Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein and Amino Acids

PAULA TRUMBO, PhD; SANDRA SCHLICKER, PhD; ALLISON A. YATES, PhD, RD; MARY POOS, PhD

The Food and Nutrition Board of the Institute of Medicine, The National Academies, recently released the fifth in a series of reports presenting dietary reference values for the intake of nutrients by Americans and Canadians (1). The overall project is a comprehensive effort undertaken by the Standing Committee on the Scientific Evaluation of Dietary Reference Intakes (DRI Committee) of the Food and Nutrition Board, Institute of Medicine of the National Academies, with active involvement of Canadian scientists[1].

The development of Dietary Reference Intakes (DRIs) expands and replaces the series of *Recommended Dietary Allowances* which have been published since 1941 by the Food and Nutrition Board of the National Academy of Sciences and the Recommended Nutrient Intakes (RNIs) of Canada. Earlier reports (2,3,4,5) in the series provided DRIs for vitamins and elements and have provided guidance on using the DRIs for dietary assessment (6); these reports have been described previously (7,8,9,10), along with details on the framework and definitions of each category (7).

Dietary Reference Intakes (DRIs) are reference values that are quantitative estimates of nutrient intakes to be used for planning and assessing diets for healthy people. They include RDAs as goals for intake by individuals but also include three additional types of reference values (see Table 1).

In the earlier reports Adequate Intakes (AIs), rather than RDAs, were proposed for all nutrients for infants to age 1 year (except of zinc and iron) and for calcium, chromium, fluoride, manganese, vitamin D, vitamin K, pantothenic acid, biotin, and choline for persons of all ages (see Tables 2 and 3). RDAs for the other nutrients were also provided (Tables 2 and 3). In this new report, AIs are set for *Total Fiber*, linoleic acid, and α-linoleic acid, with RDAs being provided for carbohydrate, protein, and each of the nine indispensable amino acids (Table 4). Estimated Energy Requirements (EERs) were set for daily energy requirements based on defined levels of activity, while an RDA for energy was not set because any intake greater than the EER may result in weight gain. While upper levels (ULs) have been set for many of the vitamins and elements (Tables 5 and 6), no ULs were set for any of the macronutrients. Recommendations were made, however, that the intake of cholesterol, trans fatty acids, and saturated fatty acids should be as low as possible while consuming a nutritionally adequate diet, along with the suggestion that added sugars be limited to no more than 25% of energy.

In addition to setting these DRIs for the macronutrients, Acceptable Macronutrient Distribution Ranges (AMDRs) were set for fat, carbohydrate, protein, and n-6 and n-3 polyunsaturated fatty acids; definitions of fiber were provided as *Dietary Fiber* and *Functional Fiber*, and recommendations for daily physical activity to decrease risk of disease and maintain body weight were made.

A.A. Yates is the director of and P. Trumbo, S.A. Schlicker, and M. Poos are senior staff officers with the Food and Nutrition Board, Institute of Medicine, The National Academies, 500 Fifth Street, NW, Washington, DC 20001.

HIGHLIGHTS OF THE REPORT

Infant Recommendations

For most of the macronutrients included in this new report, AIs rather than RDAs were set for infants to age 1 year based on the average intake of the macronutrient consumed from human milk (for 0 through 12 months of age) with complementary foods (for 7 through 12 months of age). EARs and RDAs, however, were set for protein for infants 7 through 12 months of age. EERs were established for both young and older infants. Neither an AI nor RDA was set for fiber during infancy because fiber is not a component of human milk.

Adequate for What?

A critical point in reviewing the recommendations for intake is to note the specific criterion or functional outcome that was used as the benchmark for adequacy. Three of the categories of DRIs are defined by specific criteria of nutrient adequacy (the EAR, the RDA, and the AI); the fourth is defined by a specific indicator of excess, if one is available. A key question is: "Adequate for what?" In some cases, a continuum of benefits may be ascribed to various levels of intake of the same nutrient. Thus each EAR or AI is described in terms of the selected criterion or criteria of adequacy for a particular macronutrient (Table 7). Table 4 shows the recommended intakes set for the various macronutrients. The AIs for linoleic and α-linoleic acids, or essential fatty acids, are based on median intakes of each in the United States; since essential fatty acid deficiency is extremely rare in the United States and Canada, a lower recommendation would result if the criterion chosen to be used had been prevention of a deficiency.

Estimated Energy Requirement

The Estimated Energy Requirement, a new term that is similar to the EAR, is defined as the dietary energy intake that is predicted to maintain energy balance in healthy, normal weight individuals of a defined age, gender, weight, height, and level of physical activity consistent with good health. Consuming in excess of one's EER may result in weight gain. As an example, sedentary 30-year-old women who are 5 feet 5 inches tall and weigh between 111 and 150 pounds (BMI between 18.5 and 25) can consume 1,800 to 2,000 calories each day to maintain these healthy weights following the recommended physical activity level (PAL) of 1.6 to 1.7. Men of equal size and weight can eat 2,000 to 2,350 calories. If the same 30-year-olds have an "active" lifestyle, they can consume an additional 400 to 500

Table 1
Uses of Dietary Reference Intakes for Healthy Individuals and Groups

Type of Use	For the Individual[a]	For a Group[b]
Assessment	EAR[c]: use to examine the probability that usual intake is inadequate.	EAR: use to estimate the prevalence of inadequate intakes within a group.
	RDA: usual intake at or above this level has a low probability of inadequacy.	RDA: do not use to assess intakes of groups.
	AI: usual intake at or above this level has a low probability of inadequacy.	AI: mean usual intake at this level implies a low prevalence of inadequate intakes.
	UL: intake above this level has a potential risk of adverse effects.	UL: use to estimate the percentage of the population at potential risk of adverse effects from excess nutrient intake.
Planning	RDA: aim for this intake.*	EAR: use to plan an intake distribution with a low prevalence of inadequate intakes.*
	AI: aim for this intake.	AI: use to plan mean intakes.
	UL: use as a guide to limit intake; chronic intake of higher amounts may increase the potential risk of adverse effects.	UL: use to plan intake distributions with a low prevalence of intakes potentially at risk of adverse effects.

RDA=Recommended Dietary Allowance, EAR=Estimated Average Requirement, AI=Adequate Intake, UL=Tolerable Upper Level.
[a]Requires accurate measure of usual intake. Evaluation of true status requires clinical, biochemical, and anthropometric data.
[b]Requires statistically valid approximation of distribution of usual intakes.
[c]Requires information on the variability of day-to-day intake and the variability of the requirement.
In the context of assessing groups, when the AI for a nutrient is not based on mean intakes of a healthy population, this assessment is made with less confidence.
*In the case of energy, an Estimated Energy Requirement (EER) is provided: it is the dietary energy intake that is predicted (with variance) to maintain energy balance in a healthy adult of defined age, gender, weight, height and level of physical activity, consistent with good health. In children and pregnant and lactating women, the EER is taken to include the needs associated with the deposition of tissues or the secretion of milk at rates consistent with good health. For individuals, the EER represents the midpoint of a range within which an individual's energy requirements are likely to vary. As such, it is below the needs of half the individuals with specified characteristics, and exceeds the needs of the other half. Body weight should be monitored and energy intake adjusted accordingly.

calories each day. The report provides tabled values as well as equations based on height, weight, sex, age, and level of activity to predict total energy expenditure (Table 8).

How Active Should We Be?

To prevent weight gain, as well as to accrue maximal additional, weight-independent health benefits of physical activity, 60 minutes total of moderate intensity physical activity (eg, walking/jogging at 4 to 5 mph) is recommended daily, in addition to the activities required by a sedentary lifestyle. This results in the recommended PAL of 1.6 to 1.7. This means that the level of total energy expenditure should be at least 60% to 70% above the basal, or resting, energy expediture to maintain weight and get maximum cardiovascular benefits. For children, the physical activity recommendation is also for 60 minutes or more of total daily activity and exercise.

Protein and Amino Acid Recommendations

While the RDA for dietary protein has not changed from previous reports (11), that of 0.8 g protein/kg/day, the method by which it was derived is substantially improved, in that data on over 200 adults were used as the basis for estimating the average requirements and the variation in the data used to establish the RDA. While differences in lean body mass are recognized between men and women and older and younger adults, such differences are expected to be partially offset by differences in body weight. Also, the recommendations for dietary protein during pregnancy and during lactation are increased over past recommendations based on new data related to the efficiency of utilization of dietary protein.

While RDAs are provided for each age group for the nine indispensable amino acids, histidine, isoleucine, leucine, lysine, sulfur amino acids (methionine + cysteine), aromatic amino acids (phenylalanine + tyrosine), threonine, tryptophan, and valine, the requirements for these amino acids are used to develop the FNB/IOM Protein Scoring Pattern (See Table 9).

Definitions of Fiber

In the United States, fiber in the diet, for the purposes of labeling foods, has been defined by the US Food and Drug Administration (FDA) based on various chemical and analytical techniques. At the request of the FDA, a separate panel developed three definitions for fiber in the diet: *Dietary Fiber* is defined as nondigestible carbohydrates and lignin that are intrinsic and intact in plants; *Functional Fiber* is defined as isolated, nondigestible carbohydrates that have been shown to have beneficial physiological effects in humans; and *Total Fiber* is the sum of *Dietary Fiber* and *Functional Fiber*. The primary physiological effects in humans ascribed to fiber in the diet include laxation, attenuation of blood glucose levels, and normalization of serum cholesterol levels. Using the new definitions, other physiological effects would need to be demonstrated before isolated or synthetic fiber-like materials could be classified as *Functional Fiber* for use in food labels. These recommendations are now under review by the FDA.

Acceptable Macronutrient Distribution Ranges

Based on the evidence to suggest a role in chronic disease, as well as information to ensure sufficient intakes of other essential nutrients, Acceptable Macronutrient Distribution Ranges (AMDR) have been estimated for individuals (Table 10). An AMDR is defined as a range of intakes for a particular energy source that is associated with reduced risk of chronic disease while providing adequate intakes of essential nutrients. The AMDR is expressed as a percentage of total energy intake because its requirement is not *independent* of other energy fuel sources or of the total energy requirement of the individual. Each must be expressed in relative terms to each other. A key feature of each AMDR is that it has a lower and upper

Table 2 Dietary Reference Intakes (DRIs): Recommended Intakes for Individuals, Vitamins
Food and Nutrition Board, Institute of Medicine, National Academies

Life Stage Group	Vitamin A (μg/d)[a]	Vitamin C (mg/d)	Vitamin D (μg/d)[b,c]	Vitamin E (mg/d)[d]	Vitamin K (μg/d)	Thiamin (mg/d)	Riboflavin (mg/d)	Niacin (mg/d)[e]	Vitamin B_6 (mg/d)	Folate (μg/d)[f]	Vitamin B_{12} (μg/d)	Pantothenic Acid (mg/d)	Biotin (μg/d)	Choline[g] (mg/d)
Infants														
0-6 mo	400*	40*	5*	4*	2.0*	0.2*	0.3*	2*	0.1*	65*	0.4*	1.7*	5*	125*
7-12 mo	500*	50*	5*	5*	2.5*	0.3*	0.4*	4*	0.3*	80*	0.5*	1.8*	6*	150*
Children														
1-3 y	**300**	**15**	5*	**6**	30*	**0.5**	**0.5**	**6**	**0.5**	**150**	**0.9**	2*	8*	200*
4-8 y	**400**	**25**	5*	**7**	55*	**0.6**	**0.6**	**8**	**0.6**	**200**	**1.2**	3*	12*	250*
Males														
9-13 y	**600**	**45**	5*	**11**	60*	**0.9**	**0.9**	**12**	**1.0**	**300**	**1.8**	4*	20*	375*
14-18 y	**900**	**75**	5*	**15**	75*	**1.2**	**1.3**	**16**	**1.3**	**400**	**2.4**	5*	25*	550*
19-30 y	**900**	**90**	5*	**15**	120*	**1.2**	**1.3**	**16**	**1.3**	**400**	**2.4**	5*	30*	550*
31-50 y	**900**	**90**	5*	**15**	120*	**1.2**	**1.3**	**16**	**1.3**	**400**	**2.4**	5*	30*	550*
51-70 y	**900**	**90**	10*	**15**	120*	**1.2**	**1.3**	**16**	**1.7**	**400**	**2.4**[h]	5*	30*	550*
>70 y	**900**	**90**	15*	**15**	120*	**1.2**	**1.3**	**16**	**1.7**	**400**	**2.4**[h]	5*	30*	550*
Females														
9-13 y	**600**	**45**	5*	**11**	60*	**0.9**	**0.9**	**12**	**1.0**	**300**	**1.8**	4*	20*	375*
14-18 y	**700**	**65**	5*	**15**	75*	**1.0**	**1.0**	**14**	**1.2**	**400**[i]	**2.4**	5*	25*	400*
19-30 y	**700**	**75**	5*	**15**	90*	**1.1**	**1.1**	**14**	**1.3**	**400**[i]	**2.4**	5*	30*	425*
31-50 y	**700**	**75**	5*	**15**	90*	**1.1**	**1.1**	**14**	**1.3**	**400**[i]	**2.4**	5*	30*	425*
51-70 y	**700**	**75**	10*	**15**	90*	**1.1**	**1.1**	**14**	**1.5**	**400**	**2.4**[h]	5*	30*	425*
>70 y	**700**	**75**	15*	**15**	90*	**1.1**	**1.1**	**14**	**1.5**	**400**	**2.4**[h]	5*	30*	425*
Pregnancy														
≤18 y	**750**	**80**	5*	**15**	75*	**1.4**	**1.4**	**18**	**1.9**	**600**[j]	**2.6**	6*	30*	450*
19-30 y	**770**	**85**	5*	**15**	90*	**1.4**	**1.4**	**18**	**1.9**	**600**[j]	**2.6**	6*	30*	450*
31-50 y	**770**	**85**	5*	**15**	90*	**1.4**	**1.4**	**18**	**1.9**	**600**[j]	**2.6**	6*	30*	450*
Lactation														
≤18 y	**1,200**	**115**	5*	**19**	75*	**1.4**	**1.6**	**17**	**2.0**	**500**	**2.8**	7*	35*	550*
19-30 y	**1,300**	**120**	5*	**19**	90*	**1.4**	**1.6**	**17**	**2.0**	**500**	**2.8**	7*	35*	550*
31-50 y	**1,300**	**120**	5*	**19**	90*	**1.4**	**1.6**	**17**	**2.0**	**500**	**2.8**	7*	35*	550*

NOTE: This table (taken from the DRI reports, see www.nap.edu) presents Recommended Dietary Allowances (RDAs) in **bold type** and Adequate Intakes (AIs) in ordinary type followed by an asterisk (*). RDAs and AIs may both be used as goals for individual intake. RDAs are set to meet the needs of almost all (97 to 98 percent) individuals in a group. For healthy breastfed infants, the AI is the mean intake. The AI for other life stage and gender groups is believed to cover needs of all individuals in the group, but lack of data or uncertainty in the data prevent being able to specify with confidence the percentage of individuals covered by this intake.

[a]As retinol activity equivalents (RAEs). 1 RAE=1 μg retinol, 12 μg β-carotene, 24 μg α-carotene, or 24 μg β-cryptoxanthin. The RAE for dietary provitamin A carotenoids is two-fold greater than retinol equivalents (RE), whereas the RAE for preformed vitamin A is the same as RE.

[b]Cholecalciferol. 1 μg cholecalciferol=40 IU vitamin D.

[c]In the absence of adequate exposure to sunlight.

[d]As α-tocopherol. α-Tocopherol includes RRR-α-tocopherol, the only form of α-tocopherol that occurs naturally in foods, and the 2R-stereoisomeric forms of α-tocopherol (RRR-, RSR-, RRS-, and RSS-α-tocopherol) that occur in fortified foods and supplements. It does not include the *2S*-stereoisomeric forms of α-tocopherol (SRR-, SSR-, SRS-, and SSS-α-tocopherol), also found in fortified foods and supplements.

[e]As niacin equivalents (NE). 1 mg of niacin=60 mg of tryptophan; 0-6 months=preformed niacin (not NE).

[f]As dietary folate equivalents (DFE). 1 DFE=1 μg food folate=0.6 μg of folic acid from fortified food or as a supplement consumed with food=0.5 μg of a supplement taken on an empty stomach.

[g]Although AIs have been set for choline, there are few data to assess whether a dietary supply of choline is needed at all stages of the life cycle, and it may be that the choline requirement can be met by endogenous synthesis at some of these stages.

[h]Because 10 to 30 percent of older people may malabsorb food-bound B_{12}, it is advisable for those older than 50 years to meet their RDA mainly by consuming foods fortified with B_{12} or a supplement containing B_{12}.

[i]In view of evidence linking folate intake with neural tube defects in the fetus, it is recommended that all women capable of becoming pregnant consume 400 μg from supplements or fortified foods in addition to intake of food folate from a varied diet.

[j]It is assumed that women will continue consuming 400 μg from supplements or fortified food until their pregnancy is confirmed and they enter prenatal care, which ordinarily occurs after the end of the periconceptional period—the critical time for formation of the neural tube.

Table 3 Dietary Reference Intakes (DRIs): Recommended Intakes for Individuals, Elements
Food and Nutrition Board, Institute of Medicine, National Academies

Life Stage Group	Calcium (mg/d)	Chromium (μg/d)	Copper (μg/d)	Fluoride (mg/d)	Iodine (μg/d)	Iron (mg/d)	Magnesium (mg/d)	Manganese (mg/d)	Molybdenum (μg/d)	Phosphorus (mg/d)	Selenium (μg/d)	Zinc (mg/d)
Infants												
0-6 mo	210*	0.2*	200*	0.01*	110*	0.27*	30*	0.003*	2*	100*	15*	2*
7-12 mo	270*	5.5*	220*	0.5*	130*	**11**	75*	0.6*	3*	275*	20*	**3**
Children												
1-3 y	500*	11*	**340**	0.7*	**90**	**7**	**80**	1.2*	**17**	**460**	**20**	**3**
4-8 y	800*	15*	**440**	1*	**90**	**10**	**130**	1.5*	**22**	**500**	**30**	**5**
Males												
9-13 y	1,300*	25*	**700**	2*	**120**	**8**	**240**	1.9*	**34**	**1,250**	**40**	**8**
14-18 y	1,300*	35*	**890**	3*	**150**	**11**	**410**	2.2*	**43**	**1,250**	**55**	**11**
19-30 y	1,000*	35*	**900**	4*	**150**	**8**	**400**	2.3*	**45**	**700**	**55**	**11**
31-50 y	1,000*	35*	**900**	4*	**150**	**8**	**420**	2.3*	**45**	**700**	**55**	**11**
51-70 y	1,200*	30*	**900**	4*	**150**	**8**	**420**	2.3*	**45**	**700**	**55**	**11**
>70 y	1,200*	30*	**900**	4*	**150**	**8**	**420**	2.3*	**45**	**700**	**55**	**11**
Females												
9-13 y	1,300*	21*	**700**	2*	**120**	**8**	**240**	1.6*	**34**	**1,250**	**40**	**8**
14-18 y	1,300*	24*	**890**	3*	**150**	**15**	**360**	1.6*	**43**	**1,250**	**55**	**9**
19-30 y	1,000*	25*	**900**	3*	**150**	**18**	**310**	1.8*	**45**	**700**	**55**	**8**
31-50 y	1,000*	25*	**900**	3*	**150**	**18**	**320**	1.8*	**45**	**700**	**55**	**8**
51-70 y	1,200*	20*	**900**	3*	**150**	**8**	**320**	1.8*	**45**	**700**	**55**	**8**
>70 y	1,200*	20*	**900**	3*	**150**	**8**	**320**	1.8*	**45**	**700**	**55**	**8**
Pregnancy												
≤18 y	1,300*	29*	**1,000**	3*	**220**	**27**	**400**	2.0*	**50**	**1,250**	**60**	**12**
19-30 y	1,000*	30*	**1,000**	3*	**220**	**27**	**350**	2.0*	**50**	**700**	**60**	**11**
31-50 y	1,000*	30*	**1,000**	3*	**220**	**27**	**360**	2.0*	**50**	**700**	**60**	**11**
Lactation												
≤18 y	1,300*	44*	**1,300**	3*	**290**	**10**	**360**	2.6*	**50**	**1,250**	**70**	**13**
19-30 y	1,000*	45*	**1,300**	3*	**290**	**9**	**310**	2.6*	**50**	**700**	**70**	**12**
31-50 y	1,000*	45*	**1,300**	3*	**290**	**9**	**320**	2.6*	**50**	**700**	**70**	**12**

NOTE: This table presents Recommended Dietary Allowances (RDAs) in **bold type** and Adequate Intakes (AIs) in ordinary type followed by an asterisk (*). RDAs and AIs may both be used as goals for individual intake. RDAs are set to meet the needs of almost all (97 to 98 percent) individuals in a group. For healthy breastfed infants, the AI is the mean intake. The AI for other life stage and gender groups is believed to cover needs of all individuals in the group, but lack of data or uncertainty in the data prevent being able to specify with confidence the percentage of individuals covered by this intake.

SOURCES: Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride (1997); Dietary Reference Intakes for Thiamin, Riboflavin, Niacin, Vitamin B_6, Folate, Vitamin B_{12}, Pantothenic Acid, Biotin, and Choline (1998); Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids (2000); and Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc (2001). These reports may be accessed via www.nap.edu.

Table 4 Dietary Reference Intakes (DRIs): Recommended Intakes for Individuals, Macronutrients
Food and Nutrition Board, Institute of Medicine, National Academies

Life Stage Group	Carbohydrate (g/d)	Total Fiber (g/d)	Fat (g/d)	Linoleic Acid (g/d)	α-Linolenic Acid (g/d)	Protein[a] (g/d)
Infants						
0-6 mo	60*	ND	31*	4.4*	0.5*	9.1*
7-12 mo	95*	ND	30*	4.6*	0.5*	**13.5**
Children						
1-3 y	**130**	19*	ND	7*	0.7*	**13**
4-8 y	**130**	25*	ND	10*	0.9*	**19**
Males						
9-13 y	**130**	31*	ND	12*	1.2*	**34**
14-18 y	**130**	38*	ND	16*	1.6*	**52**
19-30 y	**130**	38*	ND	17*	1.6*	**56**
31-50 y	**130**	38*	ND	17*	1.6*	**56**
51-70 y	**130**	30*	ND	14*	1.6*	**56**
>70 y	**130**	30*	ND	14*	1.6*	**56**
Females						
9-13 y	**130**	26*	ND	10*	1.0*	**34**
14-18 y	**130**	26*	ND	11*	1.1*	**46**
19-30 y	**130**	25*	ND	12*	1.1*	**46**
31-50 y	**130**	25*	ND	12*	1.1*	**46**
51-70 y	**130**	21*	ND	11*	1.1*	**46**
>70 y	**130**	21*	ND	11*	1.1*	**46**
Pregnancy						
14-18 y	**175**	28*	ND	13*	1.4*	**71**
19-30 y	**175**	28*	ND	13*	1.4*	**71**
31-50 y	**175**	28*	ND	13*	1.4*	**71**
Lactation						
14-18	**210**	29*	ND	13*	1.3*	**71**
19-30 y	**210**	29*	ND	13*	1.3*	**71**
31-50 y	**210**	29*	ND	13*	1.3*	**71**

NOTE: This table presents Recommended Dietary Allowances (RDAs) in **bold type** and Adequate Intakes (AIs) in ordinary type followed by an asterisk (*). RDAs and AIs may both be used as goals for individual intake. RDAs are set to meet the needs of almost all (97 to 98 percent) individuals in a group. For healthy breastfed infants, the AI is the mean intake. The AI for other life stage and gender groups is believed to cover needs of all individuals in the group, but lack of data or uncertainty in the data prevent being able to specify with confidence the percentage of individuals covered by this intake.
[a]Based on 0.8g protein/kg body weight for reference body weight.
SOURCE: Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (2002). This report may be accessed via www.nap.edu.

Table 5 Dietary Reference Intakes (DRIs): Tolerable Upper Intake Levels (UL[a]), Vitamins
Food and Nutrition Board, Institute of Medicine, National Academies

Life Stage Group	Vitamin A (μg/d)[b]	Vitamin C (mg/d)	Vitamin D (μg/d)	Vitamin E (mg/d)[c,d]	Vitamin K	Thiamin	Riboflavin	Niacin (mg/d)[d]	Vitamin B_6 (mg/d)	Folate (μg/d)[d]	Vitamin B_{12}	Pantothenic Acid	Biotin	Choline (g/d)	Carotenoids[e]
Infants															
0-6 mo	600	ND[f]	25	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7-12 mo	600	ND	25	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Children															
1-3 y	600	400	50	200	ND	ND	ND	10	30	300	ND	ND	ND	1.0	ND
4-8 y	900	650	50	300	ND	ND	ND	15	40	400	ND	ND	ND	1.0	ND
Males, Females															
9-13 y	1,700	1,200	50	600	ND	ND	ND	20	60	600	ND	ND	ND	2.0	ND
14-18 y	2,800	1,800	50	800	ND	ND	ND	30	80	800	ND	ND	ND	3.0	ND
19-70 y	3,000	2,000	50	1,000	ND	ND	ND	35	100	1,000	ND	ND	ND	3.5	ND
>70 y	3,000	2,000	50	1,000	ND	ND	ND	35	100	1,000	ND	ND	ND	3.5	ND
Pregnancy															
≤18 y	2,800	1,800	50	800	ND	ND	ND	30	80	800	ND	ND	ND	3.0	ND
19-50 y	3,000	2,000	50	1,000	ND	ND	ND	35	100	1,000	ND	ND	ND	3.5	ND
Lactation															
≤18 y	2,800	1,800	50	800	ND	ND	ND	30	80	800	ND	ND	ND	3.0	ND
19-50 y	3,000	2,000	50	1,000	ND	ND	ND	35	100	1,000	ND	ND	ND	3.5	ND

[a]UL=The maximum level of daily nutrient intake that is likely to pose no risk of adverse effects. Unless otherwise specified, the UL represents total intake from food, water, and supplements. Due to lack of suitable data, ULs could not be established for vitamin K, thiamin, riboflavin, vitamin B_{12}, pantothenic acid, biotin, or carotenoids. In the absence of ULs, extra caution may be warranted in consuming levels above recommended intakes.
[b]As preformed vitamin A only.
[c]As α-tocopherol; applies to any form of supplemental α-tocopherol.
[d]The ULs for vitamin E, niacin, and folate apply to synthetic forms obtained from supplements, fortified foods, or a combination of the two.
[e]β-Carotene supplements are advised only to serve as a provitamin A source for individuals at risk of vitamin A deficiency.
[f]ND=Not determinable due to lack of data of adverse effects in this age group and concern with regard to lack of ability to handle excess amounts. Source of intake should be from food only to prevent high levels of intake.
SOURCES: Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride (1997); Dietary Reference Intakes for Thiamin, Riboflavin, Niacin, Vitamin B_6, Folate, Vitamin B_{12}, Pantothenic Acid, Biotin, and Choline (1998); Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids (2000); and Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc (2001). These reports may be accessed via www.nap.edu.

Table 6 Dietary Reference Intakes (DRIs): Tolerable Upper Intake Levels (UL[a]), Elements
Food and Nutrition Board, Institute of Medicine, National Academies

Life Stage Group	Arsenic[b]	Boron (mg/d)	Calcium (g/d)	Chromium	Copper (μg/d)	Fluoride (mg/d)	Iodine (μg/d)	Iron (mg/d)	Magnesium (mg/d)[c]	Manganese (mg/d)	Molybdenum (μg/d)	Nickel (mg/d)	Phosphorus (g/d)	Selenium (μg/d)	Silicon[d]	Vanadium (mg/d)[e]	Zinc (mg/d)
Infants																	
0-6 mo	ND[f]	ND	ND	ND	ND	0.7	ND	40	ND	ND	ND	ND	ND	45	ND	ND	4
7-12 mo	ND	ND	ND	ND	ND	0.9	ND	40	ND	ND	ND	ND	ND	60	ND	ND	5
Children																	
1-3 y	ND	3	2.5	ND	1,000	1.3	200	40	65	2	300	0.2	3	90	ND	ND	7
4-8 y	ND	6	2.5	ND	3,000	2.2	300	40	110	3	600	0.3	3	150	ND	ND	12
Males, Females																	
9-13 y	ND	11	2.5	ND	5,000	10	600	40	350	6	1,100	0.6	4	280	ND	ND	23
14-18 y	ND	17	2.5	ND	8,000	10	900	45	350	9	1,700	1.0	4	400	ND	ND	34
19-70 y	ND	20	2.5	ND	10,000	10	1,100	45	350	11	2,000	1.0	4	400	ND	1.8	40
>70 y	ND	20	2.5	ND	10,000	10	1,100	45	350	11	2,000	1.0	3	400	ND	1.8	40
Pregnancy																	
≤18 y	ND	17	2.5	ND	8,000	10	900	45	350	9	1,700	1.0	3.5	400	ND	ND	34
19-50 y	ND	20	2.5	ND	10,000	10	1,100	45	350	11	2,000	1.0	3.5	400	ND	ND	40
Lactation																	
≤18 y	ND	17	2.5	ND	8,000	10	900	45	350	9	1,700	1.0	4	400	ND	ND	34
19-50 y	ND	20	2.5	ND	10,000	10	1,100	45	350	11	2,000	1.0	4	400	ND	ND	40

[a]UL=The maximum level of daily nutrient intake that is likely to pose no risk of adverse effects. Unless otherwise specified, the UL represents total intake from food, water, and supplements. Due to lack of suitable data, ULs could not be established for arsenic, chromium, and silicon. In the absence of ULs, extra caution may be warranted in consuming levels above recommended intakes.
[b]Although the UL was not determined for arsenic, there is no justification for adding arsenic to food or supplements.
[c]The ULs for magnesium represent intake from a pharmacological agent only and do not include intake from food and water.
[d]Although silicon has not been shown to cause adverse effects in humans, there is no justification for adding silicon to supplements.
[e]Although vanadium in food has not been shown to cause adverse effects in humans, there is no justification for adding vanadium to food and vanadium supplements should be used with caution. The UL is based on adverse effects in laboratory animals and this data could be used to set a UL for adults but not children and adolescents.
[f]ND=Not determinable due to lack of data of adverse effects in this age group and concern with regard to lack of ability to handle excess amounts. Source of intake should be from food only to prevent high levels of intake.
SOURCES: Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride (1997); Dietary Reference Intakes for Thiamin, Riboflavin, Niacin, Vitamin B_6, Folate, Vitamin B_{12}, Pantothenic Acid, Biotin, and Choline (1998); Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids (2000); and Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc (2001). These reports may be accessed via www.nap.edu.

Table 7
Nutrient functions and the indicators used to estimate requirements

Nutrient	Function	Criterion(a) of Adequacy
Carbohydrate (RDA)	Provide energy to cells in the body, particularly the brain, which is a carbohydrate-dependent organ	Minimum amount of glucose required by the brain without depending on fat or protein as an alternative energy source
Dietary Fiber (AI)	Aids in laxation and promotes satiety, which may help reduce energy intake and therefore risk of obesity. Also attenuates blood glucose and cholesterol concentrations. Reduces the risk of coronary heart disease.	Median intake observed to achieve the lowest risk of coronary heart disease.
Linoleic Acid (AI)	Precursor to arachidonic acid, which is the substrate for eicosanoid production in tissues, is a component of membrane structural lipids, and is also important in cell-signaling pathways. Dihomo-γ-linolenic acid, also formed from linoleic acid, is also an eicosanoid precursor. Plays important roles in normal epithelial cell function and is involved with regulation of gene expression.	Median intake of linoleic acid.
α-Linolenic Acid (AI)	Precursor of ecosapentaenoic acid and docosahexanoic acid and n-3 eicosanoids, which have been shown to have beneficial effects in preventing coronary heart disease, arrythmias, and/or thrombosis.	Median intake of α-linolenic acid
Protein (RDA)	Major structural components of all the cells of the body. Along with amino acids, proteins function as enzymes, membrane receptors, carriers of nutrients in the blood, and hormones.	Nitrogen equilibrium

RDA = Recommended Dietary Allowance
AI = Adequate Intake
SOURCE: Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (2002). This report may be accessed via www.nap.edu.

Table 8
Estimated Energy Requirements (EER) for Men and Women 30 Years of Age[a]

Height (m [in])	PAL[b]	Weight for BMI of 18.5 kg/m² (kg [lb])	Weight for BMI of 24.99 kg/m² (kg [lb])	EER, Men[c] (kcal/day)		EER, Women[c] (kcal/day)	
				BMI of 18.5 kg/m²	BMI of 24.99 kg/m²	BMI of 18.5 kg/m²	BMI of 24.99 kg/m²
1.50 (59)	Sedentary	41.6 (92)	56.2 (124)	1,848	2,080	1,625	1,762
	Low active			2,009	2,267	1,803	1,956
	Active			2,215	2,506	2,025	2,198
	Very active			2,554	2,898	2,291	2,489
1.65 (65)	Sedentary	50.4 (111)	68.0 (150)	2,068	2,349	1,816	1,982
	Low active			2,254	2,566	2,016	2,202
	Active			2,490	2,842	2,267	2,477
	Very active			2,880	3,296	2,567	2,807
1.80 (71)	Sedentary	59.9 (132)	81.0 (178)	2,301	2,635	2,015	2,211
	Low active			2,513	2,884	2,239	2,459
	Active			2,782	3,200	2,519	2,769
	Very active			3,225	3,720	2,855	3,141

[a]For each year below 30, add 7 kcal/day for women and 10 kcal/day for men. For each year above 30, subtract 7 kcal/day for women and 10 kcal/day for men.
[b]PAL=Physical activity level.
[c]Derived from the following regression equations based on doubly labeled water data:
Adult man: EER=661.8−9.53×Age (y)×PA×(15.91×Wt [kg]+539.6×Ht [m])
Adult woman: EER=354.1−6.91×Age (y)×PA×(9.36×Wt [kg]+726×Ht [m])
Where PA refers to coefficient for Physical Activity Levels (PAL).
PAL=total energy expenditure+basal energy expenditure.
PA=1.0 if PAL≥1.0<1.4 (sedentary).
PA=1.12 if PAL≥1.4<1.6 (low active).
PA=1.27 if PAL≥1.6<1.9 (active).
PA=1.45 if PAL≥1.9<2.5 (very active).
SOURCE: Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (2002). This report may be accessed via www.nap.edu.

boundary, some determined mainly by the lowest or highest value for the other judged to have an expected impact on health. If an individual consumes below or above this range, there is a potential for increasing the risk of chronic diseases shown to affect long-term health, as well as increasing the risk of insufficient intakes of essential nutrients.

The AMDR for total fat is limited to no less than 20% for adults in order to prevent the fall in HDL cholesterol associated with very low fat diets. Similarly, the AMDR for carbohydrate is limited to no less than 45% in order to prevent high intakes of fat, which has an upper range of 35% of energy. Given potential concerns related to adequate intakes of other nutrients, the upper value for protein is set at 35% of energy for adults, while the lower limit represents the approximate percentage that would meet the RDA for protein.

There is a body of evidence suggesting that saturated and trans fatty acids and cholesterol increase blood total and LDL cholesterol concentrations, and therefore the risk of coronary heart disease. Because the intake of each of these three lipids and risk of coronary heart disease is a positive linear trend, even very low intakes of each may increase risk; however it is recognized that it may be very difficult to consume a nutritionally adequate diet while completely eliminating these dietary fats. Thus the recommendation is to have as low an intake as possible for these three lipids while consuming a diet nutritionally adequate in all required nutrients.

WHAT'S ON THE HORIZON

As indicated earlier, five reports have now been released on DRIs, thus completing the initial review of vitamins, protein, energy nutrients and almost all elements (the electrolytes—sodium, chloride, potassium, sulfate and water are currently under review). Future studies will evaluate the role of alcohol in health and disease and the role of other components in food and their roles in health and disease. As with other aspects of nutrition, it soon will be time to review the data on some of the vitamins or elements already evaluated as new science dictates a need for substantive reevaluation.

The Panel on Macronutrients was chaired by Joanne Lupton (Texas A&M University); other members were George A Brooks (University of California at Berkeley), Nancy F. Butte (USDA Children's Human Nutrition Research Center, Baylor College of Medicine), Peter J. Garlick (State University of New York at Stony Brook), Scott M. Grundy (University of Texas Southwestern Medical Center at Dallas), Sheila M. Innis (University of British Columbia), David A. Jenkins (University of Toronto), Frank Q. Nuttall (Minneapolis Veterans Administration Medical Center), Paul B. Pencharz (University or Toronto), F. Xavier Pi-Sunyer (Columbia University); William M. Rand (Tufts University), Benjamin Caballero (Johns Hopkins University); J.P. Flatt (University of Massachusetts Medical Center), Susan K. Fried (University of Maryland School of Medicine), Rachel K. Johnson (University of Vermont), Ronal dM. Krauss (University of California at Berkeley), Penny Kris-Etherton (The Pennsylvania State University), Alice H. Lichtenstein (U.S.D.A. Human Nutrition Research Center on Aging, Tufts University), Eric B. Rimm (Harvard School of Public Health) and Susan B. Roberts (USDA Human Nutrition Research Center on Aging, Tufts University).

The Panel on the Definition of Dietary Fiber was chaired by Joanne Lupton (Texas A&M University) and included

Table 9
FNB/IOM 2002 Amino Acid Scoring Pattern for Use for Those ≥1 Year of Age

Amino Acid	mg/g "protein"[a,b]	mg/g N
Histidine	18	114
Isoleucine	25	156
Leucine	55	341
Lysine	51	320
Methionine+cysteine	25	156
Phenylalanine+tyrosine	47	291
Threonine	27	170
Tryptophan	7	43
Valine	32	199

[a]Protein=nitrogen×6.25.
[b]Calculated by dividing EAR for the Amino Acid by EAR for Protein for 1- to 3-year-olds.
SOURCE: Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (2002). This report may be accessed via www.nap.edu.

Table 10
Acceptable Macronutrient Distribution Ranges

	Range (percent of energy)		
Macronutrient	Children, 1-3 y	Children, 4-18 y	Adults
Fat	30-40	25-35	20-35
n-6 polyunsaturated fatty acids* (linoleic acid)	5-10	5-10	5-10
n-3 polyunsaturated fatty acids* (α-linolenic acid)	0.6-1.2	0.6-1.2	0.6-1.2
Carbohydrate	45-65	45-65	45-65
Protein	5-20	10-30	10-35

*Approximately 10% of the total can come from longer-chain n-3 or n-6 fatty acids.
SOURCE: Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (2002). This report may be accessed via www.nap.edu.

George C. Fahey (University of Illinois at Urbana-Champaign), David J.A. Jenkins (University of Toronto), Judith A. Marlett (University of Wisconsin-Madison), Joanne L. Slavin (University of Minnesota), Jon A. Story (Purdue University), and Christine L. Williams (Columbia University). The Subcommittee on Upper Reference Levels was chaired by Joseph V. Rodricks (ENVIRON Corp) and includes G. Harvey Anderson (University of Toronto); George C. Becking (Phoenix OHC), Elaine Faustman (University of Washington), Suzanne Hendrich (Iowa State University), Sanford A. Miller (Virginia Polytechnic Institute and State University), Harris Pastides (University of South Carolina), John A. Thomas (Retired from the University of Texas Health Science Center at San Antonio), and Gary M. Williams (New York Medical College). The Subcommittee on Interpretation and Uses of Dietary Reference Intakes was chaired by Susan I. Barr (University of British Columbia); other members include Tanya D. Agurs-Collins (Howard University), Alicia Carriquiry (Iowa State University), Ann M. Coulston (Hattner/Coulston Nutrition Associates), Barbara L. Devaney (Mathematica Policy Research), Janet R. Hunt (USDA Human Nutrition Research Center, Grand Forks), Suzanne Murphy (University of Hawaii), and Valerie Tarasuk (University of Toronto).

This report was conducted under the oversight of the Food and Nutrition Board Standing Committee on the Scientific Evaluation of Dietary Reference Intakes which was chaired through April 2002 by Vernon Young (Massachusetts Institute of Technology), and is cochaired by John W. Erdman, Jr (University of Illinois at Urbana-Champaign). Members include Lindsay H. Allen (University of California, Davis), Stephanie A. Atkinson (McMaster University), Robert J. Cousins (University of Florida), John D. Fernstrom (University of Pittsburgh School of Medicine), Scott M. Grundy (University of Texas Southwestern Medical Center at Dallas), Sanford A. Miller (Virginia Polytechnic and State University), and William M. Rand (Tufts University).

The study was sponsored by the US Department of Health and Human Services: the National Institutes of Health, the Centers for Disease Control and Prevention, US Food and Drug Administration, and the Office of Disease Prevention and Health Promotion; the Department of Defense; Health Canada; the Institute of Medicine; the Dietary Reference Intakes Private Foundation Fund, including the Dannon Institute and the International Life Sciences Institute-North America; and the Dietary Reference Intakes Corporate Donors' Fund, which includes contributions from: M&M/Mars, Mead Johnson Nutritionals, Nabisco Foods Group, and Roche Vitamins Inc.

The authors wish to acknowledge the following Food and Nutrition Board staff and former staff who worked diligently on this DRI project: Gail Spears, Michele Ramsey, Sandra Amamoo-Kakra, Carrie Holloway, and Alice Vorosmarti.

References

1. Institute of Medicine. *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein and Amino Acids.* Food and Nutrition Board. Washington, DC: National Academy Press; 2002.
2. Institute of Medicine. *Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride.* Food and Nutrition Board. Washington, DC: National Academy Press; 1997.
3. Institute of Medicine. *Dietary Reference Intakes for Thiamin, Riboflavin, Niacin, Vitamin B6, Folate, Vitamin B12, Pantothenic Acid, Biotin, and Choline.* Food and Nutrition Board. Washington, DC: National Academy Press; 1998.
4. Institute of Medicine. *Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids.* Food and Nutrition Board. Washington, DC: National Academy Press; 2000.
5. Institute of Medicine: *Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc.* Food and Nutrition Board. Washington, DC: National Academy Press; 2001.
6. Institute of Medicine: *Dietary Reference Intakes: Applications in Dietary Assessment.* Food and Nutrition Board. Washington, DC: National Academy Press; 2000.
7. Yates AA, Schlicker SA, Suitor CW. Dietary reference intakes: The new basis for recommendations for calcium and related nutrients, B vitamins, and choline. *J Am Diet Assoc.* 1998;98:699-706.
8. Monsen, ER. Dietary reference intakes for antioxidant nutrients: Vitamin C, vitamin E, selenium, and carotenoids. *J Am Diet Assoc.* 2000;100:637-640.
9. Trumbo P, Yates AA, Schlicker S, Poos M. Dietary reference intakes: Vitamin A, Vitamin K, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium, and zinc. *J Am Diet Assoc.* 2001;101:294-301.
10. Barr SI, Murphy SP, Poos MI. Interpreting and using the Dietary Reference Intakes in dietary assessment of individuals and groups. *J Am Diet Assoc.* 2002;102:780-788.
11. National Research Council, Subcommittee on the 10th Edition of the RDAs, Food and Nutrition Board, Commission on Life Sciences. *Recommended Dietary Allowances.* 10th ed. Washington, DC: National Academy Press; 1989.