ohio, and Indiana.	Rhizomes and roots	Treatment of indigestion, gout, and rheumatism; induction of vomiting; aid to digestion; a tonic.
Ginger *Zingiber officinale*	Perennial plant; forms irregular-shaped rhizomes at shallow depth.	Native to southeastern Asia; now grown all over tropics.	Rhizome	An expectorant; treatment of flatulence, colds, and sore throats.

TABLE 1.13 *(Continued)*

Plants Used as Herbal Remedies[1]

Common and Scientific Name	Description	Production	Part(s) of Plant Used	Reported Uses
Ginseng *Panax quinquefolia*	Hollow stems solid at nodes; leaves alternate; root often resembles shape of a man; small, inconspicuous flowers; vivid, shiny, scarlet berries.	Grows in eastern Asia, Korea, China, and Japan; some grown in United States.	Root	As a tonic and stimulant; treatment of convulsions, dizziness, vomiting, colds, fevers, headaches, and rheumatism.
Goldenrod *Solidago odora*	Grows 18–36 in. (46–91 cm) high with narrow leaves scented like anise; inconspicuous head with 6–8 flowers.	Grows throughout the United States.	Leaves	Infusions from dried leaves as aromatic stimulant and a diuretic.
Goldenseal *Hydrastis canadensis*	Perennial growing to about 1 ft (30 cm) high; one stem with 5–7 lobed leaves near top; several single leafstalks topped with petalless flowers; raspberrylike fruit but inedible.	Grows in rich, shady woods of southeastern and midwestern United States; grown under cultivation in Washington.	Roots, leaves, stalks	Root infusion as an appetite stimulant and tonic; root powder for open cuts and wounds; chewing root for mouth sores; leaf infusion for liver and stomach ailments.
Guarana *Paullinia cupana*	Climbing shrub of the soapberry family; yellow flowers; pear-shaped fruit; seed in 3-sided, 3-celled capsules.	Grows in South America, particularly Brazil and Uruguay.	Seeds	Stimulant; seeds high in caffeine.
Hawthorn *Crataegus oxycantha*	Hardy shrub or tree depending upon growth conditions; small, berry fruit; cup-shaped flowers with 5 parts; thorny stems.	Originally grown throughout England as hedges; also grows wild; some introduced in the United States.	Berry	Tonic for heart ailments such as angina pectoris, valve defects, rapid and feeble heart beat, and hypertrophied heart; reverses arteriosclerosis.
Hop *Humulus lupulus*	Twining, perennial growing 20 ft (6 m) or more; 3 smooth-lobed leaves 4–5 in. (10–13 cm) long; membranous, conelike fruit.	Grows throughout the United States; often a cultivated crop.	Fruit (hops)	Straight hops or powder used; hot poultice of hops for boils and inflammations; treatment of fever, worms, and rheumatism; as a diuretic; as a sedative.

TABLE 1.13 *(Continued)*

Plants Used as Herbal Remedies[1]

Common and Scientific Name	Description	Production	Part(s) of Plant Used	Reported Uses
Horehound (White horehound) *Marrubium vulgare*	Shrub growing to 3 ft (1 m) in height; fuzzy ovate-round leaves which are whitish above and gray below; foliage aromatic when crushed.	Grows wild throughout most of United States in pastures, old fields, and waste places, except in arid southwest.	Leaves and small stems; bark	Decoctions to treat coughs, colds, asthma, and hoarseness; other uses include treatment for diarrhea,menstrual irregularity, and kidney ailments.
Huckleberry (Sparkleberry) *Vaccinium arboreum*	Shrub or tree growing to 25 ft (7.6 m) high; leathery; shiny, thick leaves; white flowers; black berries; other species.	Grows wild in woods, clearings, sandy and dry woods in Virginia, Georgia, Florida, Mississippi, Indiana, Illinois, Missouri, Texas, and Oklahoma.	Leaves, root bark, berries	Decoctions of leaves and root bark to treat sore throat and diarrhea; drink from berry for treating chronic dysentery.
Hyssop *Hyssopus officinalis*	Hardy, fragrant, bushy plants belonging to the mint family; stem woody; leaves hairy, pointed, and about 1/2 in. (20 mm) long; blue flowers in tufts.	Grows in various parts of Europe including the Middle East; some grown in United States.	Leaves	Infusions for colds, coughs, tuberculosis, and asthma; an aromatic stimulant; healing agent for cuts and bruises.
Juniper (Commonjuniper) *Juniperus communis*	Small evergreen shrub growing 12–30 ft (3.7–9.2 m) high; bark of trunk reddish-brown and tends to shred; needles straight and at right angles to branchlets; dark, purple, fleshy berrylike fruit.	Widely distributed from New Mexico to Dakotas and east; dry areas.	Fruit (berries)	Used as a diuretic, to induce menstruation, to relieve gas, and to treat snake bites and intestinal worms.
Lemon balm *Melissa officinalis*	Persistent perennial growing to 1 ft (30 cm) high; light green, serrated leaves; lemon smell and taste to crushed leaves.	Wild in much of the United States; grown in gardens.	Leaves	Infusion used as a carminative, diaphoretic, or febrifuge.
Licorice (Wild licorice) *Glycyrrhiza lepidota*	Erect perennial growing to 3 ft (1 m) high; pale yellow to white flowers at end of flower stalks; brown seed pods resemble cockleburs.	Grows wild on prairies, lake shores, and railroad right-of-ways throughout much of the United States.	Root **Caution:** Licorice raises the blood pressure of some people dangerously high, due to the retention of sodium.	Root extract to help bring out phlegm (mucus); treatment of stomach ulcers, rheumatism, and arthritis; root decoctions for inducing menstrual flow, treating fevers, and expulsion of afterbirth.

TABLE 1.13 *(Continued)*

Plants Used as Herbal Remedies[1]

Common and Scientific Name	Description	Production	Part(s) of Plant Used	Reported Uses
Marshmallow *Althaea officinalis*	Stems erect and 3–4 ft (0.9–1.2 m) high with only a few lateral branches; roundish, ovate-cordate leaves 2–3 in. (5–8 cm) long and irregularly toothed at margin; cup-shaped, pale-colored flowers.	Introduced into United States from Europe; now found on banks of tidal rivers and brackish streams; grew wild in salt marshes, damp meadows, by ditches, by the sea, and banks of tidal rivers from Denmark south.	Root	Primarily a demulcent and emollient; used in cough remedies; good poultice made from crushed roots.
Motherwort *Leonurus cardiaca*	Perennial growing 5–6 ft (1.5–1.8 m) high; lobed, dented leaves, 5 in. (13 cm) long; very fuzzy white to pink flowers.	Grows wild in pastures, waste places, and roadsides from northeastern states west to Montana and Texas, south to North Carolina and Tennessee.	Entire plant above ground	Used as a stimulant, tonic, and diuretic; Europeans used for asthma and heart palpitation; usually taken as an infusion.
Mullien (Aaron's rod) *Verbascum thapsus*	At base a rosette of woody, lance-shaped, oblong leaves with a diameter of up to 2 ft (61 cm); yellow flowers along a clublike spike arising from the rosette to a height of up to 7 ft (2.1 m).	Grows wild throughout the United States in dry fields, meadows, pastures, rocky or gravelly banks, burned areas, etc.	Leaves, roots, flowers	Infusions of leaves to treat colds and dysentery; dried leaves and flowers serve as a demulcent and emollient; leaves smoked for asthma relief; boiled roots for croup; oil from flowers for earache; local applications of leaves for hemorrhoids, inflammations, and sunburn.
Nutmeg *Muristica fragrans*	Evergreen tree growing to about 25 ft (7.6 m) high; grayish-brown, smooth bark; fruit resembles yellow plum, the seed of which is known as nutmeg.	Native to Spice Islands of Indonesia; now cultivated in other tropical areas.	Seed	For the treatment of nausea and vomiting; grated and mixed with lard for hemorrhoid ointment.
Papaya *Carica papaya*	Small tree seldom above 20 ft (6.1 m) high; soft, spongy wood; leaves as large as 2 ft (61 cm) in diameter and deeply cut into 7 lobes; fruit oblong and dingy green-yellow.	Originated in South American tropics; now cultivated in tropical climates.	Leaves	Dressing for wounds, and aid for digestion; contains proteolytic enzyme, papain, used as a meat tenderizer.

TABLE 1.13 *(Continued)*

Plants Used as Herbal Remedies[1]

Common and Scientific Name	Description	Production	Part(s) of Plant Used	Reported Uses
Parsley *Petroselinum crispum*	Biennial which is usually grown as an annual; finely divided, often curled, fragrant leaves.	Originated in the Mediterranean area; now grown worldwide.	Leaves, seeds, roots	As diuretic with aromatic and stimulating properties.
Passion flower (Maypop passion-flower) *Passiflora incarnata*	Perennial vine growing to 30 ft (9.2 m) in length; alternate leaves composed of 3–5 finely toothed lobes; showy, vivid, purple, flesh-colored flowers; smooth, yellow ovate fruit 2–3 in. (5–8 cm) long.	Grows wild in West Indies and southern United States; cultivated in many areas.	Flowering and fruiting tops	Crushed parts for poultice to treat bruises and injuries; other uses include treatment of nervousness, insomnia, fevers, and asthma.
Peppermint *Mentha piperita*	Perennial growing to about 3.5 ft (1 m) high; dark, green, toothed leaves; purplish flowers in spike-like groups.	Originated in temperate regions of the Old World where most is still grown; grows in shady damp areas in many areas of the United States; grown in gardens.	Flowering tops, leaves	Infusions for relief of flatulence, nausea, headache, and heartburn; fresh leaves rubbed into skin to relieve local pain; extracted oil contains medicinal properties.
Plantain *Plantago* sp.	Low perennial with broad leaves; flowers on erect spikes.	Grows wild throughout the United States in poor soils, fields, lawns, and edges of woods.	Leaves, seeds, root	Infusion of leaves for a tonic; seeds for laxative; soaking seeds provides sticky gum for lotions; fresh, crushed leaves to reduce swelling of bruised body parts; fresh, boiled roots applied to sore nipples.
Pleurisy root (Butterfly milkweed) *Asclepias tuberosa*	Leafy perennial growing to 3 ft (1 m) high; alternate leaves which are 2–6 in. (5–15 cm) long and narrow; bright orange flowers in a cluster; root spindle-shaped with knotty crown.	Grows in sandy, dry soils; pastures, roadsides, and gardens; south to Florida and west to Texas and Arizona.	Root	Small doses of dried root as a diaphoretic, diuretic, expectorant, and alternative; ground roots fresh or dried for poultice to treat sores.

TABLE 1.13 *(Continued)*

Plants Used as Herbal Remedies[1]

Common and Scientific Name	Description	Production	Part(s) of Plant Used	Reported Uses
Queens delight *Stillingia sylvatica*	Perennial growing to 3 ft (1 m) high; contains milky juice; leathery, fleshy, stemless leaves; yellow flowers.	Grows wild in dry woods, sandy soils, and old fields; Virginia to Florida, Kansas, and Texas, north to Oklahoma.	Root	Treatment of infectious diseases.
Red clover *Trifolium pratense*	Biennial or perennial legume less than 2 ft (61 cm) high; 3 oval-shaped leaflets form leaf; flowers globe-shaped and rose to purple colored.	Throughout United States; some wild, some cultivated.	Entire plant in full bloom	Infusions to treat whooping cough; component of salves for sores and ulcers; flowers as sedative; to relieve gastric distress and improve the appetite.
Rosemary *Rosmarinus officinalis*	Low-growing perennial evergreen shrub; leaves about 1 in. (3 cm) in height; orange-yellow flowers; white, shiny seeds.	Native to Mediterranean region; now cultivated in most of Europe and the Americas.	Leaves	Used as a tonic, astringent, diaphoretic, stimulant, carminative, and nervine.
Saffron (Safflower) *Carthamus tinctorius*	Annual with alternate spring leaves; grows to 3 ft (1 m) in height; orange-yellow flowers; white, shiny seeds.	Wild in Afghanistan; cultivated in the United States, primarily in California.	Flowers, seeds, entire plant in bloom	Paste of flowers and water applied to boils; flowers soaked in water to make a drink to reduce fever, as a laxative, to induce perspiration, to stimulate menstrual flow, and to dry up skin symptoms of measles.
Sage (Garden sage) *Salvia officinalis*	Fuzzy perennial belonging to the mint family; leaves with toothed edges; terminal spikes bearing blue or white flowers in whorls.	Originated in the Mediterranean area where it grows wild and is cultivated; grown throughout the United States, some wild.	Leaves	Treatment for wounds and cuts, sores, coughs, colds, and sore throat; infusions used as a laxative and to relieve flatulence; major use for treatment of dyspepsia.
Sarsaparilla *Smilax* sp.	Climbing evergreen shrub with prickly stems; leaves round to oblong; small, globular berry for fruit.	Grown in tropical areas of Central and South America and in Japan and China.	Root	Primarily an alterative for colds and fevers; to relieve flatulence; best used as an infusion.

TABLE 1.13 *(Continued)*

Plants Used as Herbal Remedies[1]

Common and Scientific Name	Description	Production	Part(s) of Plant Used	Reported Uses
Sassafras *Sassafras album*	Tree growing to 40 ft (12.2 m) high; leaves may be 3-lobed, 2-lobed, mitten-shaped, or unlobed; yellowish-green flowers in clusters; pea-sized, 1-seeded berries in fall.	Originated in New World; grows in New England, New York, Ohio, Illinois, and Michigan, south to Florida and Texas; grows along roadsides, in woods, along fences, and in fields.	Root bark	Sassafras was formerly used for medical purposes, but the use of the roots was banned by the FDA because of their carcinogenic qualities.
Saw palmetto *Serenoa serrulata*	Low-growing fan palm; whitish bloom covers sawtoothed, green leaves; flowers in branching clusters; fruit varies in size and shape.	Grows in warm, swampy, low areas near the coast.	Fruit (berries)	To improve digestion; to treat respiratory infections; as a tonic and as a sedative.
Senna (Wild senna) *Cassia marilandica*	Perennial growing to 6 ft (1.8 m) in height; alternate leaves with leaflets in pairs of 5–10; bright yellow flowers.	Grows along roadsides and in thickets from Pennsylvania to Kansas and Iowa, south to Texas and Florida.	Leaves	Infusions primarily employed as a laxative.
Skullcap *Scutellaria lateriflora*	Perennial growing 1–2 ft (30–61 cm) high; toothed, lance-shaped leaves; blue or whitish flowers.	Native to most sections of the United States; prefers moist woods, damp areas, meadows, and swampy areas.	Entire plant in bloom	Powdered plant primarily a nervine.
Spearmint *Mentha spicata*	Perennial resembling other mints; grows to 3 ft (1 m) in height; pink or white flowers borne in long spikes.	Throughout the United States in damp places; cultivated in Michigan, Indiana, and California.	Above ground parts	Primarily a carminative; administered as an infusion through extracted oils.
Tansy *Tanacetum vulgare*	Perennial growing to 3 ft (1 m) in height; pungent fernlike foliage with tops of composite heads of buttonlike flowers.	Grown or escaped into the wild in much of the United States.	Leaves and flowering tops	Infusions used as stomachic, emmenagogue, or to expel intestinal worms; extracted oil induced abortion often with fat results; poultice for sprains and bruises.

TABLE 1.13 *(Continued)*

Plants Used as Herbal Remedies[1]

Common and Scientific Name	Description	Production	Part(s) of Plant Used	Reported Uses
Valerian *Valeriana officinalis*	Coarse perennial growing to 5 ft (1.5 m) high; fragrant, pinkish-white flowers opposite pinnate leaves.	Native to Europe and Northern Asia; cultivated in the United States.	Root	As a calmative and as a carminative.
Witch hazel *Hamamelis virginiana*	Crooked tree or shrub 8–15 ft (2.4–4.6 m) in height; roundish to oval leaves; yellow, threadlike flowers; fruits in clusters along the stem eject shiny, black seeds.	Found in damp woods of North America from Nova Scotia to Florida and west to Minnesota and Texas.	Leaves, bark, twigs	Twigs, leaves, and bark basis for witch hazel extract which is included in many lotions for bruises, sprains, and shaving; bark sometimes applied to tumors and skin inflammations; some preparations for treating hemorrhoids.
Yerba santa *Eriodictyon californicum*	Evergreen shrub with lance-shaped leaves.	Part of flora of the west coast of the United States.	Leaves	As an expectorant; recommended for asthma and hay fever.

Adapted from Ensminger et al., *Foods and Nutrition Encyclopedia,* 2nd ed., CRC Press, Boca Raton, 1994, pp. 1430–1441.

[1] Herbal remedies can vary widely in potency. Some may be toxic. These remedies should not be used without the advice of a physician.

TABLE 1.14

Vitamin Terminology

Vitamins were named according to a) their function; b) their location; c) the order in which they were discovered; or d) combinations of a, b, or c. Some of these names became obsolete as their proposed functions or their isolated structures were found to duplicate already named and described vitamins. Obsolescence also occurred as research showed that certain of these compounds were not needed dietary factors but were synthesized by the body in needed amounts.

Name	Comment
Vitamin A	A number of compounds have vitamin A activity but differ in biopotency. All trans retinol is the standard, and the activity of other compounds can be stated as retinol equivalents. This includes the aldehyde (retinal), acid (retinoic acid), and provitamin (carotene) forms.
Vitamin B	Although orginally thought to be a single compound, researchers found that eight major compounds comprised this "vitamin."
Vitamin B complex	A group of vitamins; includes thiamin, riboflavin, niacin, pyridoxine (3 forms), pantothenic acid, biotin, cyanocobalamin (B_{12}), folacin.
Vitamin B_1	Aneurin; antineuritic factor. Obsolete synonym for thiamin.
Vitamin B_2	Lactoflavin, Ovoflavin. Obsolete synonyms for riboflavin.
Vitamin B_3	Antipellagra factor. Obsolete synonym for niacin.
Vitamin B_4	Not proven to have vitamin activity; thought to be a mixture of arginine, glycine, riboflavin, and pyridoxine.
Vitamin B_5	Probably identical to niacin.
Vitamin B_6	Synonym for pyridoxine, pyridoxal, pyridoxamine.
Vitamin B_7	Not proven to have vitamin activity;[1] sometimes referred to as Vitamin I, a factor which improves food digestibility in pigeons.

TABLE 1.14 *(Continued)*

Vitamin Terminology

Name	Comment
Vitamin B_8	Not proven to have vitamin activity;[1] found to be adenylic acid.
Vitamin B_{10}, B_{11}	An unrefined mixture of folacin and cyanocobalamin; obsolete term.
Vitamin B_{12}	Cyanocobalamin; B_{12a} is aquacobalamin; B_{12b} is hydroxocobalamin; B_{12c} is nitritocobalamin.
Vitamin B_{13}	Orotic acid; a metabolite of pyrimidine metabolism; not considered a vitamin.[1]
Vitamin B_{15}	Synonym for "pangamic acid" a compound of no known biologic value; not a vitamin.[1]
Vitamin B_{17}	Synonym for laetrile; a cyanogenic glycoside of no known biologic value; not a vitamin.[1]
Vitamin B_c	Obsolete term for pteroylglutamic acid; a component of folacin.
Vitamin B_p	A compound which prevents perosis in chicks, can be replaced by choline and manganese.
Vitamin B_f	Shown to be carnitine.
Vitamin B_x	Probably a mixture of pantothenic acid and p-aminobenzoic acid.
Vitamin C	Synonym for ascorbic acid.
Vitamin C_2	Unrecognized, unconfirmed compound purported to have antipneumonia activity; also called vitamin J.
Vitamin D	Antirachitic factor; a group of sterols (the calciferols) that serve to enhance bone calcification.
Vitamin D_2	Ergocalciferol; one of the D vitamins from plant sources.
Vitamin D_3	Cholecalciferol; one of the D vitamins from animal sources.
Vitamin E	A group of tocopherols that have an important function in the antioxidant system; suppresses free radical formation.
Vitamin F	Obsolete term for the essential fatty acids (linoleic and linolenic acids).
Vitamin G	Obsolete term for riboflavin before riboflavin and niacin were recognized as separate vitamins.
Vitamin H	Obsolete term for biotin.
Vitamin I	Obsolete term for a mixture of B vitamins.
Vitamin K	A group of fat soluble compounds that function in the post translational carboxylation of the glutamic acid residues of prothrombin.
Vitamin K_1	Phylloquinone; vitamin K of plant origin.
Vitamin K_2	Menaquinone; vitamin K of animal origin.
Vitamin K_3	Menadione; synthetic vitamin K.
Vitamin L_1	Unrecognized factor which may be related to anthranitic acid and which has been proposed to be important for lactation; not proven to have vitamin activity.[1]
Vitamin L_2	See above.
Vitamin M	Obsolete term for pteroylglutamic acid (folacin).
Vitamin N	Obsolete term used to designate an anticancer compound mixture; undefined and unrecognized.
Vitamin P	Not a vitamin;[1] but is a metabolite of citrin.
Vitamin Q	Not a vitamin;[1] but is probably a synonym for coenzyme Q.
Vitamin R	Obsolete term for folacin.
Vitamin S	Not a vitamin;[1] but does act to enhance chick growth; related to the peptide "streptogenin" and also to biotin.
Vitamin T	Not a vitamin;[1] reported to improve protein utilization in rats; an extract from termites.
Vitamin U	Not a vitamin;[1] an extract from cabbage that has been reported to suppress gastric acid production; may be important to folacin activity.
Vitamin V	Not a vitamin.[1]
Bioflavinoids	Not a vitamin.[1]
Carnitine	Not a vitamin;[1] except in preterm infants and in severely traumatized persons.
Choline	Can be synthesized by the body but some conditions interfere with adequate synthesis.
Citrovorum factor	Synonym for folacin; a B vitamin.
Extrinsic factor	Obsolete term for vitamin B_{12}, cyanocobalamin.
Factors U, R, X	Obsolete terms for folacin.
Filtrate factor	Obsolete term for riboflavin.
Flavin	A general term for the riboflavin containing coenzymes, FMN, and FAD.
Hepatoflavin	Obsolete term for riboflavin.
Intrinsic factor	Not a vitamin;[1] an endogenous factor needed for vitamin B_{12}, cyanocobalamin, absorption.

TABLE 1.14 *(Continued)*

Vitamin Terminology

Name	Comment
LLD factor	Obsolete term for vitamin B_{12}, cyanocobalamin.
Lipoic acid	Not a vitamin,[1] but does serve as a cofactor in oxidative decarboxylation.
Myoinositol	Sometimes a vitamin when endogenous synthesis is inadequate.
Norite eluate	Not a vitamin.[1]
P-P factor	Obsolete term for niacin.
Pyrroloquinoline quinone	Not a vitamin;[1] component of metallo-oxido-reductases.
Rhizopterin	Obsolete term for folacin.
SLR factor	Obsolete term for folacin.
Streptogenin	Not a vitamin.[1]
Wills factor	Obsolete term for folacin.
Zoopherin	Obsolete term for vitamin B_{12}, cyanocobalamin.

[1] A vitamin is an organic compound required in small amounts for the maintenance of normal biochemical and physiological function of the body. These compounds must be present in food and if absent, well defined symptoms of deficiency will develop. An essential nutrient such as a vitamin cannot be synthesized in amounts sufficient to meet needs.

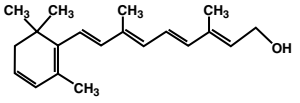
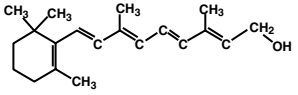
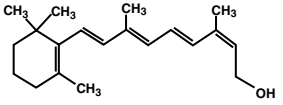
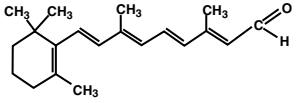
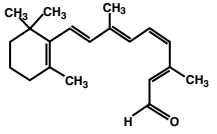
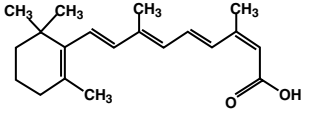
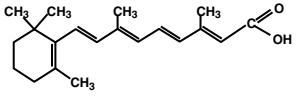
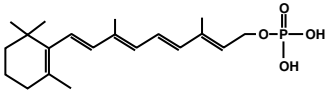
TABLE 1.15

Nomenclature of Compounds with Vitamin A Activity

Recommended Name	Synonyms
Retinol	Vitamin A alcohol
Retinal	Vitamin A aldehyde, retinene, retinaldehyde
Retinoic acid	Vitamin A acid
3-dehydroretinol	Vitamin A_2 (alcohol)
3-Dehydroretinal	Vitamin A_2 aldehyde, retinene$_2$
3-Dehydroretinoic acid	Vitamin A_2 acid
Anhydroretinol	Anhydrovitamin A
Retro retinol	Rehydrovitamin A
5,6-Epoxyretinol	5,6-Epoxyvitamin A alcohol
Retinyl palmitate	Vitamin A palmitate
Retinyl acetate	Vitamin A acetate
Retinyl β-glucuronide	Vitamin A acid β-glucuronide
11-*cis*-retinaldehyde	11-*cis* or neo β vitamin A aldehyde
4-Ketoretinol	4-Keto vitamin A alcohol
Retinyl phosphate	Vitamin A phosphate
β-Carotene	Provitamin A
α-Carotene	Provitamin A
γ-Carotene	Provitamin A

TABLE 1.16

Chemical and Physical Properties of Vitamins

Generic Name	Compound Name	Structure	Molecular wt.	Absorption (nm)	Solubility	Melting pt.	Biopotency	Stability
Vitamin A	all *trans* 3 dehydroretinol		286.4	325	Ether, ethanol, chloroform benzene acetone hexane	62–64	30	unstable to UV light, oxygen, acids, metal
	all *trans* retinol		286.4	325		63–64	100	
	13-*cis* retinol		286.4				23–75	
	all *trans* retinal		284.4				100	
	11-*cis* retinal		284.4	373		61–64		
	13-*cis*-retinoic acid		300.4	351			180–182	
	all *trans* retinoic acid		300.4	351				
	all *trans* retinyl phosphate		364			10–100		

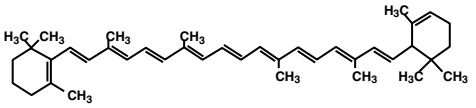
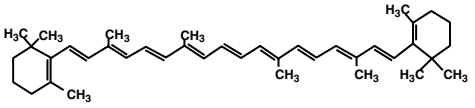
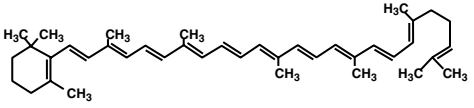
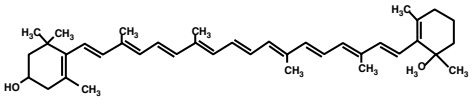
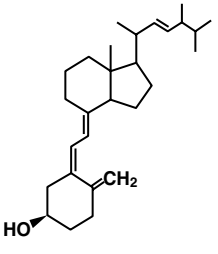
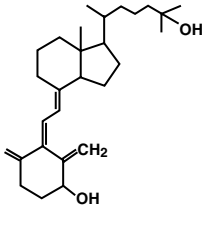
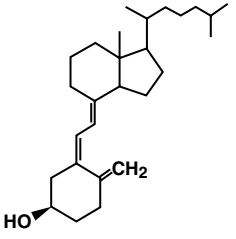
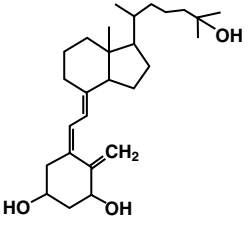
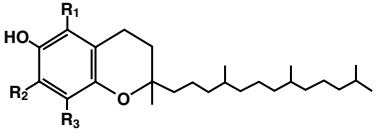
Provitamin A	α carotene		536.9		Ether, benzene	187.5	26	
	β carotene		536.9			184	50	
	γ carotene		536.9		Ethanol Acetone	178	21	
	cryptoxanthin (β-carotene-3-ol)		552.9			169	28	
Vitamin D_2	Ergocalciferol		396.67	264	Alcohol Ether Acetone	115–118	100	Unstable to UV light, oxygen, iodine, heat, mild acid
	25-OH-Vitamin D_3		411.67	265		84–85	200–500	

TABLE 1.16 *(Continued)*

Chemical and Physical Properties of Vitamins

Generic Name	Compound Name	Structure	Molecular wt.	Absorption (nm)	Solubility	Melting pt.	Biopotency	Stability
Vitamin D_3	Cholecalciferol		396.67	265	↓	84–85	100	
	1,25-$(OH)_2$ vitamin D_3		426.67	265		84–85	500–1000	
Vitamin E	Tocopherols							Unstable to oxygen, light, metal, salts

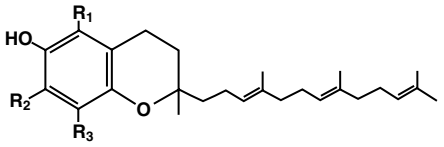
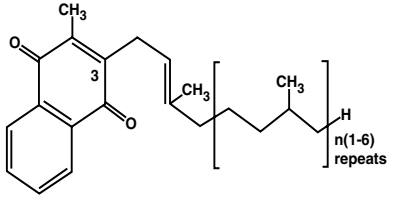
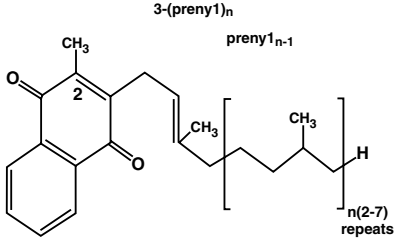
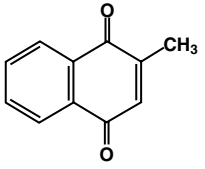
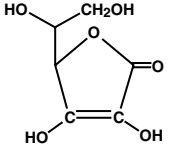
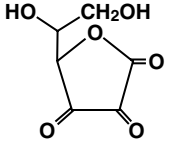
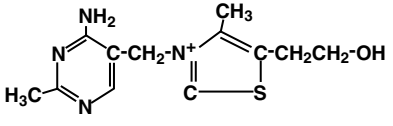
	Tocotrienols										
			R_1	R_2	R_3						
	tocol or tocotrierol	α	CH_3	CH_3	CH_3		430.7	294	Alcohol,	2.5–3.5	1.49	Unstable to O_2,
	tocol or tocotrierol	β	CH_3	H	CH_3		416.7		ether,		0.12	light, metals,
	tocol or tocotrierol	γ	H	CH_3	CH_3		416.7	298	acetone		0.05	salts
	tocol or tocotrierol	δ	H	H	CH_3		416.7		↓		0.32	
											0.05	
Vitamin K	Phylloquinone					n=1	325	240–270	Alcohol,	0°C	5	Unstable to light
							396		ether,		10	and alkali, stable
						n=2			acetone,		30	to heat
						n=3	450.7		benzene	–20	100	
						n=4					80	
						n=5					50	
						n=6						
	Menaquinone					n=2					15	
						n=3					40	
						n=4	448.7	243–328	↓	54	100	
						n=5					120	
						n=6					100	
						n=7					70	

TABLE 1.16 *(Continued)*

Chemical and Physical Properties of Vitamins

Generic Name	Compound Name	Structure	Molecular wt.	Absorption (nm)	Solubility	Melting pt.	Biopotency	Stability
	Menadione		172.2		↓		40–150	
Vitamin C	Ascorbic acid		176.14	245	Water	190–192	100	Unstable to heat and alkali ↓
	Dehydroascorbic acid		174.14	245	Water	190–192	80	
Vitamin B_1	Thiamin		337.27	—	Water	177	100	

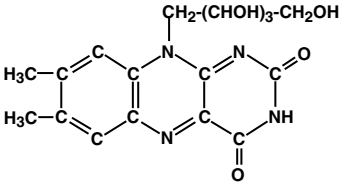
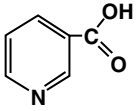
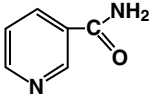
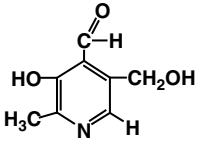
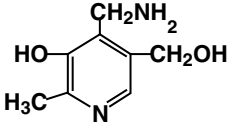
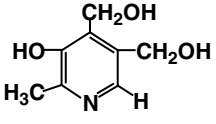
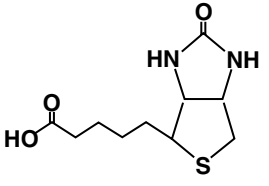
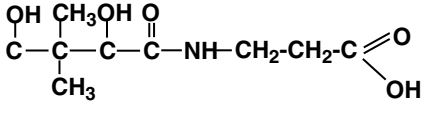
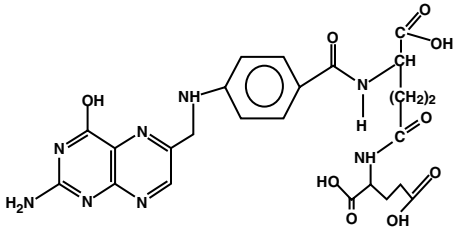
Vitamin B_2	Riboflavin		376.4	220, 225, 266, 371, 444, 475	Water	278	100	Unstable to UV light and heat
Vitamin B_3	Niacin Nicotinic acid		123.1	263	Water	237	100	
	Nicotinamide		122.1	263	Water	128–131	100	
Vitamin B_6	Pyridoxal		167.2	293	Water	165	100	
	Pyridoxamine		205.6	255, 326	Water	160	100	
	Pyridoxine		169.18	—	Water	160	100	

TABLE 1.16 *(Continued)*

Chemical and Physical Properties of Vitamins

Generic Name	Compound Name	Structure	Molecular wt.	Absorption (nm)	Solubility	Melting pt.	Biopotency	Stability
	Biotin		244.3	—	Water	167	100	Unstable to acid and alkaline conditions
	Pantothenic acid		219.2	—	Water	—	100	Unstable to heat
		as calcium salt	476.5	—	Water	195	100	
	Folate Folacin (pteroylmonoglutamic acid)		441	256, 283, 368	Water	250	100	Unstable to light, acid, alkaline, reducing agents, heat

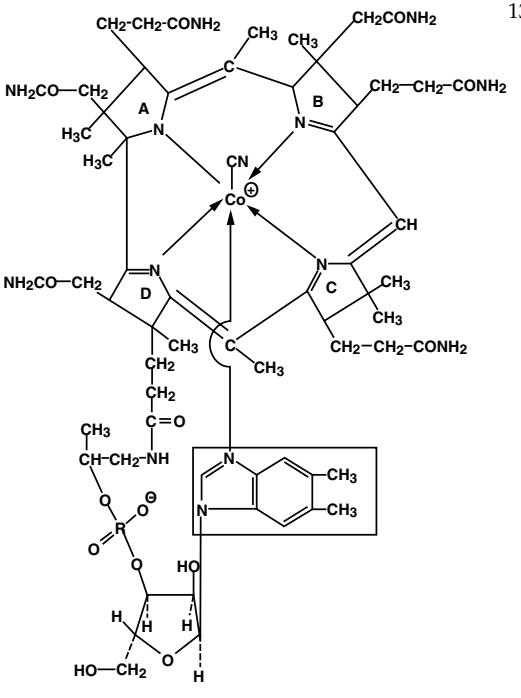
Vitamin B_{12}	Cyanocobalamin		1355.4	278, 361, 550	Water	>300	100	Unstable to light

TABLE 1.17

Summary of Vitamin Deficiency Signs and Need[1]

Functions	Deficiency and Toxicity Symptoms	Sources	Comments
Fat-Soluble Vitamins			
Vitamin A Helps maintain normal vision in dim light — prevents night blindness and xerophthalmia. Essential for body growth. Necessary for normal bone growth and normal tooth development. Acts as a coenzyme in glycoprotein synthesis; functions like steroid hormones, with a role in the cell nuclei, leading to tissue differentiation. Necessary for (1) thyroxine formation and prevention of goiter; (2) protein synthesis; and (3) synthesis of corticosterone from cholesterol, and the normal synthesis of glycogen.	**Deficiency symptoms**: Night blindness (nyctalopia) xerosis, and xerophthalmia. Stunted bone growth, abnormal bone shape, and paralysis. Unsound teeth, characterized by abnormal enamel, pits, and decay. Rough, dry, scaly skin — a condition known as follicular hyperkeratosis (it looks like "gooseflesh"); increased sinus, sore throat, and abscesses in ears, mouth, or salivary glands; increased diarrhea and kidney and bladder stones. Reproductive disorders, including poor conception, abnormal embryonic growth, placental injury, and death of the fetus. **Toxicity**: Characterized by loss of appetite, headache, blurred vision, excessive irritability, loss of hair, dryness and flaking of skin (with itching), swelling over the long bones, drowsiness, diarrhea, nausea, and enlargement of the liver and spleen.	Liver, carrots, dark-green leafy vegetables. Yellow vegetables: pumpkins, sweet potatoes, squash (winter). Yellow fruits: apricots, peaches. Some seafoods (crab, halibut, oysters, salmon, swordfish); milk and milk products, eggs. **Supplemental sources**: Synthetic vitamin A, cod and other fish liver oils.	The forms of vitamin A are alcohol (retinol), ester (retinyl palmitate), aldehyde (retinal or retinene), and acid (retinoic acid). Retinol, retinyl palmitate, and retinal are readily converted from one form to other forms. Retinoic acid fulfills some of the functions of vitamin A, but it does not function in the visual cycle. β carotene found in vegetables serves as a vitamin A precursor.

Vitamin D

Increases calcium absorption from the small intestine.

Promotes growth and mineralization of bones.

Promotes sound teeth.

Increases absorption of phosphorus through the intestinal wall; increases resorption of phosphates from the kidney tubules.

Maintains normal level of citrate in the blood.

Protects against the loss of amino acids through the kidneys.

Deficiency symptoms: Rickets in infants and children, characterized by enlarged joints, bowed legs, knocked knees, outward projection of the sternum (pigeon breast), a row of beadlike projections on each side of the chest at the juncture of the rib bones and joining (costal) cartilage (called rachitic rosary), bulging forehead, pot belly; delayed eruption of temporary teeth and unsound permanent teeth.

Osteomalacia in adults, in which the bones soften, become distorted, and fracture easily.

Tetany, characterized by muscle twitching, convulsions, and low serum calcium.

Toxicity: Excessive vitamin D may cause hypercalcemia (increased intestinal absorption, leading to elevated blood calcium levels), characterized by loss of appetite, excessive thirst, nausea, vomiting, irritability, weakness, constipation alternating with bouts of diarrhea, retarded growth in infants and children, and weight loss in adults.

D-fortified foods: Milk (400 IU/qt) and infant formulas. Other foods to which vitamin D is often added include: breakfast and infant cereals, breads, margarines, milk flavorings, fruit and chocolate beverages, and cocoa.

Supplemental sources: Fish liver oils (from cod, halibut, or swordfish); irradiated ergosterol or 7-dehydrocholesterol such as viosterol.

Exposure to sunlight or sunlamp converts the vitamin D precursor to active vitamin D.

Vitamin D includes both D_2 (ergocalciferol, calciferol, or viosterol) and D_3 (cholecalciferol).

Vitamin D is unique among vitamins because it can be formed in the body and in certain foods by exposure to ultraviolet rays, and the active compound of vitamin D (1, 25-$(OH)_2$-D_3) functions as a hormone.

TABLE 1.17 *(Continued)*

Summary of Vitamin Deficiency Signs and Need[1]

Functions	Deficiency and Toxicity Symptoms	Sources	Comments
Vitamin E (Tocopherols) An antioxidant which protects body cells from free radicals formed from the unsaturated fatty acids. Maintains the integrity of red blood cells by its action as a suppressor of free radicals. An agent essential to cellular respiration, primarily in heart and skeletal muscle tissues.	**Deficiency symptoms**: Newborn infants (especially the premature). Anemia caused by shortened life span of red blood cells, edema, skin lesions, and blood abnormalities. Patients unable to absorb fat have low blood and tissue tocopherol levels, decreased red blood cell life span, and increased urinary excretion of creatine. **Toxicity**: Relatively nontoxic. Some persons consuming daily doses of more than 300 IU of vitamin E have complained of nausea and intestinal distress. Excess intake of vitamin E appears to be excreted in the feces.	Vegetable oils (except coconut oil), alfalfa seeds, margarine, nuts (almonds, Brazil nuts, filberts, peanuts, pecans), sunflower seed kernels. **Good sources**: Asparagus, avocados, beef and organ meats, blackberries, butter, eggs, green leafy vegetables, oatmeal, potato chips, rye, seafoods (lobster, salmon, shrimp, tuna), tomatoes. **Supplemental sources**: Synthetic di-alpha-tocopherol acetate, wheat germ, wheat germ oil.	There are 8 tocopherols and tocotrienols, of which α-tocopherol has the greatest vitamin E activity.
Vitamin K Essential for the synthesis in the liver of four bloodclotting proteins: 1. Factor II, prothrombin 2. Factor VII, proconvertin 3. Factor IX, Christmas factor 4. Factor X, Stuart-Power. Its action is on the post translational carboxylation of glutamic acid residues.	**Deficiency symptom**s: 1. Delayed blood clotting 2. Hemorrhagic disease of newborn Vitamin K deficiency symptoms are likely in: 1. Newborn infants 2. Infants born to mothers receiving anticoagulants 3. Obstructive jaundice (lack of bile) 4. Fat absorption defects (celiac disease, sprue) 5. Anticoagulant therapy or toxicity **Toxicity**: The natural forms of vitamin K_1 and K_2 have not produced toxicity even when given in large amounts. However, synthetic menadione and its various derivatives have produced toxic symptoms in rats and jaundice in human infants when given in amounts of more than 5 mg daily.	Vitamin K is fairly widely distributed in foods and is available synthetically.	Two forms: K_1 (phylloquinone, or phytylmenaquinone), and K_2 (menaquinones), multiprenyl-menaquinones. Vitamin K is synthesized by bacteria in the intestinal tracts of human beings and other species. There are several synthetic compounds, the best known of which is menadione, formerly known as K_3.

Biotin Functions as a coenzyme mainly in decarboxylation-carboxylation and in deamination reactions.	**Deficiency symptoms**: The deficiency symptoms in man include a dry, scaly dermatitis, loss of appetite, nausea, vomiting, muscle pains, glossitis (inflammation of the tongue), pallor of skin, mental depression, decrease in hemoglobin and red blood cells, high cholesterol level, and a low excretion of biotin, all of which respond to biotin administration. **Toxicity**: There are no known toxic effects.	**Rich sources**: Cheese (processed), kidney, liver, soybean flour. **Good sources**: Cauliflower, chocolate, eggs, mushrooms, nuts, peanut butter, sardine and salmon, wheat bran. Supplemental sources — Synthetic biotin, yeast (brewers' torula), alfalfa leaf meal (dehydrated). Considerable biotin is synthesized by the microorganisms in the intestinal tract.	Avidin, found in raw egg white, binds biotin, making it unavailable. Avidin is destroyed by cooking.
Choline 1. As part of the neurotransmitter acetyl choline, transmits nerve impulses. 2. Is essential for one of the membrane phospholipids (phosphatidylcholine) 3. Serves as a methyl donor.	**Deficiency symptoms**: Poor growth and fatty livers are the deficiency symptoms in most species except chickens and turkeys. Chickens and turkeys develop slipped tendons (perosis). In young rats, choline deficiency produces hemorrhagic lesions in the kidneys and other organs. **Toxicity**: No toxic effects have been observed.	**Rich sources**: Egg yolk, eggs, liver (beef, pork, lamb). **Good sources**: Soybeans, potatoes (dehydrated), cabbage, wheat bran, navy beans, alfalfa leaf meal, dried buttermilk and dried skimmed milk, rice polish, rice bran, whole grains (barley, corn, oats, rice, sorghum, wheat), hominy, turnips, wheat flour, blackstrap molasses. **Supplemental sources**: Yeast (brewers', torula), wheat germ, soybean lecithin, egg yolk lecithin, and synthetic choline and choline derivatives.	The classification of choline as a vitamin is debated because it does not meet all the criteria for vitamins, especially those of the B vitamins. The body manufactures choline from methionine, with the aid of folacin and vitamin B_{12}.

TABLE 1.17 *(Continued)*

Summary of Vitamin Deficiency Signs and Need[1]

Functions	Deficiency and Toxicity Symptoms	Sources	Comments
Folacin/Folate (Folic Acid) Folacin coenzymes are responsible for the following important functions: 1. The formation of purines and pyrimidines which, in turn, are needed for the synthesis of the nucleic acids DNA and RNA. 2. The formation of heme, the iron-containing protein in hemoglobin. 3. The interconversion of the three-carbon amino acid serine from the two-carbon amino acid glycine. 4. The formation of the amino acids tyrosine from phenylalanine and glutamic acid from histidine. 5. The formation of the amino acid methionine from homocysteine. 6. The synthesis of choline from ethanolamine. 7. The conversion of nicotinamide to N-methylnicotinamide, one of the metabolites of niacin that is excreted in the urine.	**Deficiency symptoms**: Megaloblastic anemia (of infancy), also called macrocyticanemia (of pregnancy), in which the red blood cells are larger and fewer than normal, and also immature. The anemia is due to inadequate formation of nucl-proteins, causing failure of the megaloblasts (young red blood cells) in the one marrow to mature. The hemoglobin level is low because of the reduced number of red blood cells and the white blood cell, blood platelet, and serum folate levels are low. Other symptoms include a sore, red, smooth red tongue (glossitis), disturbances of the digestive tract (diarrhea), and poor growth. **Toxicity**: Normally, no toxicity.	**Rich sources**: Liver and kidney. **Good sources**: Avocados, beans, beets, celery, chickpeas, eggs, fish, green leafy vegetables (such as asparagus, broccoli, Brussels sprouts, cabbage, cauliflower, endive, lettuce, parsley, spinach, turnip greens), nuts, oranges, orange juice, soybeans, and whole wheat products. **Supplemental sources**: Yeast, wheat germ, and commercially synthesized folic acid (pteroyl-glutamic acid, or PGA).	There is no single vitamin compound with the name folacin; rather, the term folacin is used to designate folic acid and a group of closely related substances which are essential for all vertebrates, including man. Ascorbic acid, vitamin B_{12}, and vitamin B_6 are essential for the activity of the folacin coenzymes. Folacin deficiencies are thought to be a health problem in the U.S. and throughout the world. Infants, adolescents, and pregnant women are particularly vulnerable. The folacin requirement is increased by tropical sprue, certain genetic disturbances, cancer, parasitic infection, alcoholism, and oral contraceptives. Raw vegetables stored at room temperature for 2–3 days lose as much as 50–70% of their folate content. Between 50 and 95% of food folate is destroyed in cooking. Intestinal synthesis provides some folacin.

Niacin (Nicotinic acid; nicotinamide) is a constituent of two important coenzymes in the body; nicotinamide adenine and dinucleotide (NAD) and nicotinamide adenine dinucleotide phosphate (NADP). These coenzymes function as reducing equivalent (H^+) acceptors or donors.	**Deficiency symptoms**: A deficiency of niacin results in pellagra, the symptoms of which are: dermatitis, particularly of areas of skin which are exposed to light or injury; inflammation of mucous membranes, including the entire gastrointestinal tract, which results in a red, swollen, sore tongue and mouth, diarrhea, and rectal irritation; and psychic changes, such as irritability, anxiety, depression, and in advanced cases, delirium, hallucinations, confusion, disorientation, and stupor. **Toxicity**: Only large doses of niacin, sometimes given to individuals with mental illness, are known to be toxic. However, ingestion of large amounts may result in vascular dilation, or "flushing" of the skin, itching, liver damage, elevated blood glucose, elevated blood enzymes, and/or peptic ulcer.	Generally speaking, niacin is found in animal tissues as nicotinamide and in plant tissues as nicotinic acid. Both forms are of equal niacin activity. **Rich sources**: Liver, kidney, lean meats, poultry, fish, rabbit, corn flakes (enriched), nuts, peanut butter, milk, cheese, and eggs, although low in niacin content, are good antipellagra foods, because their niacin is in available form. Enriched cereal flours and products are good sources of niacin. **Supplemental sources**: Both synthetic nicotinamide and nicotinic acid are commercially available. For pharmaceutical use, nicotinamide is usually used; for food nutrification, nicotinic acid is usually used. Also, yeast is a rich natural source of niacin.	An average mixed diet in the U.S. provides about 1% protein as tryptophan. Thus, a diet supplying 60 g of protein contains about 600 mg of tryptophan, which will yield about 10 mg of niacin (on the average, 1 mg of niacin is derived from each 60 mg of dietary tryptophan). Niacin is the most stable of the B-complex vitamins. Cooking losses of a mixed diet usually do not amount to more than 15–25%.
Pantothenic acid (Vitamin B_3) Pantothenic acid functions as part of two enzymes — coenzyme A (CoA) and acyl carrier protein (ACP). CoA functions in the following important reactions: 1. The formation of acetyl-choline, a substance of importance in transmitting nerve impulses. 2. The synthesis of porphyrin, a precursor of heme, of importance in hemoglobin synthesis. 3. The synthesis of cholesterol and other sterols. 4. The steroid hormones formed by the adrenal and sex glands. 5. The maintenance of normal blood sugar, and the formation of antibodies. 6. The excretion of sulfonamide drugs. ACP, along with CoA, required by the cells in the synthesis of fatty acids.	**Deficiency symptoms**: The symptoms: irritableness and restlessness; loss of appetite, indigestion, abdominal pains, nausea; headache; sullenness, mental depression; fatigue, weakness; numbness and tingling of hands and feet, muscle cramps in the arms and legs; burning sensation in the feet; insomnia; respiratory infections; rapid pulse; and a staggering gait. Also, in these subjects there was increased reaction to stress; increased sensitivity to insulin, resulting in low blood sugar levels; increased sedimentation rate for erythrocytes; decreased gastric secretions; and marked decrease in antibody production. **Toxicity**: Pantothenic acid is relatively nontoxic. However, doses of 10 to 20 g per day may result in occasional diarrhea and water retention.	Organ meat (liver, kidney, and heart), cottonseed flour, wheat bran, rice bran, rice polish, nuts, mushrooms, soybean flour, salmon, bleu cheese, eggs, buckwheat flour, brown rice, lobster, sunflower seeds. **Supplemental sources**: Synthetic calcium pantothenate is widely used as a vitamin supplementation. Yeast is a rich natural supplement. Intestinal bacteria synthesize pantothenic acid, but the amount and availability is unknown.	Coenzyme A, of which pantothenic acid is a part, is one of the most important substances in body metabolism. It functions in acetyl group transfer and thus is important to fatty acid synthesis and degradation.

TABLE 1.17 *(Continued)*

Summary of Vitamin Deficiency Signs and Need[1]

Functions	Deficiency and Toxicity Symptoms	Sources	Comments
Riboflavin (Vitamin B_2) Riboflavin fu as an integral part of the coenzymes FAD and FMN. These coenzymes accept or donate reducing equivalents.	**Deficiency symptoms**: Unlike all the other vitamins, riboflavin deficiency is not the cause of any severe or major disease of man. Rather, riboflavin often contributes to other disorders and disabilities such as beriberi, pellagra, scurvy, keratomalacia, and nutritional megaloblastic anemia. Riboflavin deficiency symptoms are: sores at the angles of the mouth (angular stomatitis); sore swollen, and chapped lips (cheilosis); swollen, fissured, and painful tongue (glossitis); redness and congestion at the edges of the cornea of the eye; and oily, crusty, scaly skin (seborrheic dermatitis). **Toxicity**: There is no known toxicity of riboflavin.	**Rich sources**: Organ meats (liver, kidney, heart). **Good sources**: Corn flakes (enriched), almonds, cheese, eggs, lean meat (beef, pork, lamb), mushrooms (raw), wheat flour (enriched), turnip greens, wheat bran, soybean flour, bacon, cornmeal (enriched). **Supplemental sources**: Yeast (brewers', torula). Riboflavin is the only vitamin present in significant amounts in beer.	Riboflavin is destroyed by light, and by heat in an alkaline solution.
Thiamin (Vitamin B_1) As a coenzyme in transketolation (Keto-carrying). In direct functions in the body, including (1) maintenance of normal appetite (2) the tone of the muscles (3) a healthy mental attitude	**Deficiency symptoms**: Moderate thiamin deficiency symptoms include fatigue; apathy (lack of interest); loss of appetite; nausea; moodiness; irritability; depression; retarded growth; a sensation of numbness in the legs; and abnormalities of the electrocardiogram. Severe thiamin deficiency of long duration culminates in beriberi, the symptoms of which are polyneuritis (inflammation of the nerves), emaciation and/or edema, and disturbances of heart function. **Toxicity**: None.	Thiamin is found in a large variety of animal and vegetable products but is abundant in few. **Rich sources**: Lean pork, sunflower seed, corn flakes (enriched), peanuts, safflower flour, soybean flour. **Good sources**: Wheat bran, kidney, wheat flour (enriched), rye flour, nuts (except peanuts, which are a rich source), whole wheat flour, cornmeal (enriched), rice (enriched), white bread (enriched), soybean sprouts. **Supplemental sources**: Thiamin hydrochloride, thiamin mononitrate, yeast (brewers', torula), rice bran, wheat germ, and rice polish. Enriched flour (bread) and cereal has been of special significance in improving the dietary level of thiamin in the U.S.	

Vitamin B_6 (Pyridoxine; pyridoxal; pyridoxamine) Vitamin B_6 functions as a coenzyme (pyridoxal phosphate) a. Transamination b. Decarboxylation c. Transsulfuration d. Tryptophan conversion to nicotinic acid e. Absorption of amino acids f. The conversion of glycogen to glucose-1-phosphate g. The conversion of linoleic acid to arachidonic acid	**Deficiency symptoms**: In adults: greasy scaliness (seborrheic dermatitis) in the skin around the eyes, nose, and mouth, which subsequently spread to other parts of the body; a smooth, red tongue; loss of weight; muscular weakness; irritability; mental depression. In infants, the deficiency symptoms are irritability, muscular twitchings, and convulsions. **Toxicity**: B_6 is relatively nontoxic, but large doses may result in sleepiness and be habit-forming when taken over an extended period.	Rice bran, wheat bran, sunflower seeds, avocados, bananas, corn, fish, kidney, lean meat, liver, nuts, poultry, rice (brown), soybeans, whole grain. **Supplemental sources**: Pyridoxine hydrochloride is the most commonly available synthetic form, and yeast (torula, brewers'), rice polish, and wheat germ are used as natural source supplements.	In rats, the three forms of vitamin B_6 have equal activity; and it is assumed that the same applies to man. Processing or cooking foods may destroy up to 50% of the B_6. Because vitamin B_6 is limited in many foods, supplemental B_6 with synthetic pyridoxine hydrochloride may be indicated, especially for infants and during pregnancy and lactation.
Vitamin B_{12} (Cobalamins) 1. Synthesis or transfer of single carbon units. 2. Biosynthesis of methyl groups (-CH3), and in reduction reactions such as the conversion of disulfide (S-S) to the sulfhydryl group (-SH).	**Deficiency symptoms**: Vitamin B_{12} deficiency in man may occur as a result of (1) dietary lack, which sometimes occurs among vegetarians who consume no animal food; or (2) deficiency of intrinsic factor due to total or partial removal of the stomach by surgery, or infestation with parasites such as the fish tapeworm. The common symptoms of a dietary deficiency of vitamin B_{12} are: sore tongue, weakness, loss of weight, back pains, tingling of the extremities, apathy, and mental and other nervous abnormalities. Anemia is rarely seen in dietary deficiency of B_{12}. In pernicious anemia, the characteristic symptoms are: abnormally large red blood cells, lemon-yellow pallor, anorexia, prolonged bleeding time, abdominal discomfort, loss of weight, glossitis, an unsteady gait, and neurological disturbances, including stiffness of the limbs, irritability, and mental depression. Without treatment death follows. **Toxicity**: No toxic effects of vitamin B_{12} are known.	Liver and other organ meats — kidney, heart, muscle meats, fish, shellfish, eggs, and cheese. **Supplemental sources**: Cobalamin, of which there are at least three active forms, produced by microbial growth; available at the corner drugstore. Some B_{12} is synthesized in the intestinal tract of human beings. However, little of it may be absorbed.	Plants cannot manufacture vitamin B_{12}. Vitamin B_{12} is the largest and the most complex of all vitamin molecules. Vitamin B_{12} is the only vitamin that requires a specific gastrointestinal factor for its absorption (intrinsic factor); and (2) that the absorption of vitamin B_{12} in the small intestine requires about 3 hours.

TABLE 1.17 *(Continued)*

Summary of Vitamin Deficiency Signs and Need

Functions	Deficiency and Toxicity Symptoms	Sources	Comments
Vitamin C (Ascorbic acid) Formation and maintenance of collagen, the substance that binds body cells together. Metabolism of the amino acids tyrosine and tryptophan. Absorption and movement of iron. Metabolism of fats and lipids, and cholesterol control. Sound teeth and bones. Strong capillary walls and healthy blood vessels. Metabolism of folic acid.	**Deficiency symptoms**: Early symptoms, called latent scurvy: loss in weight, listlessness, fatigue, fleeting pains in the joints and muscles, irritability, shortness of breath, sore and bleeding gums, small hemorrhages under the skin, bones that fracture easily, and poor wound healing. Scurvy: Swollen, bleeding and ulcerated gums; loose teeth; malformed and weak bones, fragility of the capillaries with resulting hemorrhages throughout the body; large bruises; big joints, such as the knees and hips, due to bleeding into the joint cavity; anemia; degeneration of muscle fibers; including those of the heart; and tendency of old wounds to become red and break open. Sudden death from severe internal hemorrhage and heart failure. **Toxicity**: Adverse effects reported of intakes in excess of 8 g per day (more than 100 times the recommended allowance) include: nausea, abdominal cramps, and diarrhea; absorption of excessive amounts of iron; destruction of red blood cells; increased mobilization of bone minerals; interference with anticoagulant therapy; formation of kidney and bladder stones; inactivation of vitamin B_{12}; rise in plasma cholesterol; and possible dependence upon large doses of vitamin C.	Natural sources of vitamin C occur primarily in fruits (especially citrus fruits) and leafy vegetables: acerola cherry, *camu-camu*, and rose hips, raw, frozen, or canned citrus fruit or juice: oranges, grapefruit, lemons, and limes. Guavas, peppers (green, hot), black currants, parsley, turnip greens, poke greens, and mustard greens. **Good sources**: Green leafy vegetables: broccoli, Brussels sprouts, cabbage (red), cauliflower, collards, kale, lamb's-quarter, spinach, Swiss chard, and watercress. Also, cantaloupe, papaya, strawberries, and tomatoes and tomato juice (fresh or canned). **Supplemental sources**: Vitamin C (ascorbic acid) is available wherever vitamins are sold.	All animal species appear to require vitamin C, but dietary need is limited to humans, guinea pigs, monkeys, fruit bats, birds, certain fish, and certain reptiles. Of all the vitamins, ascorbic acid is the most unstable. It is easily destroyed during storage, processing, and cooking; it is water soluble, easily oxidized, and attacked by enzymes.

[1] See also Section 64.

TABLE 1.18

Essential Minerals and Their Functions

Function	Deficiencies and Toxicity Symptoms	Sources	Comments
Macrominerals			
Calcium (Ca) The primary function of calcium is to build the bones and teeth and to maintain the bones. Other functions are: 1. Blood clotting. 2. Muscle contraction and relaxation, especially the heartbeat. 3. Nerve transmission. 4. Cell wall permeability. 5. Enzyme activation. 6. Secretion of a number of hormones and hormone-releasing factors.	**Deficiency symptoms:** 1. Stunting of growth. 2. Poor quality bones and teeth. 3. Malformation of bones — rickets. The clinical manifestations of calcium related diseases are: 1. Rickets in children. 2. Osteomalacia, the adult counterpart of rickets. 3. Osteoporosis, a condition of too little bone, resulting when bone resorption exceeds bone formation. 4. Hypercalcemia, characterized by high serum calcium. 5. Tetany, characterized by muscle spasms and muscle pain. 6. Kidney stones. **Toxicity**: Normally, the small intestine prevents excess calcium from being absorbed. However, a breakdown of this control may raise the level of calcium in the blood and lead to calcification of the kidneys and other internal organs. High calcium intake may cause excess secretion of calcitonin and very dense bones.	Cheeses, wheat-soy flour, blackstrap molasses, milk, and milk products.	Calcium is the most abundant mineral in the body. It comprises about 40% of the total minerals present; 99% of it is in the bones and teeth. Generally, nutritionists recommend a calcium–phosphorus ratio of 1.5:1 in infancy, decreasing to 1:1 at 1 year of age and remaining at 1:1 throughout the rest of life; although they consider ratios between 2:1 and 1:2 as satisfactory.

TABLE 1.18 *(Continued)*

Essential Minerals and Their Functions

Function	Deficiencies and Toxicity Symptoms	Sources	Comments
Phosphorus (P) Essential for bone formation and maintenance. Important in the development of teeth. Essential for normal milk secretion. Important in building muscle tissue. As a component of nucleic acids (RNA and DNA), which are important in genetic transmission and control of cellular metabolism. Maintenance in many metabolic functions, especially: 1. Energy utilization 2. Phospholipid formation 3. Amino acid metabolism; protein formation 4. Enzyme systems	**Deficiency symptoms**: General weakness, loss of appetite, muscle weakness, bone pain, and loss of calcium. Severe and prolonged deficiencies of phosphorus may be manifested by rickets, osteomalacia, and other phosphorus related diseases. **Toxicity**: There is no known phosphorus toxicity per se. However, excess phosphate consumption may cause hypocalcemia (a deficiency of calcium in the blood).	Cocoa powder, cottonseed flour, fish flour, peanut flour, pumpkin and squash seeds, rice bran, rice polish, soybean flour, sunflower seeds, wheat, and bran.	Phosphorus comprises about 1/4 the total mineral matter in the body. Eighty percent of the phosphorus is in the bones and teeth in inorganic combination with calcium. Normally, 70% of the ingested phosphorus is absorbed. Generally, nutritionists recommend a calcium–phosphorus ratio of 1.5:1 in infancy, decreasing to 1:1 at 1 year of age, and remaining at 1:1 throughout the rest of life, although they consider ratios between 2:1 and 1:2 as satisfactory.
Sodium (Na) Helps to maintain the balance of water, acids, and bases in the fluid outside the cells. As a constituent of pancreatic juice, bile, sweat, and tears. Associated with muscle contraction and nerve functions. Plays a specific role in the absorption of carbohydrates.	**Deficiency symptoms**: Reduced growth, loss of appetite, loss of body weight due to loss of water, reduced milk production of lactating mothers, muscle cramps, nausea, diarrhea, and headache. Excess perspiration and salt depletion may be accompanied by heat exhaustion. **Toxicity**: Salt may be toxic when (1) a high intake is accompanied by a restriction of water, (2) when the body is adapted to a chronic low salt diet, or (3) when it is fed to infants or others whose kidneys cannot excrete the excess in the urine.	Table salt, processed meat products, and pickled/cured products.	Deficiencies of sodium may occur when there has been heavy, prolonged sweating, diarrhea, vomiting, or adrenal cortical insufficiency. In such cases, extra salt should be taken.

Chlorine (Cl) Plays a major role in the regulation of osmotic pressure, water balance, and acid-base balance. Required for the production of hydrochloric acid in the stomach; this acid is necessary for the proper absorption of Vitamin B_{12} and iron, for the activation of the enzyme that breaks down starch, and for suppressing the growth of microorganisms that enter the stomach with food and drink.	**Deficiency symptoms**: Severe deficiencies may result in alkalosis (an excess of alkali in the blood), characterized by slow and shallow breathing, listlessness, muscle cramps, loss of appetite, and, occasionally, by convulsions. Deficiencies of chloride may develop from prolonged and severe vomiting, diarrhea, pumping of the stomach, injudicious use of diuretic drugs. **Toxicity**: An excess of chlorine ions is unlikely when the kidneys are functioning properly.	Table salt (sodium chloride) and foods that contain salt.	Persons whose sodium intake is severely restricted (owing to diseases of the heart, kidney, or liver) may need an alternative source of chloride; a number of chloride-containing salt substitutes are available for this purpose.
Magnesium (Mg) Constituent of bones and teeth. Essential element of cellular metabolism, often as an activator of enzymes involved in phosphorylated compounds and of high energy phosphate transfer of ADP and ATP. Involved in activating certain peptidases in protein digestion. Relaxes nerve impulse, functioning antagon-istically to calcium which is stimulatory.	**Deficiency symptoms**: A deficiency of magnesium is characterized by (1) muscle spasms (tremor, twitching) and rapid heartbeat; (2) confusion, hallucinations, and disorientation; and (3) lack of appetite, listlessness, nausea, and vomiting. **Toxicity**: Magnesium toxicity is characterized by slowed breathing, coma, and sometimes death.	**Rich sources**: Coffee (instant), cocoa powder, cottonseed flour, peanut flour, sesame seeds, soybean flour, spices, wheat bran, and wheat germ.	Overuse of such substances as “milk of magnesia” (magnesium hydroxide) or “Epsom salts” (magnesium sulfate) may lead to deficiencies of other minerals or even to toxicity.

TABLE 1.18 *(Continued)*

Essential Minerals and Their Functions

Function	Deficiencies and Toxicity Symptoms	Sources	Comments
Potassium (K) Involved in the maintenance of proper acid-base balance and the transfer of nutrients in and out of individual cells. Relaxes the heart muscle — action opposite to that of calcium which is stimulatory. Required for the secretion of insulin by the pancreas in enzyme reactions involving the phosphorylation.	**Deficiency symptoms**: Potassium deficiency may cause rapid and irregular heartbeats and abnormal electrocardiograms; muscle weakness, irritability, and occasionally paralysis; and nausea, vomiting, diarrhea, and swollen abdomen. Extreme and prolonged deficiency of potassium may cause hypokalemia, culminating in the heart muscles stopping. **Toxicity**: Acute toxicity from potassium (known as hyperpotassemia or hyperkalemia) can result when kidneys are not functioning properly. The condition may prove fatal due to cardiac arrest.	Dehydrated fruits, molasses, potato flour, rice bran, seaweed, soybean flour, spices, sunflower seeds, and wheat bran.	Potassium is the third most abundant element in the body, after calcium and phosphorus, and it is present in twice the concentration of sodium
Cobalt (Co) The only known function of cobalt is that of an integral part of Vitamin B_{12}, an essential factor in the formation of red blood cells.	A cobalt deficiency as such has never been produced in humans. The signs and symptoms that are sometimes attributed to cobalt deficiency are actually due to lack of Vitamin B_{12}, characterized by pernicious anemia, poor growth, and occasionally neurological disorders.	Cobalt is present in many foods.	Cobalt is an essential constituent of Vitamin B_{12} and must be ingested in the form of vitamin molecule inasmuch as humans synthesize little of the vitamin. (A small amount of Vitamin B_{12} is synthesized in the human colon by *E. coli*, but absorption is very limited.)

Copper (Cu) Facilitating the absorption of iron from the intestinal tract and releasing it from storage in the liver and the reticuloendothelial system. Essential for the formation of hemoglobin, although it is not a part of hemoglobin as such. Constituent of several enzyme systems. Development and maintenance of the vascular and skeletal structures (blood vessels, tendons, and bones). Structure and function of the central nervous system. Required for normal pigmentation of hair. Component of important copper-containing proteins. Reproduction (fertility).	**Deficiency symptoms**: Deficiency is most apt to occur in malnourished children and in premature infants fed exclusively on modified cow's milk and in infants breast fed for an extended period of time. Deficiency leads to a variety of abnormalities, including anemia, skeletal defects, demyelination and degeneration of the nervous system, defects in pigmentation and structure of the hair, reproductive failure, and pronounced cardiovascular lesions. **Toxicity**: Copper is relatively nontoxic to monogastric species, including man. The recommended copper intake for adults is in the range of 2–3 mg/day. Daily intakes of more than 20–30 mg over extended periods would be expected to be unsafe.	Black pepper, blackstrap molasses, Brazil nuts, cocoa, liver, and oysters (raw).	Most cases of copper poisoning result from drinking water or beverages that have been stored in copper tanks and/or pass through copper pipes. Dietary excesses of calcium, iron, cadmium, zinc, lead, silver, and molybdenum plus sulfur reduce the utilization of copper.
Fluorine (F) Constitutes 0.02–0.05% of the bones and teeth. Necessary for sound bones and teeth. Assists in the prevention of dental caries.	**Deficiency symptoms**: Excess dental caries. Also, there is indication that a deficiency of fluorine results in osteoporosis in the aged. **Toxicity**: Deformed teeth and bones, and softening, mottling, and irregular wear of the teeth.	Fluorine is found in many foods, but seafoods and dry tea are the richest food sources. Fluoridation of water supplies to bring the concentration of fluoride to 1 ppm.	Large amounts of dietary calcium, aluminum, and fat will lower the absorption of fluorine. Fluoridation of water supplies (1 ppm) is the simplest and most effective method of providing added protection against dental caries.

TABLE 1.18 *(Continued)*

Essential Minerals and Their Functions

Function	Deficiencies and Toxicity Symptoms	Sources	Comments
Iodine (I) The sole function of iodine is making the iodine-containing thyroid hormones.	**Deficiency symptoms**: Iodine deficiency is characterized by goiter (an enlargement of the thyroid gland at the base of the neck), coarse hair, obesity, and high blood cholesterol. Iodine-deficient mothers may give birth to infants with a type of dwarfism known as cretinism, a disorder characterized by malfunctioning of the thyroid gland, goiter, mental retardation, and stunted growth. A similar disorder of the thyroid gland, known as myxedema, may develop in adults. **Toxicity**: Long-term intake of large excesses of iodine may disturb the utilization of iodine by the thyroid gland and result in goiter.	Among natural foods the best sources of iodine are kelp, seafoods, and vegetables grown in iodine-rich soils and iodized salt. Stabilized iodized salt contains 0.01% potassium iodide (0.0076% l), or 76 mcg of iodine per gram.	Certain foods (especially plants of the cabbage family) contain goitrogens, which interfere with the use of thyroxine and may produce goiter. Fortunately, goitrogenic action is prevented by cooking.
Iron (Fe) Iron (heme) combines with protein (globin) to make hemoglobin, the iron-containing compound in red blood cells which transports oxygen. Iron is also a component of enzymes which are involved in energy metabolism.	**Deficiency symptoms**: Iron-deficiency (nutritional) anemia, the symptoms of which are paleness of skin and mucous membranes, fatigue, dizziness, sensitivity to cold, shortness of breath, rapid heartbeats, and tingling of the fingers and toes. An excess of iron in the diet can tie up phosphorus in an insoluble iron-phosphate complex, thereby creating a deficiency of phosphorus.	Red meat, egg yolk, and dark green, leafy vegetables.	About 70% of the iron is present in the hemoglobin, the pigment of the red blood cells. The other 30% is present as a reserve store in the liver, spleen, and bone marrow.

Manganese (Mn) Formation of bone and the growth of other connective tissues. Blood clotting. Insulin action. Cholesterol synthesis. Activator of various enzymes in the metabolism of carbohydrates, fats, proteins, and nucleic acids.	**Deficiency symptoms**: No clear deficiency disease in man has been reported. **Toxicity**: Toxicity in man as a consequence of dietary intake has not been observed. However, it has occurred in workers (miners and others) exposed to high concentrations of manganese dust in the air. The symptoms resemble those found in Parkinson's and Wilson's disease.	Rice (brown), rice bran and polish, walnuts, wheat bran, and wheat germ.	In average diets, only about 45% of the ingested magnesium is absorbed. The manganese content of plants is dependent on soil content.
Molybdenum (Mo) As a component of three different enzyme systems which are involved in the metabolism of carbohydrates, fats, proteins, sulfur-containing amino acids, nucleic acids (DNA and RNA), and iron.	**Deficiency symptoms**: Naturally occurring deficiency in man is not known. Molybdenum-deficient animals are especially susceptible to the toxic effects of bisulfite, characterized by breathing difficulties and neurological disorders. Severe molybdenum toxicity in animals (molybdenosis), particularly cattle, occurs throughout the world wherever pastures are grown on high-molybdenum soils. The symptoms include diarrhea, loss of weight, decreased production, fading of hair color, and other symptoms of copper deficiency.	The concentration of molybdenum in food varies considerably, depending on the soil in which it is grown. Most of the dietary molybdenum intake is derived from organ meats, whole grains, leafy vegetables, legumes, and yeast.	The utilization of molybdenum is reduced by excess copper, sulfate, and tungsten. In cattle, a relationship exists between molybdenum, copper, and sulfur. Excess molybdenum will cause copper deficiency. However, when the sulfate content of the diet is increased, the symptoms of toxicity are avoided inasmuch as the excretion of molybdenum is increased.

TABLE 1.18 *(Continued)*

Essential Minerals and Their Functions

Function	Deficiencies and Toxicity Symptoms	Sources	Comments
Selenium (Se) Component of the enzyme glutathione peroxidase, the metabolic role of which is to protect against oxidation of polyunsaturated fatty acids and resultant tissue damage.	**Deficiency symptoms**: There are no clear-cut deficiencies of selenium, because this mineral is so closely related to vitamin E that it is difficult to distinguish deficiency due to selenium alone. **Toxicity**: Poisonous effects of selenium are manifested by (1) abnormalities of the hair, nails, and skin; (2) garlic odor on the breath; (3) intensification of selenium toxicity by arsenic or mercury; and (4) higher than normal rates of dental caries.	The selenium content of plant and animal products is affected by the selenium content of the soil and animal feed, respectively. Brazil nuts, butter, flour, fish, lobster, and smelt.	The high selenium areas are in Great Plains and the Rocky Mountain states — especially in parts of the Dakotas and Wyoming.
Zinc (Zn) Needed for normal skin, bones, and hair. A component of several different enzyme systems which are involved in digestion and respiration. Required for the transfer of carbon dioxide in red blood cells, for proper calcification of bones, for the synthesis and metabolism of proteins and nucleic acids, for the development and functioning of reproductive organs, for wound and burn healing, for the functioning of insulin, and for normal taste acuity.	**Deficiency symptoms**: Loss of appetite, stunted growth in children, skin changes, small sex glands in boys, loss of taste sensitivity, lightened pigment in hair, white spots on the fingernails, and delayed healing of wounds. In the Middle East, pronounced zinc deficiency in man has resulted in hypogonadism and dwarfism. In pregnant animals, experimental zinc deficiency has resulted in malformation and behavioral disturbances in offspring. **Toxicity**: Ingestion of excess soluble salts may cause nausea, vomiting, and purging.	Beef, liver, oysters, spices, and wheat bran.	The biological availability of zinc in different foods varies widely; meats and seafoods are much better sources of available zinc than vegetables. Zinc availability is adversely affected by phytates (found in whole grains and beans), high calcium, oxalates (in rhubarb and spinach), high fiber, copper (from drinking water conveyed in copper piping), and EDTA (an additive used in certain canned foods).

Adapted from Ensminger, et al. *Foods & Nutrition Encyclopedia,* 2nd ed., CRC Press, Boca Raton, 1994, pp. 1511–1521.

TABLE 1.19

Essential Fatty Acids

$CH_3CH_2CH_2CH_2\underset{18}{C}\overset{H\ H}{=}\underset{12}{C}-CH_2-\underset{9}{C}\overset{H\ H}{=}CCH_2CH_2CH_2CH_2CH_2CH_2CH_2COOH$	linoleic acid [18:2, (9, 12)]
$CH_3CH_2CH_2CH_2CH_2\underset{18}{C}\overset{H\ H}{=}\underset{12}{C}-CH_2-\underset{9}{C}\overset{H\ H}{=}\underset{6}{C}-CH_2-\underset{1}{C}\overset{H\ H}{=}CCH_2CH_2CH_2CH_2COOH$	γ linolenic acid [18:3, (6, 9, 12)]
$CH_3CH_2\underset{18}{C}\overset{H\ H}{=}\underset{15}{C}-CH_2-\underset{12}{C}\overset{H\ H}{=}\underset{9}{C}-CH_2-\underset{}{C}\overset{H\ H}{=}C-(CH_2)_7COOH$	linolenic acid [18:3 (9, 12, 15)]

TABLE 1.20

Structure and Names of Fatty Acids Found in Food

Structure	# Carbons: Double Bonds	Systematic Name	Trivial Name	Source
Saturated Fatty Acids				
$CH_3(CH_2)_2COOH$	4:0	*n*-Butanoic	Butyric	Butter
$CH_3(CH_2)_4COOH$	6:0	*n*-Hexanoic	Caproic	Butter
$CH_3(CH_2)_6COOH$	8:0	*n*-Octanoic	Caprylic	Coconut oil
$CH_3(CH_2)_8COOH$	10:0	*n*-Decanoic	Capric	Palm oil
$CH_3(CH_2)_{10}COOH$	12:0	*n*-Dodecanoic	Lauric	Coconut oil, nutmeg, butter
$CH_3(CH_2)_{12}COOH$	14:0	*n*-Tetradecanoic	Myristic	Coconut oil
$CH_3(CH_2)_{14}COOH$	16:0	*n*-Hexadecanoic	Palmitic	Most fats and oils
$CH_3(CH_2)_{16}COOH$	18:0	*n*-Octadecanoic	Stearic	Most fats and oils
$CH_3(CH_2)_{18}COOH$	20:0	*n*-Eicosanoic	Arachidic	Peanut oil, lard
Unsaturated Fatty Acids				
$CH_3(CH_2)_5CH=CH(CH_2)_7COOH$	16:1	9-Hexadecenoic	Palmitoleic	Butter and seed oils
$CH_3(CH_2)_7CH=CH(CH_2)_7COOH$	18:1	9-Octadecenoic	Oleic	Most fats and oils
$CH_3(CH_2)_5CH=CH(CH_2)_9COOH$	20:1	11-Octadecenoic	*trans*-Vaccenic	Hydrogenated vegetable oils
$CH_3(CH_2)_4CH=CHCH_2CH=CH(CH_2)_7COOH$	18:2	9,12-Octadecadienoic	Linoleic	Linseed oil, corn oil, cottonseed oil
$CH_3CH_2(CH=CHCH_2)_3(CH_2)_7COOH$	18:3	9,12,15-Octadecatrienoic	Linolenic	Soybean oil, marine oils
$CH_3(CH_2)_4(CH=CHCH2)_4(CH_2)_2COOH$	20:4	5,8,11,14-Eicosatetraenoic	Arachidonic	Cottonseed oil