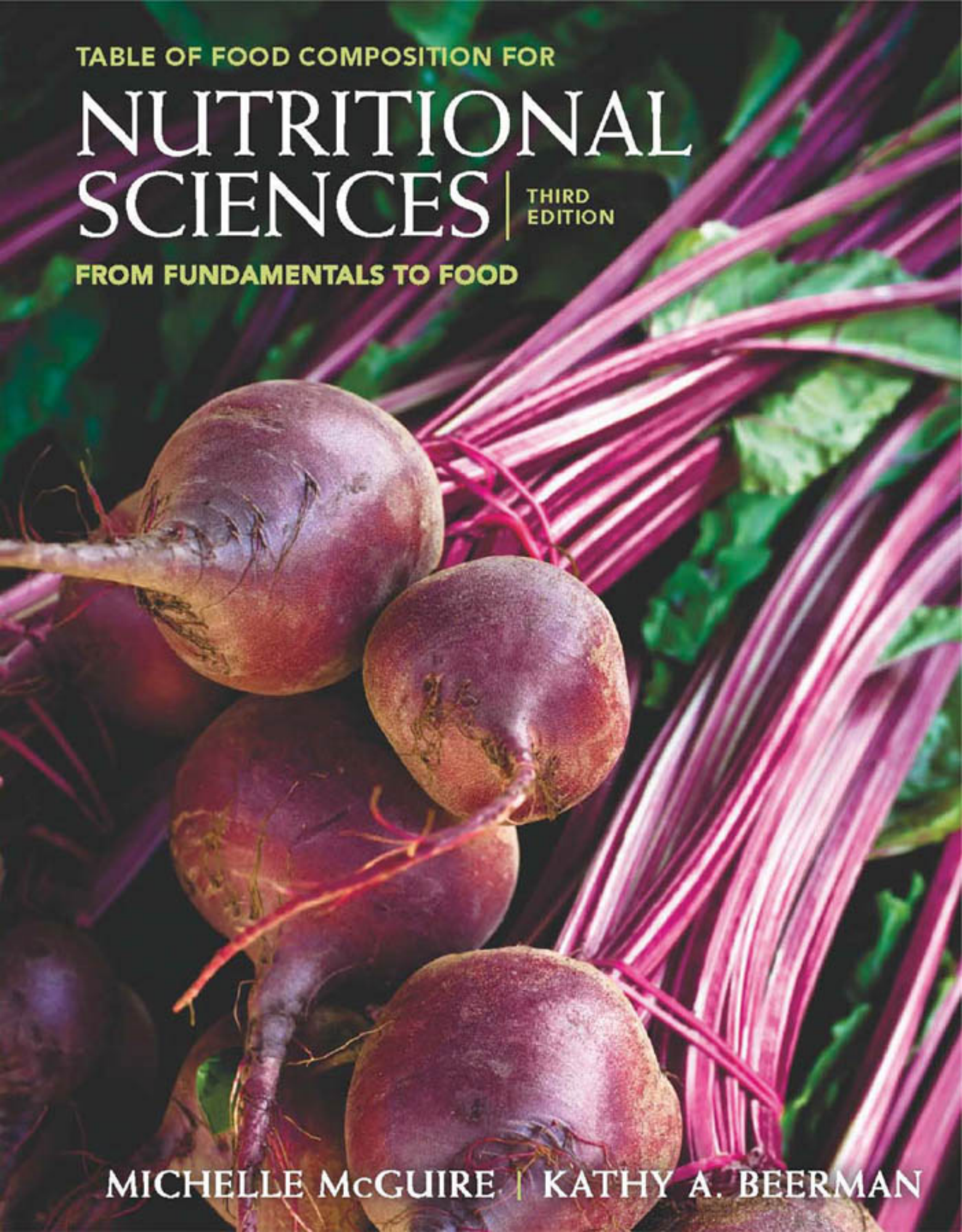
TABLE OF FOOD COMPOSITION FOR

NUTRITIONAL SCIENCES

THIRD EDITION

FROM FUNDAMENTALS TO FOOD



MICHELLE McGUIRE | KATHY A. BEERMAN

Dietary Reference Intakes (DRIs)

The Dietary Reference Intakes (DRIs) include two sets of values that serve as goals for nutrient intake—Recommended Dietary Allowances (RDAs) and Adequate Intakes (AIs). The RDA reflects the average daily amount of a nutrient considered adequate to meet the needs of most healthy people. If there is insufficient evidence to determine an RDA, an AI is set. The DRIs also include a set of values called Tolerable Upper Intake Levels (ULs). The UL represents the maximum amount of a nutrient that appears safe for most healthy people to consume on a regular basis. Turn the page for a listing of the ULs for selected vitamins and minerals and the Acceptable Macronutrient Distribution Range (AMDR) values.

Estimated Energy Requirements (EERs), Recommended Dietary Allowances (RDAs), and Adequate Intakes (AIs) for Water, Energy, and the Macronutrients

Life-Stage Group	Reference BMI (kg/m^2)	Reference height, cm (in)	Reference weight, kg (lb)	Water[a] AI (L/day)	Energy EER[b] (kcal/day)	Carbohydrate RDA (g/day)	Total fiber AI (g/day)	Total fat AI (g/day)	Linoleic acid AI (g/day)	Linolenic acid[c] AI (g/day)	Protein RDA (g/day)[d]	Protein RDA (g/kg/day)	
Males													
0–6 mo	—	62 (24)	6 (13)	0.7[e]	570	60	—	31	4.4	0.5	9.1	1.52	
7–12mo	—	71 (28)	9 (20)	0.8[f]	743	95	—	30	4.6	0.5	11	1.2	
1–3 y[g]	—	86 (34)	12 (27)	1.3	1046	130	19	—	7	0.7	13	1.05	
4–8 y[g]	15.3	115 (45)	20 (44)	1.7	1742	130	25	—	10	0.9	19	0.95	
9–13 y	17.2	144 (57)	36 (79)	2.4	2279	130	31	—	12	1.2	34	0.95	
14–18 y	20.5	174 (68)	61 (134)	3.3	3152[h]	130	38	—	16	1.6	52	0.85	
19–30 y	22.5	177 (70)	70 (154)	3.7	3067[h]	130	38	—	17	1.6	56	0.8	
31–50 y	22.5[i]	177 (70)[i]	70 (154)[i]	3.7	3067[h]	130	38	—	17	1.6	56	0.8	
≥51 y	22.5[i]	177 (70)[i]	70 (154)[i]	3.7	3067[h]	130	30	—	14	1.6	56	0.8	
Females													
0–6 mo	—	62 (24)	6 (13)	0.7[e]	520	60	—	31	4.4	0.5	9.1	1.52	
7–12mo	—	71 (28)	9 (20)	0.8[f]	676	95	—	30	4.6	0.5	11	1.2	
1–3 y[g]	—	86 (34)	12 (27)	1.3	992	130	19	—	7	0.7	13	1.05	
4–8 y[g]	15.3	115 (45)	20 (44)	1.7	1642	130	25	—	10	0.9	19	0.95	
9–13 y	17.4	144 (57)	37 (81)	2.1	2071	130	26	—	10	1.0	34	0.95	
14–18 y	20.4	163 (64)	54 (119)	2.3	2368	130	26	—	11	1.1	46	0.85	
19–30 y	21.5	163 (64)	57 (126)	2.7	2403[j]	130	25	—	12	1.1	46	0.8	
31–50 y	21.5[i]	163 (64)[i]	57 (126)[i]	2.7	2403[j]	130	25	—	12	1.1	46	0.8	
≥51 y	21.5[i]	163 (64)[i]	57 (126)[i]	2.7	2403[j]	130	21	—	11	1.1	46	0.8	
Pregnancy													
14–18 y				3.0	+0	175	28	—	13	1.4	71	1.1	
19–30 y				3.0	+340	175	28	—	13	1.4	71	1.1	
31–50 y				3.0	+452	175	28	—	13	1.4	71	1.1	
Lactation													
1st 6 months postpartum				3.8	+330	210	29	—	13	1.3	71	1.3	
2nd 6 months postpartum				3.8	+400	210	29	—	13	1.3	71	1.3	

Note: For all nutrients, values for infants are AIs. Dashes indicate that values have not been determined.

[a]The water AI includes drinking water, water in beverages, and water in foods; in general, drinking water and other beverages contribute about 70 to 80%, and foods, the remainder. Conversion factors: 1 L = 33.8 fluid oz; 1 L = 1.06 qt; 1 cup = 8 fluid oz.

[b]The Estimated Energy Requirement (EER) represents the average dietary energy intake that will maintain neutral energy balance in a healthy person of a given sex, age, weight, height, and physical activity level. The values listed are based on an "active" person at the reference height and weight and at the midpoint ages for each group until age 19. Chapter 2 and Appendix B provide equations and tables to determine Estimated Energy Requirements.

[c]The linolenic acid referred to in this table and text is the omega-3 fatty acid known as alpha-linolenic acid.

[d]The values listed are based on reference body weights.

[e]Assumed to be from human milk.

[f]Assumed to be from human milk and complementary foods and beverages. This includes approximately 0.6 L (~3 cups) as total fluid including formula, juices, and drinking water.

[g]For energy, the age groups for young children are 1–2 years and 3–8 years.

[h]For males, subtract 10 kilocalories per day for each year of age above 19.

[i]Because weight need not change as adults age if activity is maintained, reference weights for adults 19 through 30 are applied to all adult age groups.

[j]For females, subtract 7 kilocalories per day for each year of age above 19.

Recommended Dietary Allowances (RDAs) and Adequate Intakes (AIs) for Vitamins

Life-Stage Group	Thiamin RDA (mg/day)	Riboflavin RDA (mg/day)	Niacin RDA (mg/day)[a]	Biotin AI (µg/day)	Pantothenic acid AI (mg/day)	Vitamin B_6 RDA (mg/day)	Folate RDA (µg/day)[b]	Vitamin B_{12} RDA (µg/day)	Choline AI (mg/day)	Vitamin C RDA (mg/day)	Vitamin A RDA (µg/day)[c]	Vitamin D RDA (µg/day)[d]	Vitamin E RDA (mg/day)[e]	Vitamin K AI (µg/day)
Infants														
0–6 mo	0.2	0.3	2	5	1.7	0.1	65	0.4	125	40	400	10	4	2.0
7–12 mo	0.3	0.4	4	6	1.8	0.3	80	0.5	150	50	500	10	5	2.5
Children														
1–3 y	0.5	0.5	6	8	2	0.5	150	0.9	200	15	300	15	6	30
4–8 y	0.6	0.6	8	12	3	0.6	200	1.2	250	25	400	15	7	55
Males														
9–13 y	0.9	0.9	12	20	4	1.0	300	1.8	375	45	600	15	11	60
14–18 y	1.2	1.3	16	25	5	1.3	400	2.4	550	75	900	15	15	75
19–30 y	1.2	1.3	16	30	5	1.3	400	2.4	550	90	900	15	15	120
31–50 y	1.2	1.3	16	30	5	1.3	400	2.4	550	90	900	15	15	120
51–70 y	1.2	1.3	16	30	5	1.7	400	2.4	550	90	900	15	15	120
>70 y	1.2	1.3	16	30	5	1.7	400	2.4	550	90	900	20	15	120
Females														
9–13 y	0.9	0.9	12	20	4	1.0	300	1.8	375	45	600	15	11	60
14–18 y	1.0	1.0	14	25	5	1.2	400	2.4	400	65	700	15	15	75
19–30 y	1.1	1.1	14	30	5	1.3	400	2.4	425	75	700	15	15	90
31–50 y	1.1	1.1	14	30	5	1.3	400	2.4	425	75	700	15	15	90
51–70 y	1.1	1.1	14	30	5	1.5	400	2.4	425	75	700	15	15	90
>70 y	1.1	1.1	14	30	5	1.5	400	2.4	425	75	700	20	15	90
Pregnancy														
14–18 y	1.4	1.4	18	30	6	1.9	600	2.6	450	80	750	15	15	75
19–30 y	1.4	1.4	18	30	6	1.9	600	2.6	450	85	770	15	15	90
31–50 y	1.4	1.4	18	30	6	1.9	600	2.6	450	85	770	15	15	90
Lactation														
14–18 y	1.4	1.6	17	35	7	2.0	500	2.8	550	115	1200	15	19	75
19–30 y	1.4	1.6	17	35	7	2.0	500	2.8	550	120	1300	15	19	90
31–50 y	1.4	1.6	17	35	7	2.0	500	2.8	550	120	1300	15	19	90

Note: For all nutrients, values for infants are AIs.
[a]Niacin recommendations are expressed as niacin equivalents (NE), except for recommendations for infants younger than 6 months, which are expressed as preformed niacin.
[b]Folate recommendations are expressed as dietary folate equivalents (DFE).
[c]Vitamin A recommendations are expressed as retinol activity equivalents (RAE).
[d]Vitamin D recommendations are expressed as cholecalciferol.
[e]Vitamin E recommendations are expressed as α-tocopherol.

Recommended Dietary Allowances (RDAs) and Adequate Intakes (AIs) for Minerals

Life-Stage Group	Sodium AI (mg/day)	Chloride AI (mg/day)	Potassium AI (mg/day)	Calcium RDA (mg/day)	Phosphorus RDA (mg/day)	Magnesium RDA (mg/day)	Iron RDA (mg/day)	Zinc RDA (mg/day)	Iodine RDA (µg/day)	Selenium RDA (µg/day)	Copper RDA (µg/day)	Manganese AI (mg/day)	Fluoride AI (mg/day)	Chromium AI (µg/day)	Molybdenum RDA (µg/day)
Infants															
0–6 mo	120	180	400	200	100	30	0.27	2	110	15	200	0.003	0.01	0.2	2
7–12 mo	370	570	700	260	275	75	11	3	130	20	220	0.6	0.5	5.5	3
Children															
1–3 y	1000	1500	3000	700	460	80	7	3	90	20	340	1.2	0.7	11	17
4–8 y	1200	1900	3800	1000	500	130	10	5	90	30	440	1.5	1	15	22
Males															
9–13 y	1500	2300	4500	1300	1250	240	8	8	120	40	700	1.9	2	25	34
14–18 y	1500	2300	4700	1300	1250	410	11	11	150	55	890	2.2	3	35	43
19–30 y	1500	2300	4700	1000	700	400	8	11	150	55	900	2.3	4	35	45
31–50 y	1500	2300	4700	1000	700	420	8	11	150	55	900	2.3	4	35	45
51–70 y	1300	2000	4700	1000	700	420	8	11	150	55	900	2.3	4	30	45
>70 y	1200	1800	4700	1200	700	420	8	11	150	55	900	2.3	4	30	45
Females															
9–13 y	1500	2300	4500	1300	1250	240	8	8	120	40	700	1.6	2	21	34
14–18 y	1500	2300	4700	1300	1250	360	15	9	150	55	890	1.6	3	24	43
19–30 y	1500	2300	4700	1000	700	310	18	8	150	55	900	1.8	3	25	45
31–50 y	1500	2300	4700	1000	700	320	18	8	150	55	900	1.8	3	25	45
51–70 y	1300	2000	4700	1200	700	320	8	8	150	55	900	1.8	3	20	45
>70 y	1200	1800	4700	1200	700	320	8	8	150	55	900	1.8	3	20	45
Pregnancy															
14–18 y	1500	2300	4700	1300	1250	400	27	12	220	60	1000	2.0	3	29	50
19–30 y	1500	2300	4700	1000	700	350	27	11	220	60	1000	2.0	3	30	50
31–50 y	1500	2300	4700	1000	700	360	27	11	220	60	1000	2.0	3	30	50
Lactation															
14–18 y	1500	2300	5100	1300	1250	360	10	13	290	70	1300	2.6	3	44	50
19–30 y	1500	2300	5100	1000	700	310	9	12	290	70	1300	2.6	3	45	50
31–50 y	1500	2300	5100	1000	700	320	9	12	290	70	1300	2.6	3	45	50

Tolerable Upper Intake Levels (ULs) for Vitamins

Life-Stage Group	Niacin (mg/day)[a]	Vitamin B_6 (mg/day)	Folate (µg/day)[a]	Choline (mg/day)	Vitamin C (mg/day)	Vitamin A (µg/day)[b]	Vitamin D (µg/day)	Vitamin E (mg/day)[c]
Infants								
0–6 mo	—	—	—	—	—	600	25	—
7–12 mo	—	—	—	—	—	600	38	—
Children								
1–3 y	10	30	300	1000	400	600	63	200
4–8 y	15	40	400	1000	650	900	75	300
Adolescents								
9–13 y	20	60	600	2000	1200	1700	100	600
14–18 y	30	80	800	3000	1800	2800	100	800
Adults								
19–70 y	35	100	1000	3500	2000	3000	100	1000
>70 y	35	100	1000	3500	2000	3000	100	1000
Pregnancy								
14–18 y	30	80	800	3000	1800	2800	100	800
19–50 y	35	100	1000	3500	2000	3000	100	1000
Lactation								
14–18 y	30	80	800	3000	1800	2800	100	800
19–50 y	35	100	1000	3500	2000	3000	100	1000

[a]The UL for niacin and folate apply to synthetic forms obtained from supplements, fortified foods, or a combination of the two.

[b]The UL for vitamin A applies to the preformed vitamin only.

[c]The UL for vitamin E applies to any form of supplemental α-tocopherol, fortified foods, or a combination of the two.

Tolerable Upper Intake Levels (ULs) for Minerals

Life-Stage Group	Sodium (mg/day)	Chloride (mg/day)	Calcium (mg/day)	Phosphorus (mg/day)	Magnesium (mg/day)[d]	Iron (mg/day)	Zinc (mg/day)	Iodine (µg/day)	Selenium (µg/day)	Copper (µg/day)	Manganese (mg/day)	Fluoride (mg/day)	Molybdenum (µg/day)	Boron (mg/day)	Nickel (mg/day)
Infants															
0–6 mo	—[e]	—[e]	1000	—	—	40	4	—	45	—	—	0.7	—	—	—
7–12 mo	—[e]	—[e]	1500	—	—	40	5	—	60	—	—	0.9	—	—	—
Children															
1–3 y	1500	2300	2500	3000	65	40	7	200	90	1000	2	1.3	300	3	0.2
4–8 y	1900	2900	2500	3000	110	40	12	300	150	3000	3	2.2	600	6	0.3
Adolescents															
9–13 y	2200	3400	3000	4000	350	40	23	600	280	5000	6	10	1100	11	0.6
14–18 y	2300	3600	3000	4000	350	45	34	900	400	8000	9	10	1700	17	1.0
Adults															
19–70 y	2300	3600	2500[f]	4000	350	45	40	1100	400	10,000	11	10	2000	20	1.0
>70 y	2300	3600	2000	3000	350	45	40	1100	400	10,000	11	10	2000	20	1.0
Pregnancy															
14–18 y	2300	3600	3000	3500	350	45	34	900	400	8000	9	10	1700	17	1.0
19–50 y	2300	3600	2500	3500	350	45	40	1100	400	10,000	11	10	2000	20	1.0
Lactation															
14–18 y	2300	3600	3000	4000	350	45	34	900	400	8000	9	10	1700	17	1.0
19–50 y	2300	3600	2500	4000	350	45	40	1100	400	10,000	11	10	2000	20	1.0

[d]The UL for magnesium applies to synthetic forms obtained from supplements or drugs only.

[e]Source of intake should be from human milk (or formula) and food only.

[f]The UL for calcium for 19–50 y is 2500 mg; the UL for calcium is reduced to 2000 mg for 51–70 y.

Note: An Upper Limit was not established for vitamins and minerals not listed and for those age groups listed with a dash (—) because of a lack of data, not because these nutrients are safe to consume at any level of intake. All nutrients can have adverse effects when intakes are excessive.

Acceptable Macronutrient Distribution Ranges (AMDRs)

Macronutrient	Range (percent of energy)		
	Children, 1–3 years	Children, 4–18 years	Adults 19+ years
Fat	30–40	25–35	20–35
ω-6 polyunsaturated acids[a] (linoleic acid)	5–10	5–10	5–10
ω-3 polyunsaturated fatty acids[a] (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

[a]Approximately 10% of the total can come from longer-chain ω-3 or ω-6 fatty acids.

SOURCE: Adapted from Institute of Medicine, *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids,* National Academies Press; Washington, D.C., 2005.

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Nutritional Sciences

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Washington State University

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1 2 3 4 5 6 7 14 13 12 11

CONTENTS IN BRIEF

CONTENTS

LIST OF *FOCUS ON* BOXES

EVERYBODY HAS A STORY: Michelle "Shelley" McGuire

Courtesy of The Dannon Institute

Dr. Michelle "Shelley" McGuire got her academic start in the small town of Polo, Illinois, where her mother-in-law-to-be (a high school English teacher) taught her how to write, and her family and community instilled within her a strong Midwestern work ethic and love of learning. Shelley earned a bachelor's degree in biology from the University of Illinois, a master's degree in nutritional sciences from the University of Illinois, and a doctorate in human nutrition (with minors in physiology and international nutrition) from Cornell University. She is now a faculty member at Washington State University, where she conducts research related to nutrition and lactation. Recent research, conducted in collaboration with her husband Dr. Mark McGuire (University of Idaho) and funded primarily by the National Institutes of Health and the Bill and Melinda Gates Foundation, has focused on the discovery that human milk naturally contains "healthy" bacteria that likely benefit both mothers and infants. Shelley is an active member of the American Society for Nutrition, for which she is a National Spokesperson and a member of various committees. She is also a member of the International Society for Research in Human Milk and Lactation, for which she is secretary/treasurer. Dr. McGuire has been enthusiastically teaching Washington State University's basic nutrition course for mixed majors for over 15 years and has a strong appreciation for its goals and objectives, as well as the wide variety of student needs associated with the course. She also teaches an upper-level science communications course for biology majors. These experiences, coupled with her strong writing skills, research background, and personal connections within the international nutrition research community, have helped her create an exciting and refreshing text for the introductory nutrition course. When Shelley is not writing, teaching, or overseeing research, she enjoys being with family and friends, traveling, running, practicing yoga, cooking, gardening, and performing classical music.

With continued gratitude to Mark, Emily, Grace, and Keith for providing my "equilibrium" each and every day.

This book is dedicated to my dear "academic mothers" and mentors—Drs. Mary Frances Picciano and Kathleen Rasmussen. Mary Frances, thank you for gently yet securely diverting me from a path leading straight to medical school to one paving the way to academia. You taught me that a woman can be both a serious scientist and a devoted mother/wife. You also taught me that husband/wife academic teams can be incredibly productive, loving, and long-lasting. I miss your advice and wit on a daily basis. Kathy, your guidance and continued support have been invaluable. From experimental design to statistical analysis; from critical evaluation of the literature to application of current science to public health recommendations; from listening to me to providing leadership opportunities. I cannot adequately express my appreciation for all you have done and continue to do for me. You both believed in and encouraged me when I was weary and unsure of how a sensitive female could possibly cope in the sometimes brutal world of rigorous science. Thank you for teaching me that critical evaluation and continued questioning of dogma require humility, humor, courage, persistence, and (especially) a sturdy backbone.

Shelley

EVERYBODY HAS A STORY: Kathy Beerman

I express my deepest gratitude to those who supported me through the many twists and turns of this endeavor. I am very fortunate to have such wonderful friends, and you have each contributed to this book in many ways. I am especially grateful to my husband, children, brother, and sister-in-law who provided endless and unwavering love each step of the way. My greatest inspiration comes from my father, Morris Beerman, whose profound wisdom has guided me throughout life. It is to him that I dedicate this book.

Kathy

Courtesy of Washington State University

Dr. Kathy Beerman was born and raised in Buffalo, New York. She earned her bachelor's and master's degrees from the State University of New York at Brockport, Department of Health Sciences. Although her urban, East Coast roots run deep, she relocated to Corvallis, Oregon, to attend graduate school at Oregon State University, where she earned her PhD. After finishing her doctorate, Kathy and her husband (Steven) moved to Moscow, Idaho. Now a professor of nutrition, Kathy teaches in the School of Biological Sciences at Washington State University. The author of several published articles, she specializes in research focusing on dietary practices of college students and the effects of isoflavones on health parameters (immune response, thyroid function, and memory) in postmenopausal women. A collaborative clinical intervention study currently underway involves the assessment of L-arginine and L-citrulline oral supplementation on blood pressure in hypertensive men. She is a member of the American Society for Nutrition. Dr. Beerman teaches the introductory nutrition course for health-related majors, as well as courses in nutrition education, biology of women, and life cycle nutrition. She also provides educational training to graduate students in preparation for instructional roles as teaching assistants. Dr. Beerman will also be co-teaching a course with her husband in Puntarenas, Costa Rica, that explores the connectivity between agriculture, environmental quality, human nutrition, and health. Since joining the faculty at Washington State University in 1989, she has taught more than 15,000 students, and has been the recipient of several college and university teaching awards including the Burlington Northern Faculty Meritorious Achievement in Teaching Award, the R. M. Wade Foundation Award for Excellence in Teaching, and the WSU Mortar Board (honor society of college seniors) Distinguished Professor Award. In 2008, Dr. Beerman was awarded the highest teaching honor offered at Washington State University—the Sahlin Faculty Excellence Award for Instruction. In addition, Dr. Beerman was inducted into the President's Teaching Academy at Washington State University, which is composed of faculty members who provide leadership to strengthen undergraduate and graduate teaching and learning. Dr. Beerman's years of teaching experience combined with her wide knowledge base in nutrition and health sciences have helped her create this innovative introductory nutrition textbook. At home, Kathy enjoys spending time with her husband, Steven, and children, Anna and Michael. She also enjoys traveling, gardening, running, and being a part of the Moscow community.

PREFACE

Like you, we teach introductory nutrition at the college level, and our experiences in the classroom have taught us many things. We would like to share two primary insights that shaped the inception of this textbook and have guided us throughout the writing of each edition.

- First and foremost, an introductory nutrition textbook must explain nutrition concepts accurately, clearly, and completely in a way that all students, regardless of level or background, can understand. To do this most effectively, it is essential to provide students with fundamental scientific concepts. Only then can these concepts be applied to the science of nutrition in a meaningful way.
- For some students, scientific concepts are abstract and difficult to grasp. For this reason, the use of well-designed figures greatly enhances learning by providing integrated, contextually-based illustrative examples.

These two straightforward observations formed the genesis of this textbook. It is our hope that this book will allow all students, *even those with little or no science background*, to find the science of nutrition approachable, understandable, and—perhaps most imperative—useful in their lives.

Critically important to the evolution of this textbook is our commitment to getting the facts straight, updating the text as new knowledge unfolds, and presenting information in an objective, unbiased manner. As such, the revision process is an integral part of all stages of textbook development, writing, and implementation. When necessary, subject matter experts are consulted to clarify concepts, discuss implications of a new study, provide commentary on new scientific discoveries, or even help us define terms. If you are one of these people we have reached out to, thank you! We also attend national meetings, participate in conferences, and seek out nutrition-related events to ensure that we are on the cutting edge of the science. In addition, and perhaps most importantly, we use this textbook in our classrooms and solicit feedback from our students. Sometimes we learn as much from them as they learn from us.

All of these approaches made us even more eager to roll up our sleeves and dive into this new edition. If you used previous editions of this book, you will immediately notice that many changes have been made to every chapter. These changes are described in more detail later in this preface. Although we are confident that this book is one of the most accurate, clearly written, current, beautiful, and student-friendly nutrition books available, we will have already started working on the next edition by the time you are reading this page. Please do not hesitate to let us know whether these changes address your needs and those of your students, as well as what you would like us to address in subsequent editions.

The Fundamentals Are Important

We think you will agree that students need a strong knowledge base to master nutrition concepts. Without knowledge of fundamental scientific principles and associated vocabulary, many capable students in introductory nutrition courses are lost from the start. For example, when teaching nutrition we often

refer to chemical bonds—how else do we distinguish between saturated and unsaturated fatty acids? Similarly, when teaching the importance of ATP, we discuss the breaking of phosphate bonds. But how can a student grasp these concepts without understanding what a chemical bond is? The solid scientific foundation provided by this book will enable students to navigate through the most difficult of concepts, regardless of their background. For example, Chapter 3 not only introduces the basic principles of chemistry, biology, and physiology, but also applies these concepts to the study of nutrition. To our knowledge, this is the first introductory nutrition textbook to present such a "primer" on nutritional biochemistry and physiology at the level appropriate for both science and nonscience students. In fact, because we believe that the fundamentals are so crucially important, we worked hard to define and describe each new science-based term and concept when it is introduced. You will see evidence of this in every chapter.

An Integrated, Yet Systematic, Approach

As the field of nutrition grows, so does the amount of information we must teach. Consequently, it can be difficult to cover the necessary basic science and applied aspects of nutrition in a single semester. For instance, it is important to first learn about *all* the related micronutrients and macronutrients before launching into a full discussion of nutrition and bone health. Therefore, our approach has been to "lead" with the basics, followed by application whenever possible. To accomplish this, we have organized the text in a methodical, integrated manner. First, the main chapters of the book are organized in the traditional way—starting with the macronutrients and then discussing the micronutrients. However, applied concepts are integrated throughout the book. For example, active and passive transport mechanisms are carefully described in Chapter 3, but then referred to in subsequent chapters throughout the book. Another pedagogical tool, called **Connections,** is conveniently placed on pages to provide students with a quick reminder of important terms and concepts. Similarly, a structural organization of headings and subheadings provides students with a framework that presents a broad view, which then progresses to a more detailed examination of information. By posing first-level headings as questions, students are able to self-check to ensure they are extracting critical information.

Second, we have continued to use a feature entitled **Focus on...,** which highlights issues related to scientific innovation, diet and health, food, clinical applications, life cycle nutrition, and sports nutrition. These features assimilate topics that are of great interest to students within appropriate chapters, and are especially useful to instructors who do not have time to more extensively cover them during the semester. For example, a Focus on... discussion of high-fructose corn syrup accompanies the section on simple sugars, and a Focus on... discussion of nutrient–drug interactions accompanies the section on vitamin K. Most chapters have several Focus on... features, which students will enjoy reading and from which they will learn a great deal. In fact, these features received high praise from our students, who found the topics interesting and provocative.

Third, to improve the integration of important nutrients related to the maintenance of health or the risk for chronic disease, we include segments called **Nutrition Matters,** which conclude most of the chapters. These "minichapters" deal with important nutrition-related issues—such as food safety, nutrition and cancer, and dysfunctional eating. They are up-to-date and comprehensive, yet clear and student-friendly. Because these pieces conclude most chapters, instructors can easily choose to assign them in

any order that works for their class, or not assign them at all if time does not allow.

Putting a *Personal* Face on Nutritional Science

We all know that stories can greatly enhance learning. Without a doubt, teachers double as storytellers. If you are like us, your "stories" are often about people with nutrition-related challenges in their lives. And you would probably agree that everybody has such a story to tell. A special feature called **Everybody Has a Story** made its first debut in the second edition of the textbook. As in the second edition, each chapter opens with a story about a person with a real nutrition-related challenge. In this new edition, we are pleased to introduce several new people, all of whom generously shared their captivating stories. It is our hope that students can relate to these stories and refer back to them as they read the chapter. For example, Chapter 2 (Nutritional Assessment and Dietary Planning) features Emily, a student studying at the University of Cincinnati. This story was selected to get students to think about how easily overlooked medical conditions—such as celiac disease—can cascade into a host of nutrient-related concerns, especially in college students facing a multitude of changes and stresses in their lives. Chapter 8 (Energy Balance and Body Weight Regulation) features August, who describes her lifelong struggle with obesity and her decision to have gastric bypass surgery after repeated failed weight-loss attempts. This story presents a thought-provoking perspective to students about the physical, psychological, and sociocultural aspects of obesity. Most importantly, it challenges students to examine their beliefs about this sensitive topic. We are hopeful that these personal stories will help students connect the fundamentals of nutritional science to everyday living and health.

This book also provides numerous opportunities for students to apply their knowledge to the art and science of making their own good food choices on a daily basis. The **Food Matters** sections, for example, help transform the 2010 Dietary Guidelines for Americans (which are described in detail in Chapter 2) into practical ideas for choosing and preparing foods in the most health-conscious manner. These pieces can be found in most chapters, helping integrate the fundamental concepts into personal food-related decisions.

Book Length

Most introductory nutrition courses are taught over one quarter or semester. Yet textbooks written for these courses typically contain substantially more information than can be covered within a 10- to 15-week period. Addressing concepts in a concise manner has enabled us to create a slimmer, trimmer textbook that can be more easily covered in a single semester. Additional resources that might otherwise be found in an appendix are conveniently provided to students via the book's website or can be bundled as supplements to the textbook. An example is the food composition table, which can be provided free as a separate booklet with every new text.

Pedagogical Tools

As previously described, we are convinced that outstanding illustrations enhance learning. All students benefit from seeing scientific concepts articulated in clear, well-organized illustrations. The figures, tables, and graphs in

this book were designed using a unique captioning system, and the consistent use of blue text boxes and lines quickly identifies the key points of each figure. Many of our visual summaries take students step by step through complex processes, from the whole-body "big picture" to the details. We affectionately refer to these as "you are here" illustrations and have noticed other textbook writers adopting this idea and using it in their books as well.

Additionally, and to help with recognition, extra effort has been made to ensure that components found in many figures are displayed consistently throughout the book. For example, the anatomical drawings are rendered in the same way so that various organs such as the liver, pancreas, and stomach have a consistent appearance; glucose is always colored blue; and phospholipids are always drawn and colored the same way.

In addition to beautiful illustrations, each chapter contains a number of helpful tools that assist students in learning the material. New to this edition, tear-out **Study Cards** are gathered on perforated card stock at the back of the book. These cards include not only chapter summaries that identify key concepts, arranged by major subject headings, but also review questions that enable students to test their knowledge. Question types include multiple choice, essay, and practice calculations (specific mathematics-related problems encountered in nutrition). Using these cards, students can easily identify content that requires further review and locate where the information is presented in the chapter. Students can also carry these handy summaries and questions instead of the book to conveniently review key concepts and definitions for exams. In addition, **Diet Analysis PLUS Activities** are included at the end of most chapters. These activities are designed to relate the chapter concepts to the dietary analysis software that can accompany this text.

New to the Third Edition

Perhaps most exciting to us are the many subtle and not-so-subtle changes we have made to transform this book into its third edition. Many of these changes were made in response to excellent feedback that we received from both colleagues and students, and we thank you all for helping us make this edition even better. First, you can look forward to reading new challenges in the **Everybody Has a Story** features, and we welcome your feedback on how these helped in the classroom. In this edition, we also worked to strengthen the writing by using a more direct, inclusive voice. We hope that this style will resonate with students, and help them grasp important concepts more readily.

And, of course, throughout the book we have updated all of the nutrition-related guidelines (such as the 2010 Dietary Guidelines for Americans and MyPlate food guidance system) and programs (such as the National School Breakfast and Lunch Programs) discussed, as well as health statistics. Importantly, the timing of this edition nicely coincided with the releases of the 2010 Dietary Guidelines for Americans and the MyPlate food guidance system—cogent events that serve as the cornerstones of nutritional guidance. We are indeed fortunate, therefore, that they are aptly described and incorporated into this newly released book. Another of the most important considerations during the revision process was to avoid layering new material on top of old. Therefore, sections that no longer seemed relevant or supported by the literature were removed.

Perhaps most important to any rigorous college-level textbook, each chapter now includes new information that reflects changes to our knowledge that have surfaced since the last edition was released. Some of these are highlighted here.

Chapter 1 (The Science of Nutrition)

- Added new Focus on... concerning "Industrialization, Population Growth, and the Nutrition Transition."

Chapter 2 (Nutritional Assessment and Dietary Planning)

- Replaced previous Everybody Has a Story piece with one describing Emily, a college student who learns she has secondary iron deficiency caused by celiac disease.
- Updated discussion of DRIs to include new values for calcium and vitamin D released in 2011.
- Replaced information related to the 2005 Dietary Guidelines for Americans and MyPyramid food guidance system with that reflecting the 2010 Dietary Guidelines for Americans and MyPlate food guidance system.
- Updated descriptions of Healthy People to reflect newest edition (2010), and introduced the relevance of the Healthy, Hunger-Free Kids Act of 2010 to our nation's youth.

Chapter 3 (Chemical, Biological, and Physiological Aspects of Nutrition)

- While this chapter continues to provide a strong foundation in physiological functions, we have provided more examples that demonstrate their applicability to the study of nutrition.
- Added a new Everybody Has a Story chapter opener featuring a high school student who was experiencing an unspecified illness that was eventually diagnosed as Crohn's disease.

Chapter 4 (Carbohydrates; Nutrition and Diabetes)

- Added a new Everybody Has a Story chapter opener featuring an Ironman® competitor who faces the challenges of training while also dealing with the complications of having type 1 diabetes.
- Updated information regarding the controversy on high-fructose corn syrup and obesity.
- Updated information based on the 2010 Dietary Guidelines for Americans regarding added sugar consumption in the United States.
- Updated information based on the 2010 Dietary Guidelines for Americans regarding emphasis on fiber, fruit, and vegetable intake.
- Relocated information on metabolic syndrome from Chapter 4 to Chapter 8 in order to broaden the discussion of its relevance to obesity.
- Updated CDC trend maps showing recent regional estimates of adults with diagnosed diabetes.
- Incorporated 2010 Dietary Guidelines for Americans and MyPlate food guidance system where appropriate.
- Included American Diabetes Association's 2011 guidelines for carbohydrate intake.

Chapter 5 (Protein; Food Safety)

- Updated and expanded upon concepts of *epigenetics* and *nutrigenomics*, and discussion concerning personalized dietary prescriptions.
- Revised protein food intake recommendations based on the 2010 Dietary Guidelines for Americans, MyPlate food guidance system, and American College of Sports Medicine guidelines (for athletes).
- Revised recommendations regarding safe internal temperatures for meats based on new FightBAC® guidelines.
- Updated information on federal regulations related to mad cow disease, and included brief description of the FDA Food Safety Modernization Act passed in 2011.
- Updated many of the foodborne illness cases in the Food Safety Nutrition Matters to reflect outbreaks that occurred between 2009 and 2011.

Chapter 6 (Lipids; Nutrition and Cardiovascular Health)

- Replaced previous Everybody Has a Story piece with one describing Nancy, a women who has her gallbladder removed and endures somewhat troubling complications.
- Revised food intake recommendations (especially those related to omega-3 fatty acids) based on the 2010 Dietary Guidelines for Americans and MyPlate food guidance system.
- Expanded section on Tangier disease to reflect current knowledge.
- Revised information concerning nutritional essentiality of docosahexaenoic acid (DHA) based on current knowledge.
- Revised statistics related to incidence and prevalence of cardiovascular disease.

Chapter 7 (Energy Metabolism; Alcohol, Health, and Disease)

- Included new Everybody Has a Story chapter opener describing how dietary management of an inherited metabolic disease impacts daily food choices.
- Revised figure illustrating the process of enzymatic catalysis.
- Added new Focus on... feature concerning the use of therapeutic ketogenic diets to help control seizures in some children with epilepsy.
- Added a "You are here" illustration to provide students with an integrative view of the various pathways involved in energy metabolism.
- Added application of basic concepts of energy metabolism to topics such as alcohol metabolism and sports nutrition.

Chapter 8 (Energy Balance and Body Weight Regulation; Disordered Eating)

- Expanded discussion pertaining to food cravings and aversions.
- Updated information regarding the regulatory role of ghrelin in hunger and satiety.
- Included overview of the National Association for Sports and Physical Education guidelines for physical education in schools.
- Expanded presentation of 2008 Physical Activity Guidelines for Americans.
- Updated information regarding obesity, inflammation, and chronic disease.
- Included new, updated tables summarizing feelings and behaviors associated with anorexia nervosa and bulimia nervosa.
- Expanded discussion of other dysfunctional eating patterns such as food neophobia, muscle dysmorphia, and night eating syndrome.
- Updated information and statistics regarding U.S. obesity trends.

Chapter 9 (Physical Activity and Health)

- Included new Everybody Has a Story chapter opener describing the transformation of a sedentary middle-aged man into an Ironman® contender.
- Expanded text related to 2008 Physical Activity Guidelines for Americans and recommendations by the American College of Sports Medicine.
- Expanded and updated discussion of nutritional guidelines for athletes.

Chapter 10 (Water-Soluble Vitamins)

- Updated information on vitamin and phytochemical function based on current knowledge.
- Expanded and updated discussion of folate fortification, its reported benefits, and its possible unintended consequences.
- Revised intake recommendations for water-soluble, vitamin-rich foods based on the 2010 Dietary Guidelines for Americans and MyPlate food guidance system.

Chapter 11 (Fat-Soluble Vitamins; Nutrition and Cancer)
- Updated information concerning recommended intakes of vitamin D based on new DRI values.
- Revised intake recommendations for fat-soluble vitamin-rich foods based on the 2010 Dietary Guidelines for Americans and MyPlate food guidance system.
- Updated statistics related to cancer morbidity and mortality.

Chapter 12 (Major Minerals and Water; Nutrition and Bone Health)
- Updated information concerning recommended intakes of calcium based on new DRI values.
- Revised intake recommendations for major mineral-rich foods based on the 2010 Dietary Guidelines for Americans and MyPlate food guidance system.
- Updated discussion concerning dairy products, calcium, and weight maintenance to reflect current knowledge.
- Updated statistics related to osteoporosis morbidity and mortality.

Chapter 13 (Trace Minerals)
- Introduced and described importance of hepcidin to iron homeostasis.
- Revised section on hereditary hemochromatosis to reflect current knowledge related to hepcidin production.
- Updated dietary intake recommendations related to mineral-rich whole-grain products based on the 2010 Dietary Guidelines for Americans and MyPlate food guidance system.

Chapter 14 (Life Cycle Nutrition; Food Security, Hunger, and Malnutrition)
- Included new discussion related to pregnancy-induced hypertension, gestational diabetes, and dietary management of common pregnancy-related discomforts.
- Updated information pertaining to domestic nutrition-related legislation where appropriate.
- Updated DRI values for calcium and vitamin D throughout the life cycle.
- Introduced several important contemporary concepts such as food deserts and ready-to-use therapeutic foods.
- Updated information and statistics reflecting national and international food security and hunger.
- Replaced previously used CDC growth charts with currently recommended WHO growth charts for infants.
- Included data from Health, United States, 2010, which presents national trends in health statistics related to pregnancy outcomes.

Supplements

- **Diet Analysis PLUS™,** a comprehensive diet assessment program, features the latest Dietary Reference Intakes and a database with over 20,000 foods that can be personalized with recipes. The program allows students to create personal profiles based on height, weight, age, gender, and activity level. A dynamic interface makes it easy for students to track the types and serving sizes of the foods they consume, from one day to 365 days. The program also allows students to generate reports that analyze their diets and see the health implications of their eating habits. New labs and assignments promote critical thinking.
- **WebTutor™:** Provides customizable, text-specific content that allows instructors to edit, reorganize, or delete content to meet their course needs. WebTutor offers quizzing, videos, animations, Pop-up Tutors, and test bank materials along with direct access to Diet Analysis PLUS, Global Nutrition Watch, and an interactive eBook.

- **CourseMate™:** Interested in a simple way to complement your text and course content with study and practice materials? Cengage Learning's *Nutrition* CourseMate brings course concepts to life with interactive learning, study, and exam preparation tools that support the printed textbook. Access an eBook, chapter-specific learning tools, including flashcards, quizzes, videos, and more in your *Nutrition* CourseMate, accessed through **www.cengagebrain.com**.
- The student **Study Guide,** which has been thoroughly updated for the third edition, provides a thorough review of each chapter and Nutrition Matters sections through practice tests, fill-in-the-blank summaries, key term matching sets, discussion questions, word problems, and figure identification exercises.
- **PowerLecture™ DVD:** This one-stop course preparation and presentation resource makes it easy for you to assemble, edit, publish, and present custom lectures for your course, using PowerPoint®. The PowerLecture includes PowerPoint® with stepped art, animations, BBC® video clips, the instructor's manual, the test bank, "clicker" content, and ExamView computerized testing.
- The **Instructor's Manual with Test Bank** features a robust assortment of knowledge- and application-level test items, the majority of which are multiple-choice format and organized by chapter section to facilitate selection. New to this edition are several food-focused class activities (with accompanying PowerPoint presentations) designed to engage students in making more healthful choices. Also provided are student assignment materials, enrichment activity suggestions, answer keys to the Everybody Has a Story questions, instructor guides to the in-text Diet Analysis PLUS Activities, and lecture outlines.
- The **Correlation Guide for Transparency Acetates** allows the transparencies to be easily mapped to the third edition of the text.

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Revising a textbook is much like the process of spring cleaning. That is, to stay fresh, organized, and reinvigorated one must be insightful about what has proven worthy, and what can be discarded. Only when these decisions have been made and the "closet emptied" is there room for new elements to be woven into the existing tapestry of the book's pages. That is exactly what we tried to do in the third edition of this book, and we certainly could not have done it alone. We are indeed fortunate to have teamed up with the experienced and skillful professionals at Wadsworth | Cengage Learning. Their guidance was invaluable, enabling us to transform our evolving vision into this quality textbook. We will forever be grateful for their encouragement and continued support throughout this entire process. Our special thanks are extended to our visionary leader Peggy Williams, who makes herself readily available to the entire team. Peggy not only understands the world of textbook publishing, but also has the necessary insights to approach projects from multiple perspectives—including those of students and faculty. Her tough-yet-tender tact has been perfect and appreciated. In the world of publishing, she is known for taking bold and progressive steps, and we are fortunate and honored to have her serve as captain of our team. Much appreciation also goes to Suzannah Alexander for her steadfast guidance throughout the entire revision process. From beginning to end, she was keenly watchful and aware of what everyone was doing and kept us moving forward in an orderly and synchronized fashion. Under her direction and guidance, we all arrived at the finish line together with a book of which we are all so proud. A special thank you is also extended to Carol Samet, who closely monitored every step of the production process to transform the various pieces of this book into a beautiful and meaningful whole. We are also grateful to Lynn Lustberg, for her endless and needed patience and assiduity; to the talented team of artists who continued to take our sometimes-sketchy ideas and transform them into artful illustrations; and to our creative photo researcher Josh Garvin who presented us with numerous excellent photo options from which to select. We think you will agree that these photos add meaning and instructional depth to the many concepts related to nutritional science. We also appreciate his finding such a wonderful assortment of stunning photographs that illuminate the opening of each chapter. These visuals have greatly improved the book, making each page lively and engaging. Special thanks also go to Elesha Feldman, who again skillfully developed the instructor's manual, test bank, and student study guide that accompany this text; Sean Cronin, for providing his support and assistance; Laura McGinn, for her continued efforts in coordinating the marketing and promotion of the third edition; and Miriam Myers who has created the media supplements.

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We are also thankful for the many expert reviewers who took the time to read each chapter and provide invaluable feedback in terms of content and clarity. We certainly could not have produced an up-to-date textbook without this critical input. And we would like to extend a heartfelt thank you to those who allowed us to share their interesting life stories with the readers of this textbook. These stories, as featured in the new Everybody Has a Story pieces, would not be possible without these people's willingness to discuss the challenges they face on a daily basis. We all have a great deal to learn from their experiences and triumphs. Last, to all our friends, families, and colleagues who helped in more ways than they will ever know: Thank you for being fellow travelers on this ever-important journey.

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THIRD EDITION

Nutritional Sciences

FROM FUNDAMENTALS TO FOOD

The Science of Nutrition

CHAPTER 1

Let thy food be thy medicine and thy medicine be thy food.

—Hippocrates (460–364 B.C.)

Life would not be possible without the nourishment of food. Indeed, our quality of life depends greatly on which foods we choose to eat, and experts unanimously agree that the foods we eat can greatly influence both our immediate health and our risk of disease as we age. Hopefully, you are reading this textbook because you are interested in making sure your diet is as healthful as possible. The information you learn in this course—if you apply it to your life—will be beneficial.

Perhaps the first questions you should ask yourself as you embark upon this journey of learning are *"Do I choose my foods wisely?"* and *"What changes might I make to ensure optimal nutrition and a long and healthy life?"* To answer these questions, you must first understand what nutrients are and how your body uses them to maintain and fuel all of its complex physiologic processes. In other words, you must understand the science of nutrition.

Science is powerful. It helps explain our world, makes it a better place to live, and contributes to good health. Yet scientific progress almost always generates considerable debate. Not surprisingly, nutritional discoveries that have helped prevent and cure diseases are often met with both excitement and skepticism. For example, one day you may read in a newspaper, "Vitamin A decreases risk of heart disease." Later, another headline claims, "Vitamin A increases risk for cancer." Likewise, an article that says, "You should eat more fish" may be followed by one that asserts, "Fish contains dangerous heavy metals." While nutritional science offers great hope for improving health, you are likely well aware that it also generates controversy.

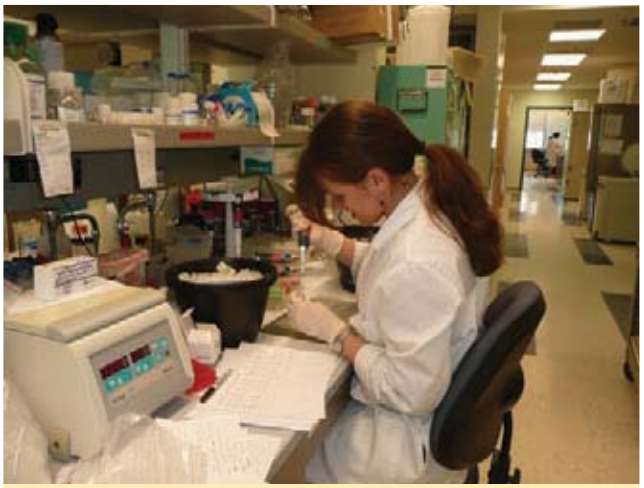
There is no argument, however, that nutrition and its impact on human health are of crucial importance. Nutritional deficiencies have always posed major health challenges worldwide, but today nutritional abundance and imbalance also contribute to many of our health problems.[1] Poor dietary choices you make now very well might play a major role in predisposing you to obesity, cancer, heart disease, osteoporosis, and type 2 diabetes later in your life.[2] This chapter discusses the fundamental concepts necessary to understand how good nutrition is basic to your health. You will also learn how scientists study nutrition. With this knowledge, you will be able to make sound decisions about selecting a healthy diet—based on scientific reason, not rumor—for years to come.

Chapter Outline

EVERYBODY HAS A STORY

Choosing Nutrition as a Career Path

Katherine has always enjoyed good food and the pleasures of eating. But she never imagined that she would pursue a career in nutrition. However, when she recalls her experiences as an overweight child competing at the local swimming club, she realizes that she has long understood the importance of a healthy diet for both physical and mental health. Science was not one of Katherine's passions as she went through her high school years. Instead, she was much more interested in music and tennis, and Katherine was emphatic that she would do nothing related to science, partly because she found her high school science laboratories "contrived and not useful to her daily experience." She instead entered the University of Idaho as an elementary education major and planned to pursue a career as a teacher in the public schools. To fulfill her general education requirement in biology, however, Katherine enrolled in an introductory microbiology class during her first year of studies—not because she was at all interested in the subject, but because her friends reassured her that the professor was engaging and fair. Much to her surprise, Katherine rapidly learned that college-level science was very different from what she had experienced in high school. She understood, for the first time, that many scientific disciplines were incredibly applicable to her own life as well as the health and well-being of society. Of exceptional interest in her microbiology course was the section on foodborne illness because it emphasized how a person's dietary choices can immediately and profoundly impact his or her health. Within a few months, Katherine had switched her major to dietetics and was working in a nutrition research laboratory on campus. She soon discovered that the science of nutrition is not only compelling, challenging, and useful, but that she thoroughly enjoyed the basic work required to carry out nutrition experiments and analyze their results. Katherine is now a graduate student working on her doctorate in nutrition at the University of Idaho. Her graduate research focuses on how a breastfeeding woman's diet influences the composition of her milk, and she has presented her work both nationally and internationally. For Katherine, the discovery that science—in particular, nutritional science—was her career calling came somewhat late in her undergraduate career. And it came as a complete surprise. Indeed, keeping one's options open during college and exploring various disciplines of study are some of the most important tasks of any college student. Sometimes one class can change your life.



Courtesy Katherine Hunt

Critical Thinking: Katherine's Story

Why are you taking this nutrition class, and what are your personal goals for what you will learn? Are there specific issues that are of special interest to you as you embark upon your study of nutrition? Why are you especially interested in these topics? Has nutrition been an interest of yours for many years, or has some situation or experience made you particularly interested in learning more about it?

What Do We Mean by "Nutrition"?

Perhaps the first question you may have is what the term *nutrition* actually means. The term **nutrition** refers to the science of how living organisms obtain and use food to support all the processes required for their existence, and the study of nutrition incorporates a wide variety of scientific disciplines. Some nutritionists, for example, are interested in food production and availability, whereas others conduct research on why people choose to eat certain foods. Still others investigate the relationships between diet and heart disease, how nutrition can influence athletic performance, or whether the composition of our meals can influence weight management. Indeed, the field of nutrition encompasses a broad array of important scientific and cultural aspects.

As such, scientists who study nutrition, called **nutritional scientists,** can be found in many disciplines, including immunology, medicine, genetics, biology, physiology, biochemistry, education, psychology, and sociology, as well as nutrition. **Dietitians** are nutrition professionals who help people make dietary changes and food choices to support a healthy lifestyle. A dietitian has the credential of "RD," which stands for *r*egistered *d*ietitian. Many dietitians are also involved in research. Thus the science of nutrition, collectively called the **nutritional sciences,** reflects a broad spectrum of academic and social disciplines.

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The dietary choices you make today can influence your health for years to come.

NUTRIENTS SUPPORT ALL WE DO

But what are nutrients, and why do we need them? **Nutrients** have traditionally been defined as substances in foods required or used by the body for at least one of the following: energy, structure, or regulation of chemical reactions. For example, carbohydrates supply energy to fuel your body's activities, calcium and phosphorus are important building blocks of your teeth and bones, and many of the vitamins are essential for chemical reactions such as those needed to protect your cells from the damaging effects of excessive sunlight and pollution. There are also many other substances present in food that appear to have health benefits such as decreasing risks for cancer and heart disease. Scores of these compounds have only recently been discovered and are therefore less understood than the "traditional" nutrients. Clearly, the definition of what is a nutrient is evolving, and the list of established nutrients will likely expand as researchers learn more about how the thousands of substances found in foods can promote health and well-being.

FOODS CONTAIN NUTRIENTS AND NONNUTRIENTS

You may be surprised to learn that not all compounds in food are nutrients. To convince yourself of this, you need only examine almost any food label. Many of these compounds found in foods, such as artificial colors, are not nutrients because they are not needed to support basic functions in your body. In general, scientists classify nutrients into six categories based on their chemical structure and composition: carbohydrates, proteins, lipids, water, minerals, and vitamins. Scientists also categorize nutrients and foods in other ways, and some of these classifications are described next.

Essential, Nonessential, and Conditionally Essential Nutrients Although our bodies can use all the nutrients in foods, we only need to consume some of them. These nutrients are referred to as the **essential nutrients.** Essential nutrients

nutrition The science of how living organisms obtain and use food to support processes required for life.

nutritional scientist A person who conducts and/or evaluates nutrition-related research.

dietitian A nutritionist who helps people make healthy dietary choices.

nutritional sciences A broad spectrum of academic and social disciplines related to nutrition.

nutrient A substance in foods used by the body for energy, maintenance of body structures, or regulation of chemical processes.

essential nutrient A substance that must be obtained from the diet, because the body needs it and cannot make it in required amounts.

must be obtained from your diet, because your body needs them and either cannot make them at all or cannot make them in adequate amounts. **Nonessential nutrients** are those your body can make in amounts needed to satisfy its physiological requirements. Hence, you do not actually need to consume nonessential nutrients. Most foods contain a mixture of essential and nonessential nutrients. For example, milk contains a variety of essential vitamins and minerals (such as vitamin A and calcium) as well as nonessential nutrients (such as cholesterol).

However, there are situations when a normally nonessential nutrient can become essential. During these times, the nutrient is called a **conditionally essential nutrient.** For example, older children and adults must obtain two essential lipids through the diet, whereas babies are thought to require at least four, which they are unable to make. The additional lipids are therefore "conditionally essential" during early life. Certain diseases also cause normally nonessential nutrients to become conditionally essential. You will learn about some of these in later chapters.

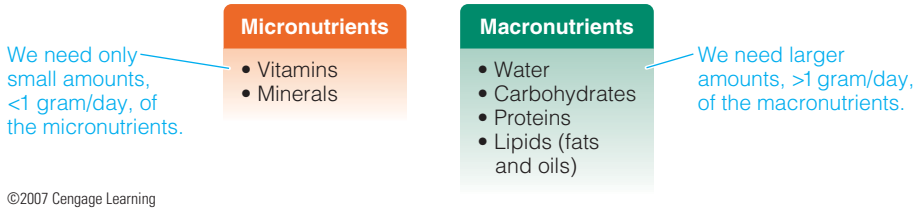
Macronutrients versus Micronutrients Nutrients can also be classified on the basis of how much of them we require from *our* diet. (Figure 1.1). Water, carbohydrates, proteins, and lipids are called **macronutrients,** because they are needed in large quantities (over a gram each day). Vitamins and minerals are called **micronutrients,** because we need only very small amounts of them (often micrograms or milligrams each day). For example, a typical adult requires about 2,726 pounds (1,239 kilograms) of the macronutrient protein over the course of a lifetime but only about 0.3 pounds (0.14 kilograms) of the micronutrient iron.

"Certified organic" foods can be identified by this seal.

ORGANIC NUTRIENTS ARE DIFFERENT FROM ORGANIC FOODS

We can also classify nutrients as being organic or inorganic. By definition, molecules that contain carbon atoms bonded to hydrogen atoms or other carbon atoms are called **organic compounds.** Carbohydrates, proteins, lipids, and vitamins are chemically organic nutrients. Water and minerals are **inorganic** because they do not contain carbon–carbon or carbon–hydrogen bonds. In this way, all foods are considered organic—at least in the chemical sense of the term. However, the term *organic* also has an additional and very different meaning when it is used to describe how a food (plant or animal) is grown and harvested. When a food is labeled "**Certified Organic,**" it has been grown and processed according to U.S. Department of Agriculture (USDA) national organic standards. For example, a farmer cannot use conventional pesticides and herbicides on organically grown crops. You can find out what percentage of organic ingredients a product has by reading its food label (Figure 1.2) and learn more about organic foods in the Focus on Food feature.

FIGURE 1.1 Micronutrients versus Macronutrients Vitamins and minerals are micronutrients, whereas water, carbohydrates, proteins, and lipids are macronutrients.



nonessential nutrient A substance found in food and used by the body to promote health but not required to be consumed in the diet.

conditionally essential nutrient Normally nonessential nutrient that, under certain circumstances, becomes essential.

macronutrients Nutrients that we need to consume in relatively large quantities (>1 gram/day).

micronutrients Nutrients that we need to consume in relatively small quantities (<1 gram/day).

organic compound A substance that contains carbon–carbon bonds or carbon–hydrogen bonds.

inorganic compound A substance that does not contain carbon–carbon bonds or carbon–hydrogen bonds.

certified organic foods Plant and animal foods that have been grown, harvested, and processed without conventional pesticides, fertilizers, growth promoters, bioengineering, or ionizing radiation.

FOCUS ON FOOD
Understanding What Is Meant by "Organic Foods"

A chemist understands the term organic to generally mean a carbon-containing compound. However, the food industry uses the term *organic* to mean something quite different. In 1992, the U.S. federal government established the National Organic Standards Board (NOSB) to help develop standards for substances to be used (or not used) in organic food production. To learn more about these standards, you can visit the USDA's National Organic Program website at http://www.ams.usda.gov/AMSv1.0/nop.htm. The NOSB developed the following definition: *"organic agriculture is an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity … based on management practices that restore, maintain, and enhance ecological harmony."* As such, an organic food must be produced, grown, and harvested without the use of most conventional pesticides, fertilizers made with synthetic ingredients, bioengineering, or ionizing radiation. Furthermore, organic meat, eggs, and dairy products must come from livestock raised without the use of growth-promoting hormones and antibiotics.

Foods with the USDA organic seal labeled as being "100% organic" must have at least 95% organically produced ingredients. Foods labeled as being "organic" must have at least 70% organic ingredients. Products with less than 70% organic ingredients may list specific organically produced ingredients on the side panel of the package but may not make any organic claims on the front of the package (see Figure 1.2).

The USDA makes no claims that organically produced food is safer or more nutritious than conventionally produced food, and the labeling of foods as "organic" is not meant to suggest enhanced nutritional quality or food safety. In fact, there is mixed evidence that organic foods are nutritionally superior to conventional foods.[3] Rather, the difference between organic foods and conventionally produced foods largely involves the methods used to grow, handle, and process them. Whether these alternative agricultural practices promote enhanced environmental integrity and balance is an area of active debate.

PHYTOCHEMICALS, ZOONUTRIENTS, AND FUNCTIONAL FOODS

As scientists learn more about the relationship between diet and health, they are discovering that, in addition to the traditional or established macronutrients and micronutrients, foods also contain other substances that influence our health. When health-promoting compounds such as these are found in plants, they are called phytochemicals. Others, called zoonutrients, are found in animal foods. Although phytochemicals and zoonutrients are not considered to be nutrients by many nutritionists, researchers think that many are

FIGURE 1.2 Understanding Food Labels of Organic Products

Must have 95–100% certified organic ingredients.

Must have at least 70% certified organic ingredients.

Organic ingredients can be listed on side panel.

No organic claim is being made.

beneficial to health. As scientists learn more about these compounds, some of them may be reclassified as nutrients in the future.

Phytochemicals: Beneficial Substances from Plant Foods Although they are not nutrients, **phytochemicals** (also called phytonutrients) are substances found in plants that may help reduce the risk for developing certain diseases.[4] In fact, many "health claims" on food packaging labels refer not to traditional nutrients but instead to phytochemicals. For example, consuming phytochemicals found in tomatoes and garlic may decrease your risk of cancer. Grapes and wine contain phytochemicals that may reduce the risk of heart disease. You will learn more about these and other phytochemicals throughout this book.

Zoonutrients: Beneficial Substances from Animal Foods Like phytochemicals, which are found in plants, **zoonutrients** (also called zoochemicals) are compounds present in animal foods that provide health benefits beyond the provision of traditional nutrients and energy.[5] Examples of zoonutrients include a variety of nonessential lipids, found in fish and dairy products, that are thought to decrease your risk for heart disease. Another example of a zoonutrient is found in the larval jelly produced by honeybees. This substance is antimicrobial and may reduce the risk of infection.[6]

Functional Foods May Offer Important Health Benefits **Functional foods** are those that may promote optimal health, above and beyond simply helping the body meet its basic nutritional needs.[7] Functional foods contain (1) enhanced amounts of traditional nutrients, (2) phytochemicals, and/or (3) zoonutrients. For example, soy milk is considered a functional food because it contains phytochemicals thought to decrease risk for some cancers. Other examples are conventional cow's milk, which has been shown to be rich in zoonutrients that may lower your risks of cancer and high blood pressure. Although consuming functional foods may improve your health, the mechanisms by which this occurs are often poorly understood.

Why might scientists consider this plate of spaghetti and glass of wine functional foods?

What Are the Major Nutrient Classes?

Nutrients are needed by your body to provide structure, regulate chemical reactions (metabolism), and supply energy. Protein, for example, is important for providing the basic structure of muscles, many vitamins help regulate the hundreds of chemical reactions that occur in your body, and dietary fats provide an important source of energy needed to power your body's activities. Each class of nutrients consists of many different compounds and contributes to most of these functions in one way or another. You will learn more about each of the nutrient classes in upcoming chapters.

phytochemical (also called phytonutrient) (phy – to – CHEM – i – cal) A substance found in plants and thought to benefit human health above and beyond the provision of essential nutrients and energy.

zoonutrient (zo – o – NU – tri – ent) A substance found in animal foods and thought to benefit human health above and beyond the provision of essential nutrients and energy.

functional food A food that contains enhanced levels of an essential nutrient, phytochemical, or zoonutrient and thought to benefit human health.

CARBOHYDRATES ARE VITAL FOR ENERGY AND REGULATORY ROLES

Carbohydrates consist of carbon, hydrogen, and oxygen atoms and serve a variety of functions in the body. There are many different types of carbohydrates; for example, those found in starchy foods like rice and pasta are quite different from those found in fruits and sweet desserts. Of the various carbohydrates that exist, perhaps the most important is glucose. Indeed, most cells use glucose as their primary source of energy. Your body uses carbohydrates for many other purposes as well. For instance, some are needed to make the genetic material (DNA) in cells. Other carbohydrates such as

dietary fiber play roles in maintaining the health of your digestive system and may help decrease your risk of certain conditions, including heart disease and type 2 diabetes. Carbohydrates are also important structural and regulatory components of the membranes that surround the millions of cells in your body.

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Grains and cereals provide most of the carbohydrates in the diet.

PROTEINS MAKE UP MUSCLES AND ARE IMPORTANT FOR ENERGY AND REGULATION

Protein is abundant in many foods, including meat, legumes (such as dried peas), and some cereal products. Although most proteins consist primarily of carbon, oxygen, nitrogen, and hydrogen atoms, some also contain sulfur or selenium atoms. The thousands of proteins in your body have numerous roles in addition to serving as a source of energy. Proteins also comprise the major structural material in various parts of your body, including muscle, bone, and skin. Proteins allow us to move, support our complex internal communication systems, keep us healthy by their roles in the immune system (which protects against infection and disease), and regulate many of the chemical reactions needed for life.

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There are many good sources of protein in the diet, including milk.

LIPIDS ARE MORE THAN ABUNDANT ENERGY SOURCES

Lipids, which include a variety of oils and fats found in foods and the body, generally consist of carbon, oxygen, and hydrogen atoms. They provide large amounts of energy, are important for the structure of cell membranes, and are needed for your nervous and reproductive systems to function properly. Lipids also regulate a variety of cellular processes. Many foods contain lipids, although the types found in plant-based products such as corn oil and nuts are typically quite different from those found in animal-based foods such as meat, fish, eggs, and milk.

WATER IS THE ESSENCE OF LIFE ITSELF

Without water, there would be no life. Indeed, water—which is made of oxygen and hydrogen atoms—makes up approximately 60% of your total body weight. Without exception, you consume water every day, be it in beverages or in the foods you eat. The functions of water are varied and vital, including transport of nutrients, gases, and waste products; serving as a medium in which chemical reactions occur; and involvement in many chemical reactions. Water is also important in regulating body temperature and protecting your internal organs from damage.

Sasha Semenov-Maron /Shutterstock.com

Lipids found in olives are thought to impart important health benefits.

VITAMINS REGULATE REACTIONS AND PROMOTE GROWTH AND DEVELOPMENT

Vitamins have a variety of chemical structures and are abundant in most naturally occurring foods—especially fruits, vegetables, and grains. Although they all contain carbon, oxygen, and hydrogen atoms, some vitamins also